

THE WEATHER OF 1991

S. J. Harrison
University of
Stirling

During 1991 rainfall and temperature were much closer to long-term averages than they have been in recent years. January started with gales and rain which were recurrent themes throughout the year. The River Allan flooded low-lying ground in Bridge of Allan on at least four occasions after a substantially lower frequency of floods since 1986, and gales posed problems throughout Scotland. In sharp contrast, fogs, which occur in calm and stable atmospheres, were more frequent than usual, and the first week of June saw widespread groundfrost with snow on the Scottish hills.

Temperature and rainfall values referred to in the following have been taken from Stirling: Parkhead unless otherwise stated.

January. Generally cold and wet with snow mid-month.

The first ten days were very unsettled with strong to gale force winds and periods of very heavy rain and occasional sleet or snow. Winds over the first four days were between west and south-west and reached storm force on the 1st, which turned out to be the wettest day of 1991 (40.0mm). The rain became showery by the 2nd and was accompanied by thunder. A further 23mm of rain fell on the 5th. Snow fell in cold polar air early on the 7th and accumulated to a depth of 9 cms on low-lying ground. The snow cover froze then lingered until the 11th. By the 12th the snowline had retreated to above 35m on local hills but under clear night skies temperatures fell very sharply, dropping below -6.0°C every night between the 13th and 17th. Unsettled wet and windy weather returned on the 18th and the daytime temperature reached a pleasant 11.3°C on the 20th. However, the remaining days were dull with occasional light drizzle and fog and temperatures fell to just below freezing in the brief breaks in the cloud cover.

February. Cold at first with snow, becoming milder.

Light powdery snow fell intermittently between the 4th and 9th in an easterly wind but accumulations in Scotland were generally smaller than in England where heavy drifting snow on the 5th-7th brought widespread paralysis to road and rail. Cloud cleared on the 10th to give four bright sunny days with sharp night frosts and milder south-westerly winds cleared away the remaining snow after the 14th. Although night frosts persisted, the daytime temperature reached 10.7°C on the 15th. More unsettled weather returned to Scotland on the 19th and conditions remained wet and windy for the remainder of the month. Heavy sleet fell in a strong south-westerly breeze on the 22nd but this soon turned to rain. One of the most remarkable features of February 1991 was that night frosts were registered for the first 19 days without interruption.

March. Mild and damp after a cold start.

The weather was unsettled for much of the month with rainfall recorded on 20 days. The weather from the 3rd was dull with a persistent cloud cover and low cloud base. The 12th and 13th were exceptionally dull and wet days with poor visibility and steady drizzle. Heavy rain fell on the 18th which resulted in widespread flooding throughout Scotland. In parts of west Scotland over 50mm fell in less than 12 hours. However, after the 21st the next four days were bright with excellent visibility and slight night frosts. The cloud cover returned on the 29th but as this cleared away the 30th was a pleasantly warm and sunny day (16.3°C).

April. Unsettled at first, becoming cool.

The first nine days were windy with heavy showers, some of which fell as hail on the 3rd and there was almost continuous rain over the next four days, culminating in a 24hr fall of 24.5mm on the 12th. The skies cleared to give sunny warm spring days, reaching 18.0°C on the 15th but with local night frosts. Light rain fell late on the 20th but on the whole the weather remained dry and clear until the 23rd. As the skies cleared again night frosts returned briefly on the 27th and 28th.

May. Very dry but dull.

Over the first five days the wind was fresh north to north-easterly but the sky was rarely cloud-free and a few spots of light rain fell on the 3rd. However, there was no substantial rain until the 12th. The 21st to 28th were warm sunny early summer days exceeding 22.0°C on the 24th, 26th and 27th at Bridge of Allan. A fresh east to north-easterly breeze developed which, although dry, brought rather murky weather at the end of the month.

June. Cold and wet.

The winds were cold northerly and arctic over the first seven days so air temperatures were well below the seasonal normal and ground frosts were widespread. Small amounts of rain on the 2nd fell as snow on the hills. The cold weather ended on the 8th and remained unsettled with heavy rain at times until the 15th. The 48hr rainfall on the 8th-9th was 24.4mm. Showery weather gave way to heavy continuous rain mixed with hail on the 18th. The following nine days were again unsettled with only occasional sunny spells.

July. Warm but wet.

There was general rain over Britain on the 1st with thundery outbreaks but from the 3rd to the 7th the weather became drier and Stirling had the first spell of really warm summer weather, although cloud cover often persisted until mid-day. The temperature reached 24.5°C on the 4th. This was brought to an abrupt end by heavy rain on the 8th (10.4mm) which was accompanied by thunder and lightning. There was more rain on the 11th

and 12th and the weather continued to be generally damp. Heavy and prolonged rain fell on the 18th and 19th (24.5mm) after which there was a pleasantly warm interlude on the 21st. However, the respite was a brief one as rain returned late on the 22nd. The weather improved again after the 25th and temperatures exceeded 25.0°C on the 28th, 29th and 30th. However, mornings had a tendency to be cloudy and temperatures felt lower in a freshening easterly breeze.

August. Warm at times and reasonably dry.

There were three bright and sunny days at the beginning of the month but rain fell between the 4th and 6th. The weather continued unsettled with occasional rain although rainfall amounts were negligible. This persisted until the 24th when the rain moved away, but mornings were misty and dull, clearing only slowly to warm sunny afternoons. The temperature reached 26.6°C at Bridge of Allan on the 30th.

September. Settled at first, becoming wet and windy.

Dense fog on the mornings of the 1st - 4th cleared to give sunny warm days. The air became clearer and much cooler after the 9th and the first autumnal air-frost was registered on the 12th. The first rain of the month fell on the 13th and in the warm air the night-time temperature remained at an exceptional 15.0°C. The weather was unsettled with spells of mainly light rain and showers until the 20th. In a fresh to strong south-westerly wind 26.3mm of rain fell on the 21st, followed by a further 17.0mm on the 23rd, and winds reached gale-force overnight on the 23rd/24th. However, under clearing night skies, night frosts returned. A severe storm on the 27th fortunately by-passed Scotland but brought a northerly gale to the Irish Sea and very heavy rainfalls, in excess of 50mm, over southern England.

October. Cool and windy with occasional rain.

The wind reached strong to gale force west-south-west over the first three days and 32.8mm of rain had fallen by the 5th. There was a very mild run of air from the south-east on the 11th which deposited dust over England, reaching Scotland later in the day. The weather remained generally dull with a complete cover of low cloud but a westerly gale affected most of Britain on the 17th and 18th. Fresh northerly winds over Scotland then brought fresher weather with excellent visibility. As the winds dropped between the 23rd and 25th, dense fog formed in calm air, which tended to persist for most of the day. After the 26th the weather became dank and dismal in a southerly wind with low cloud and poor visibility, and rain returned on the 29th.

November. Very unsettled.

The first three days were relatively mild and wet but as winds freshened north-westerly there was a drop in night temperatures with air-frosts occurring on the 4th/5th (-0.5°C). During the late evening of the 8th there was a remarkable auroral display which began at approximately 20.00 and

persisted until well after midnight. There were two days of gales on the 10th and 11th and the 48hr rainfall total was 29.9mm. On the 12th and 13th heavy snow fell which was accompanied by thunder late on the 12th. In contrast, the 16th and 17th were cold foggy days (minimum -4.0°C , -4.7°C at Bridge of Allan). There was a brief return to windy and wet conditions on the 18th but the weather was briefly brighter on the 19th with night frost. Moist and dull southerly winds dominated the weather for the remainder of the month. Winds varied between south-east and south-west and night-time temperatures remained above 8.0°C between the 21st and 24th.

December. Settled at first, becoming wet and windy.

The first eleven days were dull but when the clouds cleared late on the 2nd night temperatures fell below freezing, accompanied by dense fog on the 4th and 7th. Dense freezing fog persisted for most of the day on the 9th, 10th and 11th and the daytime maximum temperature on the 10th managed to reach only -3.4°C . In the early hours of the 12th there was a remarkable increase in temperature and the morning weather observation was accompanied by the sound of melting ice dripping from the trees. The weather was dull and very damp and the minimum temperature fell to only 7.3°C at Bridge of Allan on the 14th. By the 17th continuous rain was falling, followed by squally showers with hail. Cold arctic winds affected Scotland from the 19th and heavy snow fell, which began to lie by the 20th and the odds on a white Christmas shortened quite dramatically!! Further snow fell in central Scotland on the 21st, eventually turning to drizzle by the afternoon. The month's wettest day was the 22nd (19.1mm) and the combination of melting hill snow and rain caused extensive flooding. Further sleet and snow fell briefly in cold arctic air before the weather became more settled for the remainder of the month. Christmas Day, as seems to be the pattern in recent years, was cloudy and wet in Scotland and the last day of 1992, like the first, was blustery and wet.

The Gulf War

One of the major international events of 1991 was the Gulf War which began on January 15th and ended on February 28th during which time considerable concern was expressed regarding the effects the large number of oil-well fires could have on the atmosphere. While the local effects were severe, causing drastic reductions in incoming solar radiation and a general lowering of air temperatures, the effects further afield were, and still are, far less obvious. The smoke plumes comprised mainly soot particles which tend to settle from the lower atmosphere over relatively short distances. The upward thrust given to these particles by the heat from the burning wells was relatively small in comparison to, for example, a volcanic eruption, so they remained mostly within the lowest 3000m of the atmosphere. It was, therefore, unlikely that large amounts of soot were going to travel beyond 1000 km from Kuwait. Nevertheless soot did apparently fall on snowfields in the Himalayan range and there are those who would argue that the soot could have served to intensify Bay of Bengal typhoons. Whether or

not there has been any measureable effect on the Indian monsoon has yet to be established.

Reading:

Special issue of *Weather* 47(6) on "Gulf War Meteorology."

The February snowstorms.

As an anticyclone settled over Scandinavia on the 5th, where it remained until the 10th, the British Isles were brought into an extremely cold easterly airstream which had its origins in the continental interior of Siberia. The greatest impact was felt in southern and eastern England, which experienced severe cold and blizzard conditions. In such cold air, the snow tends to be 'dry' and is prone to drifting in strong winds. Snow fell to a depth of 30cms or so but accumulated in deep drifts in places. Visibility was reduced to less than 50m in blizzard conditions early on the 5th. In parts of south-east England this was the first substantial snowfall for 50 months, and 15cms fell in Guernsey which had its coldest February day for 43 years. Many rural communities were isolated for several days. Road transport was severely disrupted with speed restrictions on motorways, and many vehicles were abandoned. Most memorable, however, was the drastic effect on railway operations. The fine powdery snow was sucked into traction motors which then failed, and it also filled the runners under automatic doors which would no longer close. "The wrong sort of snow" for British Rail. When the general thaw came on the 14th insurance losses from both the snow and the accompanying freezing temperatures amounted to as much as £400 million.

Reading:

Brugge R 1991 The cold snap of February 1991 *Weather* 46 (8) 222 - 230

Volcanic Dust

The eruption of Mount Pinatuba in the Phillipines on the 16th June, one of the largest since Krakatao in 1883, threw millions of tons of dust into the stratosphere. Such is the nature of the circulation of the atmosphere that this dust will eventually have some measureable effect on most parts of the world, including central Scotland. Summer temperatures in the southern hemisphere, notably in Australia and New Zealand, have already been said to have been reduced by the dust veil. However, one of the visually dramatic effects of the dust occurs in the evening after sunset. There are accounts of remarkably red sunsets in the Stirling area during the 1890's following the Krakatao eruption so we should expect to see some colourful evening skies during 1992. The red/orange dust 'glow' tends to be best developed between 15 and 45 minutes after the sun has disappeared below the horizon.

Dust fall in October

The British Isles experienced a warm south-easterly airstream on October 10th and 11th 1991 which originated over the Sahara Desert. Rain showers fell on the 11th which washed the dust out of the lower atmosphere in England during the day. This didn't reach Scotland until late evening (c23.30 GMT) when a few isolated spots of rain left a deposit which was most noticeable on parked cars. Such falls are not uncommon in southern England but are more rare in Scotland. The actual quantity of dustfall in Britain is usually relatively small but the very rare 'red rain' can deposit much larger amounts.

Reading:

Burt S 1991 Falls of dust within the British Isles *Weather* 46(11) 347 - 353

Aurora Borealis

During 1991 there were at least two excellent auroral displays visible from central Scotland, on March 24th/25th and November 8th/9th. Although green-white colouration is the most common, other colours including blue and, in particular, red, appear in the strongest displays. The March display appears to have been seen only in Scotland and Northern Ireland but in November it was recorded as far south as Dorset and Norfolk. The author's own observations of the latter record that it lasted from the early evening (20.00 GMT) and persisted until well after midnight. Red colouration was dominant at its peak between 22.30 and 23.30.

Reading:

Irons P 1991 Observing the Aurora Borealis *COL Bulletin* No 251 30-33.

Stirling University Climate Services

The automatic weather station which has been installed on the roof of the Cottrell Building at the University has begun to provide some real-time data on temperature, solar radiation, and wind speed and direction. Organisations, including schools, may be interested to know that a SUCS report is now available which lists the main suppliers of automatic weather monitoring systems and includes a check list to assist in systems purchasing.

Harrison S J 1991 Automatic weather monitoring systems: a brief guide. Report SUCS/01/91. (Available from the Editor for £3)

NOTE SUCS reports and services are now listed in the National Educational Resources Information Service (NERIS) database.

Winter conditions

Recent SUCS research into winter in Scotland, with particular reference to road gritting and snow-clearing operations, has resulted in the development of an index of winter severity and a model of the spatial distribution of days with snow lying. Attention has focussed on recent changes in winter character and the

long-term effects of global warming on winter weather patterns.

The winter index has been based on the frequency of airfrosts and the number of days with snow lying at eight climatological stations in Scotland. The indications are that severity increased up to the late 1980's when winters suddenly became very mild. There is a significant correlation between the cost of winter road maintenance and the index values for Highland and Central Regions.

The simple distribution model of days with snow lie has been based on more than 60 climatological stations in Scotland. Input spatial variables are elevation, latitude and longitude. Two types of winter have been compared viz the 'typical' winter during which snowfalls are usually associated with continental easterly airstreams, and the 'mild' winter during which snowfalls tend to occur in westerly airstreams. The latter have been associated with changes in weather patterns linked to global warming so could be the more typical winter of the C21st. There are differences in the physical character of the snow in addition to modified distribution patterns, which shift the greatest snow risk from the east to the west coast.

Reading:

Harrison S J and Harrison D J 1991 Characterising winters: An index for use in applied meteorology *Journal of Meteorology* 16 329 - 333. Harrison S J Global warming and winter road maintenance Highways and Transportation (in press).

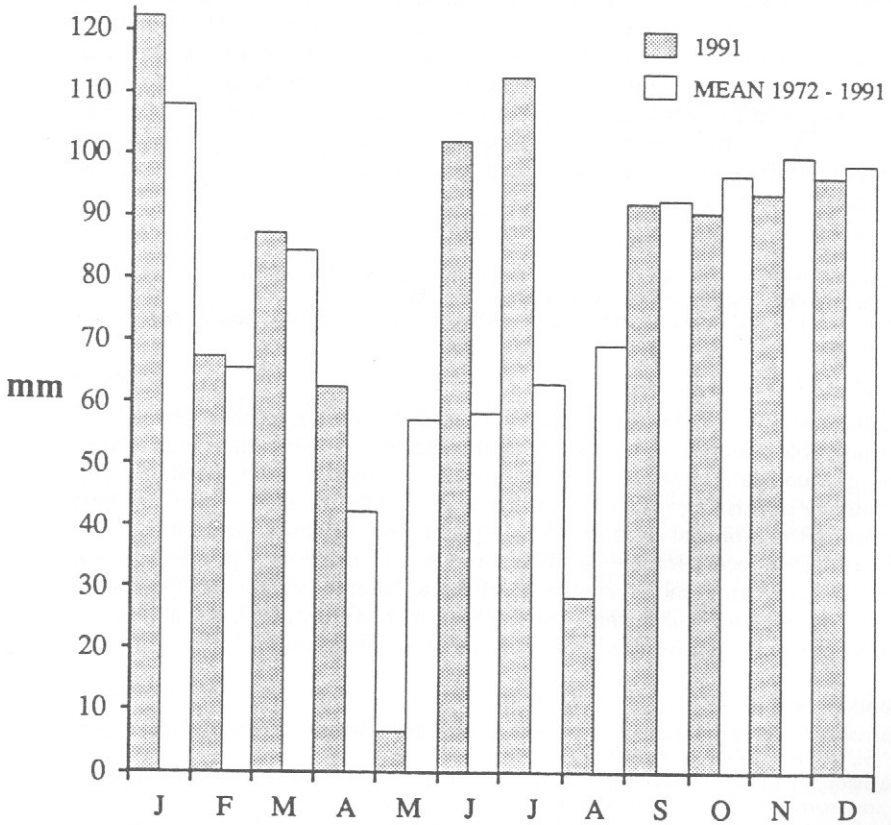
Ochil Hills: Carim Lodge

Observations at the weather station ceased during September 1991 after a considerable period during which the data obtained were less than satisfactory. The gradual deterioration in the monitoring equipment and the increasing frequency of missing records meant that closure of the station was the best option in the financial circumstances. The 10 years of data represent the only climatological record for the Ochil Hills and the closure leaves the area without any current weather monitoring. It is anticipated that the data will be published in due course and will certainly be used in the forthcoming 'Central Region' text being prepared by the Forth Naturalist and Historian.

Publications 1991

- Harrison S J 1991 Automatic weather monitoring systems: A brief guide Report SUCS/01/91 University of Stirling.
- Harrison S J and Harrison D J 1991 Characterising winters: An index for use in applied meteorology *Journal of Meteorology* 16 329 - 333.
- Harrison S J and Smith K 1991 Climatic Hazards Unit 1989-1990: Transfer to new consultancy services Report SUCS/05/91.
- Smith K 1991 Recreation and tourism In: Parry M L (Ed) Potential Effects of ClimateChange in the United Kingdom HMSO London.
- Smith K 1991 Environmental Hazards Routledge London.
- Vale J A, Harrison S J and Watts C D 1991 Aerial inputs to the Severn Estuary: Final Reports WRc Reports DoE 2747-M, NR 2748. Medmenham.

These notes have been extracted from the Annual Climatological Bulletin No.13, copies of which can be obtained for £2.50 from Dr S. J. Harrison Department of Environmental Science, University of Stirling, FK9 4LA.



Monthly rainfall (precipitation) at Stirling (Parkhead) 1991 with mean 1978-91