The JOURNAL of METEOROLOGY



DEVASTATION IN MID-WALES, 17 MAY 1993, CAUSED BY A T5 TORNADO

THE JOURNAL OF METEOROLOGY

LE JOURNAL DE MÉTÉOROLOGIE

Published in association with

The Tornado and Storm Research Organisation

a privately supported research body, serving the national public interest

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Published by the Artetech Publishing Co., 54 Frome Road, Bradford-on-Avon, Wiltshire BA15 1LD, England.

Printed by the Dowland Press Ltd., Frome, Somerset, BA11 1EB.

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ISSN 0307-5966

JOURNAL OF METEOROLOGY

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

Editor: Dr. G. T. Meaden

Vol 19, no. 188, April 1994

TORRO HAILSTORM DIVISION: NINTH ANNUAL SUMMARY DAMAGING HAIL IN THE BRITISH ISLES, 1992

By JONATHAN D. C. WEBB TORRO, Oxford

There were ten days in 1992 when "damaging" hail (TORRO scale severity H1 or more) was reported. This was in the context of a year when widespread and severe thunderstorm outbreaks occurred more frequently than in any year since 1983. Notable falls of hail were almost entirely confined to those outbreaks which occurred early and late in the "summer" thunderstorm season, the most outstanding event being the Foulness storm of 18th September. The following text describes those conspicuous falls of hail in 1992 which are known to TORRO, including the damaging events noted in Table 1 (all times refer to G.M.T.).

January-March: There was a good deal of anticyclonic weather in the first three months of the year with little thundery activity reported. Unstable polar air masses rarely penetrated very far south in the eastern Atlantic until late March.

The weather pattern began to change as an active "secondary" cold front swept eastwards across the British Isles overnight on 20th/21st March. Unexpectedly violent thunderstorms affected western Ireland (Meskill 1992, Sweeney 1992) between 2000 and 2400, accompanied by some large hail near Straide, Co. Mayo.

April 15: A depression crossed central areas of Britain overnight on 14th/15th followed by a brief incursion of strong, very cold northerly winds. This was a typical, unstable mid-spring weather situation and there were widespread wintry showers, some heavy and thundery. During a thunderstorm at Billingham, Teeside, hailstones 10-15mm diameter fell for six minutes.

May/June 1992: This was the warmest May since 1848 in the central England temperature series. Scattered thunder and hail (up to pea size) was reported during a rather unsettled "westerly" spell early in the month, chiefly on the 9th.

A very thundery spell of weather occurred between 23rd May and 10th June 1992 (Prichard 1993); numerous incidences of large hail were reported during this period. The synoptic situation displayed several persistent features. A pronounced upper trough (often with a distinct "cold pool") was situated southwest of the British Isles causing the 500 mb "storm steering winds" to blow

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from a south-easterly direction. Surface pressure remained relatively low across Biscay (especially from 23rd to 30th May), southern Britain, and neighbouring parts of north-west Europe, while high pressure persisted over the Norwegian Sea and northern Scandinavia. Minor troughs drifted erratically northwards over the British Isles.

May 23rd: The cold pool was situated in mid-Atlantic with an associated upper trough extending south-eastwards to Iberia. The British Isles were situated in a light easterly surface wind gradient between an anticyclone over the Norwegian Sea and a broad trough lying across northern France (Fig. 1). Afternoon temperatures exceeded 25°C west of London with peak values of 27°C at southern coastal locations sheltered to the east.

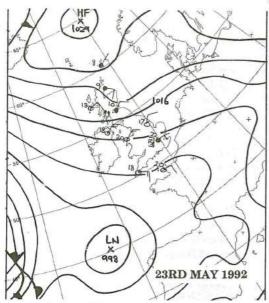


Figure 1. Surface synoptic situation, 1800 GMT 23 May 1992 (from the London Weather Centre's Daily Weather Summary).

While weakening thunderstorms drifted across from the Continent to affect East Anglia and South-east England from early afternoon, vigorous "home grown" thunderstorms developed during the late afternoon in the Thames Valley, Wiltshire and Somerset; these areas of thundery activity moved westnorth-west to affect the Bristol area, the south-west Midlands and South Wales during the evening.

Observers in Oxfordshire and Berkshire commented on how rapidly cumulonimbus clouds developed following an afternoon during which sunshine had only previously been interrupted by innocuous-looking patches of altocumulus clouds. Such a sudden release of convective energy is favourable for the development of severe thunderstorms with large hail. A sharp thunderstorm affected South Oxfordshire between 1700 and 1800 accompanied by marble-sized hailstones at Abingdon. Lightning struck the runway at RAF Brize Norton.

A much larger storm system, probably originating over Salisbury Plain, drifted across West Wiltshire, Avon and adjacent parts of Somerset. There were several reports of lightning damage (especially in Bath). Severe local winds, probably associated with a tornado, also caused extensive damage near Monkton Farleigh, Wiltshire (see *J. Meteorology*, 18, page 25). Hail fell widely. Hailstones up to 18 mm diameter covered the Wiltshire cricket ground at Trowbridge, the largest hailstones reported in the area since the great storm of July 1967 (see *J. Meteorology*, 18, pp.324-325). At Bradford-on-Avon hailstones of 18-23 mm diameter were observed around 1800. "Gobstoppers" hailstones at least 13 mm diameter fell around Bath and there were reports of car paintwork being dented. Slightly further south some unusual aggregate pieces of ice fell at Farrington Gurney, Somerset (Kidd 1993) and 12 mm diameter hail fell during a sharp thunderstorm at Yatton, Avon.

During a separate outbreak of storms which affected Western Somerset, hailstones 11 mm across damaged some garden plants at Minehead, while there was a report of hailstones around 30 mm diameter falling on Dunster beach.

May 24th: A shallow surface trough drifted northwards over central and southern England.

Early morning thunderstorms over northern England and the Wash area subsided by about 1000. However, rising temperatures (up to 27°C west of London) set off further storms, some severe, over Berkshire and Wiltshire between 1200 and 1300; these storms tracked north-westwards to affect the south and west Midlands and later north-east Wales and north-west England. Many places within this zone experienced a series of relatively brief but sharp thunderstorms and there were reports of lightning damage and hail. Bracknell, Berkshire, experienced a severe storm between 1300 and 1400 accompanied by 27 mm of rain and, for several minutes, by hailstones up to 10 mm diameter. Later in the afternoon hailstones measuring 15-16 mm diameter accompanied a succession of storms which crossed Connahs Quay (near Chester) between 1706 and 2154.

May 28th: The cold pool was now central over Biscay. A surface depression west of Brest had pushed a warm front northwards across the country overnight 27th/28th (with some thundery rain). Temperatures then rose to around 25°C in a very humid 'warm sector'. As a waving cold front moved slowly northwards into southern England, intense thunderstorms broke out over South Wales and Gloucestershire between 1300 and 1330; these storms drifted northwards across the west Midlands, Wales and north-west England. There were many incidents of lightning damage and flash flooding. Hailstones the size of five-pence pieces fell at Longlevens, near Gloucester.

May 31st: Shallow depressions were situated over western Ireland and over

France; a convergence zone was situated across eastern England (between south-easterly winds to the east and south-westerlies to the west). Some severe thunderstorms broke out along this "spawning" zone during the afternoon and evening with a few thundery showers also being reported further west (e.g. over the Berkshire Downs). 133 mm of rain was reported during an exceptional local downpour near Rickmansworth, Herts. 70 mm rain fell in parts of Northamptonshire, while hail the size of marbles and sugar cubes fell in the villages of Egginton, Winshill and Stapenhill on the Derbyshire/Staffordshire border.

June 3rd: For the past four days a belt of low pressure had extended north-westwards from Central Europe, across the British Isles to Iceland. This convergence zone was reinforced on the 3rd by an old Atlantic cold front which was drifting slowly north-east into Wales. Thunderstorms affected mid/north Wales for about 3 hours from late morning; at Blwych-y-Ffridd, near Newtown (Powys) hail fell for 15 minutes, damaging leaves and flowers.

June 9th: Thunderstorms affected parts of northern Britain in the early hours, probably associated with an old cold frontal zone. Meanwhile southern and western areas of Britain remained under the influence of the upper trough which had dominated the weather pattern during the past two-and-a-half weeks. A shallow surface depression was situated in the western English Channel.

Because surface winds were east to south-easterly some of the highest maximum temperatures (22-23°C) were displaced westwards. Consequently the first areas to be affected by daytime cumulonimbus development included north-west England and the Welsh border region where quite widespread and severe thunderstorms developed between 1100 and 1300 GMT. These storms were later reinforced by further storms moving north-west from the Midlands; Presteigne, Powys, reported a succession of storms from 1155 to 1833, with hail falling on 3 separate occasions. A severe thunderstorm struck the area between Liverpool and Fleetwood (Lancs) from 1200 to 1400 with reports of flooding and lightning damage. Hailstones at least the size of 10-pence pieces fell in the north Liverpool/Formby area and there were reports of drains being blocked by hail. The succession of storms in the north-west culminated in two exceptionally violent electrical storms which affected Cheshire, Merseyside and Clwyd during the mid/late evening. Hailstones over 15 mm diameter fell at Neston, Cheshire, and hailstones up to 14 mm across accompanied a ferocious squall at Heswall, Merseyside (Irons 1992). Hail was also observed in various parts of Clwvd.

Severe thunderstorms also affected London and the South Midlands during the afternoon. 67.4 mm rain fell in 105 minutes at Grove Park, south-east London. A severe mid-afternoon storm, which caused flooding in the Aylesbury area of Buckinghamshire, was accompanied by pea-sized hailstones; visibility was cut to a few hundred metres during the downpour.

During another outbreak of storms which affected west Somerset plants were damaged by hail west of Minehead.

June 10th: Further thunderstorms developed on the 10th although they were

mostly less severe than on the previous day. However an especially severe storm caused power cuts and cattle fatalities in Co. Mayo, western Ireland, during the early evening. Large hail was reported from the west of the County.

June 29th: As an anticyclone drifted away eastwards into eastern Europe a hot south-easterly airstream affected most of the British Isles (temperatures reached 30°C in south-east England). Meanwhile a thundery trough moved slowly north-east into Ireland and south-west England. Some severe storms affected Ireland with several reports of lightning damage. Hailstones up to 13 mm diameter fell at Knockroe, Monaghan, during an intense electrical storm which was overhead around 1343.

July/August: Although there were some outstanding thundery outbreaks, notably on 20th July and 8th/9th August, only a few instances of hail were reported (mostly in August); these reports only referred to hail of "ordinary" size (circa 6 mm diameter).

September 11th: A deep depression was situated just off north-west Scotland and a cool, unstable westerly airstream gave a very showery day in western districts with local thunder. During a 30-minute thunderstorm downpour at Chapeltown, Lancashire, hail completely covered the ground. Some very heavy hail also accompanied a storm at Blaenau Ffestiniog, Gwynedd.

September 18th: Foulness Island, north-east of Southend was seriously affected by the most severe hailstorm reported in the British Isles since 1985.

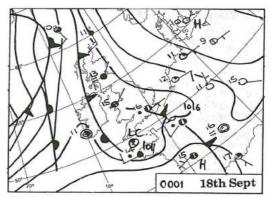


Figure 2: Surface synoptic situation, 0001 GMT 18 September 1992 (from the London Weather Centre's *Daily Weather Summary*).

A cold front had drifted slowly north-eastwards into the country on the 17th accompanied by scattered "medium level" thundery activity and by 0000, 18th, this lay from North Wales to Sussex by which time a shallow depression was centred over southern England (Fig. 2). A cold pool, situated south-west of the British Isles at noon on the 17th, was also shifting north-east, preceded by a strengthening south to south-easterly airflow at 500 mb. There was considerable vertical wind *speed* shear; the very light surface south-easterly winds increased to a velocity of 57 knots at 300 mb. Both the upper air ascent at Crawley (1800,

17th) and Shoeburyness (0600, 18th) indicated that there was a stable layer up to about 770 mb, capped by very moist and unstable conditions above. Surface temperatures on the 17th had reached 21-23°C in England (23.5°C at Heathrow) but exceeded 30°C in northern France and this hot air was continuing to be advected slowly northwards.

The sudden breaching of a stable layer and the consequent explosive release of convective energy is one factor associated with the development of severe hail-producing thunderstorms. Substantial vertical wind shear also favours the formation of long-lasting severe storms (although not by itself guaranteeing the occurrence of large hail).

After the relatively uneventful day severe thunderstorms erupted suddenly, over East Sussex, Kent and South Essex between 0000 and 0200, and over the northern Cotswolds, from 2350 to 0100. The outbreak over Gloucestershire persisted as a relatively small, although very electrically active, cluster of storms which drifted north-north-west across the west Midlands (Reynolds 1992) and Cheshire before petering out over north-west England around dawn. The eastern group of storms coalesced into a large storm area extending north-north-westwards from Kent across East Anglia and the East Midlands; radar pictures indicated conspicuously vigorous storm cells on the south-eastern flank of this system (including the Foulness hailstorm).

The devastating hailstorm swept northwards across the entire central swath of Foulness Island between 0250 and 0330. The storm's onset was heralded by frequent and exceptionally bright "strobe-like" lightning. Shoeburyness, just to the west, recorded violent rain and squall winds gusting to 34 knots. Two bursts of hail were observed at AWE Foulness (near Havengore Head); on the first occasion hailstones averaged 25 mm diameter. The hailstones descended with such intensity that visibility was reduced to only about 15 metres, while the storm was succeeded by a dense "steam fog" which resulted from the ground being chilled by the carpet of hailstones. Panels of a Land Rover were covered in dents while the vehicle's blue light was smashed, together with the windscreen of an adjacent car. Vehicles were also dented at Rugwood Farm (south of Churchend) where small branches were broken down and trees almost denuded of leaves. Churchend, the largest village on the Island, was severely affected by the hailstorm which lasted about 15 minutes. The largest hailstones were described as being the size of a large chicken's egg; one measured 48 mm x 42 mm. Conservatory and greenhouse roofs were totally destroyed. The hailstones, which covered the ground, also broke or cracked slates on a roof, punched holes in guttering, and left 5 mm dents in cars.

Fortunately no serious human injuries were recorded (although one eye witness compared the frightening experience of being caught out in the storm to being attacked with stones). However the storm inflicted disastrous casualties on the Island's wildlife. More than 2,000 birds (including over 1,000 seagulls) were killed as well as eight hares, one sheep and a small seal. Unfortunately the storm struck when many waders were gathering in advance of the high tide at 0535. Many pheasants and partridges bred at Rugwood Farm also perished.

RSPCA officials who visited the Island in the aftermath of the storm had the sad task of collecting injured and dead wildlife (see also *J. Meteorology*, 18, p.62).

The Foulness hailstorm occurred on the extreme right flank of the thunderstorm complex; indeed the coastal strips of Suffolk and Norfolk, slightly further east than the Essex coast, recorded little or no precipitation. Although the very destructive hailswath was confined to Foulness Island it is likely that the same intense storm system subsequently affected the Colchester and Stowmarket areas, where there were further scattered incidences of large hail. During the furious thunderstorm which struck Colchester between 0250 and 0400, 25 mm hailstones were reported by an observer in the south-east of the town. 20 kilometres north, lozenge-shaped hailstones, 18 mm long, fell during a vicious thunderstorm squall at Hadleigh, Suffolk (10.5 mm rain falling in 8 minutes).

Rainfall totals from these overnight storms were very variable but 38-39 mm fell in the Colchester area and further west, 41 mm was recorded at Stanford Rivers, near Epping. 20-25 mm rain fell during the overnight storms in the western Midlands. Severe storms drifted across west Norfolk between 0600 and 0900 with a fall of 59 mm of rain causing flooding in the Fakenham area. Lightning damage was reported from many locations in Kent, Essex, East Anglia and the West Midlands.

Further scattered areas of heavy, thundery rain developed during the 18th. A prolonged outbreak affected Gloucestershire, Avon, Somerset and especially West Wiltshire causing severe local flooding in the Westbury/Warminster/Trowbridge area; Upton Scudamore recorded 94.8 mm of rain and Warminster 79.7 mm, most of it in four or five hours.

October 20th: An upper trough had intensified across the British Isles during the previous week (hail and thunder accompanied showers in various coastal districts on the 15th). A waving frontal zone across the English Channel was reactivated as a small depression developed over North Biscay on the 19th. As the upper trough retrogressed to just west of the British Isles this low was steered north-eastwards into south-east England on the 20th. Frontal rain spread northwards overnight accompanied by scattered thundery activity. More widespread thunderstorms broke out to the south of the occluding frontal zone; central south and south-east England were affected by severe storms, many with hail, between about 0600 and 0900. Lightning damage was reported from the Isle of Wight, Brighton and south Essex. During the violent storm on the Isle of Wight "enormous hailstones" fell near Afton, turning the roads white. Hail also partly covered the ground in Brighton and completely whitened the ground for about 30 minutes at Burgess Hill, West Sussex. A similar hailfall occurred at Lower Beeding, near Horsham. Hail also lay very thickly following a particularly violent thunderstorm in the Brentwood area of Essex.

Further vigorous thunderstorms developed near the depression centre as it drifted very slowly across south-east England later on the 20th. Kinsgate, near Broadstairs (Kent), recorded hailstones up to 13 mm diameter between 1325 and 1330. Flash flooding was reported in Essex and neighbouring parts of Cambridgeshire and Suffolk (Prichard 1993).

October 23rd: A cool, unstable westerly airstream affected England and Wales on the 23rd. Showers near western coasts early in the day became widespread in central and eastern districts by early afternoon. During thundery showers in the Birmingham/Wolverhampton areas in mid-afternoon hail covered the ground at Pelsall Common, near Bloxwich.

October 30th: Cumulonimbus clouds developed over the English Channel in a light, cold northerly airstream. Small funnel clouds were observed off the west coast of Guernsey and 5-7 cm of hail blanketed part of the west of the Island when an early afternoon thundery shower drifted inshore.

Acknowledgements: The TORRO directors wish to thank all observers of the Tornado and Storm Research Organisation, especially those of the Thunderstorm Census Organisation division; also those of the Climatological Observers Link. Special thanks are due to: Mr. Robert Holburn of Shoeburyness Meteorological Office and Mr. Terry Mayes, COL Editor, for additional reports on the storms of 18 September; and to Mr. W. S. Pike for correspondence regarding the storms of 23 May and 18 September. We are also grateful to the Meteorological Office (archives section) for the supply of some upper air data and for useful information published in the Daily Weather Summary. Thanks are also due to the National Rivers Authority for some additional rainfall data.

TABLE 1: SUMMARY OF INCIDENCES OF DAMAGING HAIL IN 1992, BRITISH ISLES

Date		Locations	ORRO Intensity
May 23	(1)	Minehead (Somerset)	H1
	(2)	Dunster (Somerset)	H2
	(3)	Abingdon (Oxon)	H1
	(4)	Trowbridge - Bradford on Avon (Wilts) - Bath (Avon), 15 km long	H3
	(5)	Farrington Gurney - Yatton (Avon)	H1/2
May 24		Connah's Quay (Clwyd)	H1
May 28		Longlevens (Gloucestershire)	H1
May 31		Egginton - Winshill - Stapenhill (Staffordshire)	H1
June 3		Blwch-y-Ffridd (Powys)	H1
June 9	(1)	Tivington (Somerset)	H1
	(2)	North Liverpool - Formby (Merseyside)	H2
	(3)	Neston (Cheshire - Heswall (Merseyside)	H1
Sept. 18	(1)	Foulness Island (Essex) - Havengore Head - Crouch Corner, 7 km lo	ong H5
	(2)	Colchester East (Essex) - Hadleigh (Suffolk)	H2
Oct. 20	(1)	Afton (Isle of Wight)	H1
	(2)	Brighton - Burgess Hill (West Sussex)	H1
	(3)	Kinsgate (Kent)	H1
Oct. 30		Guernsey (Channel Islands)	H1
NB	Oth on:	er reports of hail either (a) > 10 mm diameter, or (b) covering the gro	und, occurred

April 15th, Sept. 11th, Oct. 23rd (Great Britain); and June 10th and June 29th (Ireland).

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Correction: to TORRO Hailstorm Division Annual Summary 1991 (J. Meteorology, 18, pp.251-254).

On page 252 for "June 3rd" read "June 16th".

However, in addition, soft hailstones 15 mm x 10 mm were observed at Castleford, West Yorkshire, on the 3rd June (during a shower occurring in an unusually cool arctic airstream).

THE INCORPORATION OF WIND DIRECTION INTO AN ASSESSMENT OF SITE EXPOSURE

By S. J. HARRISON

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Abstract. The exposure of sites, particularly to airflow, affects weather observations in addition to influencing a number of weather-sensitive operations. Methods of assessing exposure have tended to neglect wind direction. A method of incorporating wind direction into a numerical index of exposure has been devised which can be used selectively for specific weather conditions such as snowfall.

INTRODUCTION

The exposure of particular sites to airflow has a considerable bearing on weather observations as a result of its operation on the vertical fluxes of heat, moisture and momentum in the near-surface micro-environment, and on the performance of meteorological instruments such as raingauges. Site exposure affects not only wind speed and gustiness but also precipitation (raingauge catch and snow-lie), screen temperature, vapour pressure and relative humidity, and evaporation. In addition, in weather-sensitive commercial operations such as horticulture and the construction industry, excessive exposure of sites can lead to direct financial losses (for example: Bruce 1984; Prior 1989). In an earlier evaluation of site exposure, in the form of a numerical index (S_L) (Harrison 1988), equal weighting was given to exposure from all points of the compass. In the United Kingdom, for example, this clearly neglects to account for the very real differences between a more frequent exposure to milder

Atlantic airflow from the west, and a less frequent winter exposure to cold continental airflow from the east.

In a climate which is dominated by westerly airflow, a site which has a low horizon inclination to the west and a higher horizon to the east will experience a substantially greater degree of exposure than a site with diametrically opposite horizon inclinations. An attempt has been made to incorporate wind-direction frequency into the numerical assessment of local exposure at sites, based on the eight principal compass points.

THE EXPOSURE INDEX

The basic exposure index (S_I) (Harrison 1988) is given by:

$$S_L^2 = \sum_{n=1}^8 \frac{\varnothing_n \ , \ \varnothing_n \ , \ 1}{2} \ , \sin \ \frac{\pi}{4}$$

$$(\varnothing_9 = \varnothing_1)$$

Evaluation of S_L is based on the inclination, or declination, of the horizon (\emptyset_n) which is measured from the centre of a site along the eight principal points of compass, starting at north (n = 1).

In order to incorporate wind direction the approach adopted was to raise or lower these measured horizon angles according to whether there were respectively higher or lower frequencies of airflow from the particular compass point. Thus for a site with higher horizon angles to the west, the biasing upwards of these by a higher frequency of westerly winds would serve to increase the S_L value (less exposed). Conversely, lower angles to the west and higher angles to the east would result in a lowering of the S_L value (more exposed) for a similar distribution of wind direction. A wind-direction modified exposure index (S_{LW}) has thus been derived:

$$S_{LW}^2 = \sum_{n=1}^{8} \frac{X_n \cdot X_n \cdot 1}{2} \cdot \sin \frac{\pi}{4}$$

where $X_n = \emptyset_n \cdot f_n$ in which f_n is a wind-frequency term derived from the percentage frequency (F_n) for the eight principal compass points: $f_n = 8(F_n/100)$, where $F_9 = f_1$ and $X_9 = X_1$. For a uniform distribution of wind direction, $F_n = 12.5\%$, so $f_n = 1$ and there is effectively no directional bias in the index.

USING THE INDEX

The performance of the new index was checked using four of the weather stations used in the formulation of the original index (Harrison 1988), namely Brooms Barn (Bury St Edmunds), East Kilbride (Glasgow), Penglais (Aberystwyth), and Westbury-on-Trym (Bristol). Regional mean wind direction frequencies for these sites were obtained using the records from Mildenhall, Renfrew, Aberporth and Boscombe Down respectively, which were extracted from "Tables of Surface Wind Speed and Direction over the United Kingdom"

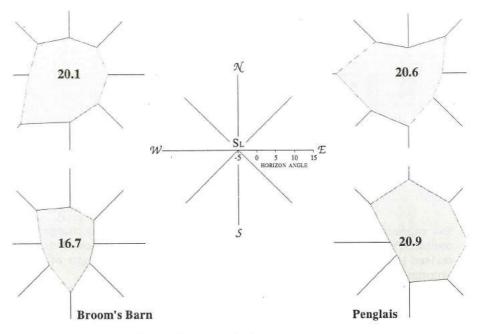


Figure 1: Sheltergrams for four weather stations.

(Met Office 1968). East Kilbride and Westbury had similar S_L values but subtly different distributions of horizon angles (Figure 1). Although Penglais had a similar S_L value to these sites, it had a marked imbalance in horizon angles, with very open exposure to the west and south, and shelter from topography and vegetation from both north and east. Brooms Barn was included as being typical of a more open and exposed site.

Table 1

The effect of mean annual wind-direction bias on exposure index values.

Station	Derived Aspect	$\begin{array}{c} \textit{Unbiased} \\ \textit{S}_{\textit{L}} \end{array}$	Biasea S _{LW}
Brooms Barn	SE	16.70	16.42
East Kilbride	E	20.64	24.24
Penglais	SW	20.86	17.48
Westbury	NE	20.11	21.04

S_{LW} values were first derived for all four stations using mean annual direction frequencies (Tables 1 and 2). The change from the unbiased to the biased exposure index value clearly differs from station to station. East Kilbride and Westbury, which are both slightly sheltered to the west, become effectively

Table 2
Description of exposure from index values (Harrison 1988)

Exposure index values	Description of exposur				
Greater than 56.8	Extremely sheltered				
56.8 to 47.8	Very sheltered				
47.7 to 40.3	Sheltered				
40.2 to 33.9	Moderately sheltered				
33.8 to 28.5	Slightly sheltered				
28.4 to 24.0	Average				
23.9 to 20.2	Slightly exposed				
20.1 to 17.0	Moderately exposed				
16.9 to 14.3	Exposed				
less than 14.3	Very exposed				

less exposed, while the exposed Brooms Barn shows almost no change. In contrast, Penglais, which is open to the west, becomes more exposed. Thus the revised index appears to be producing appropriate reassessments of site exposure.

In many cases, a particular concern is the effect of longer spells of winds from restricted directional sectors. The performance of the S_{LW} index under such persistent airflow conditions was assessed using four dummy sets of directional frequencies (Table 3). In these, generous allowance was made for directional fluctuations in a turbulent atmosphere. As may be expected, the four

Table 3
Assumed directional frequencies (%) for spells of relatively persistent wind direction

	N	NE	Ε	SE	S	SW	W	NW
Easterly	5.0	20.0	50.0	20.0	5.0	0.0	0.0	0.0
Westerly	5.0	0.0	0.0	0.0	5.0	20.0	50.0	20.0
Northerly	50.0	20.0	5.0	0.0	0.0	0.0	5.0	20.0
Southerly	0.0	0.0	5.0	20.0	50.0	20.0	5.0	0.0

stations responded very differently (Figure 2). The exposed station at Brooms Barn varied from *very exposed* in easterly winds to only *slightly exposed* in northerlies, an S_{LW} range of 10.7. Surprisingly, Westbury varied least, having a range of 5.9 while East Kilbride had a range of 12.2. In the earlier evaluation of site exposure (Harrison 1988), the observer at Westbury commented that he felt the station was "more sheltered than its S_L would suggest" due to the higher frequency of winds from between south and west in the Bristol area. This is well illustrated in Figure 2 which shows that the station does indeed become more sheltered when winds are from southerly or westerly directions. The greatest range of S_{LW} was at Penglais which varied from *very exposed* in westerly winds to *slightly sheltered* in northerly winds, a range of 18.0.

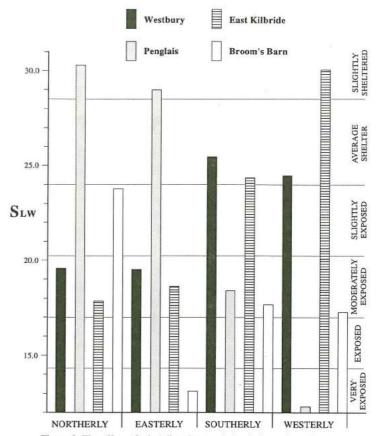


Figure 2. The effect of wind direction on shelter index values (S_{I,W})

CONCLUSION

No index of exposure can be wholly objective but the modification of the earlier S_L index (Harrison 1988) by the incorporation of wind direction frequencies has resulted in an index which appears to perform well on the basis of its application to a limited sample of sites. The direct application of wind bias to horizon angles is logical and makes the revised index easy to apply to, for example, the accumulation of snow in catchments or along sections of trunk road, or in the assessment of wind exposure risk in forestry and agriculture.

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TORRO TORNADO REPORT: MAY 1993

Pressure in May 1993 was above average in the north of Britain and below average in the south, so that the mean airflow was, unusually, from the east. Three tornadoes, all definite, occurred; one funnel cloud and three land devils. These whirlwinds shared a remarkable concentration near the Welsh border, an area not normally prone to such activity. The tornadoes were also unusual in that they moved from south-east or south, both rare directions for tornado tracks in Britain.

LD1993May3/I. Goole, South Humberside (cSE7423)

A land devil, described as a "dense mass of swirling wind", struck Clifton Gardens, Goole, at about 1400 GMT, picking up gravel, blossom leaves and dirt. Washing on a clothes line "stood bolt upright'. The weather was "calm and sunny" (*Goole, Howden and Thorne Courier*, 6th May, sent by Mr. W. G. Ellis).

A strong ridge covered all areas at 1200.

LD1993May3/II. Carno, Powys (SN9696)

Many people in Carno saw a land devil 'carrying an item of clothing' at 1310 GMT. "The weather at the time was dry, mainly cloudy, though quite bright with a light N.W. wind" (letter from Mr. Jeffrey Evans).

LD1993April/May. Lower Bryn, Hope, Leighton, Powys (SJ2506)

At lunchtime a land devil lifted hay from a field and moved off southwards "making quite a racket" as it passed through a forest. There was little general wind (letter from Mr. John H. Denton, 26th June). The date was "about two months ago".

TN1993May10/I. Arscott to Yockleton, Shropshire (SJ437078-4010)

A "towering swirl of wind" struck Arscott and Yockleton, near Shrewsbury. Mr. William Pickering of Arscott Hall, said: "It was just like a spinning pipe reaching from the ground to the clouds" (*Shropshire Star*, 11th May). Mr. Martin Hamer, of Arscott House, told TORRO that the tornado passed over his farm buildings, lifting a corrugated iron shed from next door and dumping it on his farm cottage and all over the golf course. Corrugated metal sheets were carried half a mile (one kilometre), apple trees uprooted, oak trees "ripped

apart" and branches twisted. There was a roar like a low-flying jet, and a neighbour saw a "grey funnel". The track was 50-100 metres wide and 4 km long, from south-east; time was about 1600 GMT; force T2-3.

At 1800 an easterly flow covered Britain, between a high, 1039 mbar, near the Faroes and a low, 1006 mbar, in S.E. Biscay. The 500 mbar chart was similar. Thunderstorms were occurring from the Midlands to North Wales.

1993May10/II. Loggerhaeds, Staffordshire, to Norton-in Hales, Shropshire (SJ7335-7038)

A second tornado hit the villages of Loggerheads and Norton-in-Hales, near Market Drayton. Over 20 trees up to 60 feet (19 metres) tall were uprooted and heavy objects thrown over 100 metres. "Up to ten" homes were damaged; another house was damaged by a "thunderbolt" (*Shropshire Star*, 11th May). The *Evening Sentinel* (Stoke-on-Trent) of 11th May (sent by Philip Buller) adds that at Loggerheads at least 12 houses suffered roof damage; sheds and greenhouses were smashed, trees uprooted and rear fence panels moved to front gardens. The time was about 1600 GMT; track 4 km, from S.E.; force T2.



Figure 1. Devastation at Pentulcae Farm, Pant-y-dwr, on 17 May 1993 (Mid Wales Journal).

TN1993May17. Baileyhaulwen, near St. Harmon, to Pant-y-dwr, Powys (SN991735-990751)

This was a powerful and spectacular tornado, probably force T5. It appeared as a "spinning top of grey smoke, carrying sheets of corrugated iron and steel through the air". Other descriptions were: "a dark cloud with a ball of fire underneath", accompanied by "a terrible roar", and "like a giant, black spinning top". Sheep were said to have been lifted over 50 feet (15 metres). At Pentulcae Farm (SN990751) the roof was torn off the farmhouse, barns were demolished, gates twisted, windows smashed, trees uprooted and cars overturned. A loaded trailer was lifted over a gate (a trailer 50 metres away was untouched). Farmer Ted Jones said; "The wind picked up steel sheep feeders and carried them 200 yards. I've lost a kilometre of fence and 600 metres of hedge." A Land Rover was lifted and allegedly "snapped in half".

According to a map in the Western Mail of 19th May the tornado cloud was formed about four miles south of Pant-y-dwr, but did not reach the ground until Baileyhaulwen Farm (SN991735), where it took the tops off trees. At Cwm Difwg (991739) the tornado twisted a forester's shed into a "corkscrew shape", wrecked eight vehicles and caravans and "levelled" tree plantations. The tornado, which was accompanied by a thunderstorm and followed by heavy rains had a path 1.5 km long, from south to north, and 50 metres wide it occurred during the evening. Daily Post (Liverpool), 19th May, sent by Mrs. B. Jones and Mrs. Janet Bord; Mid Wales Journal, 21st May, sent by Mr. G. A. Southern; Western Mail, 19th May, sent by David Reynolds, Jon Webb and Brian Mayor.

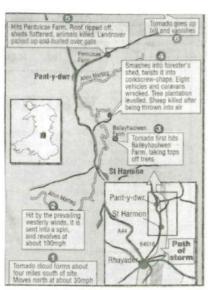


Figure 2. The course of the T5 tornado in Mid-Wales north of Rhayader (Western Mail).

At 1800 Wales lay between two cold fronts (near the E. coast of England and Scotland, and over Cornwall) in a warm southerly airstream between a deepening low, 979 mbar, over S. Eire and a high 1024 mbar, over the Baltic. At 500 mbar there was a large low W. of Ireland. Wales had showers, but thunderstorms were shown in the *Daily Weather Summary* as confined to England at 1800.

FC1993May26. Near Carmarthen, Dyfed (cSN4420)

Mr. Chris Smith, at SN414150, spotted a funnel cloud just east of Carmarthen from 1650-1657 GMT. The funnel, which extended about 100-150 feet (30-46 metres) below the cloud base, formed below cumulus on a seabreeze front. Surface wind was between S. and S.W., 7-8 knots.

At 1800 Britain lay in an easterly airstream between a high near Iceland and a complex low, 996 mbar, S.W. of Ireland. The 500 mbar chart was fairly similar. South Wales was cloudy but mainly dry at 1900.

LITERATURE REVIEWS AND LISTINGS

Book Reviews:

ATMOSPHERE WEATHER AND CLIMATE by R. G. Barry and R. J. Chorley, Routledge, Sixth edition, 1993, £60 Hardback, £16.99 Paperback, 392 pp.

Updating "Atmosphere, Weather and Climate" must be like painting the Forth Bridge, a non-stop, never ending job. There can be few serious students of the atmosphere under 50 who have not dipped into "AWC" at some time and for many generations of students it has been No.1 on the list of recommended books virtually since its appearance in 1968.

Yet another edition (the Sixth - no less) begs the question how is the old war-horse faring and can it still see off the competition? The answer to both questions is a qualified yes. The authors main problem must have been to try to keep the book up to date as atmospheric science was transformed all around them. They have tackled one or two chapters with complete re-writes for most editions, but this time they have made the most comprehensive revisions so far. New material on climate change, extended treatment of greenhouse games and added coverage on hurricanes, tropical forest climatology as well as urban climates makes the sixth edition a good buy. Anyone still using one of the older editions will find it worthwhile replacing it. We still, unfortunately, have too many maps and diagrams that are badly showing their age, especially in Chapter 3. Here we find mean contour maps for 1949-1960 and 1950-1959 and examples of variations in the north hemisphere circulation use examples from 1957 and 1958 long before many readers were born. There are also better maps of air masses that the 1950 Petterssen ones included on p.142. I realise that it costs more money to change maps and diagrams than to add to and alter text,

but surely the publishers must sell enough copies to warrant the cost. Incidentally at £60 the hardback edition seems outrageous compared with the paperback, and must qualify as a tax on library copies.

I still like its breadth of coverage, its good bibliography and above all its friendliness to a geographically trained reader. I know from talking to other publishers that for more than twenty years the challenge for any aspiring textbook writer had been to improve on "AWC". One or two authors have taken up the challenge but somehow nobody has quite managed to pull off the trick. At this rate AWC will still be around into the next century and I think it well deserves its longevity. Some people might even go so far as to say that the book is one of the better survivors of the momentous decade – the 1960's. Please, though, do eliminate some of the old "chestnuts", especially maps and diagrams that have survived since 1968 and which have outstayed their welcome.

ALLEN PERRY

ESSENTIALS OF METEOROLOGY: AN INVITATION TO THE ATMOSPHERE. By C. Donald Ahrens. West Publishing Company, St. Paul, MN 55164-0256, USA, 1993, xiv + 437 pp, £14.95 (paperback).

Since appearing in 1991, the fourth (hardback) edition of Meteorology Today by Donald Ahrens has been amongst the very best introductory texts in atmospheric science (for a review see the Journal of Meteorology July/August 1991). Now, it is joined by Essentials of Meteorology, an updated and rearranged paperback version, which is around 140 pages shorter, costs £3.55 less, but still manages to retain the positive features of its parent – these are, above all, a well-written text, an attractive layout of material and a number of associated teaching aids (instructor's manual, colour slides, etc.). Of the two versions, Meteorology Today can be recommended to students who intend doing atmospheric science at all stages of their degree course, whereas Essentials of Meteorology best suits those who propose taking the subject only in their first year. Equally, pupils in the upper forms of schools are probably best served by Essentials of Meteorology. Yet, as with all introductory environmental texts, this book could still improve on the relative weightings given to the subjects it covers (or omits, as the case may be) (cf. the abovementioned review of Meteorology Today). One of the most effective moves in this direction (academically and financially) would be to increase the number of examples quoted from Europe and English-speaking countries like Australia and New Zealand, thereby reducing the dominance of material from North America (eg. remarks on the chinook/foehn wind say nothing about its importance in the European Alps). Despite this imbalance, the present reviewer is one European who rates Essentials of Meteorology (and its parent) above all others in the field (a comparison with the previous review shows that friendly debate and differences of opinion are alive and well in the meteorological world!). This view essentially rests on the balance that has been achieved between price, academic content and the ability to stimulate an interest in the atmosphere, chiefly as a result of many beautiful illustrations. L.T.

LETTERS TO THE EDITOR

THE LONDON SNOWSTORM OF 6 JANUARY 1994

Probably, like the majority of *J. Meteorology* readers, I continually evaluate the weather, almost subconsciously. On 6 January I was working with my daughter on a flat in Hendon, and I warned her several times that we would have a snowstorm. Despite having spent most of the last 30 years in the tropics, I readily recognised the symptoms of snow arriving in a westerly system: the rising south-east wind, the increasingly heavy and *formless* sky, and temperature of a degree or two above freezing. Because of my tight schedule before my departure the prospect of snow was a cause for concern.

Precipitation commenced at 1500 and I was relieved to see that it was rain. It was apparent, however, from the size and spacing of the raindrops, that this was really melted snow. At 1700 I drove from Hendon to Harrow, and noticed the occasional sleet on the windscreen. By 1800 or so, it was snowing heavily, and this continued to 2100. North London and Hertfordshire had three to five inches. (On the following day, driving north to Uppingham, we ran out of the snow cover suddenly near Brampton Hut on the A1).

My colleagues in Hemel Hempstead had a grim time in the chaotic rush hour. One took four hours to drive from Hemel Hempstead to St Albans, and the police closed the M1 which became littered with abandoned cars in all lanes.

Throughout the day, I was tuned into Classic FM. Until at least 1730 their weather bulletins repeatedly advised that we would have "sunshine and showers, some of which would be of sleet and snow". In view of the totally sunless day in London, eventually producing six hours of rain and snow, this was both meaningless and irritating.

The event raises several questions. The first is facetious and might not be warranted: Did the duty forecasters at the Met Office not "look out of the window"? Was rain turning to snow predicted for London, with the issue of a severe weather warning? And, more importantly, could not a better forecast be supplied to the radio channels into which the majority of workers and drivers tune (Radio 1, local radio, or Classic FM, according to taste)?

Finally, do the occasional sudden and unpredicted snowstorms in colder countries (north and central Europe, U.S.A., northern Japan) cause similar traffic chaos, or are the commuter motorists better experienced to deal with snow?

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DEREK HOLMES

THUNDERSTORMS OF 24TH AND 25TH/26TH MAY 1993

I was very interested in the article published in the Journal in the February 1994 issue by W.S. Pike, on the thunderstorms of 26th May, 1993. I would like to tell you my account of this and one other storm which were severe in South Devon.

The two storms came within days of each other, the first in the early hours of Monday 24th May 1993, and the second overnight of the 25th/26th May.

As early as Friday 21st May, the forecasters were talking about possible thundery outbreaks from Sunday night onwards, but were not especially confident. Saturday 22nd was an overcast, dull day with periods of heavy rain, especially later in the day. Sunday 23rd May dawned dull and overcast with low stratus, but this quickly burnt off during the morning to give a warm, mostly sunny day with temperatures here around 22°C, The winds were a moderate south-easterly, and during the late afternoon, thundery altocumulus castellanus began to spread from the south-west. This was an ominous sign. These clouds produced some heavyish showers during the early evening with large, thundery-type drops, but these moved away later.

At about 23:00 BST, I decided to go to bed, but just before, I switched on the radio at the high end of the long wave to see if any lightning discharges were around. Straight away, it became apparent that a lot of activity was not far away. I counted around 45 discharges a minute on th radio, and so looked outside to try and see them. There was one diffuse flash at around 23:30 but that was all. I decided to go to bed.

I dozed until around 00:15, when I was aware of lightning in the distance. This was illuminating a threatening sky, with large mamma below the underside of a cumulonimbus. The discharges were typically multiple, lasting nearly a second. However, this activity seemed to be bypassing here, so I went back to bed, only to get up at about 00:35 as thunder was now audible at a range of about 20 miles (30 km). This showed the severity of the storm. It was now bearing down on our small village unleashing ever greater cloud-ground strokes, and louder thunder.

The storm began in earnest here, around 01:00 with gusty winds and severe, close lightning. This lasted around one-and-half hours and lightning struck a hilltop some 400 m from here around six times, and the closest discharge was <200 m, the thunder from which woke nearly all the inhabitants of our village, if not awake already!

I remember being overawed at the loudness of the thunder which literally shook the house. The rain was heavy, but not torrential and only lasted about 30 minutes at the most.

The storm moved on after 02:00 and the weather became misty. There were one or two claps around 08:00 as a thundery shower passed overhead. The day then continued dry and sunny with occasional Ac. Cast. passing overhead, and the winds were light, north-westerly. The temperature was still a humid 21C.

Tuesday 25th May and Wednesday 26th May, produced thunderstorms of an intensity I have not experienced since living in Bracknell during a severe storm in May 1989.

The day was mostly cloudy with one or two glimpses of the sun. The temperature was a humid 19°C, with a breezy south-easterly wind. This dropped out for a time during the evening, and the sky stayed overcast. The evening forecasts said thundery showers or storms may move from north France during the night, but gave little indication of what was going to come. I turned on my crude lightning detector (radio on LW), and heard discharges nearly constantly. I counted 58 in a minute and repeated this several times and got similar results. I remember remarking to my family that the storms were "probably going to the South-East as they get all the fun." I then turned on the radio to BBC Radio Devon for the 23:00 forecast from the Plymouth Weather Centre. The forecaster was asked by the presenter if the storms had passed, and the forecaster replicate that, on the contrary, a large area of severe storms and heavy rain was just leaving the Brest peninsula and was heading for SW England, reaching South Devon in the next hour or so. Imagine my delight at the prospect of another severe storm so close to Monday's. I thought, however, that it couldn't be so severe. How wrong I was!

I looked outside as soon as the forecast had finished and saw the first distant flash at about 23:10, These quickly grew nearer with distant thunder first audible around 23:30 or so. The entry in my severe weather log reads: "Violent storms, prolonged between 23:45 and 02:00. First lightning 23:10, last 02:20. Torrential rain, lots of spray (viz. <200 m visibility in rain, possibly hail). Flooding on roads and in our garage. Severe, close, frequent lightning – the least being 15 flashes a minute, the most 25 flashes a minute, with an average of 20 flashes/min for around or more than an hour. For about half-an-hour in the most violent phase of the storm, lightning struck within two miles around 6-8 times a minute. There were also some multiple discharges lasting four seconds. This shows the violence of the storm. 50 mph gusts added to the splendour and grandeur of this most violent storm – reported as the most violent for many years in the SW. More torrential rain and thunder and lightning around 20:00 (Wednesday 26th) – garage flooded, with 11 mm of rain in 15 minutes. The main violent overnight storm gave 31.7 mm (1.25 inches) of rain in an hour."

I hope this gives an insight to two of the most violent thunderstorms I have experienced. I am only 19, though, and hope to go the Great Plains of the U.S. and see not only severe thunderstorms, but also tornadoes.

Many thanks on a fine journal.

AUTUMN/WINTER RAINFALL AT BURTON-ON-TRENT, 1993/94

While many places in Southern England endured some extraordinary rain and flooding particularly in December 1993/January 1994, we also had to look at some long term records to find a compariso with the heavy rains of the Autumn/Winter seasons. However, the flooding was not extreme but occurred with much regularity in the Burton-on-Trent/Derby area.

Records in my possession cover Burton-on-Trent rainfall since 1865, and at my present station at Stretton, Burton-on-Trent, the two seasons together produced 523.0 mm. This is second place only to the Autumn/Winter of 1892/93 which achieved 531.4 mm at Burton. In both instances, the totals for the individual seasons were fairly evenly spread (in the range 250 to 280 mm), and in no way did any of the seasons break any records on their own account (there have been rare instances of each exceeding 300 mm). As percentages, the Autumn/Winter totals are in the order of 150-160% of normal for this season.

I observe flooding in the Dove Valley (on the border of Staffordshire/Derbyshire) with interest, since this is close to my observation sites. The floods from the river were relatively light, and certainly no worse than moderate. But, the flood meadows remained waterlogged throughout Winter, and the large pools were topped up by floods ten times during the December to February period!

I have also checked records for any two consecutive seasons producing 500 mm or more, and Autumn/Winter 1993/94 comes in fifth place overall. The leader is Summer/Autumn 1875 which produced 621.2 mm; a year in which Burton-on-Trent town centre was inundated severely in July and October! Flood defences built in 1960 should prevent this sort of flooding in the town from happening again.

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DAVID STANIER

OBSERVATION OF 'AN ARTIFICIAL' RING-VORTEX IN THE ATMOSPHERE, AND CIRCLES MADE BY ARTIFICIAL SMOKE-RING VORTICES

I have recently read with fascination your book *Circles from the Sky*. It is good to see the cropcircle business treated rationally and scientifically. As a Naval Architect I have met vortices in one form and another over many years, and I am moved to retail to you one particular incident involving a vortex in air.

In the early sixties I was working at a research establishment in Scotland. Part of our work involved studying the effects of explosions on steel plates; our concern was with the behaviour of the steel. One particular experiment involved letting off a charge of PE in air at a small distance from a heavy steel plate. The plate was lying flat on the ground, with the charge suspended about 12 inches above it.

The experiment took place on open moorland, far from human habitation. The day was damp and overcast, with 8/8 low cloud at perhaps 500 feet. Immediately after the explosion we observed a toroidal object, white and perhaps 6 to 8 feet in diameter, at the site of the explosion. The object moved rapidly upwards, emitting a loud white noise like a jet aircraft. It quickly reached the cloud overhead and punched right through it, leaving a hole through which we could distinctly see a patch of blue sky. The hole closed up again within a few seconds, but we could still hear the object roaring away into the distance beyond the cloud cover. It eventually faded from earshot, perhaps 10 seconds or so after the detonation.

We immediately concluded that the tore was a ring-vortex, made visible by water particles condensed from the wet atmosphere in the low-pressure core. (I have seen and photographed line vortices thrown off by aircraft wingtips and propeller blade tips when taking off in humid weather). We light-heartedly discussed the possibility of using a vortex so projected as a weapon, but concluded that the outlay of explosive would probably be more effectively devoted to projecting something solid at the enemy, like a shell . . .

The precise mechanism whereby the vortex was generated has puzzled me ever since. An explosion in vacant space is much like the hydrodynamicist's "source", from which fluid flow radiates outwards in all directions; there is no shearing and no generation of vorticity. If the

explosion is against an unyielding plane surface the flow is similarly radial in a half-space. With the source offset from the plane there will be some curved flow lines near source and plane, but I find it hard to envisage how these could generate a tore vortex with the flow direction needed to project the tore outwards away from the plane – ie, outwards on the inside of the tore, back towards the plane on the outside.

It is just possible that the explanation lay in the distortion of the steel plate. In these tests the steel was usually forced into a spherical bowl shape. With the concavity upwards, the post-bang geometry resembled that of a searchlight, with the source at the lamp position or focus. One could envisage that this geometry served to project much of the gas outflow from the explosion outwards in a concentrated jet. This could conceivably generate a vortex ring, much in the manner of a human smoker blowing smoke rings.

In this context I recall an invention being offered some 15 years ago for a means of projecting power-station products of combustion into the atmosphere. This involved an ordinary chimney, but instead of the smoke being drooled out uniformly to drift downwind at chimney-top height, the boiler efflux was pulsed out in the form of a brief jet every few seconds, so generating a succession of smoke rings which migrated vertically into the upper atmosphere, thereby pushing the acid rain across into some other country. I don't remember what happened to that bright idea, but I've always had the thought that vortex-ring migration was a phenomenon which might find a useful application one day.

All of this leads me to the suggestion that the generation of large toroidal vortices is something which we could very well attempt in the laboratory. Letting off explosives may well be out of the question for private individuals, but one could contemplate something like a bass drum with a hole in the middle of one diaphragm; a blow on the opposite diaphragm would eject a brief jet from the hole which, with suitable geometry, would provide a vortex ring. One could project the vortex on to a table dusted with French chalk or sawdust, in which one could create one's own crop circle. I have tried doing this, using a biscuit tin with a 20 mm hole in the lid and smouldering brown paper inside. A sharp bang on the base of the tin projects a neat ring-vortex over a range of two metres or more. The result has been a convincing set of circles, some showing the characteristic small undisturbed patch at dead centre. Oblique projection at angles down to 45 degrees produces satisfying ellipses. These amateurish experiments have convinced me that the toroidal vortex is an entirely credible mechanism for generating single, isolated crop circles.

In closing – on page 110 of your book I was most interested to note from the Fuller-Randles paper that a "ball of light" had been seen to puncture a hole in cloud; this so clearly reproduced the post-explosion phenomenon I have recounted above.

1 Chestnut Avenue, Chichester, West Sussex, PO19 40D

JAMES A. H. PAFFETT

WORLD WEATHER DISASTERS: November 1993

1-4: Typhoon "Ira" swept from the Philippines to Hong Kong, brief details below:

Philippines: Hit Luzon Island on the 1st/2nd, winds of 175 km/h, hit Aurora province, as storm moved across Luzon winds fell to 150 km/h, the storm was accompanied by heavy rains. A launch overturned in stormy seas off Laoang island, leaving six people dead and one missing, a further 63 others were rescued, one other death was reported, on land, when they were electrocuted by a downed power line. "Ira" was over the west coast of Luzon early on 2nd, heavy seas forced the evacuation of some coastal areas.

Hong Kong: Hit on the 4th, "Ira" was now downgraded to a tropical storm, but brought high winds and heavy rains to the colony, a Boeing 747 of Taiwan's China Airlines Ltd. skidded off the runway at Kai Tak airport and into Victoria Harbour, whilst attempting to land during "Ira", injuring 22 of the 296 people aboard, the aircraft was later declared a 'write-off', with an insured loss of \$145 million. The heavy rains caused flooding in outlying areas of Hong Kong, leaving one person dead and one other missing, seven others were reported injured, overnight on the 4th/5th more than 500 mm of rain fell on Lantau island and more than 300 mm fell at Tuen Mun, other areas of Hong Kong

relatively unaffected, the rains caused numerous landslips on Hong Kong island and also washed away roads. On the 5th, widespread flooding in the New Territories, flooding and 15 landslips in Tuen Mun, Yuen Long and Lantau island, many homes flooded. Llovds List.

- 2-6: Four new brush fires broke out in southern California, U.S.A., the worst fire was in the Malibu area, where some 390 homes were destroyed and three people were killed, in addition to the Malibu fire, blazes were reported to the east and south in Riverside County, San Bernardino County and San Diego County. On the 2nd the fires were being fanned by 80 mk/h Santa Ana winds.
 The fires, which burned from October 27th till November 6th, burned 1241 houses and other structures along with 107 235 cores of horseland, insured leave were estimated at
 - The fires, which burned from October 27th till November 6th, burned 1241 houses and other structures along with 197,225 acres of brushland, insured losses were estimated at \$950 million to the Altadena fire and \$435 million in the remaining fires. *L.L., Financial Times*.
- 5-6: Further heavy rain fell overnight on areas of Corsica affected by flooding at beginning of the month, (see October return), no further casualties reported. L.L.
- 5 (rep): Unusually cold summer weather and a series of typhoons in Japan since January 1st have caused record damages to crops, which has been put at Yen 1.2 trillion, (\$11 billion). L.L.
- 5 (rep): Floods and other natural disasters in China since January 1st have so far killed 3,300 people and caused damage estimated at \$10.9 billion, the floods destroyed 1.8 million homes and affected 41 million acres of land. A continuing drought, mainly in the north of the country, has affected a further 47.6 million acres. L.L.
- 5 (rep): Rains hit Morocco 'this week', causing flooding and cutting roads in some areas after two successive years of drought, between 50 and 115 mm of rain fell; the rains replenished reservoirs, L.L.
- 6-16: Heavy rains in south-east Aceh, Sumatra, Indonesia, touched off floods and landslides which have left at least five dead. On the 16th heavy rains also hit other areas of Sumatra and an overflowing river in Riau province flooded thousands of houses in Pekanbaru, some areas of the town under four metres of water. L.L.
- 8: Gale-force winds, gusting to 59.6 km/h, hit coastal belt of Sri Lanka north and south of Colombo, the gale-force winds hit Dhiwela and Mount Lavinia, to the south of Colombo, damaging 1,000 homes and forcing 5,000 people to flee to shelters. In Wennappuwa, approximately 72 km north of Colombo, strong winds and heavy rains damaged another 1,000 houses, leaving 5,000 people without shelter, no casualties reported. L.L.
- Mv. Chai Yang sank in heavy weather approximately 1.6 km off Cheju island, South Korea, leaving three dead, one missing, six others were rescued. L.L.
- 9-10: Gales reaching 180 km/h on the 10th hit port of Novorossisk, Black Sea coast, Russia, leaving five people dead, all crew from seven fishing vessels wrecked by the storm. Severe damage reported in the town and the gales cut power supplies, the storm was described as a north-easterly 'Bora' wind, the winds also affected neighbouring towns of Anapa and Gelendzhik, where power and communications were cut. Damage in Novorossisk and surrounding area put at 5 billion roubles. The storm also caused difficulties in Poti, in neighbouring Georgia. On the 26th the port of Novorossisk still closed due to continuing high winds, which had reached 72-90 km/h around the 15th; the winds were described as the worst since 1964. The winds persisted till December 2nd. L.L.
- 9-11: Two days of torrential rains in Tamil Nadu state, southern India, the rains destroyed 950 houses and damaged 1,250 others in eight counties in the state and flooded vast tracts of farmland, landslides touched off by the heavy rains blocked roads, isolating 'dozens' of villages, 32 deaths reported. L.L.
- 11-15: Storms and flooding in areas of Iran, brief details below:

11th: Rains and floods in Kohkiluyeh va Boyer Ahmad province, some 600 km south of Tehran, left four people dead, rural buildings and cars damaged.

11th/14th: Storms in the north of the country, in Gilan province some 3,000 buildings damaged or destroyed by floods and rising seas in the town of Bandar-e-Anzali, on Iran's Caspian Sea coast, the sea has risen by 630 mm in the three-day period. Heavy

- rains inundated the islands of Behesti and Talegani and winds gusting to 80 km/h damaged electrical power distribution systems. In the province of Mazandaran torrential rains and floods washed away 3,000 homes, also destroyed were 200 schools, 136 shops, more than 100 Government and public buildings and 23 bridges, the 3,000 houses were destroyed in 28 towns and more than 400 villages, making 12,000 homeless. The rains and floods also washed away 925 hectares of farmland and 527 hectares of citrus orchards, and disrupted power supplies. No casualties reported, *L.L.*
- 13-14: Storms hit the Netherlands, four deaths reported, two of whom were swept overboard from Mv. Draco 24 km off coast of Ymuiden, two other crew were injured, two containers were swept overboard. Two fishermen died when their boat capsized on the river Amer near the Biesbos National Park area to the south of Rotterdam, also just south of Rotterdam five people were badly injured when the storms contributed to a traffic pile-up on a motorway. Heavy rains caused flooding around Rotterdam. Winds up to 150 km/h were recorded on one of the islands off the north-west coast. L.L.
- 14: Gales, with winds gusting to 97 km/h, hit many areas of Great Britain, the winds were accompanied by heavy rains, the east of England was the worst affected, with many roads closed due to flooding and fallen trees. A woman driver was killed in Stetchworth, Cambridgeshire, when her car was crushed by a falling tree, while a barge broke its moorings at East Runton, Norfolk, and hit Cromer pier, 4.8 km away, causing a 30.5 metre section of the pier to collapse, no one was hurt. Daily Telegraph.
- 14: Three cyclists were electrocuted by a power cable brought down by gales near Metz, France. D.T.
- 14-16: Tropical cyclone, code number "O1A", in the Arabian Sea off the coast of Pakistan, high winds and heavy rains hit Sind province, affecting the province's cities and coastal areas. On the 14th/15th high seas accompanying the cyclone inundated nearly all the low-lying areas of Keti Bandar, forcing residents to take refuge on elevated places, the villages of Dubla, Khobar, Jamaro, Ghorho Mian and Kheersar were worst affected. On the 15th a trawler, the Safina-I-Singhar capsized in storm off coastal village of Kahir, 90 km east of Karachi, six of crew missing, a further ten were rescued, also two fishermen died in the morning when their vessel sank. In Karachi three people died when a wall collapsed on them near the main gate of Fish Harbour, West Wharf and power supplies in the city were disrupted by the winds and rain. On the 15th/16th gusting winds and rain overnight in Karachi continued till 11:00 am on the 16th, about 6 mm of rain so far in the city, low-lying areas of which were flooded. L.L.
- 16: A tornado hit Houston, Texas, U.S.A., leaving 26 people injured, the tornado touched down in the centre of the city, smashing windows in office towers and damaging an apartment complex and a restaurant. The tornado swept through downtown Houston after being spawned by a thunderstorm system which developed to the south of the city, the tornado also uprooted trees and brought down power lines. Heavy rains accompanying the tornado caused some street flooding before the weather system moved to the north-eat of the city. L.L.
- 16-17: Port of Varna, Bulgaria, closed by high winds blowing at up to 45 knots between 0700 on the 16th till 1300 hrs on the 18th, shipping movements disrupted, no casualties reported. L.L.
- 16-17: Gales, gusting to 120 km/h hit many areas of Uruguay, the gales were accompanied by heavy rains and floods which destroyed houses and other property, the gales uprooted trees and electric power poles, no casualties reported. L.L.
- 17 (rep): Serious flooding, triggered by days of incessant rains, have hit seven villages in Bandardua, Aceh, Indonesia, the rains also touched off a landslide which left two people dead and one other injured, flooding also affected the neighbouring district of Tangse-Geumpang. Jakarta Post.
- 20: A five-minute storm, with tornado-like winds, hit town of Tucabia, 644 km north of Sydney, New South Wales, Australia, eight houses destroyed, with more than 130 others damaged. The storm, which hit at 2100 hours, uprooted trees and downed power lines, two people reported injured. L.L.

- 20-21: Three days of heavy rain caused widespread flooding in Athens, Greece, washing away cars and disrupting telephone and power supplies. The city's southern suburbs worst affected, hundreds of homes flooded, along with businesses, no casualties reported. On the 21st it was reported that snow had cut off more than 100 villages in the north of the country and that many roads had been blocked. L.L.
- 20-23: Tropical storm/typhoon: Kyle" swept from the Philippines to Vietnam, brief details below: Philippines: Tropical storm "Kyle" hit the Visayas islands and Cebu island, central Philippines, on the 20th with winds of 85 km/h, gusting to 105 km/h, hit the Visayas islands. The storm was accompanied by heavy rains which touched off flooding, a river near to the town of Carcar, Cebu island, overflowed, destroying around 500 houses, forcing hundreds of people from their homes, the floods were neck-deep in some areas, no other serious damage reported. A boy was electrocuted by a fallen power line in Tacloban City, "Kyle" moved away from the Philippines on the 21st, with winds down to 75 km/h.
 - Vietnam: "Kyle", now a typhoon, hit Khanh Hoa and three other provinces in south central Vietnam, winds of more than 120 km/h hit the province of Khan Hoa. A total of 106 people were killed, another 29 were reported missing and 244 were injured. Thousands of hectares of crops destroyed and most rail and road links linking north and south Vietnam cut. The province of Khan Hoa worst affected, with 30 people reported dead and 67 others missing, more than 1,000 houses destroyed in the province and over 200 vessels were damaged. L.L.
- 21: Up to 150 mm of snow fell on the eastern half of Britain, from Scotland to the south of England. There were lesser falls in the Midlands and Wales, and 25 mm fell in London, many roads blocked. In Essex, 125 mm of snow fell at Maldon, 100 mm at Rayleigh, and 50 mm at Brentwood, near London. Falls of more than 75 mm were recorded at Bingley, West Yorkshire, and in Charing, near Ashford, Kent. In the early hours the temperature fell to -9°C in Edinburgh and -7°C in Glasgow. The freezing conditions contributing to road accidents which left six people dead. D.T.
- 22: Heavy rains led to flooding to the north of Wellington, North Island, New Zealand, one person reported dead. Two townships cut off as bridges were washed away. L.L.
- 22-24: Heavy rains touched off flooding in the provinces of Guantanamo, Holguin and Santiago de Cuba, eastern Cuba. In one part of Guantanamo province nearly 685.8 mm of rain fell in a 72-hour period, in the city of Santiago de Cuba 99 mm of rain fell in a 24-hour period ending sometime on the 24th, 'dozens' of buildings damaged and power supplies cut, a mudslide closed part of a highway near to the city. The floods destroyed at least 326 houses and damaged 3,218 others, a number of schools and shops were also damaged or destroyed. About 138.5 km of railway track and 29 km of roads damaged, along with 41 bridges damaged or destroyed. The floods also cut power and telephone links and damaged or destroyed 9,900 acres of root and other vegetable crops, sugar cane, coffee and tobacco plantations were also affected. At least 22 people were either drowned or crushed by collapsing buildings, a further 11 people were missing and 4,700 others were evacuated. L.L.
- 23: Heavy rains in Jamaica, flooding reported from the parishes of St. Thomas and St. Catherine while landslides were reported from the parish of Portland, blocking some roads. The floods and landslides severely disrupted public transport. The Bamboo river in Bath, St. Thomas, overflowed, inundating the Eastern Banana Estate. Flooding reported at Logwood Park, in Waterford and Perch Way, in Braeton, St. Catherine parish. No casualties reported, the rains commenced before the 23rd. L.L.
- 24: Storm hit the Bekasi regency, West Java, Indonesia, leaving two people dead and hundreds of buildings damaged. One of the dead was struck by lightning and the other was blown off a motorcycle taxi, a further five people were injured. The winds also uprooted many trees, some falling trees cut telephone lines. J.P.
- 27: A barge sank in gale-force winds and 2.4 metre high waves on Lake Ontario, some 15 km off Oswego, New York state, U.S.A.., leaving two crew dead. L.L.
- 27-30: Heavy rains, in association with a tropical storm, have caused flooding in five provinces of southern Thailand, the flooding has cut the rail line linking Bangkok to the south of country

and onto Singapore and Malaysia, about 150 km of track between provinces of Surat Thani and Nakhon Si Thammarat under water. The worst of the floods in the provinces of Nakhon Si Thammarat and Surat Thani, flooding also reported from the provinces of Songla and Pattani, the flooding destroyed 152 houses and cut more than 70 roads, more than 40,000 acres of farmland, mostly ricefields, damaged by the floods, at least eight deaths reported in the floods, with a further 25 others missing. Seven fishing vessels sank and seven others were missing in the Gulf of Thailand. The rains stopped on the 30th and the floods, which reached a depth of 0.6 metre, began to recede. *L.L.*

- 27 (rep): At least 31 people have died of frostbite in Moscow, Russia, so far this month, most of whom were drunk at the time. Another 160 people went to hospital complaining of frostbite or extreme cold.
- 28: Storm, with winds of 88 km/h and heavy rain, hit the north-eastern U.S. states of New York, New Jersey and Connecticut, some roads flooded, the winds cut power supplies to 34,000 households on Long Island, New York, 50,000 households in New Jersey and 21,000 households in Connecticut, the winds and heavy rain continued till the morning of the 29th, no casualties reported, L.L.
- 29-30: Heavy snow throughout Bosnia-Hercegovina and Croatia, road traffic disrupted. A state of emergency was declared in Zagreb. D.T.
- 30: Snow and ice disrupted road and air traffic in Belgium. Brussels airport closed because of snow and ice on the runways, the airport was reopened on December 1st, no casualties reported. L.L.
- 30-1 Dec: Blizzards hit wide areas of Romania, rail, road, air and shipping movements disrupted. The county of Buzau, north-east of Bucharest, which has more than 500,000 inhabitants, was isolated as the snow cut rail and road links; power lines were also brought down. In the south of the country 25 main roads blocked and many trains cancelled. On the southern plains of Craiova between 180 mm and 540 mm of snow fell in the afternoon of the 30th and winds up to 115 km/h formed snow drifts up to four metres deep, at least 20 villages blacked out as snow and wind brought down power lines, telephone poles were also brought down. The Black Sea port of Constantza closed because of force 7 blizzards. no casualties reported. L.L.
- 30 (rep): Severe weather hit areas of Iran, the heaviest snowfall in 30 years in Ardabil, in the north-west of the country, the snow fell for five days, causing crop losses. In Karaj, 30 km west of Tehran, heavy snowfall and storms set off ten avalanches in a 24 hour period, blocking mountain roads with up to one metre of snow. In the south-west of the country heavy rains damaged farms and roads and disrupted power supplies in rural areas, no casualties reported from any of the weather related incidents. L.L.

ALBERT J. THOMAS

WORLD WEATHER REVIEW: July 1993

United States. Temperature: warm in S.E. half; +3degC from C. Tennessee to C. Carolina. Cold elsewhere; -5deg locally in S.E. Oregon, N.E. Nevada, S. Montana, N.W. Wyoming. Hawaii near normal. Rainfall: wet from Washington to Wisconsin (except N.), W. Ohio, N. and W. Oklahoma, extreme W. Texas, E.. New Mexico, N. and W. Wyoming and extreme N. California; Hawaii (except N.W.); much of E. New York and S. Mississippi. Over 200% from most of Washington and Oregon to extreme N. Utah, N. Wyoming, E. South Dakota, N.E. Kansas, S. Wisconsin; locally in Hawaii. Over 400% fairly widely from E. Washington to North Dakota and N. Kansas. Dry elsewhere; under 50% from most of California to W. New Mexico and part of S. Wyoming; fairly widely from Texas (except extreme W.) to West Virginia.

Canada and Arctic: Temperature: warm from most of Ontario and Quebec through Canadian Arctic to Alaska, Greenland, N. Spitzbergen and Franz Josef Land; +3degC in N.W. Quebec and N.W. Alaska. Cold elsewhere; -3degC in N. Newfoundland; -4degC from S.E. British Columbia to S. Saskatchewan. Rainfall: wet in most of Canada (except S. Quebec, C. Alberta, W. British

Columbia and at least some of the Arctic islands); N. Greenland. Over 200% from S.E. Britis Columbia to S. Manitoba. Dry elsewhere; under 50% in S. Greenland, Spitzbergen, Franz Josef Land; in and near Baffin Island' much of Alaska; parts of Iceland.

South and Central America. *Temperature:* warm in and near Chile; E. Brazil, Bermuda Bahamas, West Indies; most of Mexico to Honduras; +2degC in E. Brazil. Cold in most of South America 15-40°S; marginally in extreme N.W. Mexico; -2degC from C. Bolivia to C. Paraguay; much of Uruguay. *Rainfall:* wet in E. Paraguay, S. Brazil, E. coastal Uruguay, interior N. and C. and S. coastal Mexico, Puerto Rico; parts of C. Chile and C. Bolivia; over 200% locally in the Mexico areas. Dry in most of South America 15-40°S; Bermuda, Bahamas, Jamaica. Martinique, Barbados, Trinidad; most of Mexico to Honduras. Under 50% generally in South America; N.W. and N.E. Mexico, Bahamas, Martinique, Barbados, Trinidad; in and near N. Belize; parts of El Salvador.

Europe. Temperature: warm from N. Norway to N. Urals; Portugal, S. Spain, W. Bulgaria, S.W. Romania; +2degC in N. Norway and N. Urals. Cold elsewhere; -2degC in S. Norway, S.W. Sweden, N. Netherlands; widely from S. Lithuania to coastal Romania and lower Volga basin; locally in C. Greece. Rainfall: wet from British Isles (except parts of S. Scotland and much of N. England) and extreme N. France through Germany. N. Poland, Switzerland, S.E. Norway and Sweden and most of Austria to W. and E. Ukraine, Latvia and much of European Russia; S.C. France; parts of N. Spain. Over 200% in S.W. Sweden, C. Latvia to W. Ukraine; lower Volga basin; locally in W. Belgium, N. Germany, S.W. Poland, S.C. France, C. Switzerland. Dry elsewhere; under 505 in N. Norway; from Mediterranean coasts N. to N. Spain, S. France, N. Italy, W. and E. of former Jugoslavia, S. Romania; locally in S. and C. Ukraine. Provisional sunspot number 57.

Africa. *Temperature:* warm from Libya to C. Morocco, then S. to Mali, Burkina Faso and S. Nigeria; S. of 20°S; +2degC in C. Algeria; +3degC widely from S.. Cape Province to S. Botswana. Cold in S.W. Morocco, N. Tunisia, S. Niger; all -1degC at least locally. *Rainfall:* wet in S. Morocco, C. Tunisia, W. Cape Province, S. Mozambique, S. Zimbabwe; locally in N. Algeria; over 200% in all these areas, especially those S. of 20°S. Sahel very mixed. Dry generally N. of Sahara and S. of 20°S; under 50% general.

Asia. Temperature: warm in S. Turkey, S.E. Kazakhstan, Kyrgyzstan, E. Tajikistan, S. Pakistan, Nepal, Bhutan, Bangladesh, S. and marginally in N.E. China; Thailand to Philippines, Sulawesi and Java; most of India; much of Ob basin; +2degC in S.E. Kazakhstan and in upper and probably lower Ob basin; locally in S.E. China, N. Vietnam, C. Laos and N.W. Thailand. Cold in Turkey; Turkmenistan to W. Tajikistan and much of Kazakhstan; in and near N. Pakistan, Mongolia, Korea, Japan, most of N. and E. China; -2degC in N. Kazakhstan; much of Korea (-3degC in E.); locally in N. and E., China and Japan, Rainfall: wet from S. Turkmenistan to Kyrgzstan, W. Tajikistan and E. Kazakhstan; N.C. Pakistan, E. Bangladesh, Mongolia, S. Korea, Japan (except N.), N. Laos, W. Malaya, N. Sumatra, N. Borneo, C. and extreme S. Philippines; most of W., C. and extreme N.E. India. Over 200% in W. Tajikistan, E. Kazakhstan, W. Rajasthan. extreme N. Borneo; parts of Kyrgyzstan and N.C. Pakistan; locally in S.E. Korea, Mongolia and Japan, Dry in Turkey; N. Turkmenistan to W. Kazakhstan; E. Tajikistan, C. Ob basin, W. Bangladesh, Nepal, Bhutan, N. Korea, S. Laos, N.E. Malaya, S. Sumatra, Java, S. Borneo, Sulawesi, Philippines; most of Pakistan, S.E. and N. India, Vietnam, Cambodia and Thailand. Under 50% locally in S.E. India, W. Bangladesh, S. Laos, Cambodia, S. Borneo and Sulawesi; more widely in the other areas except perhaps Nepal, Bhutan, N. Japan, N.E. Malaya and S. Sumatra. China very mixed.

Australia. *Temperature:* warm except marginally in W. quarter; -3degC in S.E. Queensland. *Rainfall:* wet from Queensland to N. Victoria; parts of S.W. coast; over 200% fairly widely from N.C. Queensland to S.E. New South Wales. Dry elsewhere; under 50% general in N.W. quarter.

WORLD WEATHER REVIEW: August 1993

United States. Temperature: warm E. of a line from Minnesota through E. Kansas to C. Arizona; C. Hawaii; locally on Pacific coast; +2degC locally from S. Texas to N. Michigan and West Virginia. Cold elsewhere; -2degC from N.E. Nevada to S.E. Washington and W. North Dakota. Rainfall: wet from E. Washington through N. California to New Mexico, W. Texas, N. Kansas, Arkansas, Mississispipi, E. Tennessee and Indiana (except N.W.). Over 200% from N. California to S.E. Washington, S.E. Idaho to W. and N. Montana; W. Nebraska, N.W. Kansas, S.E. Colorado, N.E. New Mexico, Iowa, N. and C. Missouri. Dry elsewhere; under 50% in W. Washington, W. South Dakota; S. California to S.W. Idaho; S.W. Utah, N.W. Arizona, C. and S. Texas, Connecticut, Massachusetts; locally from South Carolina to Ohio.

Canada and Arctic. Temperature: warm in Quebec, Ontario, Spitzbergen, Franz Josef Land; parts of Northwest Territories (but not in and near Baffin Island) and W. British Columbia; +2 degC in E. Ontario, W. and C. Quebec. Cold Elsewhere; -2degC in extreme S. of Alberta and Saskatchewan. Rainfall: wet in Greenland, C. Quebec, S. Baffin Island, Keewatin District; Manitoba to most of Alberta and C. British Columbia; Alaska. Over 200% from extreme S.W. Manitoba to extreme S. Alberta; locally in S.E. Quebec and N.E. Greenland. Iceland near normal. Dry elsewhere, under 50% in extreme N. British Columbia; Toronto to Montreal.

South and Central America. *Temperature:* mostly warm in South America 15-40°S; Mexico (except marginally on S.W. coast) to Honduras, Bermuda, Bahamas, West Indies; +2degC locally in C. Argentina and N.E. Mexico. Cold from S.E. Peru to extreme S. Brazil and S. Uruguay; locally in W. Bolivia, S.C. Brazil, S. and extreme N. Mexico; all over 200% very locally except perhaps Uruguay. Dry in most of South America 15-40°S; almost all of Mexico to Honduras; Bermuda, Bahamas, West Indies. Under 50% widely in South America 15-40°S; N.E. and extreme N.W. Mexico, Bahamas, Jamaica, Barbados.

Europe. Temperature: warm from Portugal and most of Spain to C. France, S. Germany, extreme S. Poland, W. Romania, most of Bulgaria and N. Greece; locally from N. Norway to N. Urals; –2degC widely from C. and S. Italy to W. Bulgaria. Cold elsewhere; –2degC to C. Volga basin; locally in S. Norway, S. Sweden and Denmark. Rainfall: wet from S. Norway through S. Finland to N. Poland, Baltic States and C. and S. Urals, then S.W. to extreme E. Ukraine; E. Bulgaria, N. Austria, N. Spain. Over 200% in N.W. Lithuania, W. Latvia and near St. Petersburg; parts of N. Spain. Dry elsewhere; under 50% in S. Eire, S. England, N. and E. France, S. Belgium, W. Germany, Portugal, S. Spain, coastal and S. Italy; Bosnia to Greece and W. Bulgaria; S. Poland, W. and locally in S. Ukraine. Provisional sunspot number 42.

Africa. Temperature: mostly warm N. of 5°N and S. of 20°S; +2degC in interior N. Algeria. Cold in S. Morocco (-1degC on coast) and in and near S.W. Libya. Rainfall: wet in Mauritania (over 200%), N.W. Algeria, N. Natal, E. Transvaal, S. Mozambique; most of Orange Free State. Dry from Canary Islands to Egypt, Senegal, Mali, Burkina Faso, Togo, Ivory Coast and Niger; generally S. of 20°S. Under 50% in Canary Islands, W. Morocco, E. Algeria, `Tunisia, Libya, Egypt, Togo, Ivory Coast; N. Cape Province and W. Transvaal into Namibia, Botswana and W. Zimbabwe.

Asia. Temperature: warm in Israel; N.W. Turkmenistan to Ob basin; W. Nepal, Bangladesh, S. China; Thailand to Java, Philippines and Borneo (except marginally in parts of N. Borneo and C. Philippine); most of Turkey, Pakistan and India; +2degC in upper Ob basin; locally in N.W. India and Sumatra. Cold from most of Turkmenistan through S.E. Kazakhstan to N. China, Korea, Japan and most of Mongolia; -2degC locally in extreme S. Uzbekistan, N.W., C. and E. China, S. Mongolia; most of Korea. Rainfall: wet in N.E. Turkey; N. Turkmenistan to S. Kazakhstan; N.W. and extreme E. Kazakhstan, E. Nepal,, S. Korea, Japan (except N.), C. Laos, N.W. Borneo, C. Philippines; most of Mongolia, extreme N.W. and N.E. and parts of C.S. China, Cambodia and Malaya; much of Vietnam; parts of S. and extreme N.E. India; locally in N. Sumatra. Over 200% in C. Turkmenistan, C. Uzbekistan, extreme E. and locally in N.W. Kazakhstan, extreme N.W. and locally in C.S. China, S. Korea, parts of S. Japan; locally in C. Philippines. Dry from S. Turkmenistan to W. Tajikistan; E. Tajikistan, N.W. Uzbekistan, Pakistan, W. Nepal, Bangladesh, N. Korea, S. and N.W. Philippines; most of Turkey, Kazakhstan, India, Thailand, Laos, Sumatra

and Borneo; much of N. and parts of S.E. China; parts of N. Vietnam. Under 50% at least locally in all these areas except perhaps Bangladesh, Vietnam and Laos.

Australia. *Temperature:* warm, except marginally in S.W.; +2degC fairly widely 130-145°E. *Rainfall:* wet in S.W. and most of Queensland (both locally over 200%): W. Victoria. Dry elsewhere, mostly under 50%.

M. W. ROWE

BRITISH WEATHER SUMMARY: DECEMBER 1993

It was a very unsettled month, with a steady flow of deep depressions from west to east, mostly just to the north of Scotland, but occasionally rather further south. Most places were very wet, and there was over twice the normal rainfall for December in parts of the west and south. The tracks of the depressions often allowed cold, unstable air into northern regions, and a fair amount of snow fell in hilly areas of Scotland; it was quite mild, though, in the south. North-east England and the Midlands were very sunny.

Very mild, deep air moved in from the south-west at the beginning of the month, and the temperature reached 14°C in places on the 2nd; there was considerable rainfall over much of the north and west before a cold front brought clearer, fresher weather to all areas on the 4th. There was more heavy rain in the north and west on the 6th, then, after a showery day on the 7th, wet and very windy weather spread to all districts on the 8th; there were damaging winds at night. After more rain on the 10th, winds turned more northerly for a time, with snow showers in the north. Snow preceded the next rain area on the 12th, especially in hilly central regions. Cold air then returned briefly, with some sharp frosts and wintry showers in the north. However, very mild air flooded the country (literally in hilly western areas!) on the 18th and 19th; around 70 mm of rain fell in 24 hours in the hills of south Wales. On the 19th, 15.5°C was recorded over north-east Norfolk, after overnight temperatures of 12°C in much of the south.

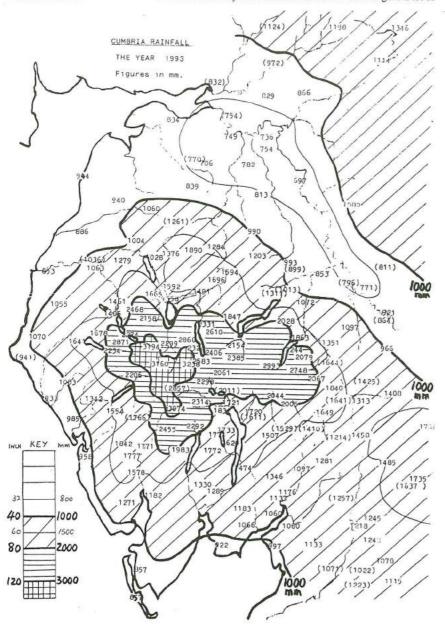
The cold air near to northern Britain made rather stronger incursions into the country as Christmas approached, and much of Scotland became snowy. There were further spells of rain elsewhere, and rivers overflowed their banks in places, especially in the West Country. Over the Christmas period itself snow was a little more widespread, and on the 26th, Altnaharra (Highland Region) recorded a minimum of -16° C, and Glenlivet and Aviemore maxima of -9° C. Milder air spread from the west on the 28th, preceded by snow. On the 30th, severe flooding developed in some southern coastal counties of England after hours of heavy rain.

CUMBRIA WEATHER REPORT: THE YEAR 1993

By P. R. CUTFORTH

The first half of 1993 averaged about 1°C above normal but this was exactly balanced by a figure of 1°C below normal for the second half which included an exceptionally cold autumn. It was the dullest year since 1980.

January was mild and wet but February was a very dry month, anticyclonic but mild. March, too was mild and dry but April broke records for its wetness and finished with a hot spell and record warmth on the 30th. Fine weather continued into May but a sudden outburst of cold air gave a lot of



hill snow on the 13th and the rest of the month was wet and very dull. *June* was better, quite dry with some warm spells but *July* was a poor month, cool and dull. *August*, too, was cool but reasonably sunny and dry after the 13th. In an exceptionally dry and cool Autumn there was a 17-day drought by the 6th *September* but the month lacked any warm spell. Rain in *October* fell chiefly in the first 12 days. The rest was exceptionally cold, frosts being notably severe in N. Cumbria around the 16th and it was the driest October in the Lakes since 1951. *November* continued the dry pattern and an early spell of cold continental air brought temperatures down to -10° and a week's skating on the tarns. It was all change in *December* as depressions crossed the UK throughout the month and it was the wettest December on record in most places, There was a white Christmas and more snow after.

MONTH BY MONTH SUMMARY

Temp.	SUN	RAIN %		Temp.	Suns	hine
anom. °C	%	25 gauges		anom. °C	hours .	%
+1.7	68	151	Aspatria	-0.2	1323	90
+1.9	59	29	Sellafield		1274	88
+1.2	95	57	Eskmeals	0.0		
+1,8	85	198	Keswick	-0.1	1035	84
-0.0	73	188	Newton Rigg	+0.0	1030	79
+0.8	82	64	Ambleside	+0.1		
-0.7	68	113	Near Swarey		1053	90
-1.4	100	63	8			
-1.0	91	65				
-2.6	131	33				
-1.8	133	58				
-0.0	72	187				
0.0	86	97				
	anom. °C +1.7 +1.9 +1.2 +1.8 -0.0 +0.8 -0.7 -1.4 -1.0 -2.6 -1.8 -0.0	anom. °C % +1.7 68 +1.9 59 +1.2 95 +1.8 85 -0.0 73 +0.8 82 -0.7 68 -1.4 100 -1.0 91 -2.6 131 -1.8 133 -0.0 72	anom. °C % 25 gauges +1.7 68 151 +1.9 59 29 +1.2 95 57 +1.8 85 198 -0.0 73 188 +0.8 82 64 -0.7 68 113 -1.4 100 63 -1.0 91 65 -2.6 131 33 -1.8 133 58 -0.0 72 187	anom. °C % 25 gauges +1.7 68 151 Aspatria +1.9 59 29 Sellafield +1.2 95 57 Eskmeals +1.8 85 198 Keswick -0.0 73 188 Newton Rigg +0.8 82 64 Ambleside -0.7 68 113 Near Swarey -1.4 100 63 -1.0 91 65 -2.6 131 33 -1.8 133 58 -0.0 72 187	anom. °C % 25 gauges anom. °C +1.7 68 151 Aspatria -0.2 +1.9 59 29 Sellafield +1.2 95 57 Eskmeals 0.0 +1.8 85 198 Keswick -0.1 -0.0 73 188 Newton Rigg +0.0 +0.8 82 64 Ambleside +0.1 -0.7 68 113 Near Swarey -1.4 100 63 -1.0 91 65 -2.6 131 33 -1.8 133 58 -0.0 72 187	anom. °C % 25 gauges anom. °C hours +1.7 68 151 Aspatria -0.2 1323 +1.9 59 29 Sellafield 1274 +1.2 95 57 Eskmeals 0.0 +1.8 85 198 Keswick -0.1 1035 -0.0 73 188 Newton Rigg +0.0 1030 +0.8 82 64 Ambleside +0.1 -0.0 1053 -0.7 68 113 Near Swarey 1053 -1.4 100 63 -1.0 91 65 -2.6 131 33 -1.8 133 58 -0.0 72 187

1993 RAINFALL TOTALS AND % OF 1961-90 AVERAGES

	mm	%		mm	%
Broadfield	813	100	Gillerthwaite	2234	94
Penrith, Newton Rigg	993	108	Seathwaite, Borrowdale	3160	101
Lowther	1072	99	Ullscarf	3238	102
Appleby	921	107	Blea Tarn	2393	99
Burnbanks, Haweswater	1863	110	Dalehead Hall	2331	107
Aspatria	940	99	The Nook, Thirlmere	2583	103
Quarry Hill, Mealsgate	1060	102	Ambleside	1721	88
Stainburn, Workington	853	82	Consiton	2292	93
Summergrove, Whitehaven	1070	87	Hawkshead	1733	94
Ennerdale, Bleach Green	1641	91	Grange-over-Sands	1066	87
Sellafield	933	92	Ulpha, Duddon	1771	87
Keswick	1592	107	Eskmeals	958	91

GREETING CARDS: FOUR WINTER SCENES

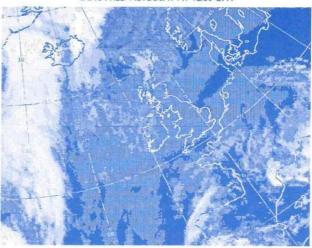
Set of four full-colour photographic cards depicting West Berkshire landscape under frost/snow. £1 for the set of four (with white C6 size envelopes) or 30p singly. Please add 50p post and packing on up to 10 cards. For 11 to 30 cards, add £1 p.&p., or £1.50 for recorded delivery. Reductions on larger orders of ten sets or more, price on application to: Mr. W. S. Pike, 19 Inholmes Common, Woodlands St. Mary, Newbury, Berks, RG16 7SX. Tel: Lambourn (0488) 72638.

TEMPERATURE AND RAINFALL: JANUARY 1994

		I M	ean		T					Т	Т
Station	Authority	Max	Min	Max	Min	Grass	Rain	%	Wettest	RD	TL
BELGIUM: Uccle	I.R.M. Belgique				1				-		
DENMARK: Frederikssund	E. Skjødt	4.4	0.7	8.8(12)	-6.2(16)	-9.2(16)	89.4	197	19.1(19)	22	1
GERMANY: Potsdam	Deut, Wetterd.	5.2	1.0	11.0(13)	-5.3(17)	-7.9(18)	76.1	181	19.4(27)	23	0
* Hamburg	Deut. Wetterd.	5.8	2.0	11.2(13)	-4.2(17)	-4.7(17)	124.0	221	16.5(23)	26	2
* Karlsruhe	Deut, Wetterd.	7.3	2.0	13.1(13)	-5.8(18)	-8.3(18)	62.9	114	11.2 (5)	21	ō
* Munchen	Deut. Wetterd.	5.8	-0.4	14.4 (7)	-9.5(19)	-12.0(19)	57.1	136	10.0(13)	16	1
HOLLAND: Ten Post	H. A. Veldman	6.3	2.3	12.1(13)	-4.2(17)	-10.3(17)	102.0	152	24.2(28)	23	2
ITALY: Casalecchio	M. Delmonte	8.9	2.5	13.0 (v)	-2.0(23)	-3.0(23)	41.6	105	11.9(18)	10	0
MALTA: Luga	Civil Aviation	16.3	10.5	19.4 (7)	4.8(31)	-1.2(31)	72.5	81	26.5 (8)	8	4
SWITZ'D: Basel	Lufthygieneamt	7.6	0.6	15.1(13)	-8.4(20)	-1.2(31)	60.3	114	9.7(16)	16	2
EIRE: Straide, Co. Mayo	M. Sweeney	8.6	2.3	11.3(26)	-4.1 (6)	-11.3 (6)	185.8	146	22.3(31)	29	1
* Mt. Russell, Limerick	David Meskill	8.4	2.9	11.3(24)	-1.6 (6)	-7.4 (6)	167.2	140	27.2(14)	27	1
SHETLAND: Whalsay	S. G. Irvine	5.2	2.0			-6.3 (8)	205.5	157	28.6(29)	28	1
* Fair Isle	D. Wheeler	5.7	2.0	8.0(20)	-1.0 (1)	-5.8 (8)	170.6	170		29	
SCOTLAND: Braemar	R. Graham	3.8	-0.9	9.1(21)	-0.2(29)		121.4	147	19.0(17)	28	0
	lain Hudson	4.2	-0.9	8.2(20)	-8.8 (1)	-10.3 (1)	121.4	152	16.8 (9)	27	0
Loch an Eilein	J.S. Powell	8.7		9.0(20)	-6.1 (8)	-13.9 (29)		129	21.1(27)		
WALES: Gower			3.9	10.5(27)	-0.7(17)	-4.6(17)	165.4		18.5 (1)	29	0
* Velindre	J. Goodger	8.2	2.6	11.1(12)	-4.3 (8)	-8.4 (8)	124.5	134	16.9(15)	26	1
Blaenau Ffestiniog	Trefor L. Jones	6.1	2.4	9.29120	-2.0 (5)		258.2		38.6(22)	28	1
GUERNSEY: Airport	Met. Office	9.5	5.8	11.9(12)	1.9 (7)		106.0		12.7 (2)	25	0
ENGLAND:											١.
Denbury, Devon	N. S. Bailey	8.9	3.9	11.6(24)	-4.2(18)	10000000000	163.1	7722	23.9 (5)	24	0
Haselbury Plucknett, Som	J. S. Kellaway	9.1	3.6	12.5(12)	-2.2 (8)	-7.7(18)	102.6	98	15.2 (4)	23	0
Minehead, Som	A. Ozanne	9.7	4.5	13.3(12)	0.5 (6)		114.2	138	13.1 (30	27	0
Gurney Slade, Som	W. J. Newman	7.8	3.1	12.0(27)	-3.3 (8)	-4.5(18)	192.3	157	19.0 (4)	28	0
Yatton, Avon	A. H. Weeks	8.7	4.0	12.7(12)	-3.3 (8)	-6.3(18)	118.7	123	14.9 (4)	25	0
Reading Univ, Berks	Ken Spiers	8.8	2.8	12.5(12)	-1.9 (9)	-7.1 (1)	79.1	135	12.0 (9)	20	0
Sandhurst, Berks	J. M. Heighes	8.4	1.8	11.9(23)	-4.7 (8)	-6.2 (8)	119.3	174	22.0 (6)	20	1
Romsey, Hants	C. Watts	8.7	2.4	12.4(25)	-5.0 (8)	-9.1 (8)	110.1	135	13.3 (4)	21	1
Brighton, Sussex	L. S. Laskey	8.3	2.9	11.0(23)	-2.0(18)	-2.4(17)	137.8	168	21.3 (1)	26	0
Hastings, Sussex	D. I. Powell	8.5	3.7	10.7 (v)	-1.7(18)	-6.0(18)	107.3	118	16.6 (1)	22	0
Dover, Kent	F. G. Thomas	9.0	3.3	12.3(25)	-2.2(18)	-3.0(18)	91.4	112	14.0 (1)	23	0
East Malling, Kent	M. F. Wickenden	9.1	2.9	13.4(25)	-3.1 (8)	-7.0 (8)	88.3	143	19.0 (3)	20	2
Epsom Downs, Surrey	John Bird	8.6	3.6	12.2(25)	-2.6 (8)	-7.2 (8)	124.1	156	18.7 (9)	21	2
Guildford, Surrey	D. C. Mullen	8.3	3.8	12.2(12)	-2.7 (8)	-4.2 (8)	113.0	158	23.1 (9)	21	0
Sidcup, London	F. A. L. Camp	9.1	3.1	13.2(25)	-3.1 (8)	-6.2 (8)	77.3	143	13.9 (9)	19	1
Hayes, London	A. J. E. Barty	8.2	2.3	12.3(12)	-2.9 (8)	-5.9 (8)	83.1	142	16.6 (6)	22	2
Hampstead, London	Philip Eden	8.5	2.7	11.7(12)	-1.3(18)	-6.7 (8)	82.0	139	15.5 (9)	21	1
Royston, Herts	R. A. Barker	8.0	3.6	12.3(12)	-1.5 (7)	-5.0(16)	66.1	132	14.4 (6)	18	1
Loughton, Essex	R. J. Prichard	7.7	2.4	12.1(25)	-2.0 (8)	-8.4 (1)	75.7	127	15.3 (9)	18	1
Colchester, Essex	Terry Mayes	8.4	2.1	13.0(25)	-2.8 (8)	-9.5 (8)	57.0	117	10.2 (4)	16	1
Buxton, Norfolk	C. E. Briscoe	7.5	2.2	12.6(12)	-2.9(29)	-6.8(20)	78.7	145	13.1 (4)	19	Ó
Luton, Beds	Philip Eden	7.8	2.9	11.7(12)	-2.3 (7)	-6.7 (1)	96.4	150	7.4 (6)	23	0
Oxford University	T. P. Burt	8.5	3.3	12.6(12)	-0.7(18)	-6.0(18)	81.2	156	17.6 (4)	23	١٠
Wolverhampton, W.Mid	D. J. Reynolds	7.0	2.4	10.5(12)	-1.5(17)	-6.2 (8)	72.5	100	13.8 (3)	21	0
Louth, Lines	Ian Trowsdale	7.1	0.8	10.6(12)	-2.7(18)	0.2 (0)	104.0	149	17.6(12)	19	l ĭ
Keyworth, Notts	J. D. Hodgson	7.7	2.6	11.6(12)	-1.4 (7)	-6.2(29)	79.8	138	16.8(12)	21	ò
Lowdham, Notts	J. F. Osborne	7.5	2.0	11.3(12)	-0.8(18)	-3.8(29)	85.5	149	14.0(12)	21	1
Derby, Derbys	D. J. Stanier	7.4	3.0	11.7(12)	-1.6 (7)	-2.6 (7)	79.8	133	11.3(12)	20	1
Middleton, Derbys	D. F. Evans	5.5	0.9			-2.0 (/)	151.1	137	20.7(25)	27	1
	Blanche Evans	6.8	1.2	9.3(2(0	-2.8(17)	7.0 /7\	135.1	131		22	4
Wirksworth, Derb.	M. B. Edge	6.8		10.4(29)	-3.4 (7)	-7.0 (7)	95.6	135	18.0 (1)		
Keele Univ, Staffs			1.5	9.9(24)	-2.9 (8)	-5.2 (8)		133	13.6 (3)	22	0
Lathom, Mersey	Pilkington Bros.	7.4	2.0	10.3(12)	-2.5(17)	l	104.4		17.3 (1)	22	0
High Bradfield, S. York	P. A. Smithson	5.1	1.1	8.9(29)	-3.4(17)	0.04471	05.0		40 4 (5)		L
Carlton-in-Cleveland	M. B. Cinderey	6.5	1.6	10.2(24)	-4.4(17)	-9.8(17)	95.2	143	16.1 (5)	21	0
Durham Univ, Durham	Helen S. Goldie	6.5	1.0	10.0(24)	-2.6 (8)	-6.1 (1)	70.8	144	13.7 (5)	24	1:
Sunderland University	D. A. Wheeler	7.5	2.8	10.8(21)	-0.2(17)		68.0	179	14.1 (5)	16	0
U.S.: Landing, N.J.	Rudy Nickman	-2.3	-11.1	11.1(28)	-24.4(19)	-28.3(19)	159.8	-	42.9(28)	9	0
U.S.: Leesburg, Virginia	Dennis Demory	-0.6	-11.6	13.9(24)	-28.9(19)	- War (5)	101.6		25.4(17)	9	0
U.S.: Norfolk, Virginia	James Fentress	7.1	3.3	19.4 (7)	-16.1(19)		124.5	113	21.3(12)	14	0
U.S.: Venus, Texas	Will A. Shaw	12.4	3.0	22.2(14)	-7.8(18)		30.7	1	9.7(11)	8	5
AUSTRALIA: Leopold, Vic.	Clyve Herbert	24.8	12.9	40.1(26)	8.4(22)	l i	21.6	54	7.5 (8)	6	3
CUMPBIA DAINEALLACO				(1 9)		701. C	1. 52	70	(1500)		

CUMBRIA RAINFALL: Carlisle 83.6 mm (113%); Appleby Bongate 111.8 mm (127%); Scathwaite 537.0 mm (158%); The Nook, Thirlmere, 344.7 mm; Eskmeals 131.2 mm; Coniston 370.4 mm; Blea Water 479.0 mm (145%); Grange-over-Sands 165.6 mm (145%).

Fig. 1
INFRA-RED METEOSAT AT 12.00 GMT



 $Fig. 2 \\ {\tt INFRA-RED \ METEOSAT \ AT \ I8.00 \ GMT}$

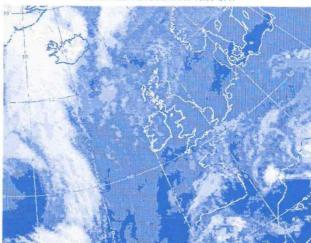


Fig.3

Weathercall's new Satellite fax with full analysis, for the only complete picture of the prevailing weather pattern. For an index page listing all our fax and phone services fax 0891 44 99 49.





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