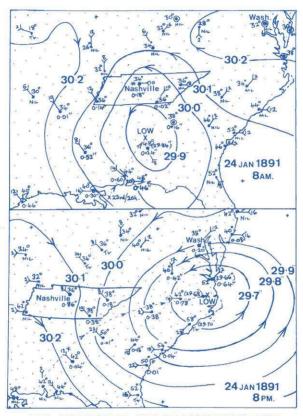
The JOURNAL of METEOROLOGY

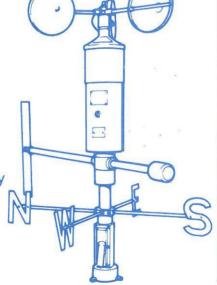


U.S. WEATHER ON 24 JANUARY 1891 THE DAY OF UNUSUALLY-LARGE SNOWFLAKES AT NASHVILLE, TENNESSEE



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UNUSUALLY-LARGE SNOWFLAKES

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

Abstract: Few reports of unusually-large snowflakes* (5cm across) exist in the literature primarily because these have not been recognised as an International observing requirement. Recorded sightings filter into journals either through a few special university studies, or have mostly followed chance encounters by enthusiastic amateurs. Eleven such records are tabulated here, and surface synoptic charts for ten of these events are given together with notes on their accompanying descriptions. A general outlie of ideas on the formation of large snowflake aggregates is also made.

INTRODUCTION

Pedgley (1962) suggests "There does not appear to be a theoretical reason to expect a maximum size for snowflakes . . . but in practice there seems to be a rough upper limit at about 5cm, and on rare occasions they are larger" (p.96). A suspected problem with some snowflake reports, as with 'the one that got away' in angling circles, has been that human nature is prone to exaggeration of size. On the other hand, abnormal events have often been discounted for the sake of regularity, and, because recording of large snowflake dimensions is not usually a concern of the busy professional weather observer, this is an area where substantiated reports from enthusiasts (preferably with photographs) can still make useful contributions.

Interest in abnormally-large snowflake agglomerations was aroused a century ago through just such a chance observation by E. J. Lowe, F.R.S., on 7th January 1887. The vivid description of this event, when published in *Nature* magazine of 20th January precipitated a reply from America, so immediate as to be printed in the 3rd March issue.

THE 'NATURE' CORRESPONDENCE OF 1887

At age 15, Edward Joseph Lowe (1825-1900) started what became 41-years of regular weather observations from his home, Highfield House, near Nottingham. He was one of three founders of the British Meteorological Society in 1850. His Highfield records included an 8-year series of 0045hr observations made each day from 1874; one of nearly 50 stations telegraphing these to the Meteorological Office for transmission on to the United States.

By profession a magistrate whose other main lifelong interest was ferngrowing, Lowe moved to Shirenewton Hall near Chepstow in April 1882, from where he submitted regular 'auxiliary' rainfall records to the Meteorological Office (1883-1890). Lowe happened to be investigating the water equivalents of lying snow at Shirenewton on the morning of 7th January 1887 when small snowflakes had been "falling with a slight thaw from 1000h", and he had two assistants plus a number of chilled flat, round, glass dishes "for the purpose of catching crystals, and measuring snow that fell upon them", so was well-prepared for what ensued.

"Suddenly at 1212h the flakes became 21/2in in length", and they continued growing in size until at 1216h when the flakes had reached 31/2in. Several measured 4in across, and there were larger ones not near enough to be caught . . ." (so these are interpreted as 'up to 11cm diameter'). Commendably, Lowe remarks on other elements during the 'storm of orange-sized flakes', which "came down nearly perpendicularly", the wind being "south and almost calm". Visibility was reduced to within thick fog limits, Lowe reporting that thousands of these "gigantic" flakes "at 50 yards off produced a dense snow-wall". Before the storm the "temperature was 34.1°F", during the heaviest snow it was "32.6°F, and the air completely saturated with moisture". The very large flakes were thought to be "within 12 inches of each other" and falling together with "many of smaller size", these appearing to be attracted to the large ones when near. Lowe further surmised that the large flakes appeared to be "falling with greater velocity and more perpendicularly, so were able to augment their dimensions still more by adding smaller ones to their bulk". By 1219h they "were somewhat less and by 1220h, the flakes although large, were not gigantic". The water from 7 large flakes weighed 1/4 of an ounce, and they are described as "not a mass of broken pieces, but composed mainly of hundreds of perfect crystals". One such flake is sketched, life size, with white chalk on black paper. Even allowing for the probable source of error where the turned-up edges of falling "boat-like" flakes expand outwards on impact, these aggregations were big enough for Lowe to remark that he had "seen nothing like it in 50 years' experience".

Unusually-large snowflakes, generally spoken of as "the largest ever seen", were also reported at nearby Itton, Chepstow, Tidenham, and further afield at Bath and Monmouth that day. Fig.1 suggests the storm described was probably one of several associated with embedded cumulonimbus clouds forming over the warmer coastal waters, just north-east of a small depression which was developing around midday while moving up the Bristol Channel. Heavy precipitation was therefore particularly likely locally near coastal hills in this synoptic situation. A note in *British Rainfall 1887* (p.4) from Ross-on Wye (32km to the N.N.E.) remarks the 4th-8th January was particularly 'snowy' there with 7in accumulating

over that period.

Eight days after Lowe's letter appeared in Nature, snowflakes three times as large were reported to have fallen in Montana, U.S.A. Word of this originated in a letter dated 13th February from Fort Keogh (no source acknowledged) which also generally described hardship caused by "extreme severity of the winter of 1886-7 throughout the north-west". This correspondence was published by the New York World immediately on 14th February (this newspaper merged to become the New York World-Sun and Telegraph, then apparently disappeared in the 1950's, so the source identity is still not traced) . . . then it was quoted from and relayed, at least third-hand, by Samuel Lockwood of New Jersey to eventually find space in the 3rd March issue of Nature in London (see p.414):

"Near Matt. Coleman's ranch on January 28 the flakes were tremendous,

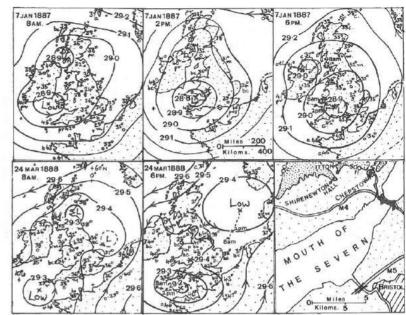


Fig.1: Top three synoptic charts for 7th January 1887 represent Fig.1a sequence. Lower two, left-hand side for 24th March 1888 compose Fig.1b. Enlarged section at bottom right (Fig.1c) shows position of Shirenewton Hall on a 180m ridge and other places mentioned in the text relative to today's motorways and the River Severn. Isobars in Fig.1a and 1b are in inches of mercury. Temperatures are readings in degrees Fahrenheit, with current Beaufort letters describing present weather.

some were larger than milk-pans and measured 15 inches square by 8 inches thick. For miles around the ground was covered with such bunches, and they made a remarkable spectacle when falling. A mail-carrier was caught in the same storm and verifies it."

Also, this interesting report is not mentioned in the U.S. Monthly Weather Review as one might expect, and Lockwood writes that he does not vouch for "the exact details" which suggests doubt in his own mind. The day's synoptic situation cannot be checked because U.S. Weather Maps do not cover this date (being irregularly issued, until 1899) so a 'question mark' remains against the degree of exaggeration in this isolated sighting of huge flakes, but it is nevertheless included in Table 1.

TWO FURTHER 19th CENTURY REPORTS

Appearing in *British Rainfall 1888*, a brief report from Lowe mentions another "storm" of large snowflakes which occurred at Shirenewton Hall on 24th March 1888:

"Snowstorm with extraordinary flakes, some were 3½ in. in diameter, yet only ¼ in. thick, falling like plates. The storm only lasted 2 minutes but in this short period the ground was covered 2in. deep. It only required 6in. of this snow to yield 1.00in. of water."

IAMETER.	SYNOPTIC SITUATION
VS ≥ 5 cm D	TEMP.
NOWFLAKE AGGREGATION	MAXIMUM ASSOCIATED DIMENSION WITH, OR (Cms.) LIKENED TO
REPORTS OF SI	APPROXIMATE ALTITUDE
TABLE 1.	LOCATION
	DATE LOCAL TIME

1	North side of a developing depression. Rain turns to snow.	Post-Frontal Precipitation; Rain turning to snow.	Heavy Shower to North-East of a developing depression moving up the Bristol Channel.	Passage of minor trough from North-West. A heavy shower.	To North-East of a developing depression moving up English Channel. Probable embedded Cb.cloud later in Afternoon/Eve	North of a developing secondary tripple-point' depression, with rain turning to sleet then snow.	Post-Frontal Precipitation; with a secondary depression passing SSE wards nearby to W.	Belper situated just North-East of track of a deep depression.	North-East of a developing low- pressure complex with much snow.	North of partly-occluded, mature depression close to its deepest. After passage of backbent occlusion, ice pellets turn briefly to large flakes.
	Approx.+1°	Falling to $+1^{\circ}$ From $+3^{\circ}$.	Falling to +0.3°.	Round and Just above 0°. Oval Dishes.	·	Falling Towards 0°	+0.5° Throughout,	Falling to +0.5°	Rising to -0.5°.	+0.5° at 1900, Falling to -0.5° at 2000hrs.
Milk Pans	Saucers	Saucers	Oranges/ Boats.	Round and Oval Dishes.	Small Plates/Dishes.	Teacups		1		
38 E	10-14 E Saucers	13 E	=	8-10	46	∞	9	SE	5	5
700m./2,300ft.	180m/ 590ft.	120 to 185m./ 400 - 600ft.	Above 60m./ 200ft.	44m./144ft.	161m./530ft.	46m./ 150ft.	2,182m./7,163ft.	62m./ 203ft.	19m./ 62ft.	41m./135ft.
A Ranch near Fort Keogh, Miles City, Montana, USA.	Nashville, Tennessee, USA.	Berkhamsted And Nearby. Chiltern Hills, UK.	Shirenewton-Itton-Chepstow Area, UK.	Berlin, Germany.	Shirenewton Hall, Near Chepstow, UK.	Richmond, Virginia, USA.	24th September 1970 Laramie, Wyoming, USA. 2, 0800-0900.	Belper, Derbyshire, UK.	Sapporo Area, Hokkaido, Japan.	Shearwater Naval Air Station, Near Halifax, Nova Scotia, Canada.
28th January 1887	24th January 1891	13th April 1951 0430-0445.	7th January 1887 1210-1230.	10th January 1915 1630.	24th March 1888 (Prob.later in PM)	25th March 1900 1730-1800.	24th September 1970 0800-0900.	30th January 1942 (Prob. early PM.)	9th December 1950 1300-1500.	22nd February 1986 1920-1950.

The editor of British Rainfall added "at this rate 5 feet of snow would have fallen in one hour". Unfortunately, no time of day is given! Fig. 1b indicates a complex low pressure area again over the British Isles, with a significant development taking place during the afternoon between Brittany and Cornwall. This had brought general rain with snow over higher ground to south-western districts by evening as it began to move up the English Channel. Lowe's storm probably occurred during late afternoon or early evening, again perhaps in association with substantial embedded convective cloud. Significantly on the 24th, Ross-on-Wye reported afternoon rain also "turning to snow of large flakes at 7.00 p.m.", this fall was "lying 3 to 4 ins. deep the next day".

Fig.2 shows the accelerating movement of a deepening depression across the south-eastern U.S.A. The Monthly Weather Review of January 1891 (p.11) suggests this was responsible for one of the "heaviest snowstorms in years" over Tennessee.

"At stations in the middle part of the state a depth of 12in, was estimated. A notable feature of this storm at Nashville was the size of the snowflakes,

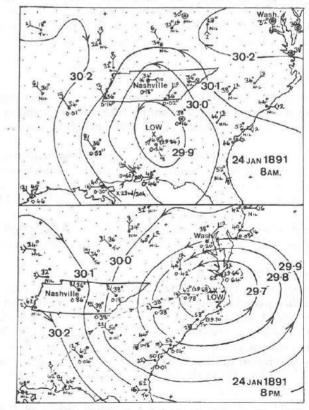


Fig.2: Charts drawn from U.S.A. Historical Weather Maps at Met. Office Archives, Bracknell to show movement of the deepening depression as it tracks over the S.E. U.S.A. during 24th January 1891. Wind speeds are in m.p.h., temperature in degrees Fahrenheit, and isobars in inches. 12-hr rainfall also given.

many of which were as large as a silver dollar and some nearly as large as a saucer. On 24th/25th the snow storm extended over the middle Atlantic states and New England, causing great damage to electric wires".

Temperatures (quoted in °F) in Fig.2 are generally a few degrees above freezing point, and wet, clinging snow might be expected, 24-hour rainfall at Nashville was 1.04in., which correlates with the reported 'foot' of snow in some districts. However, we are left wondering just exactly how big "nearly as large as a saucer" is. In the absence of more precise information from the original source, bracketed insertion of sizes was then made by Cleveland Abbe, Jr. Reporting of the Nashville snowstorms was made by the Tennessee Local Weather Service - J. D. Plunket, M.D. (Director), and H. C. Bate (Assistant) of the Army Signals Corps. Mr. Cleveland Abbe, Ir., is noted as being the "Monthly Weather Review Editor's Son, and Translator". In his review entitled 'Gigantic Snowflakes' on p.73 of the Monthly Weather Review, 1915, here, the 1891 report became: - "Many flakes were as large as a dollar (3.8cm) and some nearly as large as a saucer (14cm)". This interpretation has gained widespread subsequent acceptance, although it was never reported that flakes did reach 14cm diameter . . . for example, it is requoted in Corliss, 1977. This author believes that 'nearly as large as a saucer' would be nearer 10-12cm; however a compromise of 'estimated 10-14cm' is used in Table 1.

TWO POST-COLD-FRONTAL EVENTS

Perhaps by chance, both these observations were made over high ground and outside of the normally-recognised 'winter months'. Fig.3 shows the synoptic situation over S.E. England when E. L. Hawke appears to have written 'second hand' that'

"Snowflakes of exceptional size, variously reported by postmen and other early risers to have been 'enormous', 'as big as saucers', and 'about five inches across', fell in Berkhamsted town and neighbouring districts of the Chiltern Hills 400-600ft above sea-level between 0430 and 0445 GMT on 13th April 1951 . . . In the Chilterns, steady rain appears to have given place to sleet around 0400 GMT, the snow following just before 0430 when the surface temperature stood at 33°F". (Letter "Outsize Snowflakes", Weather, 6, p.254).

A deep depression of 976mbars at 0600 GMT was moving eastwards at 60°N 02°E with little change of central pressure. Hawke suggests a "well-marked" cold front in association "had passed south-eastwards across the area earlier in the night", to which may be added that its progress was temporarily slowed by formation of a 'wave-feature' which had moved from the Bristol Channel (see Fig.3b) to clear the Chilterns just prior to precipitation turning to snow there. The only official network station to report similar conditions was Little Rissington, some 750ft up on the Cotswolds, where heavy sleet was recorded at 0300 GMT, turning light by 0400, then reverting to rain.

The second recorded instance of very large post-frontal snowflakes also occurred when a disturbance on the cold front passed closeby the observing station. It happened during the early morning too, when diurnal cooling is likely to be at its greatest. Fig.4 indicates movement of the synoptic features over Western

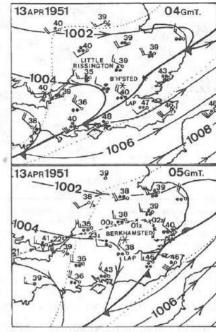


Fig.3: Synoptic charts early on 13th April 1951, showing present weather, with isobars in millibars, temperatures still reported in Fahrenheit, and hourly extent of the precipitation area indicated by the dotted lines. Dashed line shows track of the small cold-frontal wave-depression since the previous evening. Winds are in kn.

and Central parts of the U.S.A. and Canada during what was described as an "intriguing snowfall" by A. H. Auer in *Weather*, 26, pp.121-122. He appears to be writing second-, if not first-hand about the experience, which occurred between 0800 and 0900 hours local time in Laramie, Wyoming (over 2,000m in altitude) on 24th September 1970.

"This snowfall consisted of very large snowflakes or aggregates, averaging about 3cm in diameter with maximum diameters to 6cm . . . The terminal velocity of these aggregates was determined by timing their fall with a stop watch over a 2-metre height and their diameters were measured immediately they landed on some black felt . . . The author has not been able to determine any specific mechanism responsible for the aggregation. It was noticed, however, that on one occasion two 4-cm aggregates approached each other at an angle of 20° from the vertical and, at a height of about 3 metres above the ground, a stable collision took place resulting in a 6-cm aggregate".

Auer found that the fall velocities of snowflakes greater than 3cm in diameter approached a constant value (near 2.5m sec⁻¹), while those of ½cm in diameter fell at less than half this speed (1.1m sec⁻¹). The surface temperature throughout remained at +0.5°C, but 4cm had accumulated on the ground after this hour-long

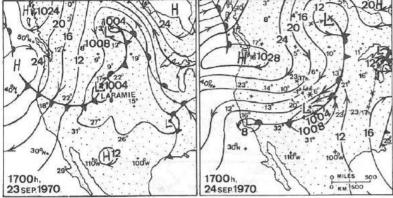


Fig.4: Available daily charts for the Western U.S.A. showing position of Laramie relative to cold frontal movement over 23rd/24th September 1970. Analysis based on a synthesis of Bracknell circumpolar, and Washington Daily Weather Reports. Temperatures in degrees Centigrade; isobars in millibars.

snowfall. A good b/w photograph of a 6cm aggregate accompanies Auer's article. Reference is made to the mass of a 5-cm aggregate found to weigh only 0.8 gram, and further to the work of Choji Magono and others in Japan.

RIMED AND NON-RIMED SNOWFLAKES AT SAPPORO, JAPAN

Some interesting observations of a heavy snowfall were made at Sapporo Meteorological Observatory (2km from Hokkaido University) by Magono and colleagues between 09 and 15 hrs local time on 9th December 1950. The synoptic situation (Fig.5) indicates a complex depression was passing to the south of Sapporo with temperatures over Hokkaido rising during the day. Aided by observations from 2,077m-high Mt. Tokachi (100km east-north-east of Sapporo), Magono noted that no snow flakes . . . only crystals . . . were observed at temperatures below -10°C. Most of these crystals were of the dendritic (rather than the needle or column) type, and Magono was armed with the knowledge that Hokkaido's Prof. Nakaya and colleagues had successfully reproduced dendritic crystals in the laboratory at temperatures between -14° and -18°C. From the vertical temperature measurement made at 1200 hrs on the 9th, Magono supposed those observed dendritic snow crystals would have grown while falling from a height of 2,400m to 1,800m, only beginning to 'clump together' as flakes when the ambient temperature reached -10°C at 1300m altitude. The largest flakes were seen when the temperature outside had climbed to -1°C, and as the air temperature became higher, cloud particles (rime) attached to the snow flakes became more numerous

Supposing 20 per cent of encountered air flowed through rather than around a falling, unrimed snowflake, Magono advanced the idea that 'riming' blocked airspaces between crystals leading to their having less drag, larger mass, and hence greater fall speeds. For all types of flakes, it was found that their fall velocities increased with size up to 2cm diameter, thereafter rates becoming regular and "almost independent of size" (up to the observed maximum, 4-5cm diameter).

Rimed oblate-type or inverted cone-shaped flakes had faster fall-speeds (measured by stopwatch at almost 2.5m sec⁻¹) than unrimed and/or tabulate type flakes (rarely more than 2m sec⁻¹). He concluded that large snowflakes grew by their collision with smaller flakes or dendritic crystals as a result of their different velocities of fall.

Finding that stopwatch-timing of descending small flakes and individual crystals was difficult and imprecise, Magono devised a photographic method of recording them in the falling state, and this was used successfully in March 1951. The falling flakes were illuminated stroboscopically once per 0.01 sec. within a dark cylindrical box using diffused light produced by electric discharge. After magnification of the photograph and averaging the interval (which was often found to be irregular) between successive images, the fall-velocity of each flake or crystal entering the 20cm high box was calculated. Results (reproduced in Magono, 1953) confirmed earlier visual reports . . . e.g., an inverted-cone-shaped flake would fall, keeping its heavier point part downwards; a tabulate flake with perimeters turned in like a dish on top fell most rapidly of all (2.1m sec⁻¹) for its size (0.8cm).

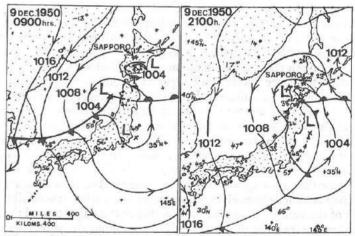


Fig.5: Synoptic charts showing north-eastward movement of the depression complex over Northern Japan during 9th December 1950. Temperature in oF; isobars in millibars.

CONES AND DISHES

A fall of large, inverted cone-shaped snowflakes is reported, apparently first-hand in Richmond by Virginia Section Director Mr. E. A. Evans (see p.156 of the Monthly Weather Review, April 1900). The synoptic situation (Fig.6) shows a very large temperature gradient, north to south over the Atlantic Seaboard U.S.A., with a 'triple-point' secondary depression passing eastwards during the period of observation just south of Virginia. A 'Col Low' was also forming over the Great Lakes and the whole depression-complex was deepening. Mr. Evans relates:-

"The morning of March 25 was cloudy, with a fresh, chilling north-east wind. The temperature rose slowly during the forenoon and at 1.17 p.m. a

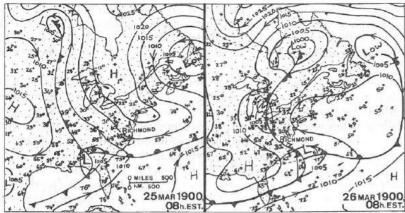


Fig.6: Daily synoptic charts based on U.S.A. "Northern Hemisphere Synoptic Weather Maps" published in Washington DWR's, showing developments around Richmond, Virginia, over 25th-26th March 1900. Temperatures in F; isobars in mb., times 'Eastern Standard'.

light rain began to fall. Soon sleet accompanied the rain, and later sleet alone fell. Some of these icy particles were nearly cubiform, measuring perhaps 1/4in. either way. Mixed with these was the sleet ordinarily seen - the small spheres of frozen rain. At 5.25 p.m. moist snow fell with sleet. At first the flakes were not large enough to be specially noticeable, but as the fall of sleet diminished in volume, which it immediately did, the size of the flakes increased until they attained unusually large proportions. They were of irregular shape, mostly oblong; several were seen the greatest diameter of which could hardly be covered by a teacup. Some were caught upon a piece of dry wood and examined. In every instance the centre of the flake was composed of a soft mass of snow about 1/2 in in diameter, while the outer edges were thin, looking as though they might have been separate flakes which had attached themselves to the central mass while it was falling. The weight of the centre being greater than that of the edges caused the larger ones to assume the form of an inverted cone in falling, the outer edges being bent up by air resistance . . . The flakes were widely separated from one another and did not obscure the vision in looking upward toward the sky."

Unfortunately no additional timings or depth of the snowfall were given, but it may be noticed on the 0800 hrs observation of 26th March (Fig.6) that temperature at Richmond was 32°F (suggesting a snow-cover) compared to 42°F the previous morning. The report of widely-spaced, large snowflakes suggests further that differing fall-speeds had been involved with the faster-moving central masses being very efficient at capturing the smaller dendritic flakes through which they fell. Other observers have since remarked on inverted-cone shaped flakes 'falling like shuttlecocks', and Magono (1955) has determined photographically that these often have parts of their tails "set like a rubber" at a constant angle to give a spirally-rotating descent.

An example of a fall of bowl- or dish-shaped snowflakes is given by Otto

Baschin at first- or second-hand in the Meteorologischen Zeitschrift, 32 of February 1915, p.93. One translation from the original German reads:-

"On 10th January 1915, at approximately 4.30 p.m., Berlin experienced a brief snowfall which contained, in addition to flakes of common size, also some of considerable dimensions. Numerous snowflakes had diameters of 8 to 10cm, which not only fell more rapidly than the small flakes, but also did not swirl about to the same extent and fell along rather more regular trajectories. Most were shaped like round or oval bowls or dishes with upturned rims. They did rock to and fro in the wind but at no time were they observed to turn over completely so that the concave side would face downward. The temperature was only slightly above the freezing point."

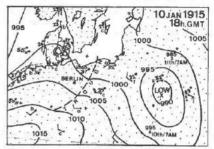


Fig.7: Synoptic chart for 10th January 1915 over part of Northern Europe to show position of a 'showery trough' at 1800 GMT. Temperatures in F; isobars at 5mb intervals.

Fig.7 indicates this snowfall took place in association with the passage of a minor showery trough from the west-north-west, with a major developing depression moving northwards over Poland. The brevity of the fall indicates these flakes were formed most probably through collision in turbulent conditions associated with the passage of an active cumulonimbus cloud.

TWO LATE-WINTER STORMS

These reported instances both occurred over low ground and involved precipitation of rain or sleet turning to snow of large 5cm diameter flakes, while an active, partly-occluded depression passed to the south of the station concerned. The first of these was reported by a volunteer observer at Belper, Derbyshire, on 30th January 1942 as "the biggest snowflakes I have ever seen, diameter approximately two inches". This quote was taken from the Meteorological Office Monthly Weather Report for January 1942, the observer unfortunately not noting the duration or even a time. However, Fig.8 suggests the fall occurred during the early to mid-afternoon period. Rain had turned to snow in Cheshire, Shropshire and Merseyside by 1300 GMT ahead of a rapidly-moving depression of 990mbars, which passed from near Malin Head at that time to be over the Thames Estuary by 2200 GMT, with little change of central pressure. Thunder was reported also from several stations in the South Midlands and S.E. England as the occlusion raced through later in the afternoon, and embedded cumuliform cloud could well have

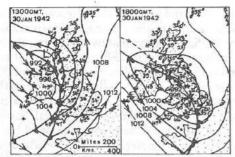


Fig.8: U.K. British Isles Charts for 30th January 1942 showing the rapid south-eastwards movement of an occluding Atlantic depression. Position of the large-snowflake report is given by a large *, as on other charts. Isobars at 4mb intervals; temperatures in F.

produced those large flakes at Belper. Temperatures were generally noted as near to or a little above freezing point in the heavier snow reported.

Precipitation continued all day on 22nd February 1986 in the Halifax area of Nova Scotia, Canada, with overnight snow turning to freezing rain and then rain during daylight hours. Fig.9 indicates a depression passing closest during the late afternoon some 150km south of the Naval Air Station at Shearwater, just northeast of Halifax. Here, detailed investigation of precipitation was being made by Dr. R. Stewart and colleagues using a 'twin otter' aircraft with a laser probe capable of precise measurement. Ice pellets of 3mm diameter were briefly encountered around 1305 GMT and then again more generally from 1700 GMT onwards, this precipitation turning to "huge snowflakes" of between 2 and 5cm diameter from 1920 to 1930 GMT as the depression moved away. Lighter snow continued, often mixed with ice pellets, until ceasing soon after 2300 GMT. Perhaps the largest temperature fall occurred during the fall of large snowflakes, this changing from plus 0.5° to minus 0.5°C in the hour 19-20 GMT (15-16 Local Eastern Standard Time) in the screen.

DISCUSSION AND SUMMARY

It appears to be no accident that almost all reports of large snowflakes are made when the temperature is just above 0°C. Since radar development in the 1940's, observers of precipitation have sometimes noticed a layer of enhanced reflectivity, known as 'the bright band', at and immediately below the melting level. Investigators believed aggregations of snowflakes were responsible, assuming a dielectric characteristic essentially that of water when they began to melt, occasionally enhancing radar reflectivity in quite a broad band by up to a factor of 5. Aircraft observations have now confirmed snowflake aggregation taking place above and throughout most of what tends to become an isothermal 0°C layer (see Stewart, 1984a and b). When continuous precipitation is moderate or heavy, adiabatic cooling of the air by melting snowflakes has been known to lower this isothermal 0°C layer over 2,300m (e.g. on 22nd February 1986, at Shearwater, see Stewart, 1987). In some circumstances, the freezing level is substantially lowered, and unexpected falls of very large snowflakes can accumulate rapidly (e.g. at Little

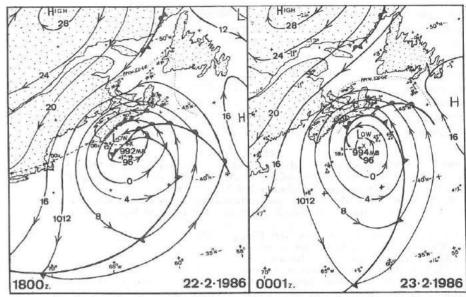


Fig.9: 12-hourly charts based on Bracknell CFO North Atlantic Analysis for 22nd-23rd February 1986 during the Canadian Atlantic Storms Project. Position of Shearwater N.A.S. is given by a large S, temperatures are in °C; isobars at 4mb intervals. The 'Low' was at its deepest around 1800 Z(GMT).

Rissington on the Cotswolds, 1st November 1942, see Lamb, 1960). Ideally, with temperatures near freezing-point helping snowflakes adhere together, winds should also be relatively light to avoid 'bunches' disintegrating.

When some flakes have reached 2cm or more in diameter, there is a fair likelihoood that these will continue to grow by collision and merger, especially at the expense of smaller flakes and crystals falling in their paths at two-thirds or half the speed. Table 1 summarises those infrequently-reported instances in which snowflake aggregate exceeding 5cm largest dimension have been recorded on the ground. There is every reason to suppose that such instances might occur almost every day during winter somewhere in Europe or the maritime fringes of North America and Asia, but that they are very seldom reported or authenticated. Here, any amateur enthusiast equipped with tape-measure/ruler or a camera can help determine the true frequency of these events.

Although higher ground in colder Maritime Climates generally appears most suitable for large-snowflake observation, particularly favourable synoptic situations to watch for include:

(i) When cold-airmass showers come in from the sea over hills near the coast.

(ii) During post-cold-frontal precipitation immediately after (or as) rain turns to snow, particularly if a 'wave disturbance' forms on the front and temporarily (1) slows its clearance (2) intensifies precipitation.

(iii) Generally on the north side of depressions, particularly towards the time they reach their lowest centre pressure (often the 'partly-occluded' stage).

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HUMAN WIND-CHILL

(from The Weather Department, Anglia Television, Norwich)

It is generally appreciated that a strong wind makes it feel colder than if there is no wind at all. This subjective assessment is usually adequate for most occasions in southern Britain. However, there is occasionally a need to provide a more quantifiable estimate of exactly how much colder it will feel because of the wind. This becomes particularly important when the cooling effect is great enough to cause biological stress, e.g. induce hypothermia or even in extreme cases freeze flesh. This is more likely in northern Britain.

The cooling effect of the wind can be usefully related to a 'Human Wind-Chill Equivalent Temperature'. This is the temperature in still air which would give a rate of heat loss equal to that which occurs with the observed wind and temperature. This equivalent temperature is described by R. G. Steadman (1984)

who used a computer model to study the effects of heat loss felt by a 'properly clothed human'.

This wind-chill temperature therefore only relates to a human body and does not apply to solid inanimate objects such as a car engine blocks and water pipes which tend to cool only to the actual air temperature. Some people, incorrectly, attempt to use equivalent wind-chill temperatures for calculating antifreeze requirements. In fact, wind strength simply serves to cool the engine to the air temperature quicker than it would in still air conditions, the same applies to water pipes. It is important to note that a negative wind-chill equivalent temperature does not mean a frost, it is the actual air temperature which determines whether there is a frost or not.

Table 1: Wind-Chill Equivalent Temperatures (Steadman).

SCREEN TEMP			10-	METRE WI	ND (KNOTS	5)		
(°C)	5	10	15	20	25	30	35	40
20	19.1	17.4	15.9	14.9	14.0	13.3	12.8	12.3
18	17.0	15.2	13.7	12.5	11.5	10.8	10.2	9.7
16	14.9	13.0	11.4	10.1	9.0	8.2	7.6	7.0
14	12.9	10.8	9.1	7.6	6.5	5.6	4.9	4.2
12	10.8	8.6	6.7	5.2	4.0	3.0	2.1	1.4
10	8.7	6.4	4.4	2.7	1.4	0.2	-0.6	-1.4
8	6.7	4.2	2.0	0.2	-1.2	-2.5	-3.4	-4.2
6	4.6	2.0	-0.4	-2.3	-3.9	-5.2	-6.3	-7.0
4	2.5	-0.3	-2.8	-4.8	-6.5	-7.9	-9.1	-10.0
2	0.4	-2.5	-5.2	-7.3	-9.1	-10.7	-11.9	-12.9
0	-1.7	-4.8	-7.5	-9.9	-11.8	-13.3	-14.6	-15.8
-2	-3.7	-7.1	-9.9	-12.3	-14.4	-16.1	-17.4	-18.6
-4	-5.8	-9.3	-12.3	-14.8	-17.0	-18.8	-20.2	-21.4
-6	-7.9	-11.6	-14.6	-17.3	-19.6	-21.3	-22.9	-24.2
-8	-10.0	-13.9	-17.0	-19.9	-22.2	-24.0	-25.6	-27.0
-10	-12.1	-16.1	-19.4	-22.4	-24.7	-26.6	-28.3	-29.8
-12	-14.2	-18.3	-21.7	-24.9	-27.3	-29.3	-31.0	-32.6
-14	-16.3	-20.6	-24.1	-27.3	-29.9	-31.9	-33.8	-35.3
-16	-18.3	-22.8	-26.5	-29.7	-32.4	-34.6	-36.5	-38.0
-18	-20.4	-25.0	-28.9	-32.2	-34.9	-37.2	-39.1	-40.8
-20	-22.5	-27.2	-31.2	-34.7	-37.4	-39.7	-41.7	-43.5

A set of Human Wind-Chill Equivalent Temperatures for different wind speeds and air temperatures is shown in Table 1, and is based upon data by Steadman. It is in common use by meteorologists in this country and is the figure quoted in most weather broadcasts, where a wind-chill is given.

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TORNADO AND STORM RESEARCH ORGANISATION TORRO HAILSTORM DIVISION: THIRD ANNUAL SUMMARY

DAMAGING HAIL IN THE U.K. AND IRELAND 1986

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Abstract: This paper summarises the extensive data collection regarding British and Irish hailstorms assembled by the Hailstorm Division of T.O.R.R.O. for 1986.

INTRODUCTION

Table 1 summarises all occasions in 1986 when hail was reported to have caused visible damage or to have had the definite potential to do so on account of its exceptional size and/or intensity. All such occurrences rate at least H1 on TORRO's Hailstorm Intensity Scale (J. Meteorology, vol. 11, no. 114, 339, 1966). The

location of these damaging hailfalls are given in Fig.1.

There were also some other occasions when hail of 10-15mm diameter was reported but with evidence suggesting that the hail either consisted of conglomerations of soft 'snow-pellet' type hailstones or fell in relatively insignificant amounts. Likewise there were instances, chiefly in the spring, when a reported intense fall and accumulation of hailstones referred to heavy showers of snow pellets. These reports are given a TORRO rating of H0, and although they are mentioned in the text they are omitted from the tables. If the hailstorms of 1985 are reviewed on a similar basis, the number of days with damaging hail is revised to 20 as compared with the 24 days suggested in the previous report (J. Meteorology, vol.12, no.118, p.119).

TORRO's historical research work indicates that, in periods of effective reporting, damaging hail is usually noted on 10-20 days per year; in 1986 there were 17 such days. There were few reports of widespread or serious hail damage during the year; no storms definitely reached the H5 'destructive' category. Even during the most severe 'events' on 29th June the hail was overshadowed by

flooding and lightning damage.

JANUARY. Local thunderstorms were quite frequently reported in this very unsettled, cyclonic month. Thunder and hail were widespread in the west on the 11th in a strong-to-gale force westerly airstream associated with an unusually deep depression south of Iceland (lowest pressure 934mb). A succession of thunderstorms affected the Glasgow area where marble-sized hailstones accumulated to a depth of 25mm. The storms penetrated right across the lowlands with up to 12mm diameter reported in the neighbourhood of Edinburgh.

FEBRUARY. This was a very cold easterly month with only isolated thunder and occasional reports of hail referred to as snow-pellet type precipitation.

MARCH. The last fortnight was very stormy with frequent hail and thunder. Vigorous cold fronts crossed the British Isles on the 20th and 23rd advecting deep unstable westerly airstreams. Thundery showers developed over southern England on 20th with hail up to 10mm diameter falling in South Buckinghamshire where a sudden storm caused a multiple car-accident on the M4 motorway near



Slough. On 23rd parts of Scotland and Northern Ireland were similarly affected with a few reports of hail exceeding 10mm diameter.

While the main low-pressure area persisted between Iceland and Norway an intense secondary depression brought violent gales to southern England on the 24th; in the wake of the cold front thunderstorms were quite prevalent in western Britain, and often accompanied by hail; hailstones up to 24mm diameter fell at Moel-y-Crio, Clwyd, North Wales, while 10mm diameter hail was observed at Cross Hands, Dyfed, and locally in Scotland. Next day 10mm diameter hail was reported from Ireland.

A complex area of low pressure became established over the British Isles during the last week of March; this was associated with a deep broad upper trough which was to dominate the weather for a month. The period 27th-31st was showery, with thunderstorms and hail over northern Britain on 27th, and southern England

on 28th, 29th and 31st. Some of the hail was of the snow-pellet type, but the early afternoon storm on 27th at Jedburgh, Borders, had 5-10 minutes of hail up to 10mm diameter, hard enough to be painful on impact. During a storm on 28th at Higham Ferrars, Northamptonshire, between 1215 and 1235, hail accumulated to 30mm depth; some of the stones were larger than peas.

APRIL. A persistent upper trough and attendant deep polar air dominated the weather over the British Isles. The synoptic pattern resembled that of April 1983 and there was a similarly high incidence of thunder and hail. A shallow depression drifted eastwards across southern England on 2nd. During widespread thundery

showers some appreciable falls of hail occurred; sharp hailstorms caused a spate of accidents on main roads near Abingdon (Oxfordshire) and Staunton (Gloucestershire). Hailstones, probably coalesced snow pellets and bigger than 10mm, were

reported at Aldenham (Hertfordshire) and Wynton (Cambridgeshire).

Another complex, filling depression moved slowly over England between 15th and 18th; heavy showers were accompanied by widespread hail and thunder. Several places in southern England reported hail covering the ground for a time on 16th and 17th. A 5-minute storm at East Bergholt, Suffolk, in the late morning of 18th had hailstones bigger than 10mm. A further depression moved towards western Britain on 20th. After early frontal rain the day was showery with local hail; hailstones over 10mm were reported from Brize Norton (Oxfordshire) and

Llangenny (Powys).

From 21st to 25th a complex depression slowly filled west of Britain. Very unstable polar air within the deep upper trough over Western Europe was responsible for widespread convective activity. Thunderstorms around the Severn Estuary on 21st were outstanding for the large accumulations of hail which were deposited in south Gloucestershire, Avon, and especially West Wiltshire. The storms caused numerous accidents on the M5 motorway near Clevedon (Avon County), where a sheet of hail lay until the following morning. During a slowmoving thunderstorm at Bradford-on-Avon (West Wiltshire) hail fell continuously for exactly one hour from 1703 to 1803 GMT. The hailstones, up to 9-10mm diameter, formed a nearly complete, level ice cover in the presence of steady melting and the absence of any drifting. Storms on the 22nd were particularly severe around Birmingham and hail accumulated to a depth of 50mm in the Northfield area. On the 24th thunderstorms were severe over Wales and adjoining English counties. Considerable falls of hail occurred locally in Powys, while a storm at Loggerheads (Clwyd) between 1540 and 1600 was accompanied by hailstones as big as 15mm.

An unstable airstream of polar origin affected northern Britain on 29th; with only light south-westerly winds surface temperatures rose to 12-13°C at most, setting off some locally heavy thundery showers. Hailstones, at least 15-20mm diameter, fell in parts of Northern Ireland, but a report of giant hailstones at Balerno near Edinburgh has been unsubstantiated by further enquiries.

MAY. May was unsettled and mostly rather cool. A complex depression covered the north-west of the British Isles from 13th to 15th in association with a deep upper trough (500-1000mb thickness fell below 528mb west of Ireland). On the 14th heavy showers were accompanied by thunder and hail especially over Ireland. Large hail was reported from Long Kesh, Co. Down, while there was a severe afternoon hailstorm in the vicinity of Lake Erne, Co. Fermanagh, where hailstones accumulated to 50mm on the Ballyshannon to Enniskillin road. A very showery westerly airstream over northern Britain on 21st and 22nd was accompanied by local thunderstorms; hail over 20mm diameter was seen at Kielder, Northumberland, on 22nd. Hail was also quite widespread over southern

England on 28th although no falls of note were reported.

JUNE. After an unsettled start the month was often dry and very warm after the 12th. The fine weather was broken by some thundery outbreaks, widespread and at times severe in the south-west but isolated elsewhere in Britain. On the 16th an anticyclone which had covered the North Sea for some three days moved away eastwards across Scandinavia, leaving a slack pressure-gradient over Britain. Rapidly rising temperatures (up to 29°C) initiated local thunderstorms. During a storm at Enfield, North London, intense hail fell for 2-3 minutes; the hail, some as big as 10-pence pieces (i.e. 25-30mm diameter) still covered the ground 3-4 hours later.

The 29th saw the most severe hailstorms of the year in south-west Wales and south-east Ireland. A surface frontal zone remained slow-moving across southwest England from the 27th to 30th. The upper air charts show a fairly strong southerly flow at 500mb. Surface temperatures above 35°C in western France triggered the development of a succession of northward-moving thunderstorms. The surface front edged westwards over south-west Britain early on 29th (acting as a warm front) and the ensuing light, low-level easterly wind provided the necessary warm air to sustain the storms propagating north-north-westwards.

An intense storm tracked across Dyfed soon after dawn on 29th; this was the only occasion in 1986 when a substantial swath of hail damage, suggestive of a travelling storm, was observed. There were several reports of lightning damage from the Haverford and Fishguard areas, but the most intense precipitation fell in a narrow band from around Tenby northwards to just west of Cardigan, mainly affecting a sparsely populated area. At Llandissilio, where flash flooding was severe, marble-sized hailstones dented lawns and shot holes through cabbageleaves. At Hebron (SN 180277) hailstones "nearly as big as golfballs" broke greenhouse glass and shattered perspex roofing. Plastic sheeting was riddled and cars had at least their paintwork dented. At Penygroes (SN 162356) the hailstorm broke at 1640 GMT, lasting 15 minutes and smashing greenhouse glass. About 20% of the stones were 30mm x 20mm in size, and they consisted of a white outer shell surrounding a small nucleus of clear ice. The most intense precipitation was reported at Moylegrove (SN 117447) where 74.5mm of rain and hail fell in 6 hours during two separate storms; crops in the area were severely damaged. This was probably the most damaging hailstorm in south-west Wales since 18th July 1926; on that occasion a series of northward-moving thunderstorms gave destructive falls of hail in several parts of Wales and S.W. England; much glass was broken in the region of Haverfordwest.

South-east Ireland also experienced violent thunderstorms on 29th June 1986, and in the vicinity of Enniscorthy, County Wexford, golf-ball sized hailstones damaged crops and dented some cars. During a series of thunderstorms that affected the Channel Islands hailstones of at least 26mm diameter fell in Jersey; a few were reported to be nearly 40mm across.

JULY. Although hail and thunder were infrequent in July, the most widespread 'damaging' hail of the year happened on the 23rd. A cool surface north-westerly airstream covered the British Isles and an upper trough moved southwards during the day. Thunderstorms broke out in northern England by early afternoon and evening. Heavy pea-sized hail fell in the Ripon area of Yorkshire from 1415 to 1430, while hailstones the size of mothballs were reported from Cawood near Selby. During afternoon thunderstorms in the Midlands the observer at Hanchurch, Staffordshire, reported hailstones like 'gobstoppers', while hail over 10mm diameter also fell in the Nottingham area; at Kimberley hailstones covered the ground and damaged vegetation. By early evening some storms had developed in many parts of southern England; at Burnt Oak, N.W. London, marble-sized hail covered the ground and chipped paint off window ledges. Later in the evening hailstones the size of marbles fell in east Berkshire, notably around Old Windsor.

AUGUST. August was cool, unsettled and very wet. Thunderstorms were not especially frequent but the year's most widespread outbreak occurred on 10th-11th. A shallow depression was situated over north-west France with an associated cold front across south-west England. Severe thunderstorms broke out in South Wales, the south-west Midlands, and central-southern England by early evening; these storms drifted slowly north-east overnight and merged with additional storms moving north from France into south-east England and East Anglia. During a ferocious electrical storm at Echinswell near Newbury (Berkshire) hailstones of up to 20mm diameter were noted.

SEPTEMBER. September was an exceptionally quiet month with only two

reports of thunder and no significant hail.

OCTOBER. October began quiet and anticyclonic but the latter half of the month was very disturbed, indeed stormy at times, and in unstable polar maritime airstreams local hail and thunder were frequently reported. A very strong westerly airflow persisted over the British Isles from 19th to 22nd. During a 10-minute thunderstorm at Lakenheath, Suffolk, on the afternoon of the 19th, the ground was covered by hailstones up to 18mm diameter. Further thunderstorms broke out behind a vigorous secondary low which crossed southern England on the 20th; pea-sized hail covered the ground at Coulsdon, Surrey. During an evening thunderstorm on 22nd 10mm diameter hailstones fell at Cheddar, Somerset. Finally, in a strong south-westerly airstream the Western Isles of Scotland had squally thundery showers on 29th; at Kneep hail up to 20mm across was observed.

NOVEMBER. This was a very mild, unsettled south-westerly month although

long sea tracks kept the surface air mild.

Incursions of cold unstable upper air occurred around mid-month. A secondary depression crossed Ireland on 14th. In a returning maritime polar airstream hail

over 10mm diameter fell at Towy Castle, Dyfed.

On the 20th an upper trough covered the British Isles (500-1000mb thicknesses were below 522mb over most of Scotland). A very unstable south-westerly airstream affected northern Britain throughout the day. Very heavy hail was reported during early morning thunderstorms along the North Wales coast, while a series of thunderstorms affected western coasts of Scotland during the day. At Armdale, Skye, the second of four storms, between 1200 and 1245h was accompanied by hailstones averaging 20mm and up to 25mm diameter; the

hailstones accumulated to a uniform depth of 100mm, and lay for up to three days. A deep depression was situated near western Scotland on 22nd with a very showery W.S.W. airstream over England and Wales. As is common in such

weather situations a succession of heavy thundery showers were reported from the Bristol Channel area, and a particularly violent evening hailstorm caused a

spate of road accidents in Bristol as vehicles skidded out of control.

DECEMBER. This was another predominantly mild west south-westerly month. A strong north-westerly airstream brought thunderstorms to western coasts on the night of 19th-20th. At Prestatyn, Clwyd, hail completely covered the ground around 1900; at 0100 on 20th a storm at Fowey, Cornwall, was accompanied by a considerable fall of 10-12mm diameter hailstones. Mothball-size hailstones were also reported at Lough Navar Forest, Co. Fermanagh, Northern Ireland.

Acknowledgements. The TORRO directors would like to thank all observers of The Tornado and Storm Research Organisation, Thunderstorm Census Organisation, and Climatological Observers Link whose invaluable reports have been the foundation of this summary; valuable information has also been reported in the Daily Weather Summary of the Meteorological Office. Finally, once again many thanks are due to members of the general public who responded very helpfully to inquiries into the more severe storms.

CORRECTIONS to paper by J. D. C. Webb on the "cold spell of January 1987": page 231, line 7: "over 75cm snow" read "over 25cm snow"; page 233, line 20, for "February 1966" read "February 1986".

WEATHER AND BUTTERFLIES IN AVON COUNTY, 1987

By A. H. WEEKS 13 Stowey Park, Yatton, Bristol, Avon

If 1987 provided far from ideal weather for lepidopterists in Avon, it was not an absolute disaster for the insects themselves – indeed, it was a good deal better than its two predecessors. As has already been reported widely, summer rainfall was much lower in the West Country than in the eastern half of England, but there was a shortfall in sunshine, especially in June, making it a no-more-than average summer. However, that followed a more equable spring than in recent years, so that overall, the weather in the butterfly season was more favourable than in the

corresponding periods in 1986 and 1985.

The winter here was severe for a very short period. There were some low temperatures in January, notably from 8th to 19th, with a succession of four days (11th to 14th) with maxima below zero (-5°C on 12th). Snow fell overnight 13th/14th but cover was only 2-3cm, increased to 7cm on 15th, but it had all gone by 19th. February was slightly warmer than average, although there was a frosty period in mid-month with just a dusting of snow on 17th. The winter overall was a little cooler and drier than average (see Table). In contrast to the two preceding years, fieldfares and redwings were few in number and there was no famine, and so

Table 1.

17.14	M	onthly Difference	Seasonal Differences						
and it min it	Max. Temp.	% Rainfall	Approx. % Sun	Max. Temp.	% Rainfall				
December 86 January 87 February	+1.9 -3.5 -0.3	143 23 91	110 100 90	Winter -0.4	88				
March April May	-1.7 +3.0 -0.2	114 100 50	90 100 105	Spring +0.4	87				
June July August	-1.3 -0.6 +0.6	98 87 37	80 95 112	Summer -0.5	63				
September October	-0.1 -0.3	76 190	97 100	Autumn +0.2	122				

* Differences between Yatton and Long Ashton Research Station long-term averages

no widespread mortality amongst these birds. No great effort was required on our part to keep residents and visitors well supplied with calories – a task which we continued until late March.

Spring started inauspiciously. March produced some hard night frosts near midmonth and overall it was colder, slightly wetter and duller than average. Yet it produced the first (and biggest) surprise of the year. This is the month when I eagerly await the day having the magic combinaton of a screen temperature in the mid-50's F (near 15°C), and a black-bulb-in-vacuo reading of about 80°F (say 25 to 30°C) - the conditions which, with only a light breeze, might rouse a hibernating butterfly into its first flight. Although the black bulb maximum had reached 30°C as early as 28th February and exceeded 26.5°C on a number of following days, the screen tempertaure was below 10°C by persistently chilly breezes. Imagine my surprise, then, to receive a letter on 11th March, reporting the sighting on 10th by a fellow weather-watcher, of a Painted Lady near Chard in Somerset. Normally, one would doubt the accuracy of such a report, but the letter was unequivocal: "It settled for some time, sunning itself on a stone, making the most of the radiant heat, and we had the opportunity to identify it without doubt". Given the general weather conditions up to then, it is inconceivable that this specimen could have flown up recently from North Africa: it must have been an individual from the 1986 migration which had found a suitable spot for hibernation and, on that day, found the sunlight irresistible. However, that was in Somerset, 36 miles to the south-south-west. Here in Yatton, with maxima of 7.3°C (screen), and 26.5°C (black bulb), nothing stirred to my knowledge. Except for a single Small Tortoiseshell, disturbed in the course of exterior house-cleaning on 30th, I made no observation of a butterfly in the month.

April was quite warm, otherwise average, with most of the rain falling in the first ten days. Because the May rainfall occurred mostly in mid-month (except for 1st), there was a nearly-dry spell from 11th April to 10th May, beneficial to the species then at the larval stage. April 5th was the first day on which butterflies burst into activity (temperatures 14.4°C/37°C) with three of the four common hibernators taking to the wing, viz. Small Tortoiseshell, Peacock and Brimstone. A week elapsed before the fourth, the Comma, was seen. Soon afterwards, Small

Tortoiseshells disappeared (their progeny appearing in late June), but Peacocks and Brimstones flew frequently during the rest of the month. Other spring species emerged in rapid succession, so that by the end of the month, I had recorded eleven species: as well as the four already named, there were (in chronological order) Small White, Orange Tip, Green-veined White, Large White, Speckled Wood, Grizzled Skipper and Green Hairstreak. In the case of the last-named, this was the first April sighting since 1984. A week later, the Dingy Skipper was added to the list. May 6th was a beautiful day and the early flowering of yellow rockrose and bird's-foot trefoil induced dreams of plentiful Brown Argus and Common Blue to come – dreams which were only partially realised. Adders were about on that day too. Alas – this early fine spell did not last: cloudy and cool weather restricted spotting excursions to only two other days in the rest of the month, during which I saw my earliest-ever Large Skipper, before altostratus covered and a deluge set in.

Summer, too, started poorly. In the days before going off on holiday in June, the highest maximum reached was 19.2°C on 4th, but with a field meeting already fixed for the 6th, I did not go out on 4th. Needless to say, the 6th was marred by heavy showers and blustery winds! In the six days after return from holiday, things were rather better, with a run of five warm ones (26th to 30th) with reasonable maxima, the highest being 27.1°C on 29th, but, except for 29th, none of these was sufficiently sunny to justify a visit far afield. Unfortunately, other duties intervened on 29th. So, in the whole of June, I took a single and less-thansuccessful walk, setting an all-time low record. July started in more kindly fashion, the first half producing some high temperatures (29.3°C on 5th, 27.5°C on 6th, 24.5°C on 7th, 25.7°C on 10th and 25.6°C on 13th). A compromise between essential gardening and pleasure enabled me to go recording on five days in this period. On 1st, I was grateful for the sight of Graylings, out early. On nearly every walk, there were good numbers of the Small Heath and even better of that graceful flier, the Marbled White. In mid-month, some wet days intervened and it was not until 25th that the next opportunity arose for resuming observations outside the garden. August was the most favourable month of all and yielded the highest number of species sighted on any one day - 16 on 1st, 13 on 5th, 15 on 10th, 13 on 16th and 17 on 20th: however, none of these is high compared with the 20, 22 and 23 on the corresponding walks taken in July 1982 and 18, 19, 20 in July-August

A feature of the summer was how dry the countryside became. The total of rain days was 31, but on the whole, amounts were small and did not penetrate the soil. A misfortune over the three months, as far as I was concerned, was a number of less-than accurate official weather forecasts. There were just-passable days on which excursions were possible, but with forecasts offering "better tomorrow", I delayed, only to find on the morrow that the weather had in fact deteriorated. (Unfortunately I cannot now substantiate this allegation because I did not keep a note of the dates). As a result of all the factors mentioned above, the number of days spent in the countryside was little more than half of 1986's.

The reader may well ask how, in these circumstances, I was able to assess the butterfly season with any degree of accuracy. The answer lies in my garden. I consider myself fortunate in its location, for it is surrounded by different types of habitat from which butterflies wander from time to time, and of course I have

planted suitable inducements for them to visit me. To the west, north and east are open, damp fields, whence come my Orange Tips and Green-veined Whites in Spring. An old overgrown lane runs close by and this supplies my Speckled Woods, Skippers and Commas. As the crow flies, there are rough grassland and woodlands within half a mile to the south-east and south, the sources of Brimstones, Peacocks, the occasional Holly Blue, Common Blue, Brown Argus, Small Copper and Silverwashed Fritillary. It is less than a mile to a disused railway course, where Skippers and Marbled Whites abound. Thus, I use my garden both as a sort of butterfly barometer and as a calendar to tell me when I should visit more distant and more rewarding sites. The total of visiting species in 1987 was 16 (against 17 in 1986 and the peak of 20 in 1984), while the total seen by me in all locations this year was 33 species.

This brings me to how the various species fared in 1987. Most populations were still rather low, probably a consequence of poor conditions for mating in 1986. As mentioned above, the spring emergence was good in April and May, particularly in the cases of the Orange Tip and the three whites. The disappointment was the continued scarcity of the Holly Blue; reports of this butterfly were few and far between. The three common vanessas - Small Tortoiseshell, Peacock and Comma - were not numerous in spring, but breeding conditions were good and the summer brought forth large numbers of the first-named which flew on into October. Peacocks were not so prolific and the summer brood had mostly retired into hibernation by the end of August. Commas were quite frequently on the scene from early July until the season's end. Of the "summer browns", only the Marbled White seemed to maintain its numbers, while Meadow Browns, Ringlets and Gatekeepers were, as usual, widespread but in lower concentrations even than in 1986 and with comparatively short seasons. The Wall Brown too was scarce in spring and summer, whereas Small Heath and Grayling seemed to be reasonably successful, and the Speckled Wood was numerous,, especially in late summer. All eight of these browns overwintered as caterpillars (the last also as chrysalises) and all are grass-feeders, so it is not easy to explain why some did better than others (except to look back again to the 1986 breeding season). Skippers were again poor, the Large being more numerous than the Small. The Green Hairstreak fared well in May, but the White Letter Hairstreak eluded me this year. The Common Blue staged a partial recovery in spring, better than its cousin, the Brown Argus; the Chalk Hill Blue did well again. The more common Fritillaries appeared on time and in near-normal numbers.

The immigrants fared differently too. The sight of a Painted Lady on a Cornish cliff-top in mid-June raised my hopes that this would be a good year, but on return home, I did not see one at all in the countryside, although I was pleased to see them in the garden in early August and again in the first week of October. Red Admirals arrived in late July and seem to have had very good results from their early matings, for they were present in the garden almost daily throughout August and September, and well into October, up to six at a time feeding on rotting fruit. I have not had a single report of a Clouded Yellow in the country this year.

The frequent and heavy rains which started early in October effectively put an end to activity. My last dates for various species in my garden were: August – Gatekeeper, 20th; Peacock, 23rd; Green-veined White, 27th; Comma Blue, 30th;

September – Speckled Wood, 20th; Brimstone, 21st; Large White, 23rd; Small Copper, 25th; October – Small White, Painted Lady, 6th; Comma and Silver Y (moth), 11th; Small Tortoiseshell, Red Admiral, 19th. 1987 is the first year since 1984 when I have not seen a live butterfly in November.



It is not difficult to name a "butterfly of the year". Last year I named the Comma for its regular appearances from mid-July to November. By the same token, the title in 1987 must go to the Red Admiral (late July to mid October) (Fig.1), but the Marbled White must be a close runner-up, because of its splendid performance in July.

Of those other forms of wildlife which tell me how the seasons have passed, I will just mention the common summer-visiting birds. We first heard the Cuckoo in Yatton on 22nd April, and the first House Martins were seen here on the following day. Swifts circled

overhead on 29th and by 9th May, they were very active, as were Swallows. Our Martins inspected the nest on 10th May but it was a week before they finally settled in. Their first brood hatched on 1st July and flew on 26th: their second brood on 18th August and 13th September respectively. By then, the Swifts had long gone (by 12th August) – a fact commented on by one of the TV forecasters – and Swallows had exhibited their inner urge to go. Over 30 perched on overhead wires on 17th August and 40-odd on 29th. There was a great overhead gathering of Martins on 25th, but it was not until 6th October that we were sure that all had gone from our nest. Four Swallows lined up as late as 25th September and a solitary bird was present here on 16th and 17th October, presumably having been blown off course by the recent great gale. None of these dates is exceptional.

So ended another season of nature and weather-watching, which was better than it could have been, if not as good as hoped. It contained two other memorable moments. The first, in April, stemmed from my preference to do my walking solo, and therefore quietly. I had been standing for a few minutes scrutinising the tree canopy for movement of any kind when I became aware, out of the corner of my eye, of movement at ground level. I was in the company of a fox, not 15 yards from me, going about his business leisurely and silently, and totally unconcerned at my presence. The second, at the same spot, came in August. A Purple Hairstreak allowed me to pick it up and place it in the palm of my hand for close inspection. Some butterflies do over-imbibe and become sozzled. This individual was replaced as gently as I had lifted it. Perhaps there is some magic in the air just there – the name of the place is Goblin Combe!

WORLD WEATHER DISASTERS: July 1987

1-20: Continuing storms and floods in areas of China, details below:

3rd: Tornado in Hulan county, Heilongjiamg province left one dead, 81 injured, the tornado, moving at 40 metres per second, cut a swath 29km long,

lifting roofs and uprooting trees and electricity poles; more than 640 buildings damaged, leaving some 2,820 families homeless.

5th: Floods after heavy rains in Anhui province, from the 1st left several people dead, collapsed homes and flooded at least 246,000 hectares of farmland, from the 1st to the 5th over 100mm of rain fell on 42 counties in province, six counties between the Yangtze and Huaihe rivers received more than 150mm of rain in a 24-hour period ending on the 6th.

7th reported: Flash floods along the Lean River, Jiangxi province, left 42 dead. 15th reported: Heavy rains, which began about two weeks earlier in the Hubei province, in south-east of country, caused widespread flooding which left 42 dead and damaged 33,600 homes; up to 400mm of rain reported to have fell on seven of the worst hit counties in the south-eastern part of province; the floods inundated 5,000 square kilometres of farmland and washed away 518 bridges.

21st reported: Floods, caused by heavy rains and melting snow, in Xinjiang province flooded 11,000 homes and left two people dead, 2,000 of homes flooded washed away. The two deaths brought to at least 554 the number of people killed by storms and floods in 10 Chinese provinces since May. Lloyds

1: Thunderstorms caused floods and landslides in central Switzerland, leaving two dead. International Herald Tribune.

3-13: Monsoon floods in Assam state, India, affected more than three million people, over 80 people died in the floods and boating accidents, along with 1.300 cattle, L.L.

4-31: Monsoon rains and floods in many areas of Bangladesh, on the 6th it was reported that one million people affected in the Sylhet and Sunamgand districts in north-east of country, by end of month death toll put at 75. Daily Telegraph, Birmingham Evening Mail.

5: Five people were burned to death trying to put out a cornfield fire apparently

started by lightning in north-east Portugal. B.E.M.

7 (reported): Heavy rain and floods in north-central Ohio, U.S.A., towns of Shelby and Bellville; in Richland county worst hit; in Shelby nine homes destroyed and 124 others damaged, along with 44 businesses; in Bellville, 12 houses and 17 businesses destroyed and 68 homes and 17 businesses damaged; five counties hit by floods, which caused damage estimated at \$36,000,000, floods still continuing on the 7th. L.L.

8: M.v. Ava Minti sank in storm in the Arabian Sea, at Devargh, 12 nautical miles from Ratnagin, south-west India, leaving three dead, 16 others missing. L.L.

9: M.ferries Cape Henlopen and North Star collided in fog off the north fork of

Long Island, U.S.A. at 0923, injuring about 20 people. L.L.

9: Express train derailed on flooded tracks near Mancherial, Andhra Pradesh, India, 14 coaches of train derailed, two of them falling into the Ganderagad River, at least 53 dead, 15 injured and 20 others reported missing. The train derailed after heavy rains washed away an embankment under the tracks. L.L.

10-24: Heavy rains and floods in central Chile, floods affected an area stretching from 130km north to 260km south of Santiago; on the 14th the government meteorological office reported that a record breaking 89mm of rain fell in a 32

hour period, presumably in Santiago, River Mapocho caused flooding in Santiago, widespread damage in areas affected by flooding; by the 18th 11 deaths, with 13 missing, reported, more than 90,000 homeless. On the 23rd eight miners drowned when flooded river broke into mine near Coronal, southern Chile; on the 24th M.bulk carrier Alborada sank in storm with 80 km/h winds 2.7km north-west of Hualpen, near San Vicente, leaving 18 dead and 12 missing, in addition the death toll from floods and accidents on roads and in mines due to rains rose to at least 44. L.L.

11: Passenger train derailed when it hit a stretch of washed out track near Jaen, Spain, one coach overturned, 23 people injured, track washed out by rain-

swollen stream. L.L.

11-16: Typhoon "Thelma" hit the Philippines, Japan and South Korea, details below:

Philippines: "Thelma" did not hit islands directly but winds sank a ferry on the 11th off Negros island leaving eight dead, on the 12th fishing vessel capsized in flooded San Jose River in village of Namoolan, Pangasinan province, north of Manila, leaving four dead.

Japan: Heavy downpours hit Japan on the 15th and 17th, on the 15th three deaths reported, with two others missing and at least three injured, about 1,000 houses flooded, floods and landslides on the 17th left two dead in landslide in Kagoshima, where some 200mm of rain fell in two days.

South Krorea: Hit on 15th and 16th by 130 km/h winds and heavy rains, which caused widespread flooding and mudslides, at least 118 dead with a further 214 missing, many of whom were fishermen or seamen whose vessels sank in the storm, worst hit were southern and south-eastern part of country, 8,753 houses and buildings damaged, 3,879 craft sunk or damaged, damage put at \$222,000,000. Rainfall during typhoon ranged to 274.3mm in Kangnung, 170km east of Seoul; typhoon degenerated into a tropical storm at 0500 hours on the 16th, at least 53,000 hectares of farmland flooded. On the 18th and 19th heavy rains unconnected with "Thelma" hit Cheju Island, off southern coast, leaving hundreds of families homeless. L.L., I.H.T.

12: Heavy seas hit coastal areas of Mindanao Island, Philippines, leaving one dead and 3,500 homeless, in General Santos 20 homes destroyed and three bridges destroyed in nearby Glan and Malapatan, in Davao, 110km to the north-east 128 homes destroyed, with another 27 damaged, altogether over 500 coastal

shanties destroyed. L.L., Jakarta Post.

14: Violent thunderstorm in Montreal, Canada, 104mm of rain fell in a 5-hour period, thousands of homes and businesses flooded, at least one death reported, floods up to 4.5 metres deep. Lightning hit transformers and trees fell on power lines leaving more than 350,000 homes without electricty. L.L.

14: Storm touched off flash flood along River Borne at Le Grand Bornand, near Annecy, in French Alps, leaving 22 dead and possibly others missing, a wave of water, mud and rock 46 metres wide and 1.5 metres deep swept through a camp site, sweeping away tents, caravans and cars. L.L., D.T.

17: A bus and van carrying 43 people from camp site swept away by flooded Guadalupe River at Comfort, central Texas, U.S.A., leaving three dead and six missing, floods along Guadalupe River described as worst in 55 years. B.E.M., Sunday Express.

18: Small ship capsized in storm between Talise Idland and Biaro Island, north Sulawesi, Indonesia, leaving two dead, two missing. J.P.

18-28: Heatwave across much of southern Europe, details below:

Italy: Heat lasted from 23rd to the 27th at least, some 50 deaths reported in south of country, where temperatures up to 40°C recorded, dozens of forest fires reported.

Yugoslavia: Heatwave lasted till the 23rd at least, again with temperatures up to 40°C, at least six deaths reported, worst of heat in eastern areas of country.

Greece: Hit from 18th to the 28th, this country being the worst hit, temperatures up to 45°C reported, Athens reporting temperatures of 40°C for several days, some 1,000 deaths reported.

Albania: Heatwave has caused water shortages.

Bulgaria: Temperatures up to 43°C reported during the heatwave, some 200 deaths reported.

Turkey: Between 20th and 26th temperatures in south-east of country up to 50°C, forest fires reported.

18-31: Storms, heavy rains, floods and landslides in Austria, Switzerland and Italy:

Austria: Storms hit on the 18th and 19th and the south-west of country was worst hit, the Gschnitz Stream, in Tirol province, carried away all bridges between the town of Gschnitz and the Laporuis Alpine pasture in Vorarlberg province 60 people evacuated when a dam broke, road blocked and camp sites evacuated in the flooded area.

Switzerland: Hit on the 18th and 19th with storms, rain and mudslides in the southern and eastern areas of country, hundreds of villages cut off, road and rail links cut, bridges and homes swept away and several hundred people evacuated; by the 28th water level on River Rhine had risen sufficiently to

cause disruption to shipping.

Italy: Hit by violent storms on the 18th and 19th, in the Lombardy region, Alpine town of Tartano, 90km north of Milano, floods and mudslides destroyed a hotel and a number of houses, leaving 12 dead, floods also in Trentino and Alto Adige provinces, about 60 towns and villages damaged by the floods and landslides, in the area around Bergamo, north of Milano, floods and landslides swept away several roads and bridges, the Brembo River, which passes Bergamo, had overflowed its banks for a stretch extending 25km. The Adda River swept through town of Sant' Antonio Morignone, and 8km of road washed away near town and leaving behind a natural dam of mud and debris some 15 metres thick, floods in the area affected left 16 dead, 189 injured and damage put at \$800,000,000. On the 28th a landslide about 2km wide and 70 metres deep buried villages of Sant' Antonio Morignone, Ponte del Diavolo and other hamlets along the Adda River in the Valtollina Valley, leaving one dead, 27 others missing and blocking Adda River by a natural dam. On the 31st a storm hit Genoa leaving one dead. L.L., I.H.T.

18 (reported): Forest and range fires in southern Oregon and northern California, Washington, Arizona, Idaho, Montanam Utah, Nevada and Alaska,

U.S.A., over 100,000 acres burned, at least 32 homes destroyed and three direct or indirect deaths reported, two loggers burned to death on the 15th in southern Oregon, this fire burned eight houses. A fire in eastern Washington destroyed 24 homes and damaged 20 others, rains on the 17th helped to dampen fires, which had been burning for at least a week. Fifty thousand acres burned in four large fires in remote areas of Alaska east and north of Fairbanks. L.L.

21: Storm in Utah state, U.S.A. caused insured property damage of £10,000,000.

L.L.

21-24: Typhoon "Vernon" hit Taiwan and South Korea:

Taiwan: Hit on 21st with high winds and heavy rains, two deaths reported,

with a third missing, no major damage.

South Korea: Hit on 21st and 22nd, mainly by heavy rains as typhoon had lost strength by this time; the storm left 136 dead, 22 missing and 36,000 homeless; damage put at 160 billion Won; central parts of country worst hit, a record 622mm of rain fell in the Sochon area (177km south of Seoul); heaviest since records began in 1907; over 80,000 hectares of farmland flooded, nearly 9,000 houses and buildings either flooded or damaged; on the 22nd a nine-coach train derailed by flood-damaged track near Chockiwon, 120km south of Seoul, injuring over 100 people. Worst of floods in Chungchongnamdo province, rail and road links cut. L.L.

22: Vessel capsized in storms to north-west of Singapore, leaving 13 missing, 14

others rescued. J.P.

23-24: Storm in Minnesota and Wisconsin states, U.S.A., caused insured property losses of \$58,000,000, of which \$55,000,000 was in Minnesota,

damage being heaviest in Minneapolis-St. Paul area. L.L.

24-27: Torrential rains and flash floods in areas of Iran, especially in and around Tehran, leaving at least 370 dead, 180 in Tehran on the 26th, when flood came down the Gulabdarrah Valley and into the northern suburb of Shemiran; a further 450 people were injured, 330 houses, 155 shops and 400 cars damaged in flood; on the 24th flood hit village of Bujan, near Neishabur, about 800km east of Tehran, leaving at least 138 dead, floods also reported in Mashad, where 23 died, Saveh, 10 dead, Bakhtaran, Ahwaz and Yazd. L.L., D.T.

25-26: Hurricane "Eugene" hit western Mexico with winds up to 177 km/h and heavy rains, leaving three dead, 18 injured and 5,000 homeless, heavy crop damage reported from coastal states of Colima and Michoacan, damage put at \$142,000,000, resort city of Manzanillo worst hit by "Eugene", floods and

landslides cut roads in the two states. L.L.

25-26: Gales and heavy rains in Hungary after a heatwave, gales uprooted trees, blew off roofs, brought down telephone lines and devastated crops. D.T.

26: Storm in state of New Jersey, U.S.A., caused insured property losses of

£,10,000,000. L.L.

26: Gales and hailstorms in northern and eastern Yugoslavia; widespread crop damage, gales blew roofs off houses and factories, uprooted trees and blocked roads, 10,000 hectares of farmland destroyed in province Vojvodina in the worst recorded storm in Yugoslavia for 17 years, serious damage to crops and homes also reported in Slovenija and northern Croatia, one person killed by lightning. L.L., I.H.T.

26-28: Rainstorm in South Korea caused widespread floods and landslides, up to 356mm of rain reported in Inchon and 309mm in Seoul, at least 74 deaths deaths reported, many homes flooded, transportation disrupted. The three storms that have hit this month in South Korea have left 333 dead, 245 missing and damage of at least 420 billion Won. L.L.

26-28: Typhoon "Alex" hit Taiwan and China, details below:

Taiwan: Hit on 26th and 27th with winds of 125 km/h and heavy rains, rains caused landslides on mountain roads around eastern city of Yilan on evening

of 26th, three fishing vessels sank.

China: Coastal provinces of Zhejiang and Jiangsu hit on the 27th and 28th, with winds of 160 km/h and heavy rains, destroying homes, vessels and bridges; storm hit Zhejiang at about 2200 hours on the 27th and hit area for 14 hours, storm then moved towards Shanghai, cities of Wenzhou and Jiaxing worst hit, up to 280mm of rain fell in thse two cities. Two hundred fishing vessels sank and 22 bridges destroyed. On the 28th a tornado hit suburbs of Shanghai, leaving one dead, 32 injured and 400 homes destroyed or damaged. About 1900 sq/km of farmland flooded, 69 deaths reported including the one in Shanghai. L.L.

28 (reported): Storms in Uzbeck, S.S.R., caused extensive damage to crops and houses, 5,000 homes damaged by mudslides, crops damaged by 20 minute hailstorm. In Tajikistan S.S.R., mudslides following torrential rains left five dead, buildings, farms and roads swept away, icy winds, followed in quick succession by duststorms and driving rain hit region, a week earlier a similar disaster hit the highlands around Leningrad destroying 32 villages, 10 bridges and sweeping away hundreds of kilometres of roads. I.H.T., Soviet Weekly.

29-30: M.tank Pulau Gajah sank in storm between 2300 July 29 and 0100 July 30 about 50 nautical miles east-north-east of Bitung, north Sulawesi, Indonesia,

leaving 12 missing. L.L.

29-2 August: Brush and forest fire in Woodfords area, California, U.S.A., destroyed 6,550 acres along with 26 homes, numerous barns, sheds and outbuildings, power and telephone lines brought down, damage put at up to \$4,000,000. L.L.

31: Thunderstorm and tornadoes hit Edmonton, Alberta, Canada, leaving 26 dead and 300 others injured, damage estimates ran as high as \$75,000,000. A caravan park in the north-east of Edmonton badly hit, with 200 caravans destroyed, with 15 dead; another 11 died at an industrial park in the south-east of city where 10 warehouses destroyed, two trains derailed and dozens of trucks and cars overturned. As many as five tornadoes moved into city during thunderstorm that produced fist-sized hailstones; storm hit in early evening, one tornado was 275 metres wide. L.L.

31: Tornado hit counties of Hailun, Baiquan and Nehe in Heilongjiang province, China, leaving 16 dead, 13 missing and 442 injured, more than 1,800 homes destroyed and about 43km of power and telephones brought down. The tornado, accompanied by heavy rain, hit between 1500 hrs and 1700 hrs. L.L.

31 (reported): Storm touched off flash flood in Port-au-Prince, Haiti, leaving at least seven dead. D.T.

ALBERT J. THOMAS

LETTER TO THE EDITOR

THE "HURRICANE" OF 16 OCTOBER 1987 IN SEVENOAKS (KENT) AND DISTRICT

Just before midnight on Thursday, I looked out at the weather: it was still raining heavily, but the S.W. wind seemed to have dropped a little from an hour or two earlier, and the barograph stood at 978mb having risen slightly in the previous two hours. It seemed that the worst of the first real gale of autumn was over. Some 3½ hours later, I was woken by a roar of wind and general noise that made me wonder if World War 3 had started, and the flashes of "lightning" puzzled me because I could hear no thunder; it was only at daylight that I realised that it was felled power cables that were responsible. I had no anemometer, but feel sure that gusts of hurricane force did occur. Pressure dropped to 970mb my lowest in 15 years.

Dawn revealed a scene of widespread devastation; trees had fallen like ninepins, roads and railways alike were blocked, but, somehow, my wife and I were able to get, by car to Orpington, zig-zagging round numerous trees that had fallen on Polhill, the North Downs south-facing scarp slope.

Sevenoaks caught the nation's imagination because six of seven oaks that border the historic Vine cricket ground had come down; in fact, those oaks are not that old, having been planted in 1902 to celebrate the coronation of Edward VII, but Knole Park, on the outskirts of the town, had lost many trees, although the casualties did not always seem to have occurred in the most exposed places. Chartwell, the former home of Sir Winston Churchill, and now one of the National Trust's most popular houses, has lost 80% of the marvellous mature trees in the grounds. The A25 Sevenoaks-Maidstone road in places went through what looked like a battleground after heavy bombing. So extensive was the damage to power lines, that it was not until 15 days later, on Saturday 31st October, that power was finally restored to the hamlet of Bough Beech, some 10 miles from Sevenoaks.

Money is pouring in for the replanting of trees, and a ceremony at which six new semi-mature oaks are to be planted around the Vine is due to take place in early December. For much of the area, however, the scars left by arguably the most significant weather event of the century, will be a reminder of what

happened for generations to come.

One intriguing possibility is that tornadoes occurred, for some of the trees were snapped off rather than uprooted in a way which would be consistent with a tornado.

15 Knole Road, Sevenoaks, Kent.

Peter R. ROGERS

STORM HAVOC COST £,500M

The storm which swept across south-east England and East Anglia, and the floods which followed it, caused £500m of damage to property, according to a report from the Association of British Insurers. This figure is still provisional, said chief executive Michael Jones, but it is "based on more reliable

This figure is still provisional, said chief executive Michael Jones, but it is "based on more reliable data than previous speculative figures" which were mostly far too high. But he pointed out that this figure was only for *insured* damage and excluded motor insurance claims, which could add another £20m to £25m. Mr. Jones said companies were receiving claims at the rate of more than 50,000 a day but they were being rapidly processed by extra staff in offices open at weekends.

TORRO TORNADO DIVISION REPORT: May 1987

May 1987 was a cool and rather unsettled month, though rainfall totals in most areas were below normal. One tornado, one pair of funnel clouds and one land devil were reported for the month.

FC1987May4. Dublin, County Dublin, Eire

Terence Meaden saw two funnel clouds above south Dublin, close to the Wicklow Mountains, at 1422 GMT (1522 Irish local time). The funnel clouds appeared as two pointed projections beneath the edge of a dark cloud of

stratocumulus type. The cloud had given some spots of fine drizzle as it passed overhead; it appeared to mark a microfront in a cool airmass behind a nominal warm front which had crossed Dublin some hours earlier. A strong anticyclone (1043mb at 1200) lay to the south-west of Ireland; the 500mb chart was similar. There were sunny periods after the passage of the warm front, but from about 1200 GMT cumulus had increased and became 7/8 stratocumulus, with the cloud base descending noticeably. The funnel clouds lasted about one minute before withdrawing into the cloud base. An airline pilot told Dr. Meaden that the area north of Wicklow Mountains is very susceptible to "air turbulence and gustiness" because of the hills. Dr. Meaden concluded that the funnel clouds may have been related to the descent of air from a cold pool aloft, giving a kind of bath-tub effect, and may have been similar to the funnel cloud outbreak in southern England on 15th May 1978.

LD1987May7. Mount Russell, near Ardpatrick, County Limerick, Eire.

Mr. David Meskill saw a land devil moving from south-east to north-west across a broad sloping field. It lifted two empty fertiliser bags about 50-60 feet (15-18 metres) into the air. The time was 1504 GMT. The weather was fine and sunny with light, variable winds; temperature was about 18°C. Ireland was under the influence of the anticyclone mentioned in the previous entry, which had now moved to be centred near the Wash, 1033mb, at 1200. At 500mb the high was centred near the Scilly Isles.

TN1987May12. Yetholm Mains, Borders (NT 8329).

The first known tornado of 1987 uprooted a tree and took the top off another, including branches nine inches (23cm) in diameter which "seemed to have been lifted right off the top of the tree and deposited some distance away leaving the lower part of the tree undamaged". The force T2 tornado occurred at about 1800 GMT and was preceded by thunder and then heavy hail. The noise of the tornado, which also caused minor damage to roofs, was "a loud roar and almost a bang". The known track was about half a mile (one kilometre) long and 200 metres wide; direction of movement was from north to south (letters from Mr. F. S. Roberton).

A cold, northerly airstream covered the whole country at 1800. A depression was centred over Denmark, 990mb; at 500mb the low was off S.W. Norway. Showers, some of them of hail, were widespread; a thunderstorm was reported in southern Scotland not long before the tornado occurred.

WW1987May. Bere Ferrers, Devon (SX 4563).

This unusual whirlwind was reported by Mr. L. Brown. "Cloud cover was thin with intermittent sunshine and a light breeze, cloud direction south to north, quite high, when a large vortex of thick black cloud appeared, I would guess about 20 miles away to the south; this would put it out to sea in the Channel". This distance is certainly too great. "It passed rapidly in an east-west direction, i.e. across the path of general cloud, horizon to horizon, in about two minutes, leaving normal clouds as though thay had been hoovered". In a second letter Mr. Brown added: "With reference to the 'vortex', I use this term as I know of no other . . . I cannot say about the top of the vortex as it protruded through the 'normal' cloud cover; we certainly did not have any rain. The cloud was rotating . . . By the time it had

reached the western horizon it was considerably reduced in size. By 'hoovering' I mean that the vortex seemed to sweep the sky clear of any 'normal' clouds which were in its path. The 'gap' did not close up until it was almost overhead". Mr. Brown sent a sketch of the whirlwind made about two days after the event.

Additions to previous reports

FC1987April29. Abbots Langley, Hertfordshire (TL 0901).

Two funnel clouds were reported 3km west of Junction 6 on the M1 (i.e. over or near Abbots Langley); one at 1015 GMT, moving from west to east; the other nearby at 1030, descending to about 300 metres and lasting about five minutes before dissipating (Daily Weather Summary; Monthly Weather Report). A cold front crossed the area at about the time of the funnel clouds. There was a complex, shallow low to the west of Ireland; at 500mb a low lay just to the south of Ireland. The day was very warm and fairly sunny, but thunderstorms were widespread.

FC1986August19/III. Woody Bay, Devon (SS 6749).

A well-developed funnel cloud was seen over the Bristol Channel in mid morning by Mr. John Dunford. The funnel did not reach the sea surface, and disintegrated after a few minutes. The weather was showery, but there was no thunder.

FC1986August20. Ilfracombe, Devon (SS 5147).

Mr. Dunford saw another funnel cloud the next day, again in mid morning. The funnel cloud did not appear to reach the sea surface, although it was well developed. The weather was more stable than on the previous day, with some cumulus but few if any showers. A ridge covered the whole of Britain; at 500mb there was a north-westerly flow.

M. W. ROWE and G. T. MEADEN

TORRO THUNDERSTORM REPORT: May 1987

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

In almost total contrast to April when thunderstorms developed in warm airflows of tropical origin, much of May's activity was the result of solar heating in airstreams from polar regions. As in April there were fewer than normal thunderdays in all countries of the British Isles, but particularly so in Scotland, Wales and Ireland being closest to a persistent area of high pressure to the west of Britain. With winds often blowing from the north-west or north thunderstorms developed most readily in areas of greatest insolation, and with the counties of Greater London, Surrey and Kent having a general figure of three to five days, which represents some 200 to 300 percent of the normal, it may be safely assumed that the 'heat island' effect of the metropolis must have played some part in the development of thunderstorms in these areas. Further north and west, but to the south-east of a line from Bristol to the Wash, thunder-day totals compared more favourably with the normal, being in the region of one to three days, but elsewhere

Thunder-days in May 1987 were as follows: (Averages refer to the period 1951-1980)

May 1987	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Ave.
England	Г	X	X							Г		X	x	X	X	x						X	X			X	X	X			х	13	16.9
Wales		X				7			14	;				-1	3											X	X					3	8.6
Scotland	X	2051										X		29																	X	3	9.1
Ireland																										X	X			X		3	8.0
Total	X	X	X									X	X	X	X	X						X	X			X	X	X		X	X	15	18.7
Netherlands		X	x										X	X	X		X	84			x	x							X	X		10	16.0
Belgium		3	X							X		X	X	X							X						X		X			8	

in the U.K. observers reported no more than a single day and many were

completely thunder-free.

A cold front moved south-east across Scotland in early hours of 1st and thunder was heard in the Edinburgh area. Hail and snow showers became more widespread and heavy in the evening and lightning was observed towards the western coasts and hills of Strathclyde. Northerly winds carried hail, sleet and snow showers southwards to many parts of England and Wales on 2nd. Thunder was heard in the Whitby area late in the morning, and during the afternoon thunderstorms developed over Tyne and Wear and moved south to reach south-east England by early evening. There was also a storm over north Wales and a thunderstorm tracked south-east from south Gloucestershire into north Wiltshire. Rain fell in a number of places. Wintry showers continued to develop widely over the country on 3rd and thunderstorms broke out over parts of southern England during the course of the late morning and afternoon. Storms were generally very brief but hail fell in substantial quantities in places. At Worcester Park (Surrey) the observer's lawn was covered with pea-sized hailstones for some 30 minutes and an apple tree in full bloom was stripped of petals. Although not accompanied by thunder, a vicious hailstorm was reported at Loughton (Essex). At Dover hailstones measured 12mm in diameter. Showers developed widely on 12th in a strong north-north-westerly flow and many were accompanied by thunder. One area of thunderstorms crossed south-eastern counties in the late morning and early afternoon, and another over southern Scotland moved south across north-west England into the west Midlands in the afternoon and evening. Heavy hail accompanied many of the storms. Among incidents of lightning strikes, houses at Needham Market (Suffolk) and at Chelmsford and Corringham (Essex) were badly damaged. At Chelmsford an observer witnessed the end wall of a house under constructon fall down, probably as a result of an extra gust of wind during a particularly windy day. At Warrington (Cheshire) a gas main exploded after lightning struck a tree and a number of buildings in the immediate area were structurally damaged, 25 residents were evacuated from their homes for several hours. Showers were much more scattered on 13th and thunder even more so, being restricted to the Norfolk coast in the very early hours and to Gatwick in the early evening. A depression moved south-east across England into the southern North Sea on 14th and thunderstorms followed an associated cold front across south-eastern counties of England in the late morning and afternoon. Again, hail fell in a number of places. With cold northerly winds blowing over the British Isles, showers of rain and hail developed over a wide area of England on 15th with

thunder in places, mainly in the south-east, but locally in the Midlands and north-west. A house was badly damaged by lightning in Surrey. During morning of 16th there was an isolated thundery shower in the Merseyside area.

Thunderstorms moved from east to west across southern counties of England on 22nd, virtually all parts of central-southern England from Eastbourne to Portland and northwards to the Thames Valley being affected. Some quite intense storms developed over west London, Berkshire and Hampshire in the late afternoon and early evening. In the Charminster area of Bournemouth lightning apparently 'cut dead' the engine of a taxi, after which the engine restarted normally. To the north of Bournemouth a 132,000 volt power line was struck, cutting off electricity supplies to around 30,000 customers for up to one-and-a-half hours. A house at Bransgrove was damaged by lightning and houses were also damaged at Hayling Island and Southampton. There was also thunder in south Cornwall in the evening of 22nd and further storms moved west to parts of Devon and Cornwall on 23rd. On 26th heavy rain and some thunderstorms affected the Channel Islands in the early morning, in association with a waving cold front over north-west France, and although storms died out for a time during the morning heavy rain moved north-east into south-west England in the afternoon with further storms breaking out in a number of places. By late evening thunderstorms had reached south Wales, south-east Eire and western parts of central-southern England, but thereafter quickly died out. Some quite active storms with almost 20mm of rain affected the north Devon and Somerset coasts while at Gurney Slade on the Mendips 36mm fell in little more than an hour accompanied by hailstones 10mm in diameter which damaged fruit trees and lay in patches until the following morning. There was thunder at Aldergrove in Northern Ireland during afternoon of 27th and in the Welsh Black Mountains, Herefordshire and around Gloucester showers were also accompanied by thunder. On 28th an isolated clap of thunder was heard during a heavy shower in east Norfolk. On 30th there were a few thundery showers in southern Eire and on 31st heavy showers and thunderstorms of a local nature affected eastern coasts of Scotland and the far north-east of England.

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

WEATHER SUMMARY: October 1987

October was a rather cold month with mean temperatures ranging from around 0.5 deg. C below the normal in southern and eastern areas of England to near one degree below in central regions and in the west and north. Temperatures were generally at their highest on 4th and 5th with 20.7°C at Northolt (London) and 16.0°C at Abbotsinch (Strathclyde) on 4th, and 21.6°C at Romsey (Hampshire) and 18.0°C in parts of south-west Scotland on the latter day. The 3rd was the warmest night with minima of 15.2°C at Exeter and 15.5°C at Plymouth. Lowest

maxima included 4.1°C at Tummel Bridge (Tayside) on 30th and 4.3°C at High Bradfield (South Yorkshire), 4.8°C at Inverdruie (Highland) and Glenlivet (Grampian), and 7.9°C at Boscome Down (Wiltshire), all on 10th. Away from the coast air frost became increasingly widespread later in the month. St. Harmon (Powys) reported the month's lowest temperature with -7.0°C on 24th and the same station recorded -5.1°C on 23rd and -5.5°C on 25th. In Scotland -5.5°C was recorded at Achnasheen (Highland) on 29th and -5.1°C at Inverdruie on 30th, while in England, -4.5°C was recorded at Kettering and -4.0°C at both Gurney Slade (Somerset) and Great Gaddesden (Hertfordshire) on 25th. Temperatures on the grass fell to -9.1°C at Glasgow on 11th and to -8.0°C at Shawbury (Salop) and -9.0°C at Velindre (Powys), both on 25th. October was a very wet month and apart from a few places in Scotland where rainfall failed to reach the normal totals exceeded 200 percent of the normal over much of England and Wales with more than three times over a wide area of south-east England. Two days, the 7th and 9th, were responsible for much of the excessive rain in the southeast. On 7th the Channel Islands and coastal regions from the Isle of Wight to Kent recorded in excess of 40mm, with 52.6mm at Shanklin (Wight) and 50.9mm at Hastings (East Sussex), and on 9th similar totals were recorded over a much wider area which included the south-east Midlands. On this day 90.0mm fell at Totland Bay (Wight), 56.5mm at Guildford, 56.4mm at Epsom Downs and 53.1mm at Heathrow. Further afield, 69.5mm fell at Trawsfynydd (Gwynedd) on 16th, 67.8mm at Moylegrove (Dyfed) on 17th, 82.3mm at Trecastle (Powys) on 18th, 71.4mm at Carrigans (Co. Tyrone) on 21st and 60.4mm at Diabaig (Loch Toridon) on 25th. Snow fell at times over the highest mountains of Scotland and there was a snow cover throughout the month over the Cairngorm summits. Surprisingly, sunshine totals were above average over a wide area. Parts of centralnorthern England and East Anglia exceeded their normal by up to 30 percent while more than 150 percent of the average was recorded in western Scotland. Those parts of the country experiencing less than the normal sunshine included southern and eastern Scotland, northern England and much of the English Channel coast.

With an anticyclone over the Baltic the month started dry and quite warm in most places, but late on 2nd and through 3rd bursts of thundery rain spread into the south-west and pushed north across the country on 4th and 5th. Heavy rain or showers spread from the west to much of the U.K. on 6th introducing much cooler Atlantic air to all parts and heralding a change to more disturbed weather as active low-pressure systems repeatedly crossed the country during the course of the next fortnight. Rain was particularly heavy on 7th and 9th in south-eastern counties as active cold fronts lingered over these parts and rain was slow to clear eastern counties on 10th. The 11th was a much drier day, apart from well-scattered showers and thunderstorms, but showers and thunderstorms developed much more widely on 12th and 13th. Cyclonic developments to the south-west were responsible for appreciable falls of rain in many parts from 14th, as frontal systems moved north-east across the British Isles.

During evening of 15th a developing depression over Biscay deepened explosively as it tracked very quickly north into south Devon around midnight, thereafter crossing the Midlands before moving into the North Sea in the vicinity

of the Humber at around 0700 GMT. Minimum central pressure would seem to have been reached over Devon, probably in the region of 955mb, pressure thereafter rising with great rapidity, 23.9mb in three hours at Exeter (Devon) and 26mb in a similar period at Guernsey Airport. Winds reached storm force very widely to the south-east of the low's track, but particularly in the Channel Islands and in a band from the Isle of Wight across south-east England and East Anglia where gusts to 80 or 90 knots were relatively common-place. Much devastation was the result with considerable structural damage and many millions of trees uprooted. Electricity supplies were cut over a wide area and remained off for anything up to two weeks in some rural areas. It is believed that 19 people died as a result of the storm.

After a couple of showery days a cold front spread heavy rain into western and northern areas of the U.K. on 18th and there was further heavy rain from 19th to 21st in many parts of Britain as low pressure moved north up the Irish Sea and across western Scotland. A ridge of high pressure built north-castwards across the U.K. from 22nd to 24th, giving most parts a brief spell of dry weather, but with fog and frost at night. However, on 25th, rain spread into the far west and during 26th and 27th some rain on a cold front crossed to central and eastern parts of the country. A rise in pressure resulted in dry weather with sunshine on 28th and 29th but slow-moving frontal systems gave some rain in places on 30th and 31st, falls being locally heavy in the south.

K. O. M.

TEMPERATURE AND RAINFALL: OCTOBER 1987

19.3										
	Me	an			Grass					
	Max	Min	Max	Min	Min	Rain	%	Wettest	RD	Th
AUSTRIA: Innsbruck	16.9	7.3	22.9(6)	1.1(1)		30.8		13.1(17)	10	1
BELGIUM: Houwaart	16.5	5.5	21.9(4)	-1.5(23)	-4.2(23)	90.2	122	21.7(8)	16	2
DENMARK: Fanø	12.9	7.2	17.3(16)	2.8(24)		148.5	158	20.5(13)	17	1
" Frederikssund	13.0	6.4	18.5(16)	1.0(1)	-3.8(21)	17.0	33	6.4(16)	11	0
GERMANY: Berlin	13.6	6.1	21.1(6)	-1.2(31)	-2.4(31)	15.4	39	7.4(17)	10	0
" Hamburg	13.2	6.6	20.4(16)	1.2(31)	-0.9(26)	58.2	84	14.8(12)	14	0
" Frankfurt	14.3	6.5	20.6(6)	2.7(1,2)	-0.2(2)	61.3	125	8.1(13)	18	1
" Munchen	14.0	4.9	25.4(16)	-0.1(2)	-3.7(2)	24.0	41	12.2(17)	9	0
GREECE: Thessaloniki	19.3	12.7	25.1(15)	7.2(31)		85.8		38.4(19)	9	0
ITALY: Casalecchio	18.2	12.5	22.0(v)	8.0(v)	6.0(2)	138.1	168	77.0(11)	8	3
MALT: Luqa	26.8	19.9	31.1(24)	15.3(20)	10.8(20)	19.2		14.1(6)	4	3
NETH'L'DS: Ten Post	13.6	6.8	19.8(10)	2.8(23)	-0.3(23)	68.8	99	14.4(7)	13	1
" Schettens	13.5	7.3	19.2(10)	1.5(23)	0.2(23)	83.1	110	15.8(15)	15	3
" De Bilt	15.1	7.0	20.1(10)	1.5(23)	-0.4(23)	97.0	141	18.9(8)	14	1
" Lemmer	13.8	6.6	19.0(10)	1.7(23)	0.9(23)	100.3	136	19.5(9)	13	2
SWEDEN: Valla	10.8	4.6	14.6(7)	-1.5(3)		35.8		12.5(16)	11	0
SWITZ'LAND: Basel	16.2	8.2	22.3(10)	3.7(1)		75.3	123	23.8(11)	15	0
EIRE: Galway	12.4	6.4	17.0(4)	1.0(24)		119.7	94	12.8(12)	24	0
" Straide	11.7	4.3	15.0(1)	-3.8(24)	-8.6(24)	112.3	93	14.8(14)	26	1
SHET'AND: Whalsay	10.2	6.8	12.6(5)	2.0(10)	-1.8(31)	213.3	213	39.5(7)	23	1
" Fair Isle	10.3	7.5	12.8(5)	3.2(10)	-1.1()	152.7	142	30.0(7)	23	0
SCOT'AND: Braemar	9.1	2.1	13.8(5)	-4.2(24)	-5.1(24)	103.9	119	16.7(17)	19	1
" Inverdruie	10.0	1.6	15.2(1)	-5.1(30)	-8.7(30)	63.6	70	7.5(20)	23	0
" Rannoch	9.5	1.6	14.8(1)	-2.7(11)	-4.1(11)	122.0		21.0(17)	24	0
" Edinburgh	10.8	4.2	15.8(3)	-2.0(22)		218.2		39.3(17)	22	1
WALES: Pembroke	13.4	6.9	18.4(5)	-0.5(24)	-3.4(24)	235.1	210	37.8(14)	25	2

	Me	an			Grass					
	Max	Min	Max	Min	Min	Rain	%	Wettest	RD	Th
WALES: Velindre	12.7	5.2	18.1(5)	-4.1(25)	-9.0(25)	177.6	217	21.1(17)	23	2
" Gower	13.4	7.8	17.9(v)	2.9(24)	-2.9(24)	240.6	180	33.0(18)	26	4
ENGLAND:				, ,		TIGET R	7 101			
Denbury, Avon	13.6	7.7	16.6(4)	0.0(25)	-2.5(25)	203.7	183	22.8(28)	22	2
Gurney Slade, Somerset	13.0	5.1	19.2(4)	-4.0(25)	-4.7(25)	155.4	141	21.2(9)	23	1
Yatton, Avon	14.5	7.0	20.5(5)	-2.9(25)	-4.6(25)	179.8	190	18.7(9)	23	3
Bradford-o-Avon, Wilts	14.3	5.7	20.4(4)	-1.9(29)	()	129.5	190	27.0(9)	21	0
Corsham, Wilts	14.1	6.0	20.0(4)	-3.3(25)	-6.5(25)	139.6	199	29.4(9)	23	0
Mortimer, Bedfordshire	13.9	5.9	20.1(4)	-2.0(25)	-5.7(29)	161.4		34.1(9)	23	1
Reading Univ., Berks	14.3	6.5	19.7(4)	-1.7(25)	-4.7(25)	154.6	318	31.7(9)	22	0
Sandhurst, Berkshire	14.5	6.1	20.6(4)	-2.3(25)	-3.4(25)	178.9	273	44.2(9)	22	1
Romsey, Hampshire	14.8	5.9	21.6(5)	-2.0(25)	-3.0(29)	179.5	226	38.7(9)	23	0
Horsham, Sussex	14.7	7.1	20.0(4)	0.7(25)	-3.8(25)	216.0	300	39.2(7)	21	2
Brighton, Sussex	14.7	8.7	18.8(4)	3.8(11)	2.0(1)	241.7	242	49.0(7)	20	7
Hastings, Sussex	14.3	9.6	18.0(5)	4.3(11)	1.8(11)		349	50.9(7)	20	6
Dover, Kent	14.7	7.8	18.8(5)	1.2(25)	1.0(11)	210.1	243	44.8(7)	21	8
East Malling, Kent	15.1	6.8	19.5(4)	-0.5(25)	-2.9(25)	145.8	227	29.6(7)	18	4
Epsom Downs, Surrey	14.3	7.1	20.4(2)	-1.0(29)	-2.8(29)	213.5	233	56.4(9)	22	3
Reigate, Surrey	14.0	6.6	19.6(4)	-0.9(25)	2.0(2)	204.1	343	35.2(7,9)	22	3
Guildford, Surrey	14.0	7.3	20.6(4)	0.6(25)	-2.0(29)		297	56.5(9)	21	0
Sidcup, London	14.8	7.1	20.4(4)	-1.1(25)	-2.0(2)	142.1	271	26.9(15)	18	2
Hayes, London	14.4	6.4	20.2(4)	-0.9(25)	-2.8(25)	180.0	251	47.6(9)	19	2
Hampstead, London	14.3	7.7	20.2(4)	3.2(29)	-2.2(25)	177.1	300	48.8(9)	22	2
Royston, Hertfordshire	14.1	7.3	19.8(5)	1.1(29)	-4.8(29)	118.2	239	23.9(15)	18	0
Loughton, Essex	14.0	6.8	19.9(5)	-0.5(25)	-4.9(25)	141.7	240	35.6(9)	20	3
Pulham St.Mary, N'folk	14.5	7.0	19.0(5)	-1.5(25)	-3.5(25)	127.8	241	22.3(7)	17	4
Buxton, Norfolk	14.5	6.0	18.0(5)	-2.2(25)	-3.7(25)	134.2	249	33.1(9)	17	3
Ely, Cambridgeshire	14.1	5.2	19.4(5)	-2.5(29)	-3.5(29)	112.6	225	22.7(15)	17	1
Luton, Bedfordshire	15.8	6.3	19.3(5)	-2.8(25)	-3.1(25)	190.1	325	50.2(9)	19	Ô
Buckingham, Buck'shire	13.8	5.6	19.8(7)	-3.3(25)	-5.5(29)	141.4	223	23.9(20)	21	0
Oxford University	13.9	6.7	19.2(5)	-2.2(25)	-6.1(25)	139.0	187	32.7(9)	21	_
Churchdown, Glos.	14.1	6.7	17.8(5)	-5.6(25)	-0.1(23)	157.3	240	22.9(6)	21	1
Stourbridge, W.Mid'nds	1 7.1	0.7	17.0(3)	3.0(23)		107.0	210	22.7(0)		
Birmingham Univ'sity	12.7	5.9	17.8(5)	2.2(29)	-7.0(25)	133.7	227	21.4(9)	20	0
Kettering, North'shire	12.4	4.8	18.3(2)	-4.5(25)	-7.8(27)	123.0	22,	26.7(9)	19	1
Louth, Lincolnshire	13.2	6.1	17.2(5)	-0.1(29)	-7.0(27)	104.4		24.1(10)	18	Ô
Nottingham, Nott'shire	13.8	5.5	17.7(1)	-1.5(29)	-2.0(29)		269	25.4(20)	19	Ö
Middleton, Derbyshire	10.5	5.1	14.2(2)	1.4(25)	-2.0(2)	152.0	142	17.8(9)	22	1
Mickleover, Derbyshire	13.0	6.0	17.1(3)	-0.6(25)	-5.4(25)	108.4	205	18.9(9)	19	1
Keele University, Staffs	11.9	5.7	16.9(5)	0.7(25)	-5.6(25)	111.5	159	21.6(15)	20	1
Liverpool, Merseyside	12.9	6.0	17.6(6)	-0.1(24)	-3.0(23)	159.7	216	26.1(15)	21	
Lathom, Merseyside	12.6	6.6	17.0(3)	11.9(19)		146.8	210	22.0(15)	21	100
Huddersfield, W.Yorks	10.8	5.4	15.0(7)	0.0(29)	-4.4(29)	127.4	133	22.0(15)	22	4
	9.7	5.0	13.1(5)	2.2(25)	-4.4(2))	127.7	155	22.0(13)	22	7
High Bradfield, S. Yorks Cottingham, Humb'side	13.4	5.9	16.3(1)	-0.1(29)	-3.1(29)	100.4	190	21.3(10)	18	1
Carlton-in-Cleveland	12.2	5.8	16.3(5)	-0.2(23)	-3.9(29)	102.9	170	24.0(10)	21	1
Durham Univ., D'rham	11.8	5.1	14.5(18)	-1.5(29)	-5.0(29)	99.6	155	28.0(20)	21	_
Sunderland, Tyne/Wear	12.1	6.9	16.1(5)	1.8(24)	-3.0(23)	98.2	185	28.7(15)	15	0
Carlisle, Cumbria	11.8	6.2	16.8(5)	-0.7(23)		128.0	160	17.7(5)	13	U
CANADA: Halifax	13.4	5.7	18.0(4)	-0.7(23) -1.0(27)		160.0	132	35.8(29)	= ==	100
742 2 2		5.7	22.8(2)	-2.2(26)	3 3(26)		132	54.4(28)	7	1
U.S.: Bergenfield, NJ	16.9	8.4		2.8(12)	-3.3(26)	33.2	60	10.0(5)	9	1
AUST'ALIA: Leopold	18.8	8.5	32.0(31)			86.3	00		9	1
" Mt.Waverley	19.2	0.0	32.3(31)	4.3(12)		00.3		19.3(17)	7	1

CUMBRIA RAINFALL:

Seathwaite, 428.0mm (138%); The Nook, Thirlmere, 448.9mm (172%); Consiton, 300.7mm (119%); Hawkshead, 288.3mm (158%).

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FRONT COVER:

United States weather 24th January 1891 when a depression tracked across south-eastern states and snowflakes "nearly as large as a saucer" were reported at Nashville, Tennessee (W. S. Pike).

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