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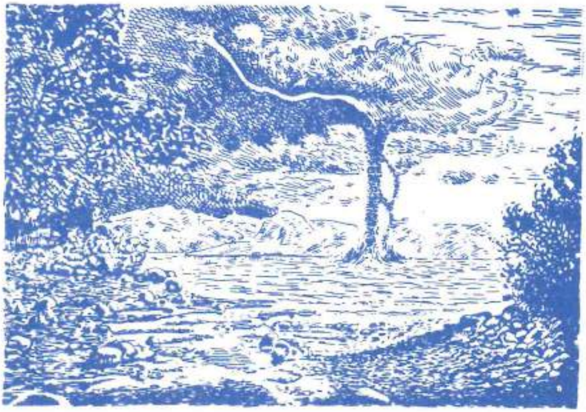

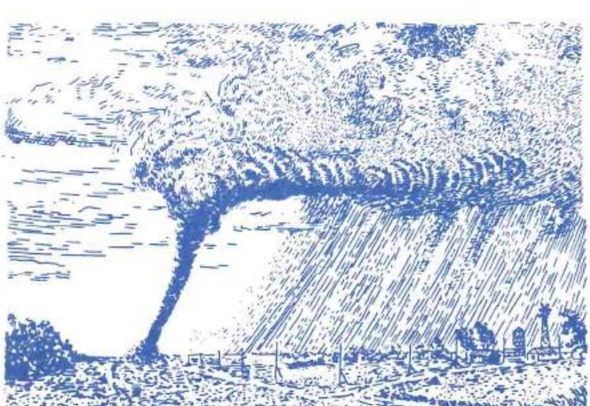

TORNADOES IN THE SOVIET UNION

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TORNADOES IN THE SOVIET UNION AND THE DELIMITATION OF REGIONS EXPERIENCING DEVASTATING TORNADOES

By DEREK M. ELSOM
TORRO, Geography Section, Oxford Polytechnic

Abstract: The spatial and seasonal distribution of some of the worst tornadoes (T6 or more) known to have occurred in the Soviet Union are described. 80 per cent of devastating tornadoes occur between June and September. The spatial distribution reveals that there are two 'devastating tornado zones' in the Soviet Union.

INTRODUCTION

TORRO provides regular details of tornadoes in Britain and increasingly, details of destructive tornadoes in France and the Low Countries. However, details of tornadoes in Eastern European countries are severely limited. Despite these countries lying in an area of Europe which may be expected to experience devastating tornadoes there are few papers published which discuss tornado events or outline national tornado climatologies. For example, the extensive literature search undertaken by Peterson (1981) uncovered only 17 papers referring to Soviet Union tornadoes. Even so, more than 30 destructive tornado events in the Soviet Union (mostly T6 or more) are known to TORRO and this paper provides a preliminary examination of the spatial and seasonal distribution of tornadoes in the Soviet Union.

SPATIAL DISTRIBUTION

Tornadoes occur most frequently in the central and southern parts of the European territory of the Soviet Union. The northernmost tornado known to have occurred was that at Solovets Island (65°N) but tornadoes are seldom reported north of Leningrad, on the 60th parallel. The southernmost tornadoes occur around the Black Sea, especially along the northern and north-eastern coastline (including the smaller Azov Sea). Nalivikin (1983) suggests an average of four tornadoes (or tornadic-waterspouts) occur in this region each year though not all cause severe damage.

Few tornadoes are known to have occurred further eastwards than the Ural Mountains for meteorological reasons and because of the sparse population to report such events. The only tornado event known for the western foothills of the Urals is that which occurred near Cherdyn (60°N) on 23rd May 1957. Trees were felled along a track 300-400m wide and 5-6km long. One 200-year-old cedar tree was described as having been twisted like a rope at a height of 2m, uprooted and thrown a distance of 8m. One tornadic event near the Pacific coast of the Soviet

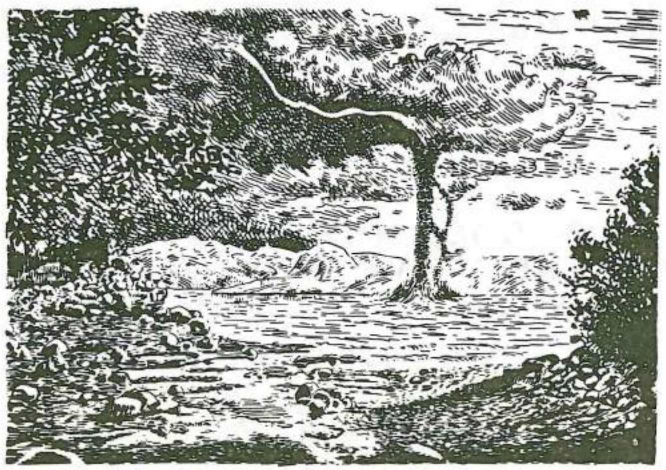

Fig.1: Tornado over Lake Issyk-Kul on 14th October 1928. A smooth horizontal pipe entering the cloud is evident.

Union to have gained widespread mention took place near Vladivostock, located on the coast of the Sea of Japan. During a summer thunderstorm in 1933 at the village of Kavalerovo, 50km from the coast, saline rain fell together with fresh, live jellyfish. It seems that a tornadic-waterspout must have sucked up sea water with jellyfish into the parent cloud and retained it aloft for at least an hour before releasing its load. Another tornado event which occurred outside the area usually associated with tornadoes was that at Lake Issyk-Kul, east of the Caspian Sea near

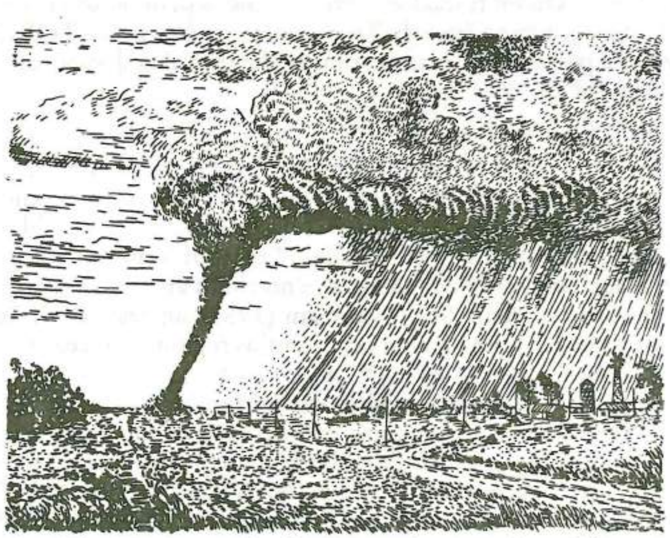

Fig.2: The Moscow tornado of 2nd September 1945 observed from an aircraft revealed a horizontal 'rotor cloud' connected to the tornado.

the Chinese–Soviet border, on 15th October 1928. Several tornadoes formed during strong rain and hail and one tornado covered a distance of 12-15km away from the lake (Fig.1).

The central parts of the Russian Plain appear to be the principal region which suffers from devastating tornadoes. Moscow lies at the heart of this area and tornadoes have caused severe damage in the city in 1904, 1945, 1951, 1956 and 1957 (Fig.2). The areas in the Soviet Union which have experienced devastating tornadoes (generally T6 or more) are shown in Fig.3.

EXAMPLES OF SOVIET TORNADO EVENTS

The first Soviet tornado occurred in 1795 in Latvia where a 160km long by up to 1.5km wide track of destruction occurred. No details of the damage are readily available for this unusually long and wide tornado track. For the nineteenth century, only four tornadoes are known and even then details of the damage are limited. All four tornadoes appear to have been widely reported because of the devastation they caused and because of the levitation effects produced. At Sevastopol, on the shores of the Black Sea, on the morning of 8th September (27th August) 1820 a violent thunderstorm produced a tornado which caused extensive damage along a S.W.-N.E. track. Stone buildings were destroyed, 14 launches were overturned, and six boats carrying seven people were lifted and carried a great distance. The tornado and lightning killed six and injured 27 people. During

Fig.3: The two zones in the Soviet Union experiencing devastating tornadoes (T6 or more).

the tornado in the Belorussia (White Russia) region on 25th April 1859 a beehive was lifted and carried over 500m and a woman carried some 100m. The tornado which struck the Kostrom province, north-east of Moscow, on 6th September 1869 devastated the village of Yakushino leaving not a single house intact and heavy objects were transported more than 300m. Such a distance seems minimal compared with the Latvia tornado of 10th May 1872 which lifted a 2m long board, transported it a distance of 25km, and dropped it 10-15km to the left of the tornado track.

The first tornado known to have struck Moscow occurred on 29th June 1904 when a 15km diameter storm cell produced several funnel clouds and at least two tornadoes on almost parallel tracks. The storm was accompanied by lightning, intense rain, egg-size hail, and ball lightning. Large stone-built houses suffered extensive roof damage, smaller stone-built houses suffered extensive damage to upper floors, wooden houses were destroyed, and light structures simply 'disappeared'. Mature trees were snapped or uprooted along the twin tornadic tracks which were 200-400m wide at Sokol'nik (part of a 40km long track) and 500m wide at Kupotin respectively. When one of the tornadoes crossed the Moscow river it sucked up the river water and exposed its muddy bottom for a few seconds and formed a trench with walls of water. Reports of roofs, trees, bricks, logs, people and animals being lifted were numerous. One curious case concerns a small boy who was engulfed by one of the tornadoes, lifted and dropped to the ground a few kilometres *back* along the tornado track.

Not surprisingly, unusual effects produced by tornadoes led to the widespread reporting of certain nineteenth century tornadoes. On 12th June 1927, a tornado at Serpukhov, south of Moscow, passed over a small lake and sucked up almost all the water. After a few kilometres rain with fish was reported. Near Minsk, on 18th August 1956, during the total destruction of a collective farm along a 20-22km tornado track a horse was lifted and the twisted body was deposited 1.5km from the farm. However, undoubtedly the most famous – and welcome – feat recorded was that at the village of Merchery in the Gorki region on 17th June 1940. During a thunderstorm, over 1,000 sixteenth century silver coins dropped from the sky. These evidently came from a hidden treasure trove buried at a shallow depth in the ground, sucked up by a tornado and lifted into the thunderstorm. The coins dropped not from the tornado but from its parent cloud and they dropped as a compact mass.

The tornado of 23rd August 1953 at Rostov became the focus of a major investigation by I. V. Chizhikov who prepared a detailed map of the damage track (Fig.4). The tornado displayed considerable power along its 9-10km track and although massive stone walls of the old houses and church remained intact, the roofs of the houses, main church and light structures all 'disappeared'. Two heavy freight cars were overturned and an iron frame weighing more than a ton was lifted from a 5 ton truck and carried 10-12m to the side. Where the tornado passed over gardens, the bushes were stripped of leaves but the bushes themselves were pressed flat to the ground and 'squeezed by the base of the tornado'. Straws and plant tops pierced the soil. The tornado vortex at its base fluctuated in width from 35 to 75m but the width of the belt of destruction was 300 to 500m (Nalivkin, 1983).

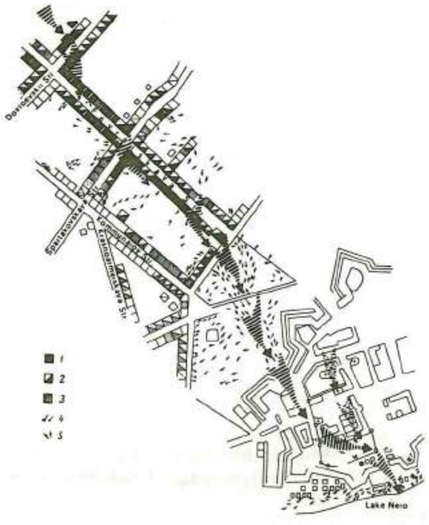

Fig.4:
Route of the tornado of 1953 in Rostov (shown by arrows). The damage pattern reveals that a second vortex formed in the area just north of Lake Nero. Key to damage categories: 1 – thorough destruction; 2 – considerable destruction; 3 – slight destrucion; 4 – broken trees; 5 – flattened grass.

TORNADOES SINCE 1984

Information concerning tornadoes in the 1980s and 1970s is scant but since 1984 details of Soviet Union tornado occurrences have become more readily available (for example, refer to the regular listings of world-wide weather disasters prepared by Albert J. Thomas for this journal as well as the country-by-country listings of seasonal weather in *Climate Monitor*). Recent events included a tornado in the Ukraine on 13th June 1984 which carried a cow 33m through the air but was unharmed, a tornado in 'western Russia' on 7th July 1985 which overturned a rail carriage, and a tornado in the Penza region on 23rd August 1986 which uprooted trees and tens of kilometres of high-voltage power lines, demolished 200 buildings and resulted in one death and several injuries.

Probably the most devastating event of recent years was that of 9th June 1984 when a series of tornadoes struck the areas of Ivanovo, Gorki, Kalinin, Kostroma and Yaroslave. The tornado which struck the village of Belyanitsky, 5km from Ivanovo, was described as 'a pillar as high as the sky with flames in the middle. All the time there was a terrible drone, like a whole squadron of jets flying low overhead'. Pravda reported that wind speeds reached 100 m/sec (224 mph) which would place the tornadoes at TORRO intensity T8. Throughout the region hundreds of homes were destroyed and 400 people were estimated to have been killed. The scale of this tornado disaster was highlighted by the Central Party Committee providing £100,000,000 for capital investments and additional transport to speed the economic recovery of the region. This disaster provides an example as to how the Soviets tackle the problem of recovering from a natural disaster. Each family that suffered damage to their home had the choice of either having their house repaired (if the damage was not too great), or moving to a flat in a state-owned block (giving up their plot of land), or getting a bank loan and help to build a prefab wooden house (many of the houses destroyed were made from solid logs), or getting assistance in demolishing the damaged house and building a new

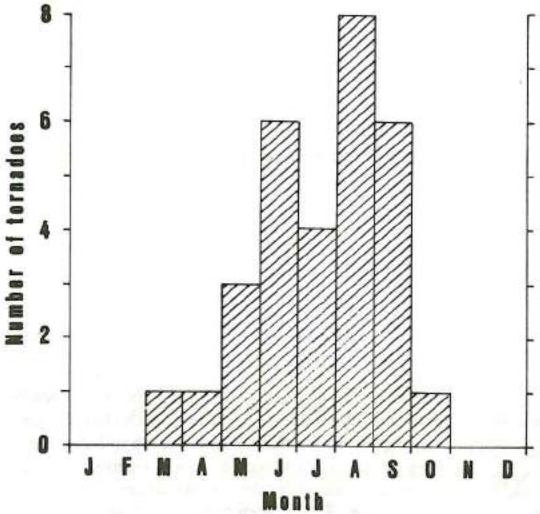

Fig.5:
Monthly distribution of a sample of 30 devastating tornado-days in the Soviet Union.

one with a bank loan. Loans were granted for 20 years without the usual first payment, monthly instalments not being due until 1989 when all the families were expected to have recovered from their experience (Kraminova, 1984).

SEASONAL DISTRIBUTION

To eliminate the bias of several tornadoes occurring on the same day, Fig.5 presents the monthly distribution of tornado-days during which destructive tornadoes are known to have occurred in the Soviet Union. A pronounced seasonal distribution is evident with all the tornadoes having occurred between March and October and with a peak between June and September – as also found by Peterson (1982). Such a pronounced summer/late summer peak contrasts with the seasonal distribution of tornado-days in the United Kingdom where any month can experience tornadoes – though June through February tend to have the highest frequencies (Elsom and Meaden, 1984). When considering only the more destructive British tornadoes (say, T5 or more), the months of October, December and January are most likely to experience such tornadoes (Rowe, 1985). The differences between the two countries arise because whereas Britain experiences destructive tornadoes associated with eastward-moving cold fronts or instability troughs as well as isolated storm cells (Meaden, 1985), the Soviet Union experiences its destructive tornadoes mostly from the latter.

CONCLUSION

TORRO has made a substantial contribution to improving our knowledge concerning British tornadoes. Further, tornado reports have been collated (and case studies published in this journal) from France and the Low Countries. The challenge for the future is to extend the information-collection expertise of TORRO to the rest of Europe. Many European countries experience devastating tornadoes and it is TORRO's aim to improve our knowledge and understanding of tornado activity throughout the continent so as to assess tornado-risk probabilities for all European countries (Elsom and Meaden, 1985). This discusson of Soviet Union tornadoes is but a preliminary step towards achieving this long-term aim.

REFERENCES

ELSOM, D. M. and MEADEN, G. T. (1985): The tornado threat in Europe. *J. Meteorology, 10(100)*, 243-246.

ELSOM, D. M. and MEADEN, G. T. (1984): Spatial and temporal distributions of tornadoes in the United Kingdom 1960-1982. *Weather, 39*, 317-323.

KRAMINOVA, N. (1984): In the wake of the tornado. *Soviet Weekly*, 4th August, 10-11.

MEADEN, G. T. (1985): The classification of whirlwind types and a discussion of their physical origins. *J. Meteorology, 10(100)*, 194-202.

NALIVKIN, D. V. (1983): *Hurricanes, Storms and Tornadoes.* Rotterdam: A. A. Balkema Publishers.

PETERSON, R. E. (1981): Kinematics of translating tornado wind fields, *NUREG Report CR-2014*, US Nuclear Regulatory Commission, Washington D.C.

PETERSON, R. E. (1982): Tornadic activity in Europe – the last half-century. *Preprints 12th International Conference on Severe Local Storms, San Antonio, Texas*, American Met. Soc., pp.63-66.

ROWE, M. (1985): Britain's greatest tornadoes and tornado outbreaks. *J. Meteorology, 10(100)*, 212-220.

SUMMER PRECIPITATION IN THE MOUNTAINS OF THE PICOS DE EUROPA OF NORTHERN SPAIN

By STEPHEN J. GALE
CCAT, Cambridge CB1 1PT
and
HILARY P. M. WINCHESTER
Department of Geographical Sciences, Plymouth Polytechnic, Plymouth PL4 8AA

Abstract: This study investigates the altitudinal distribution of summer precipitation in the mountains of the Picos de Europa of northern Spain. Measurements made during 1984 and 1985 show that precipitation occurs under two sets of synoptic conditions. Precipitation is either associated with onshore moist airstreams or with the passage of cold fronts across the region. Under the former conditions, a significant proportion of precipitation is in the form of fog, and precipitation totals appear to be at a maximum close to the altitude of the cloud base. Under the latter conditions, precipitation displays a far more complex relationship with altitude. These results suggest that earlier efforts to calculate the water budget of the region by extrapolation of observations of precipitation made at lower altitude may not be reliable and may only provide a partial picture of the complexities of precipitation in the mountains.

INTRODUCTION

The influence of mountains on precipitation has been the subject of long-standing controversy (see, for example, Barry, 1981), yet remarkably few studies have been made of precipitation in mountain areas. To a considerable extent, this is a result of the remoteness of such regions and the problems involved in maintaining recording stations there. One aspect of the debate which is of particular relevance to studies of the water budget of mountain regions is the spatial distribution of precipitation in such areas. Lauscher (1976) has reviewed the global distribution of mean annual precipitation with altitude, but despite the usefulness of his generalisations, many mountain areas display local factors which complicate the pattern of precipitation distribution, while distinctive patterns of precipitation can occur on seasonal or shorter timescales, or even as a response to particular synoptic situations. This note seeks to consider local, short timescale

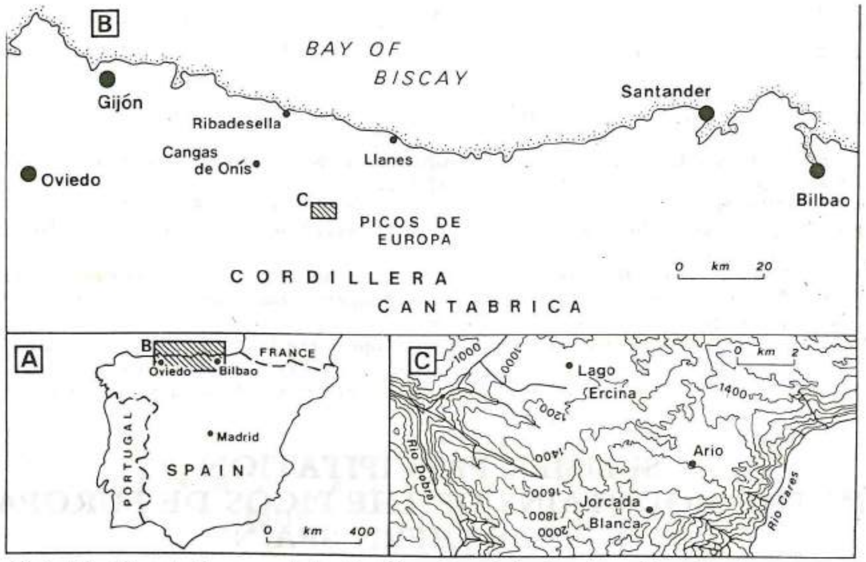

Fig.1: The Picos de Europa and the Cordillera Cantábrica: location of precipitation stations.

precipitation patterns in the alpine mountains of the Picos de Europa of northern Spain. Mid-latitude mountains of this sort generally display an increase in mean annual precipitation with altitude, and previous efforts to estimate precipitation in the region have all been based on a presumed relationship of this type. Consequently, previous workers have simply extrapolated the positive relationship observed between mean annual precipitation and height for lower altitude stations in the region to obtain an indication of high-altitude precipitation patterns (see, for example, Collignon, 1985). This work represents the first attempt to test these ideas, in this case using observations of summer precipitation in the mountains.

THE STUDY AREA

The Picos de Europa rise to altitudes of over 2,600m within 30km of the coast of northern Spain. The Picos, as part of the mountain chain of the Cordillera Cantábrica, form a major orographic barrier to moist northerly and north-westerly airflows originating over the Bay of Biscay. At present, measurements of precipitation are only made up to altitudes of approximately 1,200m in the mountains, and then only on a monthly basis. Previous studies of precipitation in the area, therefore, have only considered the distribution of precipitation as summed over relatively long time periods and have ignored the pattern of precipitation in the high mountain zone.

PRECIPITATION MEASUREMENT

During the summers of 1984 and 1985, three Meteorological Office Mark II type raingauges were set up in the Picos de Cornión, the westernmost massif of the Picos de Europa, at altitudes of 1,120m (Lago Ercina), 1,580m (Ario) and 1,885m

(Jorcada Blanca) (Fig.1). In mountain areas, gauge catch is strongly affected by variations in exposure and by local and microscale wind effects. Consequently, care was taken to locate each gauge in comparable situations and at sites where the effects of wind eddies would be minimised. The gauges were therefore located on level ground in areas of short grass, on northwesterly-facing slopes, and on the windward side of the mountain range. The sites chosen provided the best available locations for gauges in the region, taking into account meteorological considerations and the requirements of logistics and security. Nevertheless, it was recognised that, although the aspect and site of each gauge were comparable, local-scale wind effects could have given rise to variations between the catch of each gauge. Variations both in relative catch resulting from local-scale winds and in absolute catch resulting from the use of raised gauges can be as high as 50% under the worst conditions (Hovind, 1965; Sevruk, 1974). Yet, even with relatively high wind speeds, it would appear that variations in catch are commonly no greater than 10-20%. In this study, high wind-speeds were experienced only during the rare intense precipitation events. Under these conditions, therefore, only large-scale variations in relative catch were considered. By contrast, under the light wind conditions characteristic of most of the precipitation events experienced, variations in gauge catch were not deemed to be of major significance.

Precipitation readings at the three mountain stations were taken daily at 0700 GMT. These readings were supplemented by precipitation records made daily at 0600 GMT at the meteorological stations at Gijón (22m) and Oviedo (215m) (Fig.1). Taken together, these five stations represent a northwest-southeast aligned altitudinal transect across the windward side of the Cordillera Cantábrica from just above sea level to just below the summit level of the mountains.

RESULTS AND DISCUSSION

Daily measurements of precipitation were made during the periods 14th July – 16th August 1984 and 11th July – 8th August 1985 (Fig.2). From this evidence, it would appear that summer precipitation in the Picos de Europa occurs under two main synoptic conditions. First, precipitation results from moist northerly and north-westerly airflows associated with anticyclones located in the eastern north Atlantic. Airstream precipitation of this type, resulting from orographic uplift of persistent, moist, quasi-geostrophic winds has been shown to be particularly significant where the airflow is perpendicular to mountain barriers (Pedgley, 1967; Smithson, 1970), as is the case in the Picos de Europa. Normally, the winds are relatively light and conditions are stable so that clouds only extend up to altitudes of 1,000-1,800m, with a cloud base typically at 1,000-1,300m. Synoptic conditions of this type prevailed during most of the periods of observation, with these moist airflows giving rise to episodes of steady, low intensity precipitation of less than 3.0mm d^{-1}. Under these conditions, the mountains lie within a well-developed fog belt and much of their precipitation comes from the interception of fog droplets and from precipitation within the cloud layer. Despite the fact that precipitation of this type is inadequately recorded by conventional raingauges, most of the trace amounts of precipitation received at the three mountain stations were from this source, while on several occasions fog alone resulted in precipitation totals of 0.15-

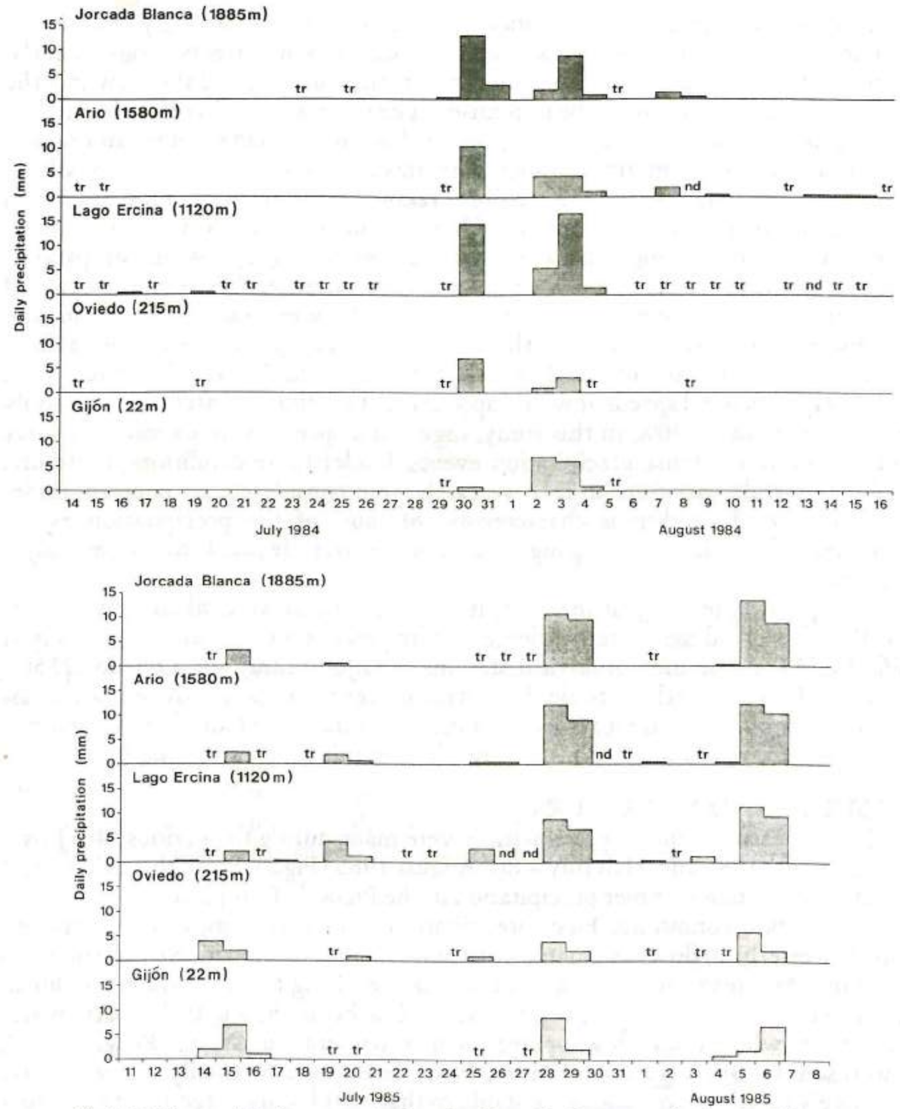

Fig.2: Daily precipitation records for the Picos de Europa and the Cordillera Cantábrica, summer 1984 and summer 1985.

0.20mm d^{-1}. In these situations, precipitation tends to be at a maximum at or near to the cloud base, where the greatest depth of cloud is able to contribute to precipitation and where the minimum amount of evaporation of precipitation occurs. Characteristically, therefore, precipitation totals under these conditions increase up to the altitude of the cloud base and decrease at higher altitudes. Thus, on the 37 occasions on which precipitation occurred under these conditions

during the periods of observation, the maximum precipitation was recorded at Lago Ercina on 17 occasions and at Ario on 10 occasions; in other words, the maximum precipitation fell at altitudes close to that of the cloud base. By contrast, under less stable conditions, northerly and north-westerly airstreams can give rise to heavy precipitation. On 6th August 1985, for example, cold, moist, unstable air, funnelled across the region from the Arctic, brought snow to the station at Jorcada Blanca and precipitation in excess of 11mm at all three mountain stations (Fig.3).

The second set of conditions which can give rise to summer precipitation in the Picos de Europa is associated with the passage of cold fronts across the region. Certain of these fronts are rather weakly developed and consequently modify little the prevailing pattern of moist northerly and north-westerly airflows. Cold fronts of this sort crossed the region on 29th July 1984, 19th July 1985, 25th July 1985, 27th July 1985 and 3rd August 1985. In no case did precipitation exceed 5mm d^{-1}. On other occasions, the fronts are more strongly developed and give rise to the most intense summer storm events experienced in the region. Events of this type were observed on 30th July 1984, 3rd August 1984, 28th July 1985 and 5th August

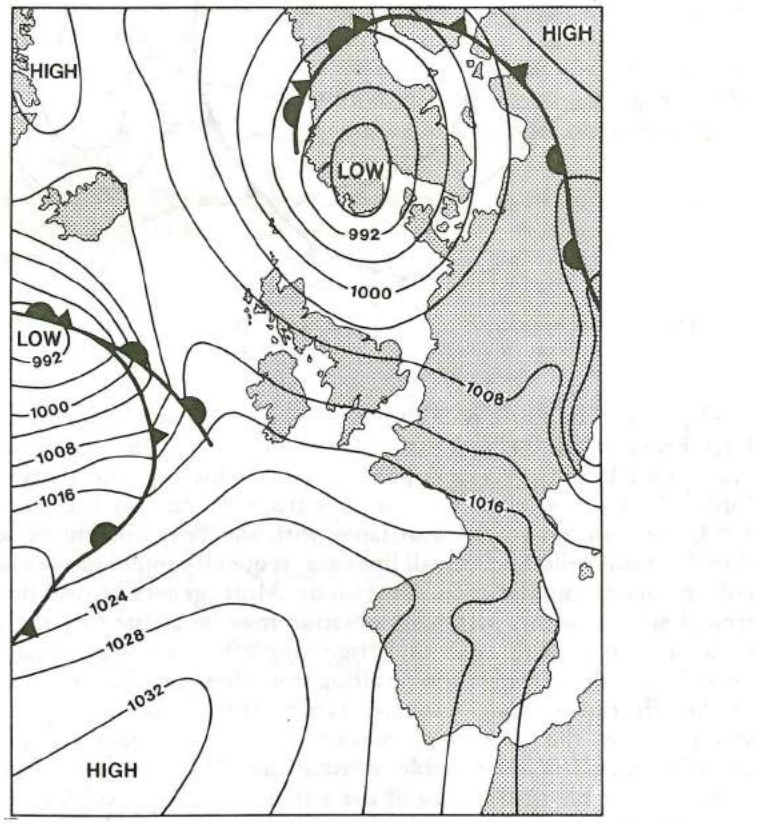

Fig.3: Surface synoptic chart of western Europe, 1200 GMT, 6th August 1985 (source: Daily Weather Summary for Tuesday 6th August 1985, London Weather Centre).

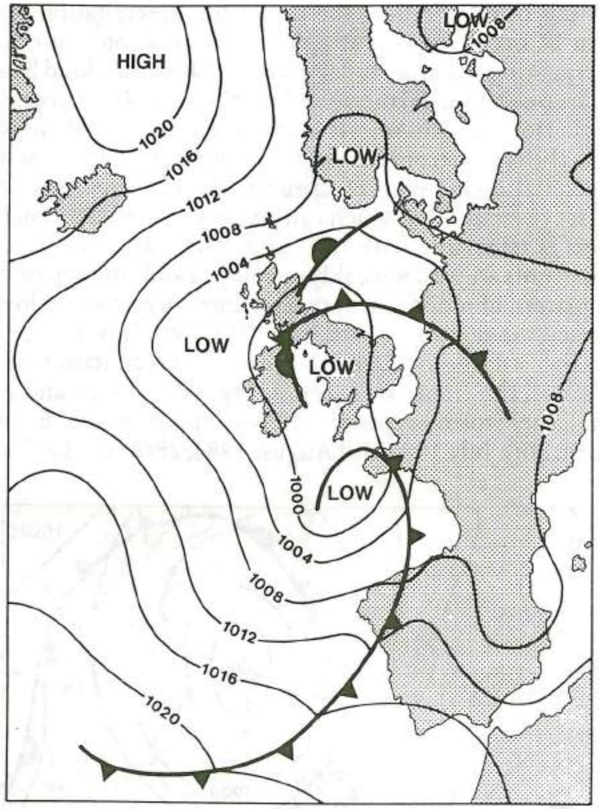

Fig.4: Surface synoptic chart of western Europe, 1800 GMT, 28th July 1985 (source: Daily Weather Summary for Sunday 28th July 1985, London Weather Centre).

1985 (Fig.4). The storm of 30th July 1984 resulted in 14.4mm of precipitation at Lago Ercina in the 24-hour period between observations (Fig.2), whereas that of 3rd August 1984 gave a peak precipitation intensity of more than 3.3mm h^{-1} at Jorcada Blanca. Certain of these intense frontal storms, such as that of 3rd August 1984, seem to have been associated with the development of squall lines of thunderstorm cells. Such squall lines are frequently found in association with the cold fronts of mid-latitude depressions. More generally, the development of frontal storms in this particular situation may be assisted by the effects of the mountains in causing uplift and triggering off conditional instability. It is also possible that the precipitation resulting from these mechanisms may be increased by the effect of the mountains in retarding the rate of movement of the frontal systems across the massif. By contrast with the airstream precipitation, frontal precipitation is highly variable altitudinally. This obviously depends to some extent on the physical nature of the airmass because, it is clear that, on certain occasions, uplift across the coast alone is sufficient to result in the coastal stations receiving the greatest precipitation in the region. On other occasions, far more

uplift is required to initiate precipitation and the greatest precipitation is received by the mountain stations. However, the altitudinal variability of frontal precipitation at the three mountain stations may also be a response to local topographical complexities and the effects that these produce on three-dimensional patterns of windflow over mountains (Pedgley, 1970).

CONCLUSIONS

This study of short-term variations in summer precipitation patterns supports the idea that complex spatial patterns are characteristic of mountain precipitation both within single storms and even seasonally. Although airstream precipitation in the region does appear to display a systematic relationship with altitude, this is not the linear relation with height which has been proposed for mean annual precipitation in mid-latitude mountains in general and for the Picos de Europa in particular. It seems rather that precipitation totals are at a maximum at or around the altitude of the cloud base, at least under stable conditions. On the other hand, frontal precipitation appears to be highly variable spatially. This seems to be a consequence of the particular conditions of stability, humidity, and temperature of each air mass and the distinctive patterns of airflow that result in the complex topography of the mountains. Finally, the frequent occurrence of fog precipitation in the mountains should be stressed: it would appear that fog precipitation provides a far from insignificant contribution to the moisture budget of the mountains, particularly given the under-recording of precipitation of this sort by conventional raingauges.

Acknowledgements: We thank members of the Oxford University Cave Club La Verdelluenga 1984 and Jultayu 1985 Expeditions for their help in making meteorological observations. We also thank Mr. A. H. C. Carter, Dr. R. H. Motts and Mr. C. G. Smith for their comments on an earlier draft of this note, Mr. B. T. C. Good for assistance in obtaining Spanish precipitation data, and Mr. B. Rogers and Miss J. Wyatt for drawing the figures.

REFERENCES

BARRY, R. G. (1981): *Mountain Weather and Climate,* London, 313p.
COLLIGNON, B. (1985): Les Picos de Europa, quelques éléments de géologie et d'hydrogéologie. *Spelunca, 19,* 7-12.
HOVIND, E. L. (1965): Precipitation distribution around a windy mountain peak. *J. geophys. Res., 70,* 3271-3278.
LAUSCHER, F. (1976): Weltweite Typen der Höhenabhängigkeit des Niederschlags. *Wetter. Leben, 28,* 80-90.
PEDGLEY, D. E. (1967): Why so much rain? *Weather, Lond., 22,* 478-482.
PEDGLEY, D. E. (1970): Heavy rainfalls over Snowdonia. *Weather, Lond., 25,* 340-350.
SEVRUK, B. (1974): The use of stereo, horizontal, and ground level orifice gages to determine a rainfall-elevation relationship. *Wat. Resour. Res., 10,* 1138-1141.
SMITHSON, P. A. (1970): Influence of topography and exposure on airstream rainfall in Scotland. *Weather, lond., 25,* 379-386.

SOME NOTES ON THE COASTAL CLIMATE OF NORTH NORTHUMBERLAND

In his recent article (*J. Meteorology,* No.114, December 1986) Dennis Wheeler referred to an observation of Manley's about north-east England being a region little known (climatically) to dwellers in other parts of the country. It might be of interest, therefore, particularly to those familiar only with central, southern or western areas of Britain, if I offer a few impressions (based on recent personal experience) of the climate of the Northumberland coast, with reference chiefly to the area around Berwick, on the Tweed estuary near the Scottish/English border.

In short, it is an uncongenial climate, and cannot be much recommended (unless you are the sort of person who disdains warm weather), though it is popularly reckoned to be a healthy climate on account of its relative dryness and its remoteness from sources of air pollution. 'Bracing' is the usual euphemism for such climates.

Berwick-upon-Tweed, with an average annual rainfall of rather less than 600mm is among the driest places in the British Isles, while farther up the coast, Dunbar (in East Lothian) receives only 570mm a year, making it the driest (and sunniest) place in Scotland. These low rainfalls come about largely because of the failure of most warm fronts to produce any measurable rain at all in this area; even quite active warm fronts, which may have given 12-15mm or more on the western side, degenerate into little more than a brief passing shower at Berwick, and can pass unnoticed by the casual observer. This is because the area of the Tweed estuary is thoroughly sheltered by high ground from all directions between south and north-west; and the usual thick alto/nimbostratus clouds of a warm front often break up into layer upon layer of lenticular types – a veritable cloud-spotters' delight! especially when accompanied by the typically superb visibility that allows even those clouds low down on the distant horizon to be seen in clear detail. Most of the frontal rain in this area comes either from cold fronts (or cold occlusions), which seem less prone to weakening after crossing the hills than do warm fronts moving from unusual directions. One consequence of this is that drizzle, so common in the South-west, is a relatively rare form of precipitation in this north-eastern area.

In the winter months, when overland heating is insufficient to generate showers, unstable maritime Polar air-masses are characterised by almost cloudless skies (though in such situations the distant Cheviot is often to be seen shrouded in shower-clouds all day long); only if the air-stream contains minor troughs are showers likely to reach the north-east coast. Unstable northerly and easterly air-streams in winter and spring produce frequent, although mostly light, showers of a wintry nature: of ice pellets (small hail) or snow pellets (soft hail) mixed with rain or snow. Thunder is uncommon, and there are no favoured situations for it.

On the coast itself, snow-cover is seldom deep or long-lasting, but there is often a marked increase just a short distance into the Hinterland (at least, as far as the coastal showers penetrate inland), especially where the ground rises appreciably, as on the Kyloe Hills. Most of the snowfall occurs in showery northerlies and easterlies, but warm fronts or occlusions moving from the south can give a covering of rather wet snow.

The worst feature of the weather in these parts, which more than offsets any of the positive aspects, is the coolness of the springs and summers. As noted by Wheeler *(loc. cit.)*, the sea temperatures off the Northumberland and Berwickshire coasts are the lowest to be found anywhere around the British Isles, and the deleterious effects on the climate of the area are apparent. While the winters are no colder than they should be, the seasonal rise of air temperature through March, April and May is slow, especially if there is a preponderance of easterly types; and even in summer, temperatures over 70°F (21°C) are rare and more or less confined to the late summer/early autumn, when the North Sea has become a little less cold. 80°F (27°C) is virtually unknown on the coast, though inland – at Kelso (Roxburghshire), for example – 90°F has been recorded. Many a summer day indeed begins with great promise, with early warm sunshine and the temperature soon into the sixties; but it always ends in a disappointment when, sometime between 10 a.m. and noon, the sudden chill of the sea-breeze is felt, which, even if it does not bring the haar in with it, still succeeeds in holding the temperature at about 50°F (14°C) for the rest of the day. And if the pressure-gradient wind is strong enough to inhibit the sea-breeze the cooling effect of the wind itself nullifies the benefit of any higher temperatures that may then be attained. A particularly dismal situation arises with a cloudy northerly flow behind a low in the central North Sea, with daytime temperatures in the low fifties Fahrenheit (11 or 12°C) even in July and August.

The sea does, however, have an ameliorating influence in winter; because even the severest of continental easterlies must of necessity have a long sea-track to the north-east coast, and temperatures are usually above freezing (just) by the time the air arrives there. But, as other coastal dwellers will know, the sea is of no benefit in this respect when the wind is from landward; so that given a gentle nocturnal land-breeze down the Tweed valley, and a snow-cover, quite severe frosts (as low as −10°C) can occur right down to the coast.

Radiation fog is uncommon, although it sometimes forms along the Tweed valley, and drifts toward the coast. However, most of the fog that occurs on the Northumberland coast is of the type known as haar, which is sea fog brought on to the coast either by a prevailing onshore breeze or by a diurnal sea-breeze. In the latter case, it usually arrives in the early afternoon, and disperses or recedes out to sea overnight. Its penetration inland is only a few miles at most, and sometimes considerably less (though the sea-breeze itself goes a good deal farther). The haar may occur in any of the spring and summer months, but is most prevalent in the later part of spring (see also the aforementioned article by Wheeler).

Whereas winds from the seaward directions – between north and south-east – are often fresh or strong, they do not normally reach gale force except on the headlands (e.g. St. Abb's Head, where the weather station is at the top of a steep cliff-face); a feature of these winds is a monotonous steadiness in the speed, with no great gusts. The worst gales, in fact, in the Berwick area come with westerly or south-westerly winds, usually behind a cold front; these may be very gusty.

Finally, in common with all coasts, the sunshine figures are rather higher than inland due to the absence of overhead daytime convective clouds in the summer months.

While the foregoing comments have been chiefly related to the coastal area of north Northumberland, most of them can probably be taken as equally applicable to the north-east coast in general, at least between the Tees and the Firth of Forth. It is an area to be visited for its historical interest and its natural beauty (particularly the more northerly part, from about Alnmouth to St. Abb's Head): it is not the sort of place to indulge such summer habits as wearing shorts and T-shirts, sunbathing, or swimming in the sea (though it must be admitted that one will usually find some determined, but fully-clothed, characters sitting and enjoying the sea air on the beaches and promenades).

12a Atlas Road, Bedminster, Bristol. PAUL R. BROWN

TORRO BALL LIGHTNING DIVISION REPORT: April 1987

By MARK STENHOFF
Director, TORRO BL Division, Department of Physics, St. Dunstan's College, London SE6 4TY (tel: 01-690 6317)

BALL LIGHTNING IN WEST MIDLANDS, 1977 (ref BL7/1)

Robert McGregor, a student,observed what he believes to have been ball lightning while a pupil at Collingwood School (grid ref SJ 922 025), Bushbury, nearly 4km from Wolverhampton, West Midlands, one morning in September 1977.

'I was sitting on the edge of the school playground just as a storm was passing. I looked to see if the cloud was clearing and I saw a very bright blue ball. It zig-zagged down, and seemed to pause whenever it changed direction. It vanished suddenly and silently. It left no traces of anything. I was not frightened at the time, and no-one would believe me!'

The ball appeared late during an unusually violent thunderstorm, although the rainfall just before the observation was only moderate. He did not see the ball originate, and its appearance did not follow a stroke of lightning. Its estimated distance when first seen was 70 metres, and its diameter throughout the observation was estimated at 8 inches to 1ft. It was round with a corona, opaque, and bright enough to illuminate nearby objects. The brightness was the same over its entire surface, and remained constant. There was no impression of rotational movement. It was seen for 4 to 5 seconds, vanishing in mid-air. There were no other known witnesses, and Robert McGregor has not seen ball lightning on any other occasions. David Reynolds, who passed on the report to me, said, 'Robert is interested in Physics and he did say that he had read one or two ball lightning reports, but had abolutely no idea what it was (and was unaware that scientists are now showing an interest in ball lightning).'

BALL LIGHTNING IN BAVARIA, 1921 (ref BLN5/12)

Further information has just been received directly from the eyewitness concerning event BLN5/12 reported in Ball Lightning Newsletter Number 5.

The event took place at 9.00 a.m. on 2nd August 1921 at Hohenschäftlern in Isartal, Bavaria. The witness who reported the event was nine years of age at the time of the observation, and was indoors with her uncle on the first floor of a building during a severe morning thunderstorm with heavy rainfall. There was a lull in the storm and the ball lightning appeared on the left side of the window sill about 4-5m from the observers. The window had been left open because there was a balcony above it which prevented the rain from entering the room.

The ball fell to the floor where it jumped up and down once or twice. It then started to roll slowly towards the observers across the floor, at about the speed of a dropped ball of wool. Its diameter was about 20cm, it was translucent, and the rapidly changing colours showed spots of light green, crimson, light blue and pale yellow. It was bright enough to be clearly visible in daylight, and it was uniformly bright over its entire surface. It had protrusions 'like the Andromeda nebula'.

'When it came near the table, where my uncle and I were sitting, I tried to get up to have a closer look. My uncle (fortunately) held me back. It then rolled towards the tiled stove on the right side of the room, crept up the iron parts of the stove leaving (in its path) a deep groove about the width and depth of a thumb, then it exploded in the (air vent) higher up, the sound was like that of a blown up paper bag when (burst) leaving a smell of ozone'. The path of the ball was about 5-6m in length, and it left no marks on the wooden floor.

BALL LIGHTNING IN CARDIFF (ref BL7/2)

Although anecdotal accounts of ball lightning are of limited scientific value, particularly when the witness to the events are dead, they are nonetheless of interest to researchers when they compare favourably with other accounts. One such anecdote is recounted by Gwynne Goaman, and is somewhat similar to the preceding desciption (ref BLN5/12):

'I . . . thought you might be interested in my father's experience. He died a few years ago, but was always very nervous about thunderstorms. This resulted from an experience that he had as a young man. He and an uncle were sitting, playing cards, in a thunderstorm in Cardiff. It must have been a bad one, as they had left the back door open. They were astonished to see what he descibed many times as a slowly revolving ball which rolled up the back door steps slowly, crossed the back kitchen floor (leaving no mark), and then . . . slowly disappeared up the chimney. Both men rushed out of the house expecting an explosion, but nothing happened. The ball, I'm told was about the size of a football.'

'EXPLOSIVE BALL LIGHTNING' – WINCHESTER, MASSACHUSETTS, U.S.A., 1985 (ref BL7/3)

The unfamiliar appearance of ball lightning often leads to an interpretation of it as an unidentified flying object (UFO), and hence many reports of ball lightning are received by organisations and individuals investigating UFOs. The above observation, ref BLN5/12, was originally received from a UFO research organisation run by scientists in West Germany, and the following report was investigated by Walter N. Webb and is to be published in a UFO magazine (ref.1).

The event occurred at 2.20 p.m. on 3rd July 1986, and was witnessed by Domenica Falcione, 15 Taft Drive, Winchester, Massachusetts. She wrote about her observation to the Museum of Science, Boston, and they passed the information to Walter Webb. Although thunderstorm conditions were noted some 16 miles from the site of the event, the witness recalls only light rain. The ball appeared in a darkening sky, but she said there was no thunder or linear lightning. The weather reported from Bedford, 7 miles north-west of Winchester was as follows:

Cloud cover	rain and fog
Last thunderstorm	1.30 p.m.

Ceiling	3,000 feet
Visibility	2 miles
Temperature	64°F, 18°C
Dew point	61°F, 16°C
Relative humidity	90%
Wind direction and speed	350°/7 miles per hour

At the time of the observation, Mrs. Falcione was standing behind the kitchen table when she suddenly looked out of the north-facing windows and saw a glowing object stationary above some trees in a neighbour's back garden. She walked toward the window to get a better look. The ball was red, and of the apparent size of 'a harvest moon'. The investigator estimated the elevation at about 15 degrees and the distance at more than 100 feet from the rear of the house. The witness returned to her original position near the table, looked out and briefly saw the ball again, then looked away. Just then, she heard a tremendous explosion like a bomb and thought something had hit her roof. The electric light in the kitchen remained on, but the burglar alarm and automatic lawn sprinkler systems in her house and neighbouring houses were going off. In the garage, the cover on the meter box for the lawn sprinkler had been blown off, and the box was blackened and smoking. The plaster wall behind the box was buckled. The lights in the garage no longer worked.

Other damage was later discovered: the furnace oil burner and television were burned out and two upstairs light bulbs were shattered. A tree in a neighbouring garden had been struck, bark had been stripped, and branches thrown in all directions. A 1 ft deep hole was discovered below the perimeter fence near the tree, leading to a junction box.

The ball was also seen by a neighbour.

The explosion and damage may be explained by a linear lightning flash to the damaged tree, with a side-flash to underground cables running beneath the fence, or, if the fence was metal (not stated in the report), to the fence itself. The current would then be carried to the electric appliances in the house and garage. It is therefore suggested that the 'ball' seen over the trees was actually corona discharge. Some thunderstorms end with a single anomalous, positive lightning flash which may be particularly energetic, and would be expected to be preceded by highly-enhanced **E**-fields at the ground surface, with consequently pronounced corona effects (ref.2).

REFERENCES

1. *MUFON JOURNAL*, July, 1987.
2. MOORE, C. B. and VONNEGUT, B.: 'The Thundercloud', in *Lightning: Volume 1: Physics of Lightning*, ed. R. H. Golde, Academic Press, 1977.

A POSSIBLE CASE OF BALL LIGHTNING AT DANBURY, ESSEX, IN 1402

The *Historia Anglicana* (English History) of Thomas Walsingham contains an account of a damaging thunderstorm at Danbury, Essex, on 25th May (3rd June, New Style) 1402. "A diabolical apparition appeared in Essex, at Danbury, on the feast of Corpus Christi, at the hour of Vespers, in the likeness of a Minorite Friar, entering the church and running riot in the most outrageous fashion, which struck inexpressible terror into the parishioners. At the same hour, with a whirlwind and most dreadful thunder, the crash of thunderbolts and the flashing of shining globes, the top of the whole church was broken in pieces, and the middle of the chancel was wrecked and scattered."

It is tempting to suggest that the "shining globes" *(globis collucentibus)* may have been ball lightning. However, there is no description of the globes, and the witnesses may well merely have said that they had seen fireballs, which, as we know from modern reports, are probably often not true ball lightning. (The word *fireball* is not recorded in the *Oxford English Dictionary* until 1555, but there is no reason why it should not have been in use 150 years earlier, like *snowball* (recorded from c1400); or indeed at any time after the word *ball*) first recorded c1205) was borrowed from Old Norse).

Another problem is that there is no mention of the shining globes in the account of the storm in the *Annales Henrici Quarti* (Annals of Henry IV), an account which is certainly not indepentent of Walsingham's. The *Annales* merely say: "There came down lightning and flashes, with a whirlwind and the din of most terrifying thunder." It is therefore conceivable that the shining globes are an invention of Walsingham's, to make his account of the storm more impressive. This seems unlikely, however, since he barely mentions the strangest part of the whole incident, the behaviour of the "diabolical apparitions", which is described in detail in the *Annales*. He would hardly have omitted these details if he had been trying to write a weird, exciting story. At the very least, Walsingham's account of the storm is one of the earliest in Britain to show an awareness of the existence of fireballs.

It is not the purpose of this note to discuss what the "diabolical apparition" *(diabolica species)* may have been, but it is worth remarking that an extremely similar incident occurred at Bungay, Suffolk, on 4th August 1577 (14th August, New Style) (Harvey 1951; Anon 1976).

It is not clear what the earliest British record of ball lightning is. The earliest known to the present writer is a case at Little Sodbury, Avon, in the summer of 1556, when several people are alleged to have been killed by "a fiery sulphureous globe rolling in at the parlour door . . . It made its passage through a window on the other side of the room" (Anon 1976; Mortimore 1983). Then there is the puzzling "dark" fireball at Wells, Somerset, in December 1596 (Anon 1976). There is also this quotation (under *fireball*) in the *Oxford English Dictionary*, from Speed's *The History of Great Britaine* (1611): "There was such a Tempest & thunder with great firebals of lightning". I do not know what year Speed is referring to, and his words could be a translation of Walsingham's account of the Danbury storm.

REFERENCES

Annales Henrici Quarti, 340. London, Rolls Series (1866).
ANON (G. T. MEADEN) (1976): Fireballs – some fiery, some dark. *J. Meteorology, 1*, 312-313.
HARVEY, J. B. (1951): An historic storm. *Weather, 6*, 159-160. (In this and some other sources the Bungay event is wrongly dated 1557).
MORTIMORE, K. O. (1983): Historical ball lightning. *J. Meteorology, 8*, 289.
SPEED, J. (1611): *The History of Great Britaine*, 616/2.
WALSINGHAM, T. (1864): *Historia Anglicana, 2*, 249-250; ed. H. T. Riley, London, Rolls Series.

MICHAEL ROWE

LITERATURE REVIEWS AND LISTINGS

Book Reviews

CLIMATE AND SOCIETY. By Allen and Vivien Perry. Bell and Hyman, 96pp.

Climate and Society is one of the *Man and Environment* series which is aimed at the post 'O'-level student. It is essentially an applied climatology text based on the justification that "physical geography is now much more people-orientated", a statement with which I would be inclined to agree. The fact that Allen and Vivien Perry are experienced writers is clearly in evidence in a text which flows well. As to content, the opening batsman is that current favourite 'the systems approach' although a large part of this first chapter is, in fact, devoted to basic meteorology. The reason for the inclusion of the material on systems is not entirely clear as it is not used in the succeeding chapters. The meteorology is romped through at breath-taking pace, managing to cover all the basic concepts in the short span of a few pages. I do wish the 'hydrological cycle' concept could be dropped as it always appears to suggest that no precipitation falls over the oceans!! Chapter 2, the longest in the book, tackles spatial variation in climate, which includes climatic classification. To the authors' credit they manage to make this interesting, which is achieved by considering, for example, human shelter and style of clothes under different climatic regimes. Chapter 3 moves on to temporal variation in climate including the nature of, the evidence for, and the effects of changes in climate over different timescales. The following chapters, 4 to 12, then tackle the various dimensions of the relationship between climate and society. From these I would pick out the chapter on climatic hazards as the most comprehensive, dealing with floods, cyclones, tornadoes and drought.

All in all I suspect that teachers may well find this to be a very useful sourcebook. There are ample tables and many of the figures could be easily reproduced on the blackboard or overhead projector. The inclusion of study questions is a bonus. However, the material is, in places, far too compressed, leaving little room for explanation, and there is an almost exponential decay in chapter length, spatial variation in climate being given 12 pages while atmospheric pollution (Ch.8) has 4 and controlling the weather (Ch.12) 3. Although the style is laudably direct there are occasional lapses into needless complexity and over-simplification. After a relatively clear discussion of climatic change, for example, the reader encounters in Figure 3.2 terms such as "Quasi-periodic variation" and "Impulsive change of central tendency" neither of which are explained in the text. At the other extreme, to suggest that the natives of the U.S.A. simply have to get into their cars and make a dash for it when 'hazards' threaten (Ch.5) is simplistic and neglects the limiting carrying-capacity of their road systems.

These minor criticisms aside, I would recommend the book to teachers and suggest that it could also stimulate students interest in climatology.

S. J. HARRISON

SOCIAL AND ECONOMIC RESPONSES TO CLIMATE VARIABILITY IN THE U.K. By K. T. Parker *et al.* The Technical Change Centre, 114 Cromwell Road, London SW7 4ES. 160pp. £17.00.

In compiling this book the authors have followed the laudable policy of

consulting no fewer than 40 individuals, 33 institutions and over 170 published works. The results are wide-ranging and of interest to people in several disciplines. Even so, there exist a variety of restrictions on the scope and approach of the text, some deliberately imposed by the authors, but others apparently unintentional. For example, the phrase *climatic variability*, which occurs in the book's title, raises problems of interpretation. Those who expect a long-term (multi-decadel/centennial) perspective, with frequent reference to the work of people such as Manley and Lamb, will be disappointed. Instead, the emphasis is much more on the short-term viewpoint (there are many references to extreme events since 1960). Another problem is that the book only partially exploits current knowledge about the spatial aspects of weather/climate variability in the U.K. Hence, important regional and local variations often do not get the treatment they deserve. Given that the authors have not penetrated deeply enough into the subject of climatic variability, it is hardly surprising that the problem carries over into the other aspect of the book, which is a discussion of social and economic responses to that variability. Admittedly, writing successfully about cross-disciplinary matters of this sort is very difficult. Nevertheless, it has to be said that the authors do give up rather easily on some subjects. For instance, they dismiss hail, lightning and tornadoes in under 3 lines, because these things "*appear* to be of relatively small economic importance" (my italics) – there is no mention of TORRO or the mass of data it has produced on these subjects. Likewise, it is hardly satisfying that weather, climate and tourism have only 2½ pages, largely occupied by a section entitled 'The influence of August rain on tourist trips'. The brevity of the account is in this case attributed to an "apparent lack of research". However, since even a quick glance down the book's bibliography reveals that a fair number of relevant articles are not quoted, one cannot help feeling there is sometimes more of a story to tell than the authors imagine. Furthermore, this is probably one of the factors contributing to the highly unequal length of the book's 7 chapters (e.g. agriculture is given over 40 pages, whereas industry has only 3½). Despite such shortcomings, this book can be recommended as a useful contribution to an important and difficult subject. It undoubtedly has more substance than some earlier literature in the field, though equally it stands as a revealing commentary on the great amount of work which remains to be done.

L. T.

Announcement

METEOROLOGICAL OFFICE ANNUAL REPORT

The Annual Report for the Meteorological Office for 1986 was presented by the Director General to the Secretary of State for Defence on 21st May 1987. The report covers all the activities of the Office. Special topics include services to the public and also a detailed account of the meteorological aspects of the Chernobyl accident and the lessons to be learned.

A team of Met. Office scientists who had designed and implemented the global forecast model received the 1986 Esso Energy award of the Royal Society in recognition of the consequent fuel saving made by airlines. Public services were improved by the introduction of the premium-rate 'Weathercall' system in conjunction with British Telecom and Telephone Information Services. The first element of a new Weather Information System was installed in October. It uses digital data transmission techniques and soft-copy displays and will eventually replace the existing overloaded and obsolescent system which has kept forecasters and observers in touch with headquarters for many years.

The possibilities of changes in climate are being investigated using for the first time computer models of the atmosphere and oceans coupled together. A forecast of summer rainfall based on sea-surface temperatures was provided experimentally to African Meteorological Services. It proved surprisingly accurate and very useful.

The Office's programme of activity continued to expand despite further reduction in staff numbers – by some 30% over the last 12 years. The Office continues to attract high-quality recruits. The Report is published price £11.95 by Her Majesty's Stationery Office and is available through all bookshops.

WORLD WEATHER DISASTERS: January 1987

1-5: Heavy rains in Antananarivo, Madagascar, left 6,000 homeless, no casualties reported, rains associated with a cyclone which hit Comoros archipelago on 3rd/4th, the cyclone hit north-east Mozambique on the 5th. *Lloyds List.*

1-3: Gales and high tides and heavy seas hit eastern coast of U.S.A., from the Carolinas to Maine, at least 19 deaths attributed directly or indirectly tostorm, described as worst since 1978, winds up to 93 km/h reported along the Virginia coast, damage put at several million dollars, up to 250mm of snow fell inland from coastal areas. *L.L., International Herald Tribune, Birmingham Evening Mail.*

2: During gale in Irish Sea, hatch cover blown off m.v. *Weisa,* leaving one crew member dead and another injured. *L.L.*

2-3: Cyclone "Sally" hit the Cook Islands, south Pacific, with winds gusting to 160 km/h and waves up to 11 metres high, widespread damage reported with at least 85 injured, the injuries reported from Avania, the capital, on Raratonga; cyclone described as worst in island's history, most of cash crops destroyed, the total damage put at $50,000,000, storm wave destroyed many buildings in Avarua, several small boats in harbour sank. *L.L., B.E.M.*

3: Thunder squall during night at Cilincing, north Jakarta, Java, Indonesia, destroyed 31 houses and damaged 14 others, leaving 109 homeless, no casualties reported. *J.P.*

3-31: Severe cold weather, with snow and blizzards, in many areas of both eastern and western Europe, brief details as follows:–

3rd/4th: Heavy snow in West Germany delayed air traffic, on 4th car skidded off motorway covered in ice near Oldenburg, leaving three dead.

7th/8th: Temperatures in U.S.S.R. falling to levels not seen for 40 years or more –43°C in Leningrad, –38°C in Moscow, very low temperatures also in Sweden and Norway, in Poland temperatures down to –34°C in central and eastern areas of country, near Wloclawek farmer froze to death.

8th/9th: Blizzards in east and north-east Romania, temperatures down to –22°C.

9th: Temperature in Helsinki, Finland, fell to –34°C in morning, lowest for at least 30 years.

10th: Blizzards in West Germany and temperatures down to –20°C, lowest for more than 30 years, temperature in Italy fell to –8°C and snow fell in Venice.

10th/11th: Blizzards in Austria isolated hundreds of holidaymakers in Alpine resorts.

12th: It was reported that temperature in Dmitriev, 483km south of Moscow, fell to a record –39°C for three days running, the heaviest snowfalls in 50 years cut off many villages and towns in Georgia S.S.R., avalanches claimed 29 lives in same republic. Gales and snowstorms have left five dead in Greece; Sweden reported four deaths in the worst cold spell this century, blizzards reported in Hungary, freezing temperatures in France, in Paris temperature fell to –12°C, in Jura mountains, in east of country temperature fell to –37°C, meanwhile temperature down to –24°C in Ardennes region of Belgium. Avalanches in Turkey left at least 13 dead, in Swiss village of La Brevine temperature fell to –41.8°C, a record low for Switzerland. Ice began to form on canals and other navigable waterways in northern Europe. Snow fell in Barcelona and Madrid, Spain and ten towns cut off in north of country, snow also blocked roads in Portugal.

13th: M.v. *Testarossa* sank in storm, with 10 metre high waves, 290km west of Cape St. Vincent, Portugal, with loss of some 30 lives, M.bulk carrier *Cathay Seatrade* sank in storm in Atlantic some 300km north of Lanzarote, Canary Islands, leaving 27 dead; meanwhile death toll in U.S.S.R. in cold wave put at 77; near Toulon, France, five died when two cars collided after skidding on ice, bringing to 14 total since cold wave began; heavy snow in many areas of France, winds up to 120 km/h in south-west of country, where up to 380mm of snow fell, temperatures began to rise in northern areas of Europe, at least eight motorists died of exposure on Budapest-Vienna road.

15th: It was reported from Spain that 50,000 people cut off by snow and that 51 mountain passes blocked by snow, emergency declared around Marseille, France, because of snow; roof of factory in Satu Mare, north-west Romania, collapsed under weight of snow, leaving 10 dead, 47 injured; ice on canals and other waterways in northern Europe delayed shipping especially on river Danube in Czechoslovakia and Hungary.

16th: It was reported from Czechoslovakia that snow in some areas deepest since 1921, death toll in Hungary rose to 18, snow fell on Huelva, south ern Spain, for first time since 1952, death toll in Spain stood at 11, temperature in Paris, France, down to –11°C.

17th: M.v. *Kythera Star* sank in Mediterranean Sea during storm some 105km off Barcelona, Spain, leaving three dead, 15 missing.

18th: M.v. *Nikolaos L* sank in storm near island of Thasos in Mediterranean Sea, leaving seven dead; in north-east Italy winds hit Trieste, uprooting trees, power and telephone lines; slabs of ice fell from roof tops; damage throughout Italy during cold spell put at 1,660 billion Lira, temperatures rising over much of Europe, death toll from cold rose to at least 343, direct or indirect.

19-31st: Effects of cold spell lingered in many areas of Europe. On 31st-1st February heavy rains fell on top of up to 4.6 metres of snow in S.S.R. of Georgia, causing widespread flooding which left at least 28 dead and caused widespread damage, including four electricity power stations. *Daily Telegraph, L.L., I.H.T., B.E.M.*

4: Forest fire destroyed 300 hectares of forest in southern Swiss canton of Ticino. *I.H.T.*

7-22: Severe cold and snow in many areas of Great Britain, brief details below:–

7th: Car skidded off icy road near Portmadoc, north Wales, leaving one dead.

8th: About 60 vehicles collided in dense fog on M1 on Leicestershire-Northamptonshire border, leaving 19 injured, temperature at Aviemore, in Scottish highlands down to −11°C.

11th: Cold spell began in earnest, with day temperature in London down to −3.3°C, lowest since records began in 1961, many accidents reported on icy roads.

12th: Heavy snow in Kent, east Sussex and Norfolk caused widespread disruption to rail and road traffic, up to 203mm fell in Norfolk and up to 460mm in Kent and Sussex, temperature at Aviemore down to −15.9°C, at East Hoathly, Sussex down to −15.5°C, snow in north-east England and Glasgow, first heavy snowfall in Scilly Isles for at least 40 years, with 75mm to 100mm reported.

13th: Heavy snow in many areas of country, including Birmingham, again widespread traffic disruption throughout much of nation, Scotland cut off for a time from England, whole of Norfolk cut off, Lincolnshire, Kent, Sussex, Devon, Cornwall, parts of Wales and Scotland badly affected by drifts.

15th: Little snow fell but many areas still very cold, temperatures rose above freezing in Scotland bringing flooding to some areas, many areas still cut off by drifts in eastern England and Kent and Sussex, in last two counties drifts still up to 6 metres deep.

16th: Slow thaw began in some areas, hundreds of homes flooded in Birmingham as pipes burst, many homes flooded in London, again as pipes burst.

18th: Five villages in Kent still cut off by drifts and many minor roads in county still blocked, but most other areas in country slowly returning to normal.

21st: Four lorries and four cars collided in dense fog on the M2 motorway in Kent where the A229 joins the motorway, one dead, three injured. Ten vehicles piled up on A31 road between Guildford and Farnham, Surrey, in dense fog, four injured.

22nd: Twenty vehicles piled up in thick fog on M61 near Chorley, Lancashire, leaving one dead, one injured.

During cold spell one direct death reported, with at least 28 indirect deaths. *D.T., B.E.M.*

13-14: Monsoon rains and floods in Central and West Java, Indonesia, left two dead, one missing, in Rembang regency, where two dead occurred, floods rose to a height of two metres, 1,400 homes flooded, dozens of homes flooded in other areas. *J.P.*

15-18: Snow and strong winds in New Mexico, U.S.A., up to 1.25 metres of snow fell, with drifts up to 2 metres reported, at least 5 deaths reported, two from exposure, three in traffic accidents, three counties in state declared disaster areas. *D.T.*

17: Cyclone 'Tusi' hit Samoan islands of Ofu, Olosega and Tau with winds of 130 km/h, injuring at least 30 people and causing damage estimated at $100,000,000, islands of Ofu and Olosega worst hit, with some 2,000 homeless, crops of bread-fruit, coconut and banana destroyed. *L.L.*

21-24: Snowstorm from Deep South to north-east states of U.S.A., roads and airports closed, up to 500mm of snow fell in some areas, at least 48 direct or indirect deaths reported, storm moved into Canada on the 23rd. *I.H.T.*

24-30: Heavy rains and floods in Sao Paulo state, Brazil, worst hit was city of Sao Paulo and its environs, 250mm of rain fell, leaving 75 dead in floods and landslides, 15,000 people made homeless, damage put at $62,000,000; river Tiete, which flows through Sao Paulo, overflowed its banks on the 26th after two days of rain, rail and road transport cut as floods rose to a depth of 1.83 metres in parts of city. In northern Sao Paulo state farmers reported they had lost nearly 80% of their vegetable crop. *L.L., I.H.T.*

25-26: Ice floes broke up and drifted away from shore along Soviet Union's Baltic coast in storm and into the Gulf of Riga, 1,100 fishermen rescued by helicopters from ice floes, at least two died. *I.H.T., B.E.M.*

25-28: Second major snowstorm hit north-eastern states of U.S.A., up to 480mm of snow fell in southern New Jersey, 500mm at Andrews Air Force base outside Maryland; winds gusting to 80 km/h caused considerable drifting in southern New Jersey; airports closed down, many roads blocked, worst of snow on 25th and 26th; freezing rain and sleet fell in some more southern states, on the 27th record low temperatures at several places in Virginia, New York, Maryland, Delaware and Tennessee, on the 28th temperature fell to −25°C, a record low, at Dulles International Airport in northern Virginia. *I.H.T.*

27: Vessel, the *Ping-ping II*, sank in stormy seas near Siberut Island, west Sumatra, Indonesia, leaving one dead, 12 others missing. *J.P.*

28 (approx.): Speed boat sank during sudden storm near south-east Maluku, Indonesia, leaving five dead. *J.P.*

28 (approx.): Heavy rains, floods and landslides in Denpasar area of Bali, Indonesia, left one dead and one missing. *J.P.*

30-31: Heavy rains, up to 250mm reported in a 24-hour period, in the Seychelles archipelago caused widespread flooding and landslides, two deaths and several injuries reported, widespread crop damage. *L.L.*

31 Jan – 1 Feb: Heavy rains, floods and mudslides in central Peru, wall of water and mud moved down Entaz river and into town of Villa Rica, leaving at least 60 dead, industrial sector of town reported to be under 7.6 metres of mud and water, flash flood along river Uamaquisu swept through town of Oxapampa, leaving 13 dead, it is believed another 400 people could be missing in the two towns. *L.L.*

ALBERT J. THOMAS

LETTERS TO THE EDITOR

AN EXCELLENT EXAMPLE OF SNOW SHOWERS AT HIGH AIR TEMPERATURES

Ten years ago, correspondence in this journal by Keith Mortimore (1977) drew attention to the phenomenon that falling snow is sometimes observed at the ground when the air temperature is considerably above 0° Celsius. In a subsequent article, Burton (1978) examined in some detail the mechanism leading to the occurrence of snow at high screen temperature.

On 29th March 1987, a textbook example of this phenomenon was observed over Berkshire. During late morning and the afternoon, many shallow cumulonimbi could be observed crossing in the strong N.N.W'ly airflow. Snow showers, perhaps better described as flurries as they were mainly very slight and brief, were observed widely, *but with the air temperature in the range 6 to 8° Celsius.* During the period 1000 to 1600 GMT, the screen temperature at Wokingham recorded on my thermograph fluctuated between 5.8 and 9.1°, the latter value being the recorded maximum on that day.

Although most of the cumulonimbi were trailing vast curtains of precipitation (virga) on several occasions the cloud base could be discerned, and was very high. I estimated it to be between 6,000 and 7,000 feet (near 2,000 metres) at 1400 GMT. Using the diagram, Fig.2 in Burton (1978), the implied humidity mixing ratio would be near 1.9 g kg between cloud and ground, giving a dew-point temperature of -9°C at sea level, and an air temperature of nearly 7°C. With the strong late-March insolation, the screen temperature would easily reach 9°C with a surface-based superadiabatic lapse rate in the first few metres. Widely-reported dew-point temperatures on that afternoon were -5 to -7°C, the slightly higher observed over the theoretical values can be accounted for by the moisture flux from the ground, which was still very wet after several days rain (17mm at Wokingham in the previous three days).

I hope other readers would have noticed these fine clouds on 29th March, standing purple against a crystal clear blue sky, trailing masses of virga, and with many clouds displaying excellent mamma. They might perhaps also have wondered at the accompanying snow flurries falling through high air temperatures.

REFERENCES

BURTON, B. J. (1978): An examination of the mechanism for snow showers at high screen temperatures. *J. Meteorology, 3,* no.25, 7.
MORTIMORE, K. O. (1977): Snow showers at high air temperatures. *J. Meteorology, 2,* no.20, 243.

27 Cantley Crescent, Wokingham, Berkshire. B. J. BURTON

PHOTOGRAPHS OF SPIRAL-CIRCLES FROM 1978 AND 1982

On Saturday 16th August 1986 while awaiting Terence Meaden for the purpose of visiting the anticlockwise circle at Headbourne Worthy together, I made the acquaintance of a farm hand who lives in the village. He showed me photographs that he had taken some years earlier and two are reproduced here.

He gave details of the five sites where he had himself seen spiral-circles on the farm where he works. The first he could remember was a single circle formed in a cereal crop in the summer of 1975. Another appeared nearby the following year. Next, in 1978 at harvest time, he came across a set of five while doing his job of combining. He was so taken aback at what he saw that he insisted his family should come and see the circles for themselves. The photograph in Fig.1 shows his wife and children moving away from the large central circle. The girls in the photograph are now married and have children of their own. This formation was located just west of the railway line and south of the A34 trunk road, grid reference SU 481329. The central circle of the clockwise set was estimated to be 54 feet (16-17 metres) in diameter. The date when the photograph was developed is given on the reverse side (October 1978).

Other circles followed. During 1981 and 1982 single formations appeared. The second figure (2) shows the clockwise circles of 1982 which was 38 feet (12 metres) in diameter. This was in a field on the north side of the A34 at Headbourne Worthy. He added that no-one on the farm had ever witnessed the circles being made. After 1982 the farm had no further new circles until the anticlockwise one of 1986, which has been fully reported in *J. Meteorology,* vol.12, no.116, 44-51.

Fig.1: A 1978 photograph of the central circle of a quintuplet circle set.

Fig.2: A 1982 photograph of a single clockwise spiral-circle.

Andover, Hampshire. Colin ANDREWS

THE ARRIVAL OF SPRING IN TEN DAYS! A REMARKABLE APRIL 1987

After a cold wet March, it was disappointing to find no improvement in the situation during the first half of April. The grass at Mickleover was making rapid progress, but the clay soil had given up absorbing the rain long since, and every footstep to the screen and raingauge was accompanied by a loud squelch with water oozing round the shoes. Even less inspiring was the water lying on the garden adjacent to the lawn - this warranted the digging of a drainage trench to try and take the water away. Would I get the grass cut this month? Over 100mm of rain in 29 days was just too much.

How did this compare with earlier Aprils? The *Weather Log* charts were consulted. 1979 seemed to show a likeness with the 1987 general situation, and things warmed up around mid-month that year.

The writer even planned a short holiday around mid-month with this in mind – anything to get away from the soggy garden!

The development of anticyclonic conditions around mid-April 1987 was almost beyond belief. Returning from a pleasant holiday I found that the garden had dried sufficiently to allow a grass-cutting operation on the 17th, undertaken on a day when the temperature reached 20.9°C – the highest value seen in April for some three years. The second half of April bore no comparison with the first half. Apart from the 20th and 21st, every day from the 15th to the 30th had a maximum temperature in excess of 16°C (61°F), and from the 23rd to the 29th each was above 20°C (68°F). The warmest day was the 29th, at 21.8°C. While no individual maxima broke any records, the duration of this April warm spell has no equal during the 18-year record I have maintained in this area. The mean maximum for the ten-day period from the 21st to the 30th was 19.5°C, comparing favourably with a typical mid-June or early-September mean maximum. This was some 6 degrees C above normal. The mean maximum for the month as a whole came to 15.5°C, which relates closely to 1975 locally and is understood to have been close to 1949 also. An interesting comparison can be made with March at this stage. The improvement in overall mean temperature between the two months was 6 degrees C. From the records I have for this area, there is no comparable value on a record of 31 years.

What a remarkable turn-round. By the 27th April, the lawns were looking neat and tidy again, and the cherry trees in the area were in full bloom. This is probably two to three weeks ahead of schedule, and certainly more than this when compared to 1986. The risk of frost damage to plants after an April such as this must now be great, should we experience a "normal" May. As these notes are written, the immediate prospect is not good, with northerlies from the Arctic regions about to plunge through the country.

Pendlebury Drive, Mickleover, Derby. David J. STANIER

MET. OFFICE FORECASTS ANOTHER SAHEL DROUGHT

The Meteorological Office has sent a forecast of rainfall in the Sahel area of Africa for the coming four months to the Directors of the African Meteorological Services and to the World Meteorological Organisation. The expectation is that, in the Sahel as a whole, rainfall will be similar to, or less than, last year when it was only about 75% of normal.

This is the second year that the Met. Office has issued such a forecast. Last year's prediction proved accurate. The forecast is seen as a contribution to the planning for drought conditions in Africa and has been sent in response to requests from Directors of African Meteorological Services who found last year's forecast valuable. The techniques are experimental and result from research on the response of the atmosphere to anomalous ocean temperatures.

TORRO TORNADO DIVISION REPORT: September and October 1986

September 1986 was a very cool but mostly settled month in Britain. A tornado occurred near Thaxted, Essex, on 3rd, and a funnel cloud in the Isles of Scilly on 18th; there were also two reports of land devils during the month. On the continent, two tornadoes struck the Heemskerk area of the Netherlands on 10th.

TN1986September3. *Thaxted, Essex (TL 595290)*

A "whirlwind" caused damage at Armigers Farm, Thaxted, about 0200 GMT on 3rd September. The farmer, Mr. Ronald Haigh, was woken up by the "terrific noise" of the tornado, which was followed by "a deadly silence". A barn roof was blown 100 metres; a dozen trees and telegraph poles were uprooted, and vehicles in the farmyard were damaged by flying debris, including chunks of wood weighing four or five hundredweight (200-250kg). Force: T2, possibly T3 (*Saffron Walden Weekly News.* 4th September, and information from David Brooks of Anglia Television).

The tornado was on a vigorous cold front which crossed England rapidly during the night of 2nd-3rd September, in association with a secondary low which deepened appreciably as it crossed the north of Ireland and England. At 500mb there was a pronounced trough over the North Sea.

FC1986September18. *St. Agnes, Isles of Scilly (SV 8808)*

A funnel cloud was observed by Mrs. Ethel M. Scott during the afternoon. It lasted for five to ten minutes and then faded away.

A strong anticyclone covered most of Britain, with near-record pressure values for September. At 500mb there was a small low off Brittany. It was a mainly sunny day, but less so in the far S.W. (6 hours sun at Scilly).

NLTN1986September10. *Heemskerk, Netherlands*

Two tornadoes struck an area of glasshouses near Heemskerk about 0610 GMT. An eye-witness reported: "Suddenly I heard the crash of glass outside. I went to the window and was greatly shocked to see, 70 metres away, two black tubes (*slangen,* literally "snakes") descending from the clouds to just above the glasshouses. I was rooted to the spot. The whole thing lasted only about ten seconds. The tubes made some peculiar movements and suddenly dissolved into nothing. Immediately there followed a bombardment of glass fragments falling from the sky, which I at first thought were hailstones". The track was about 100 metres long, from the W.N.W. Force uncertain, probably T2 (Rob Groenland, De duinwindhozen van Heemskerk, *Weerspiegel, 13,* 739-741, October 1986).

The tornadoes were associated with a line of showers ahead of a cold front which was moving very slowly south in the rear of a low over central Sweden (999mb at 1200). The 500mb situation was similar.

Land Devils in September 1986

LD1986September9. *Parkend, Gloucestershire (SO 6107)*

This whirlwind hit a camp site, lifting sun loungers, a barbecue grill and a basket and damaging the awning of a caravan. Tables and chairs were tossed about and some chairs had the back ripped off (*The Citizen,* 10th September, sent by David Brooks of Gloucester, who added that a caravan was partly lifted off the ground).

A ridge of high pressure covered most of the country on this date. The day was sunny but rather cool.

LD1986September11. *Barton-le-Clay, Badfordshire (TL 092305)*

Mr. Mike Williams observed four land devils in a field of burnt stubble. An interesting feature was that each devil had "various 'arms' rotating, as far as one could see, in a clockwise movement". The devils were lifting ash and other burnt particles from the field surface to an estimated height of 60 metres. The four devils moved slowly to the N.W., rapidly disappearing as soon as they moved from the burnt stubble into an arable field.

11th September was a cool, mainly cloudy day in the east Midlands. A ridge covered the whole country.

October 1986 was anticyclonic till 17th, then unsettled. Three whirlwinds were reported: a probable tornado on 19th, a water devil or eddy whirlwind on 24th and a waterspout on 28th.

tn1986October19. *Sparkbrook, Birmingham, West Midlands (SP 0984)*

At least 20 houses in four roads were damaged by this T1-2 "mini-hurricane", which tore off slates and chimney pots and smashed windows (*Birmingham Evening Mail,* 21st October). Although this event was probably a tornado, no conclusive evidence is given in the press report and more information would be welcomed by TORRO.

Britain lay in a fairly strong westerly airstream in the circulation of a complex low near Iceland (966mb at 1200). The 500mb situation was similar. It was a showery day, many of the showers falling as hail, with thunderstorms in East Anglia in the afternoon.

WD1986October24. *Afon Mawddach, Barmouth, Gwynedd (SH 6315)*

A whirlwind moved along the estuary of the Afon Mawddach from W.S.W. for about one minute, covering a distance of about 400 metres. The track was roughly parallel to the shore of the estuary. The prevailing wind in the area was S.W., about force 8 (report by Robin Harper). If this whirlwind had occurred in fine weather in summer one would have called it a water devil, but in view of the date and the weather conditions it seems more likely that it was an eddy whirlwind.

A deep low moved east to be over the southern Hebrides, 966mb, by 2400. The 500mb chart showed a low west of Ireland and a ridge over the North Sea. A belt of rain crossed Wales during the day, preceded and followed by showers.

WS1986October28. *Dublin Bay, Co. Dublin, Eire*

A waterspout was observed on 28th October in Dublin Bay (information from Martin Sweeney). No further details are known.

A cold front passed through the area in the late morning, followed by showery weather. A low (976mb at 1800) was centred near Iceland. The 500mb situation was similar.

Additons to previous reports

WS1982? *Bristol Channel*

Mr. Stephen Canning saw two waterspouts about half way between Milford Haven and Lundy. The wind was westerly, force 5-7, with cumulonimbus and nimbostratus.

FC1982? *Runcorn/Warrington area, Cheshire (SJ 58)*

This funnel cloud was described as "quite a long thin tube which widened a bit at the top before merging with the clouds above. The bottom of it was well above the ground" (Mary Thorp).

WS1983?July? *Berry Head, Devon (SX 9456)*

Mr. M. D. MacKenzie, of H.M. Coastguard, was on watch at Berry Head Lookout when he noticed "a disturbance in the water about two miles north of the Head. The wind was westerly and cloud cover was about 6/8. Eventually the sea formed a circular formation with white horses. The spout developed to a height of six to eight feet and the whole thing moved to the east and appeared to cross Lyme Bay."

This was clearly a fair-weather or devil waterspout as defined by Meaden (*J. Meteorology, 10,* 201, 1985), rather than the more commonly reported and more spectacular tornadic waterspout. Although the great majority of British waterspout records relate to the tornadic variety, it cannot be assumed that it is necessarily more frequent than the devil waterspout. The latter type is much more likely to pass unnoticed: the specimen seen by Mr. MacKenzie would probably not have been recorded if it had not happened to appear within sight of a coastguard lookout. It is noteworthy that Mr. MacKenzie saw another devil waterspout only about a year later from the same spot (see next item).

WS1984?July? *Berry Head, Devon (SX 9456)*

Mr. MacKenzie saw a second waterspout "a year later almost at the same time, but the distance was much greater, and the spout was at least 12 feet (four metres) high. The whole thing, with much more disturbance and much more heavy cloud, moved off to the east. I could follow its track for about ten miles" (15 kilometres).

WS1984?December. *Prestatyn, Clwyd (SJ 0682)*

Two waterspouts were sighted about 1530 in mid December, about 1984. They looked about 15 seconds; their shape was perfectly cylindrical. The weather was overcast and calm, with good visibility (Mr. Hugh Lupton).

FC1985June26. *Birsay, Orkney (HY 2327)*

Mr. Jeremy Godwin saw a funnel cloud which he estimated to be over the Birsay area. It first appeared at 1515 GMT, lasting only for one minute. It reappeared at 1520 and finally disappeared at 1527. There was a light W.N.W. wind. A small low was centred over N.E. Scotland at 1200.

WS1985summer. *Loch More, Highland (NC 3237)*

The first sign of this waterspout was what looked like "a lot of smoke coming from the north shore" of the loch. Mrs. Deidre Mackay said that the spout "was rotating anticlockwise, with the top leading the way across the loch . . . We could see it picking up the water as it went." In a second letter she added: "The sky was quite stormy but it was not raining at the time. The spout was not joined to a cloud."

fc1986March31. *Marden, Kent (TQ 7444)*

A probable funnel cloud was seen at Marden about 1300 GMT. It lasted about 30 seconds and was about three or four miles away to the south. No rotation was visible, even through binoculars. There had been extensive cumulonimbus and large cumulus all day, with strong winds and frequent showers. The funnel was observed and reported by Chris Chatfield. A large low, 993mb, was centred over the North Sea at the time.

TN1986April21. *Camelford, Cornwall (SX 1083)*

This tornado, reported by Mr. Derek Bogle, struck at 1005 GMT after a heavy fall of hail. It went very dark and there was a sudden roar, which lasted only a few seconds. Mr. Bogle described the passage of the tornado as being "like a jet fighter flashing over at roof-top height". Eight ridge tiles and number of slates and lumps of concrete were dislodged from the roof of Mr. Bogle's house. The two adjacent houses to the north were also damaged, but the houses either side of the three damaged ones were untouched. Force: T1. A barograph showed a fall of 0.04 inches (1.3mb) at the time of the tornado. Pressure was low over and to the west of

Britain. The tornado appears to have been on a trough which passed through Cornwall in the morning.

WW1986July31. *Fareham to Titchfield, Hampshire (SU 5806-5305)*

A "mini-whirlwind" lifted glass cold frames at Titchfield after damaging roof tiles at Fareham (*Monthly Weather Report,* July 1986). The T1 damage suggests either a weak tornado or a strong land devil. If the damage at both places was caused by the same whirlwind it cannot have been an ordinary land devil. On the other hand, if it was a tornado one might have expected more powerful cloud development in the area; there were only a few light showers during the day, most of which did not produce measurable rain. It is conceivable that the whirlwind formed on a sea breeze front. A low was off eastern Scotland, 995mb, at 1200. A trough covered Britain at 500mb.

FC1986August19/I. *Lundy, Bristol Channel (SS 1445)*

"On the 19th the Lundy South lighthouse on Lundy Island at the mouth of the Bristol Channel reported funnel clouds" (*Monthly Weather Report,* August 1986). Britain was in a rather slack N.N.W. airstream between a ridge to the west of Ireland and a complex low over Scandinavia and eastern Europe, while at 500mb a trough covered the country. The Bristol Channel area was largely dry, with a good deal of sunshine.

FC1986August19/II. *Hepple, Northumberland (NT 9800)*

A funnel cloud was seen by Prof. Malcolm Newson about 1440 GMT. The funnel, which was N.W. of Hepple, was moving in a N.E. direction. The area had rain or showers during the day.

Corrections to report for July and August 1986

The grid reference of Barmouth (FC1986July23) is SH 5815. The land devils at Borstal and Burnham-on-Sea were on 9th August, not 19th.

M. W. ROWE, G. T. MEADEN

WORLD WEATHER REVIEW: March 1987

United States. *Temperature:* mostly warm; +5 deg. in E. Minnesota and W. Wisconsin. Cold in S. from S. Utah and E. Arizona to Mississippi Delta; S.E. Virginia to N. Florida; -3 deg. in W. Texas. *Rainfall:* wet in W. half (except much of S.W.); S. Louisiana, Florida to coastal S. Carolina; N.E. North Carolina, Connecticut to Maine. Over 200% in C. California, C. Nevada, E. Utah, W. Wyoming, N.E. Washington to N.W. North Dakotas; S.E. South Dakota to much of Kansas; W. Texas; most of Florida. Dry in E. and much of S.W.; under 50% in a narrow band from E. Texas to Kentucky then N. to Michigan and N.E. to E. Pennsylvania; N. Wisconsin, S.E. California, S.W. Arizona, much of New Mexico.

Canada and Arctic. *Temperature:* warm in Alaska, most of Canada, extreme N.E. Greenland, Jan Mayen, Spitzbergen, Bear Island; +5 deg. in W. Alaska, S. Saskatchewan, Manitoba, W. Ontario. Cold in S. Yukon, Canadian Arctic islands, N. Quebec, Greenland, Franz Josef Land; -3 deg. in S. Baffin Island; -5 deg. in Franz Josef Land. *Rainfall:* wet from British Columbia to Saskatchewan and most of Northwest Territories; N. Ontario, E. Greenland, Jan Mayen. Over 200% in S. Canada near Montana border; Keewatin area. Dry from Alaska to N. British Columbia and Victoria Island; S. Ontario through Quebec and most of Maritime Provinces to S. Baffin Island and most of Greenland; Bear Island, Spitzbergen and Frans Josef Land; mostly under 50%.

South and Central America. *Temperature:* warm in N. and C. Chile, most of N. and part of C. Argentina; Uruguay, extreme S. Brazil, extreme W. Bolivia, extreme S. Mexico to Honduras; Mexico City area; +2 deg. near Buenos Aires. Cold in Paraguay, most of Bolivia, part of C. Argentina, much of S. Brazil, most of Mexico; -2 deg. in N. Paraguay and much of N. Mexico. *Rainfall:* wet in C. Chile, C. and N.E. Argentina, N. Uruguay, N. Paraguay, E. Bolivia, extreme S. Brazil, S. Mexico to N. Honduras (except Pacific coast); extreme N.E. Mexico, Bahamas. Over 200% at least locally in all these areas (except perhaps Bahamas), especially C. Argentina and from Yucatan to N. Honduras. Dry elsewhere 15-40°S.; from N. and W. Mexico along Pacific coast to S. Honduras. Under 50% in N.W. Argentina, S. Paraguay, S. Brazil, N.W. and W. Mexico to S. Honduras.

Europe. *Temperature:* warm in N.E. European Russia, Portugal and most of Spain; +2 deg. locally in Portugal and S. Spain; +4 deg. in N. Urals. Cold elsewhere; -2 deg. over most of Europe; -4 deg. in N. Denmark, S. Sweden and from W. Germany and extreme N.E. Italy to Greece and lower Volga Basin; -6 deg. in Crimea and E. Ukraine. *Rainfall:* wet from Faeroes and British Isles through N. France, Low Countries, S. Sweden, extreme S. Norway and Denmark to W. Germany, Austria, Hungary, E. Czechoslovakia, most of E. Italy; Jugoslavia, Greece (including Crete), W. Romania, S.E. Poland and S. half of European Russia; in and near N. Finland. Over 200% in N. Scotland, N.E. France, S. Sweden, N.W. Germany, C. Austria, S.E. Italy, E. Czechoslovakia, S.E. Jugoslavia, E. Greece; locally in S. European Russia. Dry elsewhere; under 50% in much of Norway, most of Portugal and Spain; S.E. France, N. and W. Italy, N.W. Poland, C. Czechoslovakia, N.W. coastal Jugoslavia, E. Bulgaria, N.E. Romania, large area from near Leningrad to most of Urals. Provisional sunspot number 15.

Africa. *Temperature:* mostly warm in and around South Africa and N. of Sahara (except N.E. Algeria to Nile Delta; -1 deg. widespread); +2 deg. from C. Morocco to W. Algeria; E. Namibia, N. Cape Province, E. Botswana to W. Mozambique. *Rainfall:* wet very locally from Morocco to N. Tunisia; Tenerife, Nile Delta, S.E. Botswana to W. Natal; over 200% in S.W. Natal. Otherwise dry N. of Sahara (mostly under 50%) and in and near South AFrica (under 50% in Namibia and W. Cape Province).

BRITISH WEATHER SUMMARY: April 1987

April 1987 was a warm month, the warmest for a considerable number of years, with mean temperatures ranging from around one degree C. above the normal in west Scotland to near three degrees above in many parts of England. St. Helier (Jersey) recorded 23.5°C as early as 17th and during the last week of the month temperatures approached summer values quite widely. At Costessey (Norfolk) 24.4°C was recorded on 29th with 24.3°C at the Norwich Weather Centre, and values above 23°C were widespread between 24th and 29th. In Wales 24°C was reached near western coasts on 28th, and Inverdruie, near Aviemore, recorded 23.7°C on 29th. Apart from 13.2°C at Barry (south Wales) on 26th highest minima were reported on 29th and 30th with 12.9°C at Hastings (East Sussex) and Ringway (Greater Manchester), and 13.8°C in central London, all on 29th and 10.5°C at Inverdruie on the latter day. Despite the overall warmth of April, temperatures were very much on the cold side at the start of the month. The 2nd was a particularly cold day with maxima of 1.7°C at Aviemore and 2.0°C at Inverduie (Highland); even on Exmoor Exford recorded only 4.0°C. At High Bradfield (South Yorkshire) the maximum was only 2.9°C. At Salsburg near Glasgow the highest maximum throughout the six-day period 3rd to 8th was just 4.0°C. On 11th Fylingdales in North Yorkshire recorded 3.3°C. Air frost was also a problem early in the month. In Scotland the temperature fell to -4.3°C at Aviemore and Inverdruie (Highland) on 7th and to -4.2°C at Tummel Bridge (Tayside) on 12th. Over England -1.4°C was recorded at Hurn (Bournemouth) and -1.3°C at Boscombe Down (Wiltshire), both on 2nd. Lowest grass minima included -9.8°C at Glenlee (Dumfries and Galloway), -8.6°C at Straide (Co. Mayo) and -6.3°C at Birmingham University, all on 12th. On 2nd the grass temperature fell to -7.8°C at

Cwmbargoed (Mid Glamorgan) and to −7.1°C at Velindre (Powys); even as late as 23rd −5.0°C was recorded at Beaufort Park, Bracknell. April began very wet with the first ten-days producing well over the month's average rainfall in many places, particularly in the south-west and north-east of England. Some places had as much as two and a half times the average for the whole of April. In contrast, west Wales, north-west England, western Scotland and Northern Ireland all reported below normal totals, as did the south-eastern corner of England. The 2nd was the wettest day of the month in the south-west with 49.0mm at Okehampton, 47.5mm at Exeter and 42.2mm at Denbury, near Newton Abbot. On 4th many parts of Wales and the west Midlands were very wet with falls approaching 30mm quite widely. On 10th 30.5mm fell at Dyce (Aberdeen). Considerable accumulations of snow were reported in the Highlands of Scotland early in the month and by 12th the best overall snow-cover of the winter was reported on the Cairngorms followed by a two-metre thaw in just two weeks. Large diurnal temperature ranges at Inverdruie (Highland) during April included 24.9 degrees (−3.6°C to 21.3°C) on 17th and 23.3 degrees (−1.0°C to 22.3°C) on 25th. Following a maximum of 23.7°C on 29th the highest recorded at Inverdruie on 30th was only 16.5°C and by midnight the temperature had fallen to 1.9°C with the rain turning to sleet. By the morning of 1st May 3.5cm of snow had fallen.

England and Wales had a wet day on 1st, as a depression transferred slowly east across the country, and from 2nd to 7th, with pressure persistently low to the south-west, troughs moving north-east into the British Isles gave frequent spells of rain, heavy in many places, particularly in the south-west and north-east of England while northern Scotland largely escaped. Showers or longer spells of rain continued to affect many parts of Britain until 10th, although by this time the centre of low pressure had transferred to between Scotland and Iceland, but during 11th and 12th as a ridge of high pressure crossed the country there was sunshine in many places. Weak frontal systems crossed the British Isles from the Atlantic on 13th but rising pressure then turned the weather much drier in all parts and by 17th (Good Friday) it had become very warm. The Easter weekend was mostly settled although a weak front crossed the country during the 18th/19th giving a little rain, mainly in the west and north, and lower temperatures. A further spell of dry, sunny weather set in on the 20th as an anticyclone became established to the north and east but a breakdown threatened southern parts on 25th and after two more sunny, warm days thundery rain and thunderstorms crossed the British Isles on 29th. During 30th a cold front moved into the U.K. from the north-west bringing much colder conditions to Scotland and there was snow late in the day over some of the higher mountains.

K. O. M.

TEMPERATURE AND RAINFALL: APRIL 1987

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*D*	*T*
AUSTRIA: Innsbruck	16.8	4.8	26.9(29)	−1.4(2)		36.4		11.5(10)	12	0
BELGIUM: Uccle	16.4	7.1	24.6(24)	3.0(1)	−2.1(1)	22.5	43	6.7(11)	15	–
" Rochefort	16.0	2.2	24.2(24)	−5.4(1)		45.8	77	12.7(25)	12	–
" Houwaart	18.6	4.1	27.6(25)	−2.4(1)	−5.8(1)	19.8	32	5.6(12)	10	2

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*D*	*T*
DENMARK: Fanø	10.1	3.7	21.3(29)	−0.3(12)		22.6	59	5.5(20)	9	0
" Frederikssund	11.1	2.4	21.5(30)	−3.0(1)	−6.6(19)	41.6	111	21.5(20)	11	0
GERMANY: Berlin	14.4	4.8	27.1(30)	0.5(1)	−2.4(1)	40.1	95	13.1(5)	13	0
" Hamburg	13.9	4.4	25.5(29)	−2.2(1)	−3.3(14)	67.9	144	22.7(30)	14	3
" Frankfurt	16.9	4.6	25.4(25)	−1.1(14)	−3.9(2)	15.8	34	5.7(11)	13	3
" Munchen	14.6	3.2	22.7(30)	−4.8(2)	−7.5(2)	67.0	92	22.6(9)	16	2
GREECE: Thess'loniki	18.2	9.0	24.8(19)	4.8(29)		88.4		36.4(1)	13	0
ITALY: Casalecchio	18.3	8.7	23.0(30)	2.0(2)	1.0(2)	85.1	180	30.5(10)	6	3
MALTA: Luqa	19.2	11.3	25.1(6)	7.0(17)	2.2(17)	17.9		8.9(13)	4	3
NETH'L'DS: Ten Post	14.3	5.2	26.7(29)	0.2(1)		22.6	46	5.8(12)	8	1
" Schettens	13.7	4.8	23.0(29)	1.7(1)		16.3	35	4.4(11)	7	1
" De Bilt	15.8	5.4	24.4(29)	0.5(1)	−2.6(1)	44.0	84	11.6(12)	10	2
" Lemmer	14.2	5.0	25.6(29)	0.9(1)	−0.2(1)	21.5	42	8.6(12)	8	1
SWEDEN: Valla	10.0	−0.2	24.4(30)	−6.9(9)		9.0		3.9(20)	9	0
SWITZ'LAND: Basel	17.4	5.1	26.3(29)	−2.6(1)		56.3	102	24.0(9)	11	2
EIRE: Galway	13.8	6.8	21.6(28)	1.1(2)		62.3	98	10.8(4)	18	–
" Straide	13.7	6.0	21.0(28)	−2.2(12)	−8.6(12)	43.5	68	12.0(30)	14	1
SHETL'ND: Whalsay	9.4	4.8	13.2(23)	0.7(1)	−2.9(1)	33.8	60	9.7(30)	11	0
" Fair Isle	8.4	5.0	11.9(28)	1.7(2)	−2.4(1)	36.4	85	9.4(1)	10	0
SCOTL'ND: Braemar	11.3	1.6	21.0(28)	−3.0(12)	−4.4(12)	57.4	104	16.0(30)	15	0
" Inverdruie	13.3	1.8	23.7(29)	−4.3(7)	−8.2(7)	51.0	89	20.4(30)	9	0
" Edinburgh	12.3	4.8	22.9(27)	−1.5(12)		59.0		13.8(8)	13	0
WALES: Pembroke	14.3	5.8	21.8(26)	1.6(12)	−1.5(12)	68.8	206	16.3(2)	15	0
" Velindre	14.5	5.5	20.7(28)	−1.6(2)	−7.1(2)	90.9	165	25.9(4)	14	1
" Gower	13.6	6.9	21.0(28)	1.5(12)	−3.0(12)	78.9	125	13.9(3)	16	0
GUERSEY: Airport	13.4	7.5	20.8(28)	3.0(2)		58.7		19.8(6)	11	0
ENGLAND:										
Denbury, *Devon*	14.3	4.9	20.2(27)	0.2(2)	−6.2(12)	109.9	254	42.4(2)	16	1
Bournemouth, *Dorset*	13.8	6.3	21.1(24)	1.2(2)	−3.2(2)	63.3	128	19.8(3)	11	1
Gurney Slade, *Somerset*										
Yatton, *Avon*	16.0	5.6	23.7(28)	−0.2(2)	−3.4(2)	57.2	100	10.7(4)	14	0
Bradford-o-Avon, *Wilts*	15.9	5.3	23.4(28)	−0.5(8)		64.2	146	14.8(4)	12	1
Corsham, *Wiltshire*	15.3	5.8	23.1(28)	−0.7(2)		68.2	139	14.7(4)	14	2
Reading, *Berkshire*	14.9	6.1	22.6(24)	1.0(2)	−2.5(2)	51.9	134	14.0(4)	11	1
Sandhurst, *Berkshire*	15.5	4.8	23.9(28)	0.5(10)	−1.2(10)	48.6	95	15.6(6)	11	1
Romsey, *Hampshire*	15.6	4.5	23.9(28)	−1.6(2)		72.3		14.7(4)	12	1
Horsham, *Sussex*	15.1	5.7	23.5(27)	1.0(5)	−1.6(5)	66.1	138	20.4(1)	11	2
Brighton, *Sussex*	14.6	6.9	23.9(24)	2.0(12)		63.4	133	14.1(6)	12	1
Hastings, *Sussex*	–	–	22.4(24)	3.3(15)	−1.6(–)	40.2	103	–	–	1
Dover, *Kent*	15.0	5.7	21.7(29)	0.5(13)		36.7	80	11.7(1)	12	2
East Malling, *Kent*	15.5	6.0	22.9(29)	1.0(14)	−3.0(3)	40.6	91	11.4(1)	9	1
Epsom Downs, *Surrey*	15.5	5.7	23.4(28)	1.9(13)	−1.6(13)	45.2	91	13.0(1)	9	2
Reigate, *Surrey*	15.8	5.4	23.8(24)	1.5(v)		49.6	108	16.5(6)	9	2
Guildford, *Surrey*	15.3	6.3	23.3(24)	1.6(2)	−0.9(2)	56.1	127	10.8(6)	10	1
Sidcup, *London*	16.1	6.4	24.0(26)	0.9(5)	−2.0(5)	40.9	97	10.3(6)	9	2
Hayes, *London*	15.6	6.1	23.2(28)	2.1(5)	−2.1(5)	43.2	100	12.8(6)	10	0
Hampstead, *London*	15.2	6.1	22.1(29)	1.2(12)	−1.6(12)	46.2		13.4(1)	10	1
Royston, *Hertfordshire*	15.4	7.0	22.7(29)	2.6(2)	−2.6(13)	36.7	92	10.3(1)	11	1
Loughton, *Essex*	15.6	6.0	21.9(29)	1.4(5)	−2.7(5)	43.2	95	13.9(1)	10	3
Leigh-on-Sea, *Essex*	15.9	6.5	23.8(29)	1.0(13)	−0.1(10)	32.2		9.6(1)	9	2
Pulham St.Mary, *N'folk*	14.8	5.2	24.0(29)	−0.5(13)	−4.3(13)	39.1	100	11.5(1)	14	0
Buxton, *Norfolk*	15.6	4.9	23.9(29)	0.0(13)	−2.9(13)	43.8	91	16.3(1)	11	1
Ely, *Cambridgeshire*	15.4	5.1	23.0(25)	1.4(13)	−1.6(13)	40.3	111	17.1(1)	13	1
Luton, *Bedfordshire*	15.4	6.3	23.6(28)	1.9(12)	−2.2(13)	47.7	105	10.7(4)	11	1
Buckingham, *Buck'shire*	15.2	5.5	22.2(28)	0.2(12)	−3.3(12)	52.5	104	15.0(7)	12	0
Oxford University	15.2	6.5	22.5(28)	0.8(2)	−1.6(13)	51.5	120	12.5(4)	14	0

	Mean Max	*Mean Min*	*Max*	*Min*	*Grass Min*	*Rain*	*%*	*Wettest*	*D*	*T*
Stourbridge, *W.Midla'ds*	15.1	6.5	21.4(28)	–0.2(12)	–6.3(12)	63.0	114	21.0(4)	11	0
Birmingham Univ'sity	14.7	6.0	21.2(28)	1.8(10)	–1.6(10)	79.9	152	25.6(4)	13	2
Kettering, *North'shire*	15.4	5.2	22.1(29)	1.2(5)	–2.5(10)	57.7	111	17.1(7)	13	1
Louth, *Lincolnshire*	14.2	5.3	22.4(29)	1.7(3)		51.5		16.4(1)	14	2
Nottingham, *Nott'shire*	15.8	5.8	23.6(28)	2.4(2)	–0.8(7)	51.9	128	18.0(7)	9	2
Middleton, *Derbyshire*	12.1	5.3	18.2(28)	0.3(2)		70.1	104	19.6(7)	15	2
Mickleover, *Staff'shire*	15.1	5.8	21.8(29)	1.0(11)	–2.7(12)	54.4	124	15.9(7)	11	1
Keele University, *Staffs*	13.7	5.3	20.6(17)	0.4(10)	–3.5(10)	45.9	83	9.9(7)	12	0
Liverpool, *Merseyside*	15.2	5.7	23.3(25)	–0.6(12)		51.3	100	11.5(4)	13	0
Lathom, *Merseyside*	14.3	6.5	21.8(27)	2.4(2)		49.4		10.3(6)	10	0
Huddersfield, *W.Yorks*	13.4	5.4	21.1(17)	0.0(2)	–3.3(12)	67.9	117	21.0(7)	12	1
Sheffield, *S.Yorkshire*	14.8	6.0	22.1(28)	1.2(2)	–1.2(12)	61.6	101	22.5(7)	11	1
High Bradfield, *S.Yorks*	11.6	5.1	18.7(29)	–0.1(2)	66.3			18.6(7)	13	–
Cottingham, *Humb'side*	14.8	5.5	23.4(29)	1.9(2)	–1.3(10)	59.4	114	15.7(1)	12	3
Carlton-in-Cleveland	14.0	5.7	21.9(26)	0.2(2)	–1.2(12)	48.3		17.8(1)	14	1
Durham University	13.5	5.0	20.7(27)	0.5(2)	–3.0(10)	59.4	129	15.0(7)	13	–
Sunderland, *Tyne/Weir*	12.7	6.1	22.8(27)	0.8(2)		65.9	157	15.3(7)	15	1
Carlisle, *Cumbria*	12.9	5.6	22.6(28)	–1.4(12)		42.5	89	11.6(7)	–	–
CAN'DA: Halifax, *NS*	9.3	1.0	21.5(19)	–3.0(28)		96.2	96	23.0(29)	16	0
" Wolseley, *Sask*	16.6	0.9	28.5(28)	–14.0(10)		10.7		4.3(8)	–	–
" Vanderhoof	12.7	–0.2	21.5(27)	–6.0(18)		30.5		22.3(30)	–	–
U.S.: Bergenfield, *NJ*	16.8	6.0	25.0(11)	–2.2(2)	–3.3(1)	139.7		72.2(4)	10	1
" San Diego, *CA*	23.7	12.2	33.0(21)	8.5(2)		10.2		7.1(4)	–	–
" Colorado Spr's	17.9	0.8	27.4(26)	–8.0(2)		10.9		5.3(12)		
" Boston, *Mass*	12.2	5.2	22.3(11)	–0.5(2)		240.0		60.2(5)		
" New York C'y	16.4	5.2	26.7(20)	–1.5(2)		125.5		62.7(4)		
" Durham, *NC*	21.1	8.0	32.2(30)	–3.3(1)		134.1		45.5(15)		
" Columbus	16.9	3.9	30.5(21)	–7.2(2)		35.6		9.1(5)		
" Milwaukie	19.1	6.8	30.5(27)	1.1(20)		67.8		21.1(17)		
" Galveston, *Tx*	25.6	14.2	32.2(28)	3.5(3)		5.1		3.8(2)		
" Virginia Be'ch	17.6	9.2	26.7(12)	3.3(1)		86.4		12.8(1)		
AUSTR'LIA: Leopold	21.1	10.0	30.1(5)	3.6(21)		26.6	53	9.0(29)	7	1
" Mt. Waverley	21.0	11.3	30.3(6)	4.8(9)		48.2		11.8(7)	10	1

CUMBRIA RAINFALL: Broadfield, 42.8mm (93%); Seathwaite, 131.0mm (70%); Honister, 143mm; The Nook, Thirlmere, 105.4mm (75%); Sellafield, 54.0mm (92%); Coniston, 103.8mm (70%); Hawkshead, 65.2mm (59%); Kendal, Kirkbie S., 64.9mm (81%).

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