

TEMPERATURE RECORDS ON FOUNTAINS FELL, WITH SOME PENNINE COMPARISONS

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ABSTRACT

A thermograph was operated on Fountains Fell in North Yorkshire between May 1963 and December 1968. The resulting data are discussed and compared with other observations made at Malham Tarn Field Centre, Moor House, Great Dun Fell and other Pennine sites. Estimates of the averages of temperature, growing season, snowfall and snow cover are derived from the data.

INTRODUCTION

IN May 1963 a thermograph was installed in a Stevenson Screen on the broad and nearly flat summit plateau of Fountains Fell in, what is now, the County of North Yorkshire. The site is at an altitude of approximately 660 metres (2,160 feet) and lies about 400 m south of the interesting Fountains Fell Tarn (a shallow tarn 300 m×150 m×less than 1 m depth). It is at Grid Reference 8697.7085, about 5 km north-west of Malham Tarn Field Centre, and almost 1 km south-east of the "summit cairn" 668 m (2,191 feet).

The instrument was a Negretti & Zambra mercury-in-steel pattern with a 10-inch bulb originally purchased in 1937. With this type of instrument the pen records on a revolving dial-type chart about 20 cm (8 inches) in diameter; it is connected through 15-20 feet of tubing with the bulb in the screen. The response showed a small lag behind an adjacent sheathed thermometer, but considerably less than that of the common bimetallic recorder; it is also better protected. It was this instrument that I used between 1937 and 1941 at 844 m (2,735 feet) close to the summit of Great Dun Fell in the Northern Pennines (Manley, 1942). Subsequently the instrument was carried down, three miles to the eastward, and installed at Moor House (556 m : 1,825 feet) in extreme Upper Teesdale. Here it operated for a further three years. The older Moor House temperature record, originally begun in 1932 and terminated in 1947, has been discussed by Manley (1936 and 1943). In 1952, Moor House, which is exceptionally remote (nearest habitation 4 miles distant) and had, for many years, ranked as the second highest inhabited house in the British Isles, was acquired by the Nature Conservancy as a field station. Since then it has continued to provide a particularly interesting climatological record which is regularly summarised in the Monthly Weather Reports of the Meteorological Office.

Malham Tarn Field Centre has operated a climatological station since 1948, and for several years this was the second highest station providing a daily record. Its characteristics were discussed in an earlier paper (Manley, 1957) and averages, representative of the 30 years 1941-1970 have recently been published by the Meteorological Office. When I learnt that a temperature record on Fountains Fell might be of interest in connexion with other studies at the Centre, I passed on my instrument, together with its screen. The initiation, maintenance and scrutiny of the record owed a great deal to Miss Deirdre Williams (now Mrs Southgate) formerly of Bedford College, who was then Field Assistant and, briefly, Assistant Warden. The instrument was established on Fountains Fell in May 1963. Anyone who knows the Craven Pennines can appreciate the labour of maintaining regular visits to the site

every fortnight throughout the years. During Miss Williams' absence, and after her departure, several of her colleagues maintained the visits although it was not always possible to ensure continuity. The instrument was finally dismantled early in 1969. For a few months a rain-gauge was also operated, but, in that extremely windswept location, results were unsatisfactory.

It was generally considered that an 18-inch mercury-in-steel bulb was preferable for the maintenance of a continuous temperature record. However, this instrument requires a large screen and in 1937 I took the view that, in such exceptionally windy and exposed positions, a 10-inch bulb should give satisfactory results. This proved to be the case on Great Dun Fell; readings were regularly checked against standard maximum and minimum thermometers.

There was evidence in winter that accumulation of snow could affect the record; either through the blocking of the screen louvres by wind-driven wet snow followed by frost, or by the drifting of sufficient fine dry snow to pile up round the bulb. This had occasionally been noted on Dun Fell, but there the screen had been attached to the leeward side of a small wooden hut so that snow accumulation from between south and north-west was to some extent checked. Although winds are less strong on Fountains Fell there was no protection whatever. The result, as shown by the trace, was that the pen might remain for several days marking the same temperature, usually at or very close to freezing point. The recording mechanism was protected from wind driven snow, water, or exuberant passers-by in a pad-locked box on the ground beside the screen.

RESULTS

Between late May 1963 and December 1968 charts are available that provide approximate daily means and extremes for 51 months out of the 66. There were, unfortunately, at least five months in 1963-1964 during which the results are so much out of keeping with surrounding stations as to suggest some gross error, presumably instrumental. To all appearances there were months when the setting of the pen was about 3° too low. Occasionally the clock would stop, and there were other months during which the recording was so affected by snow that the results are unreliable.

Daily returns have been extracted and tabulated to the nearest whole degree Fahrenheit as the charts were graduated on that scale. Reading to decimals was not justified on account of instrument lag, occasional blurring of the trace, and known instrumental corrections between 0° and 0.3 °F. Monthly extremes, especially the maxima, have been checked against those at Malham Tarn Field Centre (Tarn House), about 5 km (3 miles) distant to the S.E. and 265 m (860 feet) below.

Despite the imperfections of the record the effort expended on keeping a summit station going from the Field Centre seems to justify the making of a summary (Table 1).

DISCUSSION

Fountains Fell compared with Malham Tarn House

The overall average difference between the monthly means on Fountains Fell and at Tarn House is 3.8 °F (2.1 °C). Maxima are lower by 4.4 °F, minima by 3.2 °F. This, at first sight, implies an unusually rapid fall of average temperature with height of 1 °F for 226 feet. (The altitudinal correction of 1 °F for 300 feet, often

Table 1. Average temperatures (°C) for Malham Tarn House and Fountains Fell

(the latter, approximate) reduced to the period 1941-1970

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Malham Tarn House (395 m)	0.9	1.1	2.9	5.7	8.7	11.7	12.9	12.7	10.9	7.9	4.1	2.1	6.8
Fountains Fell (660 m)	-1.0	-1.0	0.5	3.0	6.0	9.5	10.5	10.5	9.2	6.0	2.0	0.0	4.6

Approximate average annual extremes at Fountains Fell -9.5 °C to 19.5 °C (15 °F to 67 °F)
 Latest air frost in spring: late May. Earliest in autumn: late September
 Approximate length of the "growing season" (temperatures averaging above 5.5 °C or 42 °F) 10 May to 15 October

Table 3. Average number of days with snow cover recorded at Malham Tarn House 1950-1975.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Snow falling	10	10	7	5	<1	<0.1	—	—	—	1	3	7	42
Snow lying	11	13	5	1.5	—	—	—	—	—	—	3	6.5	40 (range 11 to 71)

Table 4. Derived "probable" figures for the number of days with snow lying on Fountains Fell, compared with actual data from Moor House.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Fountains Fell	18	18	15	7	1	0.1	—	—	<0.1	1	8	14	82
Moor House	16	17	12	6	0.5	0.1	—	—	<0.1	0.4	6	11	69

quoted in atlases, will be more familiar to many readers than its equivalent of 0.6°C for 100 metres.) In fact it has frequently been demonstrated that in the more windy and cloudy maritime climates of Scotland and northern England the overall rate of fall of temperature with height is more rapid, about 1°F for 270-280 feet (0.65°C per 100 metres).

I have shown elsewhere (Manley 1957) that the overall average temperature at the Tarn House is about 0.4 or 0.5°F (say 0.3°C) higher than we should expect at that altitude by extrapolation from lowland stations. The yearly frequency of "air frost" (screen minimum of 32°F (0°C) or below) was also less than might have been expected. This local amelioration of the climate arises from the Field Centre's position on a south-facing slope, little more than 100 metres from the edge of Malham Tarn. These features produce air movement sufficient to diminish the fall of temperature on quiet clear nights. Unless the Tarn is completely frozen, air or "screen" frost is neither as frequent, nor as severe, as one might expect. In addition, the extensive belt of trees around the house shelters the screen from the breeze on fine sunny days; thus tending to increase the maxima. In other words, were these local peculiarities not combining to raise the temperatures at the Tarn House the fall in temperature to the summit of Fountains Fell would be of the order of 1° in 270 feet: comparable to the rate of fall observed elsewhere.

Fountains Fell compared with some other upland stations and the Central Lancashire Plain

The comparisons between Fountains Fell and Malham Tarn cannot be carried very far owing to the incompleteness of the records. Comparisons have therefore been made with the published results of observations through 1963-1968 at the two high Pennine stations; Great Dun Fell and Moor House. A further series of comparisons has been made with the overall monthly means representative of the Central Lancashire Plain—broadly the area around Preston. These are tabulated from 1753 onwards and have been drawn up from the average of a group of north-western stations (Manley, 1946 : 1977).

The average difference between the monthly means on Fountains Fell and those representative of Central Lancashire around Preston is 8.4°F (4.7°C). Fountains Fell is north of Preston, so allowance should be made for a slightly lower set of lowland temperatures. The average falls towards Lancaster, Kendal and Carlisle. The resultant rate of fall of temperature with height in the same latitude is about 1°F for 265 feet, which accords with the 1°F for 269 feet recorded for Dun Fell in 1937-1941 (Manley, 1942).

Over the limited number of months available it appears that the average altitudinal decline of temperature is greatest in spring and least in autumn. It ranges between 9.1°F in March, 9° in April-May and 7.9° in October, 8.1° in December. This pattern agrees with the differences between upland and lowland sites at Dun Fell (9.8°F May to 7.6° November) and Moor House (5.7°F March/April to 4.6° November/December). Similar lag effects were noted at Ben Nevis and are characteristic of other European summits such as Puy de Dôme, Santis, Brocken and Fanaraken. They can also be noted for a more recent Meteorological Office station at Lowther Hill in South Scotland.

Monthly means (based on daily maxima and minima) on Dun Fell average 2°F below those on Fountains Fell. This is consistent with the difference in altitude of 184 metres (520 feet). Let it be remembered, however, that the differences are far

from uniform and that the data relate to a relatively short series of months. It is noteworthy that the mean daily range on Fountains Fell is about 1.2 °F greater than that on the rounded summit of Dun Fell (average maxima+2.6 °F, and average minima+1.4 °F). This significant difference is probably a consequence of the screen position on a much broader summit plateau, approaching 2½ km north to south and 1 km west to east; and perhaps also of the slightly lower surface wind speeds and greater likelihood of relative calm at night. Such a "plateau-effect" is noteworthy.

The monthly means at Moor House average 0.9 °F above those at Fountains Fell, consistent with the difference in altitude. Means maxima average 2.2 °F above, but means minima average 0.4° below; hence the mean daily range on the summit is about 2.6 °F less than that at Moor House in its broad upland basin, although the latter, on its wide expanse of treeless moorland, seems at first sight equally exposed.

The mean daily range at Malham Tarn Field Centre is also about 1 °F less than Moor House. This must be largely ascribed to the local amelioration of night temperatures provided by the neighbouring Tarn, as mentioned above.

On many clear nights the minimum temperature occurs around midnight on Fountains Fell, whilst on others there is only a slight further fall before sunrise. Similar effects were noted on the summit of Dun Fell, but the pattern at Moor House on many clear nights was unusual. Temperature fell to a minimum sometime before midnight to be followed by a sudden rise of several degrees and, later, by a renewed fall towards dawn. I hazarded an explanation (Manley, 1943) that this represented an effect of local ponding of air. Similar situations could occur on the upland around Malham Tarn leading to sharp local differences in temperature and incidence of frost, for example amongst the coarse vegetation on ill-drained boggy moorland such as Tarn Moss; they might be worth investigating.

On Fountains Fell the extremes of temperature recorded during the period were 70 °F (21.1 °C) on 10 June 1968 and 10 °F (−12.2 °C) on 3 March 1965. In general the minima are not particularly low, and it seems unlikely that the air temperature will fall below freezing between late May and late September in most years. There were few outstanding events during the period of operation, although a maximum of 63 °F (17.2 °C) at the end of March 1965, during a succession of warm, clear anticyclonic days, is noteworthy. On the same day Wakefield recorded 77° (25 °C), equalling the highest March maximum previously recorded in Britain, while "Lancashire Plain" sites achieved 74 °F.

30-year estimates

From the information available it is possible to provide estimates of the monthly mean temperature over a longer period for comparison with the recently published figures for Malham Tarn Field Centre 1941-1970.

At Moor House the average "growing season" was estimated to be 4 May to 20 October, and on Dun Fell from 23 May to 25 September. Fountains Fell is likely to be intermediate. The monthly number of days with "air frost" (screen min 32 °F : 0 °C or below) over the period of observation is consistently less than on Dun Fell, and similar to Moor House. This supports an annual average of about 130 days on Fountains Fell, compared with about 80 at Malham Tarn, 57 at Ilkley, 53 at Stonyhurst and 67 at Slaidburn (all based on the 20-year period 1956-1975 which has included a number of milder seasons).



FIG. 1.

A map of Northern England to show the position of sites mentioned in the text.

Recent Additional Sites in the Pennines

For some years another Pennine climatological station has been maintained by the Nature Conservancy Council on Widdybank Fell, altitude 513 m (1,683 feet). It was established in connexion with studies on the Teesdale relict flora and is located on the exposed moorland rising above the east shore of Cow Green Reservoir. The screen is on a gentle slope about 200 metres from the shore and 25-30 metres above the water level. When full the reservoir is about 4 km long by 800 m wide. Eastwards of the screen the ground rises more slowly to near 525 m (1,720 feet). Results of the observations have been published in the Monthly Weather Report since January 1975. Moor House is about 6 km distant to the west-northwest.

On the basis of 25 months of published observations, Widdybank Fell is very consistently 1.4 °F (0.8 °C) warmer than Moor House, whereas the difference in altitude (138 feet : 43 m) would suggest less than half that amount. The mean

Table 2. *The position and altitude of the Pennine sites mentioned in the text*

Site	Altitude	Grid reference
Blencarn	183 m (600 ft)	NY 640310
Buxton	307 m (1007 ft)	SK 060725
Cragg	427 m (1400 ft)	SD 895255
Cross Fell	893 m (2930 ft)	NY 687343
Fountains Fell	660 m (2160 ft)	SD 870708
Great Dun Fell	844 m (2735 ft)	NY 710322
(present summit station)	857 m (2780 ft)	
Helmshore	260 m (854 ft)	SD 774205
Ilkley	83 m (272 ft)	SE 125478
	(until 1970, 96 m)	
Malham Tarn	395 m (1297 ft)	SD 893672
Moor House	556 m (1825 ft)	NY 758328
Onecote	412 m (1350 ft)	SK 035576
Scar	549 m (1800 ft)	NY 668330
Slaidburn	192 m (629 ft)	SD 717547
Snaizholme	290 m (950 ft)	SD 830865
Stonyhurst	115 m (377 ft)	SD 692388
Widdybank Fell	513 m (1683 ft)	NY 818297
Wilsden	262 m (860 ft)	SE 088349

maxima and mean minima are both higher by almost the same amount: 0.7 to 0.8 °C. The proximity of the reservoir, and the opportunity for drainage, are both likely to play a part in this amelioration but there are, as yet, insufficient data for a period when the reservoir is frozen over for a long spell. What may be more interesting is that Moor House lies on a gentle slope within a wide basin, although not at the bottom of it, whereas Widdybank Fell appears to give more opportunity for nocturnal cold air to slide off. Predominance of coarse, ill-drained vegetation may play its part at Moor House.

Nearer to Malham Tarn, interesting results of observations at the Snaizholme Experimental Farm (290 m : 950 feet) in Widdale have been available since January 1976. This is a valley station, on the lower slopes a little above the bottom, and is interesting because the monthly means are (so far) nearly the same as those at the Field Centre, 12 miles distant south-southeast, and 350 feet higher. Days are a little warmer but nights, as a general rule, are slightly colder.

Further away, in the Southern Pennines, and under a rather different climatic regime, an interesting station was operated from 1959-1969 near the Staffordshire border at Onecote (412 m : 1,350 feet). Its establishment owed much to the interest of Professor Monica Cole. At almost the same altitude at Malham Tarn Field Centre, it was located on the crest of a southward-trending ridge, and demonstrated some slight local climatic advantage. In general it was warmer than the Centre, although differences were irregular. Lying in the lee of Wales, it is a much more "inland" location and should be compared with Welsh-border stations such as those at Bwlchgwyn, Alwen, Vyrnwy and Clee Hill.

Between Buxton (307 m : 1,007 feet) in its valley and Malham Tarn no other temperature records are kept above the 305 m : 1,000 feet, although Helmshore Experimental Farm in Rossendale (260 m : 854 feet) and Wilsden (262 m : 860 feet) near Bradford can be consulted by those who wish to make comparisons. Further north, Bellingham (848 feet) in Northumberland terminated in 1963.

The 427 m : 1,400 feet site at Cragg, near Bacup, is a recent addition to the stations providing Snow Survey data. So far its totals compare well with the data from Malham Tarn. For industrious workers wishing to make further comparisons, mention can be made of Mr W. E. Richardson's excellent record (1952-1956) at Alston (1,070 feet). In Victorian days records were kept for several years near Alston, also at Allenheads and Hawes Junction, all over 1,000 feet.

Snowfall and Snow-Cover

These topics are always matters of interest in discussion of the upland Pennine climate. Although it was not possible to keep a record of events on Fountains Fell (which is not visible from the Field Centre) some general comments can be made based on the available records at other sites.

Data for the Field Centre between 1950 and 1975 (Table 3) are nearly complete. A day qualifies as "with snow cover" if more than half of the visible ground at station level is covered by snow at the morning observation (0900 hrs). Records of snow or sleet falling depend on observation by eye and small amounts may easily be missed, especially at night. The Malham figures may be compared with data from the Dun Fell-Cross Fell area. Mrs C. Tudor maintained a continuous record, beginning in 1949, of the frequency of snow cover at the morning observation around Blencarn (183 m : 600 feet) at the foot of Cross Fell, on the Scar above (approximately 550 m or 1,800 feet), and, as cover and not merely as residual drifts, on the summit of Cross Fell (893 m : 2,930 feet). From 1953 we also have the record at Moor House on the other flank of the Cross Fell-Dun Fell watershed. As might be expected there are generally a few more days each year with snow cover on this eastern side.

Through 1950-1975 the summit was covered on an average of 103 days each year (range 57-169); the Scar 62 days (range 29-110) and Moor House 69 days (range 27-111). The few observations on Dun Fell suggest an average close to 100.

It would thus seem likely that the summit plateau of Fountains Fell can be regarded as "covered" on an average of 80 to 85 days a year. A probable distribution between months is set out in Table 4, with data for Moor House added for comparison.

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