NOTES ON TEMPERATURE AND SNOW CONDITIONS IN THE EVEREST REGION IN SPRING 1952 AND 1953

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ON the expedition in 1952 to Cho Oyu (26,570 ft.*), 30 miles (48·3 km.) north-west of Everest, a study was made of climatic conditions in connexion with the physiological research programme that was carried out. The data thus obtained, in conjunction with records from pre-war Everest expeditions, provided the basic information on which protective equipment for the 1953 Everest expedition was designed. On the 1953 expedition, no systematic observations of temperature were made, but some temperature records are available from physiological protocols. A thermometer was taken on the second assault by Hillary, who obtained readings with it up to Camp 8, at nearly 28,000 ft.

The following account of climatic conditions in the Everest region is taken from the physiological report to the Medical Research Council after the return of the Cho Oyu expedition.

CLIMATIC CONDITIONS

An expedition to the Himalaya passes through a wide range of climates. This is a necessary consequence of the lapse of environmental temperature with increasing altitude. At low altitude expeditions encounter dry heat during the approach march, and moist tropical conditions on the way home after the monsoon has broken. On the recent expedition, the march across the plains and foothills was made at temperatures of 89° F. (32° C.) to 98° F. (37° C.) and humidity of 30 per cent. Radiation temperatures, recorded with the black bulb thermometer, were around 156° F. (66° C.). There followed a period of pleasant conditions at altitudes between 6000 and 10,000 ft., with day temperatures reaching 60° F. (15·5° C.) to 70° F. (21·1° C.), humidity around 40 per cent, and night temperatures falling to near freezing point. The snow line in April extended down to 17,500 ft., and from this level to 21,000 ft. conditions were similar to those encountered in the Alps at 10,000 ft. to 15,000 ft. at the same season of the year (Table I).

TABLE I. COMPARISON OF DIFFERENCE BETWEEN SHADE TEMPERATURE AND BLACK BULB RADIATION TEMPERATURE IN THE ALPS AND HIMALAYAS

Locality	*Altitude* (*ft.*)	*Temperature* (°C.) *Shade*	*Sun*	*Difference* (°C.)
Pontresina	6,000	25·5	44·0	17·5
Diavolezza	9,833	6·0	59·5	53·5
Peak of Monte Rosa	15,200	−14·0	54·0	68·0
Chesapane	1,000	31·7	69·0	37·3
Namchi	11,800	9·5	53·0	44·5
Jesamba	18,800	2·0	69·0	67·0

The temperatures recorded at various altitudes show a lapse rate of 3·6° F.† which agrees well with the standard figure of 3·5° F. used by meteorologists. Minimum night temperatures between 17,500 ft. and 20,000 ft. varied from +12° F. (−11° C.) to +3° F. (−16° C.).

Mid-day shade temperatures could not be measured accurately owing to the difficulty of finding shade—the zenith angle of the sun being less than 12° from the vertical—and the difficulty of protecting the thermometer from reflected radiation. The shade temperature of 44° F. (7° C.) which was recorded at 18,500 ft. was probably too high.

* 1000 ft. = 304·8 m.

† 1 degree Fahrenheit = $\frac{5}{9}$ degree Centigrade. The conversions to Centigrade are approximate.

On account of the intense solar radiation at high altitude, climbers often suffered severely from the effects of heat while climbing on glaciers in calm sunny weather. The temperatures in tents for the same reason rose rapidly after sunrise, and reached levels as high as 100° F. (37·8° C.) during the day. Sun temperatures of 156° F. (69° C.) were observed on the black bulb thermometer at 19,000 ft.

The weather from 15 April to 10 June was unsettled: periods of fine weather lasting several days alternated with short storms accompanied by fairly high winds and considerable snowfall at altitudes over 20,000 ft. On 10 June the monsoon broke.

The meteorological factors determining weather conditions in the Everest region have been described in detail by Wager [1] and by Sen and Chatterjee.[2] Winter conditions prevail from November to April and are characterized by low temperatures and frequent westerly or north-westerly blizzards caused by cyclonic weather systems travelling eastwards from south-east Europe, the eastern Mediterranean and the Arabian Sea. In April, May and June the effect of the strong insolation of the Indian plains extends upward; there is a more or less sudden break in the frequent precipitation over the Himalayas, and the weather becomes much warmer. The advent of the monsoon in the first half of June brings moister and still warmer conditions, but precipitation is less than in the cold weather season. In October, there is another interval of fine calm weather between the end of the monsoon and the onset of the winter storms. On account of the frequent blizzards and the heavy deposition of soft snow at high altitude, mountaineering expeditions can only operate during these fine periods; of the two, the May to June period is preferred, since the weather is warmer at high altitude.

Although no serious gales were encountered on the 1953 expedition, very strong winds have been experienced by climbers at high altitude on Mount Everest, and pilot balloon data from Indian Hill Stations suggest that winds of 100 m.p.h. (161 km./hr.) and over are to be expected above 25,000 ft.

Temperatures down to −40° F. (−40° C.) are to be expected on Everest at 27,000 ft. from consideration of the normal lapse rate of temperature with altitude; and the katabatic air flow on still nights may bring these temperatures to lower altitudes. Such records as are available, however, suggest that the temperatures so far experienced on Everest have not been as low as −40° F., and appraisal of the protective equipment used suggests that the climbers would certainly have suffered from cold more severely than they are reported to have done, had temperatures been as low as −40° F.

Records of atmospheric temperature obtained on Mount Everest in 1953 are presented in Table II.

TABLE II. TEMPERATURES RECORDED ON MOUNT EVEREST IN 1953

Date	*Place*	*Temperature* (°F.)	(°C.)	*Time* (*hr.*)
12.4.53	Base Camp 18,000 ft.	+15	− 9·4	19.30
16.4.53	Base Camp 18,000 ft.	+15	− 9·4	07.00
21.4.53	Base Camp 18,000 ft.	− 4	−20	?
24.4.53	Base Camp 18,000 ft.	+ 0·5	−17·5	Minimum temp.
27.4.53	Base Camp 18,000 ft.	+12	−11·0	Minimum temp.
28.4.53	Base Camp 18,000 ft.	+10·5	−12·0	Minimum temp.
3.5.53	Base Camp 18,000 ft.	− 9	−23·0	Minimum temp.
30.4.53	Camp 2 19,500 ft.	+10	−12·2	?
11.5.53	Camp 3 20,500 ft.	+15	− 9·4	06.30
12.5.53	Camp 3 20,500 ft.	+13	−10·6	21.30
24.5.53	Camp 4 21,200 ft.	+17	− 8.3	21.15
25.5.53	Camp 4 21,200 ft.	+18	− 7·8	21.00
26.5.53	Camp 7 24,000 ft.	−13	−25·0	03.00*
27.5.53	Camp 8 25,800 ft.	−13	−25·0	03.00*
29.5.53	Camp 9 27,900 ft.	−17	−27·2	03.00*

* Recorded by E. P. Hillary.

Conditions were on the whole similar to those of the previous year. There was considerable variation in night temperature. At Base Camp (18,000 ft.) the lowest temperature was −9·4° F. (−23° C.). This would correspond to a temperature of −45·4° F. (−43° C.) at 28,000 ft., assuming a lapse rate of 3·5° F. per 1000 ft. Usually night temperatures were considerably higher than this and in the Western Cwm in the latter half of May, the lowest night temperature observed was +14° F. (−10° C.). The Swiss party, in the autumn of 1952, recorded temperatures of −22° F. (−30° C.) in the Western Cwm. The intense cold was one of the main factors which defeated their autumn expedition.

Snow Conditions

Snow fell almost every afternoon from 10 April to 15 May on the Khumbu Glacier. This greatly increased the work of making routes and ferrying stores up the glacier. It is doubtful whether a smaller and less well equipped expedition would have been able to continue operating in these circumstances.

Every morning fresh snow, varying from a few inches to 2 ft. (0·6 m.) in depth, had obliterated the route and fresh tracks had to be made. The transition from fresh powder snow to old firn snow was, however, extraordinarily rapid and was accomplished within a day.

An interesting effect of the intense solar radiation was the "honeycombing" of the snow surface on the lower part of the ice fall with myriads of small shafts several inches deep due to the differential melting caused by aggregations of dust and gravel on the snow surface.

Other strange effects attributable to local conditions of temperature and radiation were the strange fluted pyramids and the upright blades of ice, shaped like Roman swords, which were a feature of the lower part of the glacier.

Whereas the Western Cwm was relatively sheltered from wind, the snow plume on the south-east ridge showed that high winds prevailed on most days above the South Col. Hillary's account of snow conditions climbing up the 400 ft. (122 m.) slope towards the South Summit are strongly suggestive of wind-crust, since he describes the crust breaking up all round his legs and sliding away down the slope.* Above the South Summit (28,700 ft.) he was relieved to find hard snow on the summit ridge in which step cutting was necessary.

Even above the South Col, some melting of the snow on the rocks was observed by the climbers. Thus, on the southern route on Everest, conditions in 1953 were very different from those reported by previous parties on the northern route, who reported that the snow did not melt or consolidate above 25,000 ft.

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REFERENCES

1. Wager, L. R. The weather. (*In* Ruttledge, Hugh. *Everest 1933*. London, Hodder & Stoughton Ltd., 1934, p. 337–51.)
2. Sen, S. N., *and* Chatterjee, N. P. Himalayan meteorology. (*In* Ruttledge, Hugh. *Everest 1933*. London, Hodder & Stoughton Ltd., 1934, p. 352–79.)

* One would have thought that this was wind slab, and this was suggested to Sir E. Hillary by Dr. Pugh, but he did not agree.—*Ed.*

THE INITIATION OF DIRT CONES ON SNOW

COMMENTS ON J. WARREN WILSON'S PAPER†

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Mr. Wilson confirms the explanation given by Spethmann in 1908 regarding the formation of dirt or sand cones on ice or snow, according to which the transport by wind or dust or fine sand furnishes the primary cause for the production of these cone shapes, the secondary cause being

† *Journal of Glaciology*, Vol. 2, No. 14, 1953, p. 281–87.