Ben Nevis – a case study

Ben Nevis and Fort William observatories

Ben Nevis (1343 m) is the highest mountain in Britain. It towers above Fort William, a town on the shores of Loch Linnhe.

Use maps to show the children where Fort William and Ben Nevis are.

The actual summit is a small plateau with great cliffs to the north and steep slopes to the south. The upper part of the mountain has little vegetation, is often veiled in cloud (hill fog) and can be lashed by fearsome storms. These mainly occur during the months from November to April, but even in midsummer the weather can be very severe, with gale-force winds, torrential rain and temperatures close to freezing point. In winter, there are large accumulations of snow, which can persist at the summit for up to nine months in any one year. Anyone attempting to climb the mountain should be aware of these conditions and how quickly the weather can change on the Scottish mountains. Those who reach the summit find the remains of a large building, with a plaque telling them that these are the remains of a meteorological observatory, which was built in 1883 and where hourly recordings of weather were made for 21 years.

In the late 1800s (before radio, satellites and mobile phones), there was great interest in understanding weather and weather forecasting. The only way to improve knowledge of weather systems at higher levels in the atmosphere was to build mountain observatories.

The data recorded on Ben Nevis form an important record of mountain weather and have the potential to enhance the science and numeracy elements of the primary curriculum.

The tables contain figures drawn from the original hourly data, which were published in full at the time, along with tables of averages, in five volumes of the Transactions of the Royal Society of Edinburgh. The tables are also included the resources sheet (resources download)

Children can construct graphs from the monthly averages of rainfall and temperature and draw conclusions. It should be noted that similar measurements were taken at Fort William, initially several times a day by the schoolmaster, and from July 1890 at a purpose-built observatory. These are included to enable comparisons to be made and to challenge the able child to explain the reasons for the differences. There are obvious links here to other concepts, for example the water cycle.

Other interesting raw data include the snow depth, which was measured at a site on the summit close to the observatory. This illustrates the extremely harsh conditions that the staff of the observatory had to endure. Continuous instrumental measurements of wind speed were not possible, due to the severe icing which prevented the cup anemometer, mounted on the tower, from being used for much of the year.

Children may be amused to learn that the observers often estimated the force of the wind by the angle at which they could lean into it, when standing on the flat roof of the observatory.

Winds at the summit of the mountain were much affected by the complicated topography, which affected both the speed and the direction. The strongest winds were almost always from a southerly direction and could reach speeds of 120 miles per hour, but when ‘free-air’ westerlies would have been expected from the pressure pattern, the observed winds were often very gusty, but generally lighter, northerlies. As a result, average wind speeds were lower than might have been expected at such an exposed location.

These concepts are probably too difficult to explain at primary level, so no wind data have been included.

In dealing with these data, teachers are advised to provide average figures for their own school, and, if necessary, provide some visual representation of the differences. This allows for direct comparisons.

The fascinating story of the individuals who lived and worked in the observatory can be used to enhance literacy, drama and art.

Before the Scottish Meteorological Society could make an appeal for money to build the observatory, it had to be shown that the venture would be worthwhile. Now a very famous character enters the story. Clement Wragge offered to provide the Society with daily readings from the top of the mountain throughout the summer and early autumn of 1881, and he did this again, with the help of two assistants, in 1882. A number of instruments were placed securely on the summit and every day he (or one of his assistants) would set off at 4.40 am and climb the mountain. In those days, there was no path, as there is today. He reached the summit around 9 am, spent two hours there making recordings and returned to Fort William by 3.30 pm. Day after day, despite blizzards, storms and torrential rain, he and his Newfoundland dog, Renzo, struggled to reach the summit. On some occasions, his hands were so numb he had to light a fire to warm them before he could turn the key to the door of his instrument screen. Blinding heavy hail would make his clothes a frozen mass. One day his hands were so swollen he could not reset the barometer. At other times, the winds were so strong that he had to lie down and hold on to boulders for fear of being swept over the cliffs. Wragge's work and the publicity it attracted were critical in drawing attention to the need for a permanently staffed summit observatory, where recordings could be made throughout the 24 hours.

At this point, teachers may want to use the remarkable story of Clement Wragge and his dog Renzo for some imaginative writing. The children can also be asked to consider what kind of building would best serve the purposes of the observatory. Some historical and modern pictures, including a plan of the observatory, are included in the resources sheet (resources download). The children can be asked why the tower, which had a door leading directly on to the roof, was so important during the winter.

A pony track had to be built up the mountain to transport building materials (no mean feat in its own right) and on 17 October 1883 the observatory was opened. Two observers and a cook lived on the mountain, sometimes in the early years for ten months at a time, but after the Fort William observatory was opened the observers changed over every three months. During the summer months, the staff complement was supplemented by a telegraphy clerk, since so many of the tourists who climbed Ben Nevis wanted to send telegrams to their friends. The telegraph line had been installed so that daily recordings could be sent to Fort William and then on to the newspapers in Scotland and London. Hourly readings were not telegraphed, since that would have cost too much, and the observations sheets were taken down with the mail to Fort William. The roadman, weather permitting, climbed the Ben each week. In the summer, a number of volunteer observers relieved the permanent staff, enabling them to take holidays or prepare the data for publication. Several of the permanent staff were employed at the two observatories for many years.

All the instruments had to be read manually every hour of the day and night, so while one observer was on duty the other slept. Oilskin suits were worn in poor weather (most days) to go outside and read the thermometers and rain gauges. Then it was on to the roof to estimate the wind speed. In severe storms, when the roof was covered in snow and ice, this was a particularly hazardous undertaking. When snow built up outside the building, often the only means of exit was on to the roof through a door in the wooden tower. Having got out, the staff could then dig down to clear the main door and windows. During the first winter, before the tower was added, they had to dig a tunnel ten metres long to reach the outside world. In a storm, snow would find its way through every crevice into the building:

‘The lower doors were tightly closed and bolted in the gale, but in the morning there was fully a ton of snow in the lobby and passages, while the bedroom and kitchen floors were covered.’

(Kilgour 1905: 83)

Because of the very exposed situation, lightning was a particular hazard, but fortunately thunderstorms do not occur very frequently in western Scotland. However, during a severe thunderstorm in June 1895 the observatory narrowly escaped destruction. Despite the lightning conductor on the tower, at 3 pm a bolt of lightning hit the observatory. Inside there was a blinding flash, a cloud of smoke came from the telegraph instrument and the stove pipe, and a fire started behind the wood panelling. Before it could do any damage it was quickly put out and the log book reported that ‘no-one was hurt’, though one of the staff, who was sitting in the office at the time, must have had a terrible fright.

Food and other provisions were taken up to the observatory on horseback, but this was impossible in the winter months, so the store room had to carry provisions for nine months. The observatory was heated by an open cooking stove in the kitchen and a closed stove in the office. Food was mostly of the tinned variety. Water was obtained from a spring near the summit, but in winter this froze and melted snow was used instead. Letters and newspapers might not be delivered for weeks on end.

Children will no doubt have lots of ideas about the difficulties faced by the scientists, not just during extreme weather conditions, but also in their day-to-day lives. What happens if someone becomes ill or has a toothache? If you are stuck on top of a mountain for several months, how would you get a haircut? What if you were scared of lightning? What kind of person would make a good companion for months at a time? What kinds of sports might you be able to enjoy when the weather was fine?

Sadly, the observatory closed in 1904 through lack of funds, but many of the observers went on to careers in meteorology, some sailed on Antarctic expeditions, and one of the relief observers, C T R Wilson, later won the Nobel Prize for physics.

For more information:

Roy, M (2004) *The Weathermen of Ben Nevis 1883–1904*. Reading: The Royal Meteorological Society. ISBN 0 948090 24 3

Copies are available directly from Marjory Roy at the special schools’ concession rate of £7 each plus postage and packing. Email m.g.roy@btinternet.com, or phone 0131 332 3117.

Kilgour, W T (new edition 1985 – originally published 1905) *Twenty Years on Ben Nevis*. The Ernest Press. (No longer in print but available at some libraries.)

Forrest, J (1993) *Introducing Ben Nevis*. Fort William: Fir Tree Publishing. ISBN 1 872825 03 6

Ben Nevis and Fort William average rainfall

Ben Nevis Observatory average rainfall: 1885-1903	
Month	***Rainfall in millimetres***
January	465
February	344
March	386
April	215
May	201
June	191
July	274
August	339
September	400
October	392
November	390
December	484

Fort William Observatory average rainfall: 1891-1903	
Month	***Rainfall in millimetres***
January	221
February	175
March	178
April	101
May	088
June	088
July	118
August	175
September	208
October	201
November	191
December	287

Ben Nevis and Fort William average temperatures

Ben Nevis Observatory average monthly temperatures in degrees C: 1884-1903		
Month	***Average daily maximum***	***Average daily minimum***
January	-2.5	-6.3
February	-2.8	-6.4
March	-2.6	-6.3
April	-0.5	-4.3
May	+2.6	-1.6
June	+6.5	+2.2
July	+7.1	+3.1
August	+6.4	+2.8
September	+5.3	+1.4
October	+1.4	-2.1
November	+0.1	-3.5
December	-2.0	-5.5

Fort William Observatory average monthly temperatures in degrees C: 1891-1903		
Month	***Average daily maximum***	***Average daily minimum***
January	+ 5.9	+ 1.4
February	+ 6.2	+ 1.2
March	+ 7.6	+ 1.9
April	+11.0	+ 3.7
May	+14.0	+ 5.9
June	+17.2	+ 9.2
July	+17.7	+10.8
August	+17.0	+10.6
September	+15.1	+ 8.7
October	+10.9	+ 5.3
November	+ 8.8	+ 4.2
December	+ 6.7	+ 2.2

Depth of snow in cm at mid-month at Ben Nevis Observatory

Year	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*
1883 / 84	nil	102	203	203	267	289	267	305	140	nil
1884 / 85	nil	nil	84	145	310	310	343	340	221	18
1885 / 86	79	58	112	137	218	234	310	234	160	nil
1886 / 87	nil	nil	33	117	99	118	124	129	nil	nil
1887 / 88	nil	nil	117	117	132	142	155	163	58	nil
1888 / 89	nil	nil	18	84	118	127	129	nil	nil	nil
1889 / 90	nil	nil	28	61	168	175	223	178	nil	nil
1890 / 91	18	56	23	25	97	112	142	91	nil	nil
1891/ 92	nil	nil	104	132	173	178	145	132	nil	nil
1892 / 93	58	20	69	66	137	157	140	nil	nil	nil
1893 / 94	8	53	69	127	239	317	239	244	180	nil
1894 / 95	nil	89	46	66	84	109	135	15	nil	nil
1895 / 96	nil	33	84	86	102	132	173	86	nil	nil
1896 / 97	nil	25	38	84	94	89	127	196	nil	nil
1897 / 98	nil	nil	61	99	132	178	185	196	56	nil
1898 / 99	nil	nil	nil	69	127	140	152	119	nil	nil
1899 / 00	nil	nil	nil	76	145	147	226	142	nil	nil
1900 / 01	41	48	30	84	112	147	221	129	nil	nil
1901 / 02	nil	nil	48	102	109	122	150	137	36	nil
1902 / 03	nil	nil	23	91	109	178	287	307	102	nil