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THE WEATHER OF 1987

Temperature *and rainfall values referred to in the following relate to Stirling (Parkhead) unless otherwise stated.*

Scotland was certainly the place to be during 1987. England and Wales had snowstorms in January, severe floods, and the destructive October storm. 1987 in Scotland was a comparatively unexceptional year after the brief period of severe snowfall in January. After a generally cool and wet spring, and a traditionally damp summer, autumn was mild and lasted well into November. The frost-free season, between the last air-frost of spring (12th April) and the first of autumn (23rd October) was exceptionally long.

January. Very cold and heavy snow.

A complex depression and associated fronts brought rain in a cold south-easterly wind on the 1st, the wettest day of the month. High pressure developed to the west of the British Isles after the 2nd resulting in a spell of cold dry weather. Temperatures increased overnight between the 3rd and 4th as fronts moved south-eastwards across Scotland but the temperature began to fall again in a strong showery north-westerly wind on the 5th. High pressure dominated the weather until the 8th bringing very low night temperatures. As pressure began to increase to the north and north-east of Scotland a fresh to strong easterly airstream brought fine drifting snow from the 10th. The snowfall increased in severity over the next four days bringing general paralysis to road and rail. By the 14th the snow was 30 cms deep on low ground drifting to a metre or more. On the 16th a warm front began to make very slow eastwards progress across Britain bringing a slow thaw. However it was not until the 20th that the thaw reached south-east England by which time conditions had become exceptionally severe. An anticyclone dominated the weather from the 21st until the end of the month. Frosts were frequent and visibility generally poor with fog patches. The deeper snowdrifts, by now very dirty, were still in evidence at the end of the month.

February. Mild and wet, becoming colder

As high pressure retreated slowly eastwards into Europe, night frosts

gave way to mild wet weather as fronts approached from the west. Rain falling on cold road surfaces on the 2nd and 3rd resulted in black ice. As a ridge began to extend eastwards across Britain after the 3rd Scotland was brought into an unsettled but mild westerly airstream. From the 8th a complex area of low pressure and associated frontal troughs drifted eastwards and filled bringing at first some rather dull and wet weather with snow on higher ground, but clearer conditions after the llth. The 9th was exceptionally wet (20.1mm). High pressure dominated the weather until the 24th when vigorous Atlantic cyclonic systems moved in from the west again. The llth to 18th were bright and sunny with moderate night frosts (-5.2°C on 15th). A weak frontal trough moved slowly south-eastwards across Scotland late on the 18th bringing cloud and an overnight fall of light snow. The weather remained cloudy and as a cold front crossed from the north-east further light rain fell on the 22nd. After the 24th, as pressure fell, the weather was more unsettled but temperatures rose quickly in a mild south-westerly airstream on the 28th (maximum 13.8°C) which was the warmest February day in England since 1961, exceeding 16°C in southern counties.

March. Cold and wet.

A shallow depression with active frontal systems moved to the west of Scotland on the 1st bringing heavy and continuous rain (17.3mm) and strong winds. As pressure increased from the south-west on the 2nd the temperature fell in a cold north-westerly wind. As high pressure drifted slowly eastwards frontal systems brought rain from the west which turned to snow in the late evening of the 3rd (5cms in Stirling). With high pressure established over Scandinavia complex frontal systems became almost stationary over the British Isles from the 5th bringing heavy and continuous rain which began to turn to snow. On the 7th sleet and snow fell in a bitterly cold south-easterly wind, daytime temperatures rising to only 2.9°C. On the 8th a ridge of high pressure extended across Britain from the east which gradually cleared the skies and brought some glimpses of the sun by the 10th. Under clear night skies there were moderate night frosts on the llth and 12th but daytime temperatures were much improved. Frontal systems crossing south-eastwards on the 13th heralded more unsettled weather which dominated the remainder of the month. As pressure increased to the west of Scotland on the 17th the winds went round to a more northerly quarter and sleet and snow affected parts of the British Isles over the next few days. The high gave way to complex frontal troughs on the 21st with wet but milder weather. A vigorous depression approached from the south-west on the 26th and deepened very quickly as it crossed the British Isles, pressure falling to 956mb in Stirling. Heavy rain (25.9mm) fell in gale force winds on the 26th and 27th which resulted in storm damage and some deaths over Britain. In the wake of the storm winds were generally fresh north-westerly. Frontal troughs brought further rain after the 29th.

April. Mild and wet, becoming drier.

As an area of low pressure drifted southwards and deepened the weather remained dull with light rain in a freshening easterly wind until the 5th. The low filled as it drifted northwards but rain continued to fall from a northwards moving front. As pressure increased to the south-west, the British Isles were brought into an unsettled period dominated by Atlantic weather systems. Heavy rain on the 10th (23.0mm) fell as snow on higher ground. The weather became more settled as a ridge of high pressure extended north-eastwards across Scotland on the llth and 12th but rain returned late on the 12th. High pressure returned on the 14th to dominate the weather for the next four days. A fresh westerly wind decreased slowly and the 17th was calm and sunny (15.6°C). Early morning fog on the 18th cleared slowly in a freshening south-easterly breeze as pressure began to fall from the west. Rain fell on the 18th and 19th. An anticyclone over continental Europe controlled the weather until the 28th bringing early mists clearing to hot sunny days. The temperature reached 22.2°C on the 28th. A cold front moving south-eastwards on the 30th brought rain in the late evening.

May. Cool but dry.

While pressure was high to the west of the British Isles winds were cold clear north-westerly for the first four days. As the anticyclone moved eastwards wind speeds increased and daytime temperatures improved. The 7th was a sunny and warm day (17.8°C). Pressure again began to increase to the west and by the 9th cold north-westerly winds had returned. Shallow depressions and associated fronts brought occasional rain between the 10th and 15th. Winds gradually veered northerly and the weather remained dull until the 19th when skies cleared behind a southwards moving weak front. The 20th was warmer than previous days (19.0°C) but felt cold in the fresh northerly breeze. As the anticyclone moved towards Iceland after the 21st the winds veered north-easterly and the next six days were grey and cold. A vigorous depression and associated fronts which moved in from the west on the 29th returned winds to a warmer quarter but brought continuous heavy rain (11.5mm on the 29th) followed by showers.

June. Cool, cloudy and wet.

A series of Atlantic lows and fronts brought unsettled weather for the first seven days. A vigorous depression moved across Scotland on the 5th and 6th depositing 38.6mm of rain during less than 48 hours, with occasional claps of thunder. A cool and moderately dry north-westerly airstream developed in its wake but unsettled weather returned on the 10th as a shallow low persisted over the British Isles and the North Sea until the 15th. Heavy showers occurred during this period some of which fell as hail.

While pressures remained low over Scandinavia visibility was excellent in the cool polar air and the days 16th to 19th were sunny. As a warm front approached from the south-west on the 21st visibility deteriorated and rain began to fall in the late evening. The 22nd and 23rd were dull wet days with continuous light rain as a shallow low formed to the north-west of Scotland. The weather remained unsettled for the rest of the month but, apart from rain on the 27th, was generally dry with occasionally long sunny periods. A warm front which brought rain late on the 27th also imported warm tropical air and the last three days of the month were very mild.

July. Warm with unsettled periods.

As pressure increased from the south, the weather was generally settled for the first nine days although light showers fell on the 1st and 3rd. Daytime temperatures reached 24.5°C on the 5th and 6th. As high pressure retreated south on the 8th a cool northerly breeze lowered temperatures and by the 9th fronts were approaching from the west bringing overnight rain. The weather in England remained settled for a few more days but as a broad low drifted slowly south-eastwards from Iceland generally unsettled weather affected most of Britain after the 14th, which was the wettest day of the month (9.4mm). The low persisted until the 20th when it moved to the Low Countries and filled. As a ridge of high pressure lay over Scotland the 21st to 25th were again sunny and warm. As high pressure drifted south-westwards after the 26th more changeable weather returned for the remainder of the month.

August. Cloudy cool and wet.

With high pressure over the Atlantic and low pressure over Scandinavia Scotland experienced a cool northerly airstream during the first six days. Night-time temperatures fell below the seasonal average (3.5°C on the 5th). Weak fronts brought thundery showers to southern England and a waterspout was observed off the Isle of Wight on the 6th. The Scandinavian low began to drift westwards and fill on the 6th bringing light overnight rain after which the weather became warm and sunny until the 10th. Atlantic lows brought rain after the llth, which was heavy at times. 30.0mm was recorded on the 15th. Southern England became very warm with heavy thundery rain and floods on the 22nd and 23rd (82.7mm in Birmingham). Temperatures reached only 21.0°C at Stirling University although 23.9°C was recorded in Bridge of Allan. High pressure extended briefly across Scotland on the 24th which was sunny and warm. Although high pressure affected much of the British Isles the weather remained unsettled for the rest of the month with occasional rain and sunny periods. A vigorous depression to the north of Scotland brought a further 17.4mm of rain to Stirling late on 31st. September. Unsettled at first becoming dry.

A ridge of high pressure extended northwards across Britain bringing a warm and dry first three days. Eastwards moving depressions to the north of Scotland and their associated fronts dominated the weather until the 14th when pressure began to increase from the south-east. A vigorous and deepening depression brought stormy conditions with sleet and hail between the 10th and 12th. While pressure remained high the days 15th to 17th were relatively dry but as the anticyclone retreated eastwards unsettled weather with some sunny periods returned until the 24th. An anticyclone to the west moved slowly eastwards across Britain to bring a period of fine autumnal weather between the 24th and 29th. However, night-time air temperatrues fell sharply, almost reaching freezing point (0.3°C on 27th).

October. Cool and wet.

A ridge of high pressure extending eastwards from the Baltic kept Scotland in a run of dry easterly winds associated with generally poor visibility for the first three days. Fronts moved south-eastwards across Scotland on the 5th and 6th bringing rain (15.9mm). A deepening depression crossed northern Scotland on the 7th and 8th bringing heavy rain (17.2mm) and strong winds. With complex areas of low pressure dominating the weather map conditions in Scotland remained generally changeable until the 21st. The most noteworthy events during this period were the vigorous depressions which affected England and Wales between the 15th and 17th. A rapidly deepening depression approached Britain from the south-west on October 15th which crossed the English Midlands in the early hours of the 16th. Winds gusting to hurricane force caused considerable damage (See Notes 2). Another depression following in its wake brought rain which was heaviest in Wales where there was severe flooding. Further heavy rain and floods in England and Wales on the 21st were followed by somewhat more settled weather under the influence of high pressure. The first autumnal night frosts occurred under clear night skies (-3.4°C on 23rd) although these were restricted to lower ground. A slow moving frontal system lay over Scotland on the 25th, 26th and 27th bringing heavy rain. Night frosts returned on the 29th as skies cleared again.

November. Mostly dull; unsettled mid-month.

High pressure dominated the weather in Scotland for the first seven days. Although mild, the weather was dull with poor visibility. After the 8th high pressure drifted eastwards to be replaced by depressions and associated fronts which brought changeable but generally wet weather until the 19th. As a deep depression crossed northern Scotland on the llth and 12th winds became strong with driving rain (48 hour total 18.9mm). Pressure increased to the west of the British Isles from the 21st bringing in

cold northerly air. Air temperatures fell over the next seven days reaching a maximum of only 0.2°C and a minimum of -4.5°C on the 26th. As a ridge extended northwards across Britain the weather became cold and grey with mist and fog on the 27th and 28th. A weak front brought a brief period of rain on the 29th but improved visibility. The weather was bright and sunny on the 30th with high pressure centred over Scotland.

December. Dry and cold at first, becoming wet and very mild.

High pressure dominated the weather map for the first two weeks. After a relatively clear day on the 1st, a cloudy easterly airstream kept the weather cold and dull until the 6th when a cold front advanced southwards across Scotland importing colder clearer air. Temperatures remained very low until the 14th with night frosts. Light rain fell as a weak frontal system moved in from the east during the afternoon of the llth, which ameliorated overnight temperatures a little. However, on the 13th daytime temperatures rose to only -0.7°C after an early morning minimum of —6.5°C. High pressure retreated quickly eastwards on the 15th and by the early hours of the 16th the temperature had risen several degrees. Frontal systems and a fresh south-westerly airstream ensured that the weather remained wet and unseasonally mild for most of the remainder of the month. As pressure rose briefly on the 22nd the weather became calmer and colder but rain returned on the 23rd as high pressure drifted eastwards. After a Christmas Day which was pleasantly mild and sunny, rain fell on every remaining day of the month. The rain was at times very heavy and associated with fresh to strong winds from a southerly quarter. 18.3mm fell on the 27th, the month's wettest day and by the 28th there was moderate local flooding. 1987 bowed out with a wild and wet Hogmanay.

DATA SOURCES

Stirling (Parkhead) Grid Reference: NS 815 969
Height above sea-level: 35 metres Established: 1970
Aspect: South-east Shelter Index: 33.2 (Slightly sheltered)
Location: University gardens at the north-east corner of the campus.

Monthly returns of daily (0900 to 0900 GMT) observations are submitted to the Meteorological Office and the Climatological Observers Link. Data are published occasionally in the Journal of Meteorology. Missing temperature data are estimated using observations from Westerlea Drive Bridge of Allan (S. J. Harrison). During 1987 a ground-level raingauge and 2m run-of-wind anemometer were installed. These are read on Mondays.

Ochil Hills (Carim) Grid Reference: NN 864 049
Height above sea-level: 332 metres Established: 1980
Aspect: North-west Shelter Index: 16.6 (Exposed)
Location: The upper catchment of the Burn of Ogilvie near to the ruined Carim Lodge. Surrounded by open moorland.

Autographic recording station serviced on Mondays. Due to a variety of circumstances data were lost for several days during 1987. The autographic raingauge was unreliable for most of the year and is to be replaced. The Autographic Weather Station was out of action for all of 1987 due to the failure of the storage unit and the delay in obtaining a replacement. As in 1986, the ground-level raingauge occasionally collected less than the standard gauge. This is currently under investigation.

CLIMATOLOGICAL AVERAGES

Climatological averages are usually calculated for periods of 30 years (temperature) or 35 years (rainfall). This is because in Britain there is an inbuilt year to year variation in all the parameters used to define climate. Averages based on a smaller number of years may be unduly biased by one extreme value. As there are only 17 years of records for Stirling (Parkhead) and 7 for Ochil Hills (Carim) the averages published in Tables 5 and 6 should be used with caution.

INDEX TO FOLLOWING TABLES:

NOTES

1 The January snowstorms Figure 4

During the first ten days of January pressure had been increasing to the north-east of the British Isles while pressure remained low over southern Europe. This generated an easterly airstream by the 10th which imported cold air from eastern Europe. In Scotland heavy snow fell every day between the 10th and 14th accumulating to 30 cms or more on low ground and considerably more on the hills. Fresh snow drifted in the fresh east to north-easterly wind making it difficult, and at times impossible, to keep roads open and maintain rail services. Third-rail electric services in south-east England were badly affected which eventually saw snow-moving

equipment being sent south from Inverness. Very low temperatures accompanied the snow, daytime temperatures on the llth and 12th rising to only -2.8°C and -3.2°C respectively. The North Sea, at a temperature of 7° C, protected Britain from the very low temperatures (—20°C or less) being experienced in north-west Europe. Temperatures were not as low as those experienced in January 1982 and the snow accumulation was less than in January 1984 but, taken together, the conditions were reminiscent of February 1947. As warm air edged very slowly eastwards Britain was divided into a mild north and a cold south. On the 19th the maximum temperature in north-west Scotland was 8°C but only -3°C in the Channel Islands.

2 The October 'Hurricane' Figure 5

A vigorous depression developed in Biscay early on the 15th and began to move very quickly north-eastwards towards the British Isles after 18.00 GMT. Depressions which approach from the south-west are well fuelled with tropical air and have a tendency to deepen. This one deepened quickly, its centre pressure falling from 970mb at 12.00 to 958mb at midnight, when its centre lay over Cornwall. By 06.00 on the 16th it lay over North Yorkshire (Figure 5A) then it travelled northwards along the North Sea coast to a position north of Shetland by 18.00. The winds were strongest on the south-eastern side of the depression and during the early hours of the 16th much of southern England and northern France experienced mean wind speeds of storm force, which had abated by 09.00. Gusts exceeded 'hurricane' force (64 knots) in many places (Figure 5B) causing considerable structural damage to property, an almost total paralysis of communications and widespread electrical power failure as overhead lines were brought down. The damage was estimated at many millions of pounds. To those of us in Scotland the picture was reminiscent of the great 'Glasgow Gale' of 1968 which flattened large areas of Hermitage Woods behind the University.

At the time, much was made of the apparent failure of the Met Office to provide adequate warnings. In their defence it must be said that such depressions are notoriously fickle in their behaviour and are therefore more difficult to forecast accurately. Warnings were issued as the storm was almost on the doorstep. One may well ask what could have been done had warnings been given. True, emergency services could have been placed in a state of greater readiness but the general level of damage could not have been prevented. When such events occur it is clear that there is a desire to lay blame at somebody's door. Much of the material used by James Wilkinson on the BBC TV national news was provided by Dr Harrison of the University's Climatic Hazards Unit. Use of the term 'hurricane' by the media was a little misleading as such storms have a totally different structure to the intense mid-latitude depression which brought the strong winds on this occasion. Also, only *gust* speeds exceeded hurricane force, mean wind

speeds being slightly less but of storm force.

Footnote: The Royal Meteorological Society intends to devote one of the 1988 issues of Weather to the October storm.

3 The Summer of 1987

It was remarkable how frequently the news media south of the border referred to the summer of 1987 as being particularly poor. This statement was certainly true if you lived in East Anglia or the South-East, which had as much as three times their normal rainfall. However, the summer up here in Scotland wasn't all that bad. Indeed, if you spent your holiday on the west coast or in the Hebrides you probably had pleasantly sunny weather.

Over the years many indices of summer quality have been used, some based on simple averages (temperature, rainfall, sunshine etc.) others on more detailed statistical analyses. An index has been developed for Central Scotland based on temperature and rainfall. Use is made of numbers of days of particular weather character rather than monthly averages or totals. The index is derived from the number of days when the maximum air temperature is greater than or equal to 20°C (Warm Day), and when rainfall is 0.2mm or greater (Rain Day). Numbers of days have been determined for each of the months June, July and August for each year since 1971. Summer totals have been derived from these values and the standard deviations and means calculated for warm days (CTWD.XWD) and rain days (drd.XRo). The index for each individual year is then determined by:

$$\text{Index} = \frac{\text{No. Warm Days - XWD}}{\sigma WD} \_ \frac{\text{No. Rain Days - XRD}}{\sigma RD}$$

Negative index values indicate a generally poor summer, positive a good summer. The warm dry summers of 1983 and 1984 have index values of 2.78 and 2.80 respectively while the wet summer of 1985 scores -3.91. In comparison, the summer of 1987 scored 0.25 which places it on or about the average.

4 Weather Sensitivity and Services in Scotland - Climatic Hazards Unit

Weather and climate have always been important to Scotland. In the past, extreme atmospheric conditions have led to notable disasters such as the collapse of the Tay Bridge in 1879 and the Glasgow Storm of 1968 which killed nine people and badly damaged some 70,000 local authority houses. In the summer of 1985, much of Scotland had more than double the normal amount of rainfall with a direct loss in agricultural production estimated to be between £150 and £200 million. Today, there are few aspects of Scottish life that are not affected, in some way, by the weather. Because of the latitude and altitude

alone Scotland suffers a harsher climate than the rest of the British Isles so certain economic activities are more marginal. For example, Scotland has a shorter growing season and a longer heating season than is found elsewhere in the country. Many of Scotland's major industries and other economic activities are highly weather sensitive. A significant percentage of Scotland's economy is directly or indirectly used to mitigate the socio-economic effects of climate variability. Many industries such as energy or insurance exist, at least in part, to smooth out the irregular burdens which the atmosphere imposes on society. Often, however, poor planning and social attitudes have tended to obscure some of the relationships and preclude the effective use of weather and climate information. In view of this the Climatic Hazards Unit is organising a major seminar in February 1988.

The purpose of this seminar is to demonstrate the benefits which result when decision-makers in weather-sensitive enterprises take advantage of existing information services. It also aims to encourage greater dialogue between the suppliers and consumers of weather services in order to mitigate weather sensitivity. The seminar is organised jointly by the Meterorological Office and the Climatic Hazards Unit at Stirling University. The Meteorological Office will explain how recent advances in atmospheric sciences are leading to improved forecasting techniques and the development of more specialised weather services, including the use of climatic data bases for long-term analysis. These produces will then be evaluated by major users with practical experience of operating weather-sensitive businesses and making investment decisions under climatic uncertainty. Contributions will describe current weather-related practices in transport, natural resources, energy, construction, and other industries in Scotland. In open discussion the seminar will seek to address key issues such as the real costs of Scottish weather, the need for better meteorological information, management limitations on weather precautions, and the scope for future progress. Report by Professor K. Smith

During 1987 Professor Smith has undertaken feasibility studies on weather impact for General Accident and British Rail. He also delivered the Royal Meteorological Society's annual talk to schools in Stirling (10th June) and Edinburgh (16th December). The former was postponed from January when bad weather prevented schools attending the talk which was titled appropriately "Weather Hazards: Can We Reduce the Risk?"

The Climatic Hazards Unit is considering offering regular annual schools lectures on aspects of weather extremes and would welcome comments from teachers on possible dates and topics.

5 Effects of Elevation

During 1987 the average difference in daily maximum air temperature between Stirling (Parkhead) and Ochil Hills (Carim) stations was 2.9°C which is equivalent to a lapse-rate of 9.76°C per 1000m. This compares with a 1981-87 average of 10.84°C per 1000m. That the difference during 1987 was lower

than the average was due, in part, to a higher frequency of more stable atmospheric conditions in which lapse-rates are lower. The average difference in minimum temperatures was 0.8°C, or a lapse rate of 2.69°C per 1000m, again lower than the average (3.94). The difference in mean temperature was 1.8°C, representing a lapse-rate of 6.06°C per 1000m one of the shallowest since the Ochil Hills station was established and considerably lower than the 6.5°C per 1000m normally used in climatological maps. The difference in annual precipitation between the two stations during 1987 was 577.7mm giving a gradient of change of 1.95mm/m. This compares with the 1981-87 average of 501.0mm or 1.69mm/m. Steeper precipitation gradients tend to be associated with slightly more stable atmospheres.

6 Cold weather allowances.

There has been much political debate about the payment of cold weather allowances in Scotland, some of which has been based on an incomplete grasp of the true nature of the Scottish climate. In the depth of winter minimum temperatures in south-east England are certainly as low as those in Scotland, due to a closer proximity to cold continental high pressure areas. Observations of grass surface temperature in the North Downs of Surrey (Harrison and Currie 1979) established the severity of microclimates developed in dry downland valleys, even during the summer months. Although over much of Scotland mid-winter temperatures tend to be lower than in England, there are the dual problems of length of winter or the heating season, which is between one and two months longer than in southern England, and the generally greater strength of the winds which accompany low temperatures. This latter 'wind-chill' factor is not accounted for in the current criteria for the payment of cold weather allowances yet only moderate increases in wind speed can drop the effective temperature by several degrees. For example, a temperature of - 1.0°C in calm air becomes -5.0°C at 10 mph and -9.4°C at 20 mph. Incorporation of a wind speed factor in the calculations would be a positive benefit to Scotland. Matthew Sully, an undergraduate student of Environmental Science at Stirling University, is currently assessing the probability of temperatures falling below fixed thresholds on single days, and over runs of several days. Calculated probabilities are considerably increased when temperatures are corrected downwards for wind-chill.

HARRISON, S. J. and CURRIE, I. 1979. A severe frost hollow on the North Downs, Surrey. *Journal Meteorology* 4(43) 265-70.

7 Bridge of Allan floods.

During 1987 Phillippa Rowling, an undergraduate student in Environmental Science, submitted her dissertation on the Bridge of Allan flood problem and has since graduated from the University. The work

was awarded the Association of British Climatologists' FHW Green Memorial Prize for the best UK dissertation in climatology in 1987. The conclusions, which draw attention to recent increases in heavy autumnal rainfalls, have been published in the local press.

The upward trend in annual rainfall totals in Stirling (See Note 7 in Issue 8) appears to have been checked in 1987 which had 904.2mm in comparison to the 1057.9mm, 1078.0mm and 1038.4mm of the last three years. It will be the end of 1988 before we can say whether or not this indicates a reversal of the recent trend towards higher totals. There were considerably fewer than usual heavy falls during 1987.

8 Atmospheric Pollution in the Severn Estuary

The Water Research Centre in Medmenham (Bucks.) is funding a three-year postgraduate studentship under the supervision of Dr Harrison, the principal aim of which will be to evaluate the atmospheric inputs of heavy metals and organic pollutants into the open waters of the Severn Estuary. Jacqueline Vale, formerly an oceanography student at Swansea University, has been awarded the studentship and will be starting work on the project in early January 1988.

9 Weather Station Siting Characteristics

During 1987 final checks were made on a new method of assessing weather station shelter and aspect. The results, which are to be published in *Weather* early in 1988, will hopefully provide a basis for discussion and lead to the development of methods for determining the true effect of local siting factors in meteorological data.

HARRISON, S.J. (in press). Numerical assessment of local shelter around weather stations. *Weather*.

10 Training Sessions for Teachers of Physical Geography

The department of Environmental Science is currently planning to hold full-day training sessions on the structuring of project work in physical geography, with particular reference to weather and soil study. It is likely that these will be held during May or June 1988. Teachers interested in attending should contact either Dr Harrison or Dr Davidson. Full details will be available in due course.

The Department may also be holding general Information Days for teachers and the University will be holding an Open Day during September, 1988.

11 Extra-Mural Study Courses on Weather

Two evening study courses, begun in 1987, are available again during 1988. Weather and Society (February 8th for eight weeks) considers the impact of weather extremes on society, and Watching the Weather (late

September for nine weeks) examines the methods by which weather observations are made. These courses are open to all. Enquiries should be addressed to the Continuing Education Department at Stirling University.

12 Reference Material

The Microclimatology Laboratory and the Climatic Hazards Room contain an increasing amount of reference material including climatic data (local, national, and global), synoptic weather data and scientific reports.

The Annual Climatological Bulletin is published in the *Forth Naturalist and Historian* back copies of which are available from its Editor/Secretary, L. Corbett c/o The University Library and from bookshops.

Monthly summaries of observations from Stirling (Parkhead) and Ochil Hills (Carim) stations can be accessed by University VAX users. The AWS data for Ochil Hills up to 1986 are available on magnetic tape.

Use of these data in publications should be acknowledged.

13 Publications During 1987

HARRISON, *S. J.* Stream temperatures at Howietoun Fish Farm. *Forth Naturalist and Historian* 9 25-37

HARRISON, S. J. Spatial and temporal variation in the precipitation-elevation relationship in the maritime uplands of Scotland, pp 117-33. *Proceedings of the International Symposium on Topodimatology and its Applications,* editor M. Erpicum, University of Liege, Belgium.

HARRISON, S. J. and PHIZACKLEA, J. Automatic weather station instrumentation: a System appraised. *Weather.* 42 218-221.

HARRISON, S. J. and PHIZACKLEA, A. P. Temperature fluctuation in muddy intertidal sediments. Forth Estuary, Scotland. *Estuarine, Coastal and Shelf Science* 24 279-88.

HARRISON, S. J. and PHIZACKLEA, A. P. Vertical temperature gradients in muddy intertidal sediments in the Forth Estuary, Scotland. *Limnology and Oceanography* 32 954-63.

SMITH, K. The climate of the Estuary and Firth of Clyde. *Proceedings of the Royal Society of Edinburgh.* 90B 43-54.

SMITH, K. Applied Climatology, pp 64-68 of J. E. Oliver and R. W. Fairbridge (editors). The Encyclopedia of Climatology. Van Nostrand Reinhold, New York.

Note

Single copies of the departmental form of the Annual Climatological Bulletin are available to schools free of charge. Further copies cost £1 each and are obtainable from the Department of Environmental Science at Stirling University.

	Mean Maximum °C	Difference from Average	Highest Maximum	Lowest Maximum	Mean Minimum °C	Difference from Average	Highest Minimum	Lowest Minimum	Mean °C	No. days No. of <0°C	Mean Soil Temp. °C (0.3m at 09)
January	3·7	−2·0	10·0	−3·2	−2·4	−2·3	4·1	−7·5	0·7	26	1·4
February	6·4	+0·3	11·6	1·6	−0·3	−0·6	6·4	−6·6	3·0	26	1·4
March	7·1	−1·4	11·0	2·2	0·2	−1·3	6·3	−5·5	3·7	15	3·3
April	12·9	+1·3	22·2	6·3	4·3	+1·2	9·0	−1·2	8·6	1	7·7
May	14·1	−0·7	19·0	9·9	5·4	−0·1	9·8	1·0	9·7	0	11·8
June	15·6	−1·7	20·8	11·8	7·1	−1·1	12·9	3·3	11·3	0	13·9
July	20·0	+0·2	24·5	16·1	10·0	−0·8	14·5	6·3	15·0	0	16·6
August	19·0	−0·1	22·3	14·8	9·7	−0·2	16·0	3·5	14·3	0	16·4
September	15·7	−0·2	20·7	11·8	7·7	−0·5	12·3	−0·3	11·7	0	14·4
October	10·9	−1·7	15·7	5·9	4·2	−1·2	10·4	−5·3	7·5	5	9·8
November	8·4	−0·4	14·2	0·2	3·4	+0·9	8·6	−4·5	5·9	4	6·9
December	7·3	+0·3	12·5	−2·4	2·5	+1·1	7·4	−6·5	4·9	10	4·3
YEAR	11·4	−0·9	26·0	− 0·5	3·7	−1·1	15·4	−9·2	7·6	85	8·4

Table 1 Monthly Temperatures (Stirling, Parkhead) 1987

* = Some Missing Values	Mean Maximum °C	Difference from Average	Highest Maximum	Lowest Maximum	Mean Minimum °C	Difference from Average	Highest Minimum	Lowest Minimum	Mean °C	Difference Parkhead to Carim	No. days < 0°C
January *	0·6	−1·7	7·0	− 6·8	−2·6	−1·1	3·1	−11·2	− 1·0	1·7	25
February	3·7	+1·5	8·3	− 1·5	−1·4	+0·4	6·0	− 8·0	1·2	1·8	18
March	3·9	−0·9	8·5	− 0·5	−1·5	−1·5	4·0	− 7·5	1·3	2·4	18
April	9·8	+1·4	19·0	2·0	3.6	+2·3	11·0	− 2·0	6·7	1·9	2
May *	11·2	−0·1	16·0	7·3	3·6	−0·5	7·5	0·5	7·4	2·3	0
June *	12·2	−1·4	17·5	8·0	5·6	−1·3	11·0	2·0	8·9	2·4	0
July	16·1	−0·3	21.0	12.0	8.7	−0·5	13.0	4.0	12.4	2·6	0
August *	15·8	+0·1	18·0	13·8	8·8	0·0	14·3	4·3	12·3	2·0	0
September	12·1	−0·2	18·9	9·2	7·3	+0·3	10·3	2·6	9·7	2·0	0
October	9·0	0	12·7	6·1	4·8	+0·2	9.0	1·8	6·9	0·6	0
November	6·2	+0·1	11·6	2·0	3·1	+1·2	8·0	− 4·0	4·6	1·3	3
December *	5.9	+1.8	11.1	1.0	1·9	+1·6	7·0	− 4·2	3·9	1·0	11
YEAR	8.9	0	21·0	− 6.8	3.5	+0.1	14.3	−11·2	6·2	1·8	77

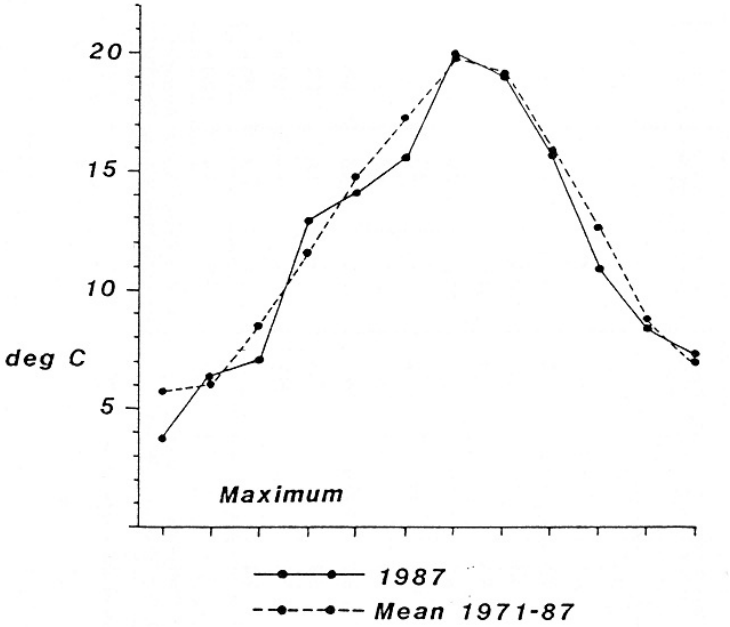
Table 2 Monthly Temperatures (Ochil Hills: Carim) 1987

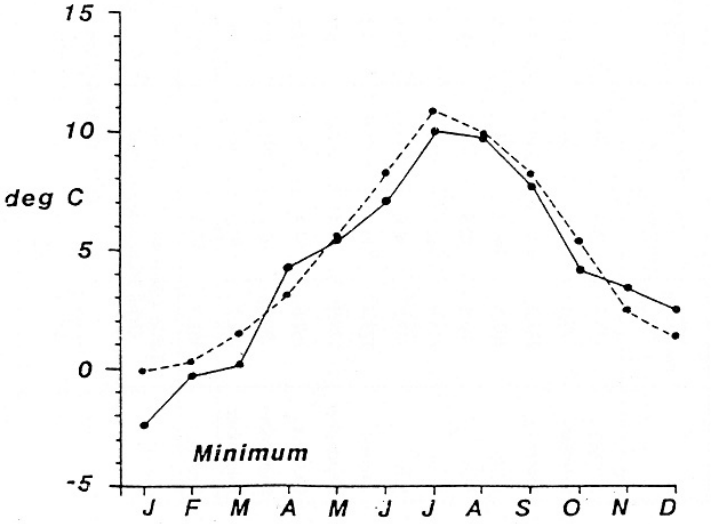
	Total Precipitation mm	Percentage of Average	Percentage of Average Accumulated	Greatest fall in 24 hours		Number of Days			
				Amount (mm)	Date	Precipitation Recorded	0·2mm or more	1·0mm or more	5·0mm or more
January	72·6	72·2	72·2	18·2	1st	14	13	12	5
February	53·0	99·4	81·6	20·1	9th	14	12	7	2
March	96·1	119·8	94·7	21·7	26th	20	20	15	5
April	58·6	148·4	102·4	23·0	10th	12	12	10	3
May	32·4	51·9	93·1	11·5	29th	10	10	8	3
June	88·6	159·9	102·5	22·4	4th	18	16	13	6
July	58·2	103·6	102·7	9·4	14th	16	14	11	6
August	102·6	155·2	109·4	30·0	15th	18	17	10	7
September	72·0	73·2	103·6	14·4	11th	19	18	15	5
October	115·1	124·7	106·4	17·2	7th	22	22	15	9
November	60·6	55·2	99·5	13·6	11th	14	14	10	5
December	94·4	93·0	98·8	18·3	27th	15	15	14	7
Year	904·2	98·8	–	30·0	15th/8th	192	183	140	63

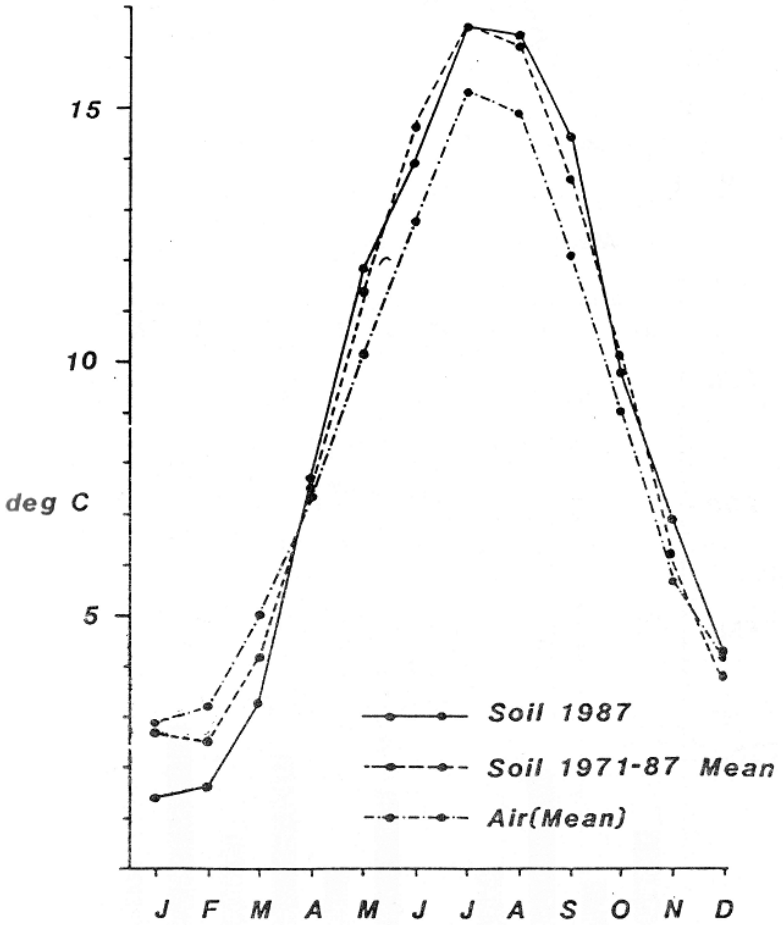
Table 3. Monthly Precipitation (Stirling: Parkhead) 1987

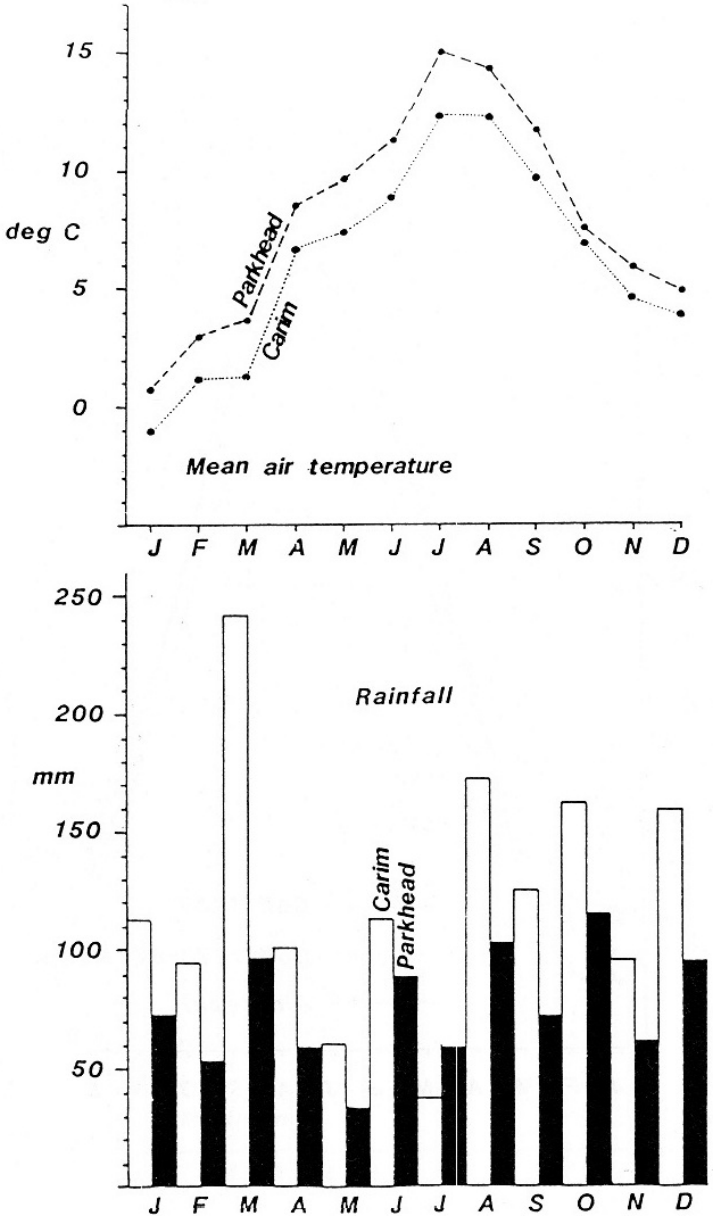
	Total Precipitation mm	Percentage of Average	Percentage of Accumulated Average	Maximum Temperature °C	Minimum Temperature °C	Soil Temperature (0.3m at 09.00°C)	Total Precipitation mm	Maximum Temperature °C	Minimum Temperature °C	Total Precipitation mm
January	113.1	78.4	78.4	5.7	– 0.1	2.7	100.6	2.3	–1.5	144.2
February	95.4	134.0	96.8	6.1	0.3	2.5	53.3	2.2	–1.8	71.2
March	242.5	147.5	118.7	8.5	1.5	4.2	80.2	4.8	0.0	164.4
April	101.6	160.3	124.7	11.6	3.1	7.5	39.5	8.4	1.3	63.4
May	60.4	52.8	109.9	14.8	5.5	11.4	62.4	11.3	4.1	114.5
June	113.9	142.6	114.0	17.3	8.2	14.6	55.4	13.6	6.9	79.9
July	37.5	56.6	108.6	19.8	10.8	16.6	56.2	16.4	9.2	66.2
August	173.4	145.1	113.9	19.1	9.9	16.2	66.1	15.7	8.8	119.5
September	125.9	74.4	107.2	15.9	8.2	13.6	98.4	12.3	7.0	169.3
October	162.5	94.1	105.2	12.6	5.4	10.1	92.3	9.0	4.6	172.6
November	96.0	67.2	101.1	8.8	2.5	6.2	109.7	6.1	1.9	142.8
December	159.7	85.5	99.1	7.0	1.4	3.8	101.5	4.1	0.3	186.8
YEAR	1481.9	99.1		12.3	4.7	9.1	915.6	8.9	3.4	1494.6
	Table 4 Monthly Precipitation Ochil Hills (Carim) 1987			Table 5 Climatological Averages for Stirling (Parkhead) 1971-87				Table 6 Climatological Averages for Ochil Hills (Carim) 1981-1987		

Tables 4, 5 and 6 Rainfall and temperatures, 1987


20
15
10
deg C
5
Maximum
1987
Mean 1971-87


15
10
deg C
5
0
-5
Minimum
J F M A M J J A S O N D


15
10
5
deg C
J F M A M J J A S O N D
Soil 1987
Soil 1971-87 Mean
Air(Mean)


15
10
deg C
5
0
Parkhead
Carim
Mean air temperature
J F M A M J J A S O N D
250
200
mm
150
100
50
Rainfall
Carim
Parkhead
J F M A M J J A S O N D