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Windchill at Leh

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सार — द्रुत शीत पवन, किसी दिए गए तापमान और पवन पर वायुमंडल की शीतलन शक्ति की माप है। इस शोधपत्र में हिमालय पर्वत की परिसीमा माध्य समुद्र तल से 3514 मी० की ऊंचाई एवं 34° 09′ अक्षांश और 77° 34′ देशान्तर में स्थित पर्वतीय स्टेशन लेह की द्रुत शीत पवन की गणना की गई है। इसके ऊपर आधारित एक तुल्यतापमान, जिसे 5 कि० मी० प्रतिघंटा पवन चलने पर मानव के खुले शरीर पर महसूस किया जा सकता है, शांत दशा के अलावा वायु संचार की राशि की गणना की गई है। 1958 से 1968 तक (भारत मौसम विज्ञान विभाग द्वारा एकत्रित) की 11 वर्ष की अवधि के दैनिक आंकड़े लिए गए हैं और अधिकतम और निम्नतम तापमान कालावधि की गणना की गई है। इससे निम्नलिखित निष्कर्ष निकाले गए हैं :

(1) द्रुतशीतन अधिकतम तापमान काल में बार-बार होता है और अक्तूबर में इसकी बारंबारता उच्चतम होती है।

(2) द्रुतशीतन निम्नतम तापमान काल में कम बार-बार होता है। इसकी निम्नतम बारंबारता जनवरी में होती है।

(3) द्रुतशीतन का परिमाण निम्नतम तापमान काल में अपेक्षाकृत अधिक होता है।

(4) पवन और तापमान परस्पर स्वतंत्र हैं। इस कारण शीतलतम मास या शीतलतम दिन में द्रुतशीतन में वृद्धि की प्रवृत्ति नहीं दिखाई पड़ती।

(5) अधिकतम द्रुतशीतन 14 डिग्री सें० पर पाया गया।

(6) वार्षिक विचरण में, अधिकतम द्रुतशीतन अवधियां पवन द्वारा और निम्नतम द्रुतशीतन अवधि तापमान द्वारा नियंत्रित होती है।

ABSTRACT. Windchill, a measure of cooling power of atmosphere for any given condition of temperature and wind, has been calculated for the mountain station Leh, situated in the Himalayan mountain range located at an altitude of 3514 m above mean sea level at Lat. 34 deg. 09′ and Long. 77 deg. 34′. Based on this an equivalent temperature; which would be felt on exposed human body in a 5 kmph wind — the amount of ventilation in an otherwise calm condition, has been calculated. The daily data for eleven year period of 1958 to 1968 (collected by India Met Dep) were taken and calculations have been done for maximum and minimum temperature epochs. The following conclusions have been arrived at:

(*1*) Windchill is more frequent in maximum temperature epoch with highest frequency in October.

(*2*) Windchill is less frequent in minimum temperature epoch with least frequency in January.

(*3*) Magnitude of windchill is greater in the minimum temperature epoch.

(*4*) Wind and temperature are independent so that there is no tendency to increase windchill on coldest month or on the coldest day.

(*5*) Maximum windchill was found to be 14 deg. C.

(*6*) In the annual variation, the coldest windchill periods are controlled by wind and the least windchill period by temperature.

1. Introduction

Windchill is an important aspect of Biometeorology. It is known that temperature alone would not indicate as to how cold one might feel and many other environmental factors are involved. Particularly important with regard to this aspect is the wind factor which influences the human body by altering its heat-transfer to environment and also its rate of evaporative cooling. A measure of the cooling power of the atmosphere for any given temperature and wind conditions was given by Siple and Passel (1945) after a number of experiments. The relation given by them is :

$$K=(10.45 + 10\sqrt{v} - v)\,(33 - T_a) \qquad (1)$$

where, K is the cooling power (kilocal m^{-2} hr^{-1}), v is the wind speed (m sec^{-1}) and T_a is the ambient air temperature (°C) under conditions of calm

wind, average outgoing radiation and convection. Based on the above relation, an equivalent temperature is defined, called the windchill equivalent temperature, which would be felt on exposed flesh in a 3 mph wind — the amount of ventilation one might experience in walking in an otherwise calm condition (Falconer 1968). The idea of windchill in determining the feasibility of outdoor activity has been widely used (Steadman 1971). The windchill equivalent temperature (T_e), as defined above can be shown to be :

$$T_e = 33 - (33 - T_a)\,(10.45 + 10\sqrt{v} - v)/20.69 \quad (2)$$

where T_a is the ambient air temperature and v is wind speed as above. $(T_e - T_a)$ is the quantity of windchill and is the correction required to be applied to T_a to get T_e. Since wind speeds are generally reported in kmph, the relation for $T_e - T_a$ becomes :

$$T_e - T_a = (33 - T_a)\,(.495 - .255\sqrt{v} + .0134\,v) \quad (3)$$

The factor $(.495 - .255\sqrt{v} + .0134v)$ in this equation is negative for range of speed $4.8 \leqslant v \leqslant 283$ km/hr. Wind speeds in excess of 283 km/hr are rare and, for practical purposes, wind speeds in excess of 5 km/hr can be taken to cause feeling of chilliness, when environmental temperature is less than skin temperature.

In the following, this quantity of windchill is examined for Leh (34° 09′ N, 77° 34′E), a station in the Himalayan mountain range located at an altitude of 3,514 metres a.m.s.l. and where even the climatic mean monthly values fluctuate between —14.0°C and 10.2°C in minimum temperatures, —2.8°C and 24.7°C in maximum temperatures [*Climatological Tables of observatories in India* (1931-1960), India Met. Dep. 1967].

2. Data

The daily data, collected by India Met. Dep. from 1958 to 1968 are considered in the analysis. As seen in the above given values of climatic normals, even the maximum temperature during day is quite low in some months. Therefore, the aspect of windchill $(T_e - T_a)$ is examined on daily minimum and maximum temperatures separately. The corresponding daily values of average wind speed during 1730 to 0830 IST are used to obtain the windchill on minimum temperature ($T_e - T_{min}$ from Eqn. 3) and that during 0830 to 1730 IST to obtain the windchill on maximum temperature ($T_e - T_{max}$). These values are used since (*i*) there are no continuous recording instruments and, therefore, instantaneous wind speeds are not available for the epochs of minimum and maximum temperatures, and (*ii*) the instantaneous wind speeds available for 0830 and 1730 IST report more often calm wind.

The separate analysis on maximum and minimum temperatures rather on the daily mean temperature would provide some information on the diurnal variation of windchill. Such an analysis would also largely reduce the possibility of underestimating the occurrence of windchill which arises in the use of mean monthly or mean of 24-hourly values (Smithson and Baldwin 1978; Mumford 1979).

3. Percentage of days with windchill

From the above definition of equivalent temperature, cooling would be experienced for wind speeds above 3 mph (approx. 5 kmph) and for speeds below this value there would be a heating. Since there is no evidence to confirm such heating at the lower wind speeds (Steadman 1971). $T_e - T_a$ is calculated only for days when the average wind speed of the period exceeded the above limit, *i.e.*, when the windchill is experienced. The percentage number of such days (wind speed $\geqslant$5 kmph) in each month, based on the data of 1958 to 1968, is given in Table 1. It may be seen that the lowest value is 36.1 per cent, which occurs during 1930 to 0830 IST in January. This indicates that in any month at least 36 per cent of days experience windchill. The highest value of 92.2 per cent is seen during 0830 to 1730 IST in October, indicating that in this month more than on 90 per cent of days windchill is experienced. It may also be seen from the table that in any month excepting in August, windchill is experienced on more number of days during 0830 to 1730 IST than during 1730 to 0830 IST, which is relatively a chillier period of the day. Also, the number of days of windchill are relatively less in winter months. These features indicate that while windchill is experienced quite frequently, it is not aggravated by being more frequent during either the coldest period of the day or during the coldest months of the year.

4. Distribution of windchill

Considering only the days when windchill is experienced, *i.e.*, the days when wind speed exceeds 5 kmph, the corresponding windchill values on minimum and maximum temperature epochs are classified in intervals of 0.5° C, the percentage frequencies of occurrence in each of these classes are computed. These values are given in Table 2 and Table 3 for minimum and maximum temperatures respectively. Cumulative frequencies are also given for each class in the table to show the percentage number of days during which windchill exceeds the lower limit of each class interval.

(a) *Windchill on minimum temperature*

It may be seen from Table 2 that, during January the windchill at the time of minimum temperature is colder than —8.0° C on 0.9 per cent on the total windchill days, colder than —5.0° C on 1.8 per cent of days, than —4.5° C on 2.7 per cent of days etc. The windchill on 46.3 per cent of days is colder than —1.5° C. In February, 66.9 per cent of days experience windchill of this order : in March —76.3 per cent; in April —79.7 per cent and so on.

TABLE 1

Percentage of days with windchill during 1730-0830 and 0830-1730 IST

Duration (IST)	Percentage number of days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1730-0830	26.1	51.0	66.8	77.7	76.2	74.6	64.7	78.1	61.6	64.8	68.1	45.0
0830-1730	40.1	54.5	81.7	87.2	87.3	84.4	73.2	72.3	76.3	92.2	84.0	54.0

In each month, the values of windchill which are exceeded (colder) on 50 per cent and 25 per cent of the days are respectively indicated by full and dotted underlines below the frequencies of the respective classes. These are respectively the median and the upper-quartile classes. Thus, considering the values shown by the full underlines, it may be seen that on 50 per cent of the days the windchill at the time of minimum temperature is only slightly colder than 0°C in January, but it is colder than — 2.0°C in February, than —3.0°C in March etc. Similarly on 25 per cent of the days (dotted underlined values) the windchill on minimum temperatures is colder than —2.0°C in January, than —3.0°C in February, than —4.5°C in March etc. Thus, both the 50 per cent and 25 per cent values suggest that windchill is frequently very cold during March. However, during the data period the coldest windchill values (less than —14°C) is seen in December. In general, the values presented in the table suggest, two maxima in the distribution of very cold windchill values, one during March and the other during December.

(b) *Windchill on maximum temperature*

The frequency distribution of windchill on maximum temperature, presented in Table 3 show the following features : (*i*) Considering the lower limit values of windchill in the median class, these values are respectively 0.0°C for January, —1.5°C in February, —2.0°C in March, —2.5°C in April etc...., being —1.0°C in December. Comparing with the corresponding values for minimum temperature, it may be observed that, excepting in the months of January, April, May and November when the median class is same for both the temperatures, the median value of windchill is not as cold as that on the minimum temerpature. In the case of the 25 per cent frequency class, in all the months the windchill on maximum temperature is less than that on minimum temeperature. (*ii*) The coldest value of windchill observed is experienced in the months of January and March, and not in December as on minimum temperature. This value is between —12.0 & —12.5°C, whereas the coldest value observed on minimum temperature is between —14.0 & —14.5°C and occurred in December. (*iii*) While the annual variation in the occurrence of very cold values at the epoch of minimum temperature showed a double maxima, one in March and another in December, this features is not prominent in the case of maximum temperature. Here, the maxima occurred in the months of January and March and during March, frequencies are seen continuously up to the —12.0 to —12.5°C class.

5. Windchill equivalent temperatures

While the frequencies presented in Tables 2 and 3 give important information on the temporal variation of windchill and the extremes experienced, the mean values of windchill and the windchill equivalent temperature in comparison with the mean monthly temperature would give a generalised picture of the phenomenon. This information is presented in Fig. 1. The thin line represents the mean temperature (either minimum or maximum as is the case) of all the days in the month. The thin dashed line represent the mean temperature of only those days when windchill is experienced (wind speed 5 kmph), before correcting for the windchill and the solid line after correcting for the windchill. This curve represents the variation of the windchill equivalent temperature. In the bottom the mean variation of windchill itself, (T_e—T_{min}) and (T_e—T_{max}) are shown.

It may be observed that both the thin lines (full and dashed) are nearly indentical indicating that there is no difference in any month in the mean air temperature of only those days when windchill occurs from the mean of all days. In other words, temperature and wind speed seem to be relatively indpendent of each other and there is no tendency for wind speeds to be high either only on warm days or only on cold days. The mean equivalent, temperature (thick solid line) follows the same pattern as the uncorrected mean temperature, which shows that the effect of windchill, in the mean, is not large enough to alter the natural annual variation. The thick solid curves of windchill presented below show an annual variation between —1.2 and —2.8°C in the case of minimum temperature and between —0.6 and —2.5°C in the case of maximum temperature. Both show a double maxima (coldest values), one in March to April and the other in the month of November. The windchill effect is least in the month of August with second minima in December and January. It may be noted that the variation in both the frequency distribution and mean values show the

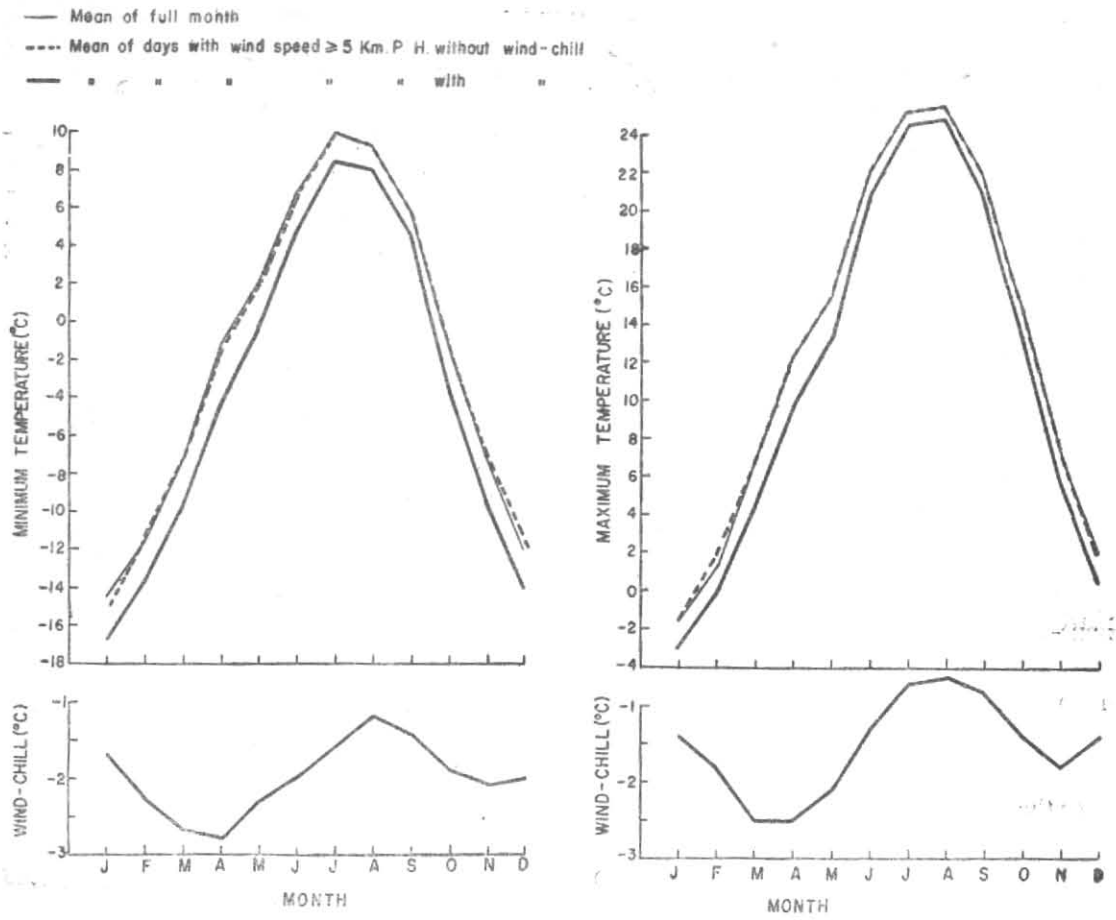

Fig. 1. Windchill (°C) and max. temp. (°C) during Jan-Dec

occurrence of maximum windchill in the month of March. The occurrence of secondary maximum is shown in mean values in November, while the extreme values of the frequency distributions show it in December in minimum temperature and in January in maximum temperature.

6. Discussion

It was mentioned in the beginning that the climatic monthly mean of maximum temperature has an annual variation below 24.7° C. The mean value of the data period in this analysis also shows a similar value (*see* Fig. 1). Thus, the temperatures experienced at Leh are below 33°C, which is considered as the skin temperature, and the temperature factor $(33—T_a)$ is always positive in Eqn. 3. In this analysis, only the values of wind speed exceeding 5 kmph are considered and, therefore, the sign of the wind factor, $(.495—.255\sqrt{v}+.0134\ v)$, is always negative for $v < 283$ kmph. Thus, as signs of both the factors remain constant, variation in windchill is only in the magnitude of these two factors.

It is seen that the frequency of days with wind speed in excess of 5 kmph are more during the epoch of maximum temperature than during that of minimum temperature. But, it is seen from either the median values in Tables 2 and 3 or the mean values in Fig. 1, windchill is more at the epoch of minimum temperature. From this it may be inferred that, since $(33—T_{min})$ would be larger than $(33—T_{max})$, the temperature factor exercises more control for the relatively colder windchill on minimum temperature.

Again, in the case of annual variation it may be seen from Fig. 1, the windchill on both minimum and maximum temperatures is least in the month of August. Maximum temperature reaches its highest value in this month. The minimum temperature reaches its highest value in July but the August value is not very different from it. Thus, the occurrence of least windchill in this month is again controlled by the temperature factor.

However, it may be seen in Fig. 1 that, the occurrence of coldest windchill values in the month of March and April and again in November cannot be explained by the annual variation of temperature, which is lowest in January. It may be seen in Table 1, days of wind speed reaching 5 kmph are generally more in the months April, August and November during 1730 to 0830 IST and in the months of April to May and October to November during 0830 to 1730 IST. Thus, the occurrence of largest windchill

TABLE 2

Windchill on minimum temperature and percentage number of days (Figures in brackets are cumulated percentages. Values of 50% and 25% frequency classes are shown by full and dotted underlines)

Range* of windchill (in °C)	Percentage number of days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
—ve values												
0.0–0.5	53.7 (100.0)	33.1 (100.0)	22.7 (100.0)	19.1 (100.0)	20.8 (100.0)	20.2 (100.0)	18.6 (100.0)	26.1 (100.0)	25.9 (100.0)	31.3 (100.0)	35.6 (100.0)	32.5 (100.0)
0.5–1.0	—	—	—	—	—	1.0 (79.8)	9.0 (81.4)	3.4 (73.9)	—	—	—	—
1.0–1.5	—	—	—	1.2 (80.9)	17.2 (79.2)	25.4 (78.8)	24.1 (72.4)	41.5 (70.5)	39.5 (74.1)	1.1 (68.7)	—	—
1.5–2.0	2.7 (46.3)	8.1 (66.9)	17.6 (78.3)	15.5 (79.7)	7.0 (62.0)	5.2 (53.4)	15.6 (48.3)	12.8 (29.0)	4.9 (34.6)	26.7 (67.6)	21.4 (64.4)	3.0 (67.5)
2.0–2.5	26.4 (43.6)	30.1 (58.8)	5.3 (58.7)	0.8 (64.2)	6.7 (55.0)	11.9 (48.2)	14.6 (32.7)	7.3 (16.2)	18.5 (29.7)	0.6 (40.9)	7.3 (43.0)	19.7 (64.5)
2.5–3.0	7.8 (17.2)	1.5 (28.7)	2.6 (53.4)	13.9 (63.4)	14.1 (48.3)	10.9 (36.3)	10.6 (18.1)	5.1 (8.9)	5.7 (11.2)	10.2 (40.3)	0.9 (35.7)	—
3.0–3.5	—	3.7 (27.2)	14.5 (50.8)	10.8 (49.5)	7.5 (34.2)	7.3 (25.4)	5.0 (7.5)	3.0 (3.8)	1.2 (5.5)	18.2 (30.1)	11.8 (34.8)	—
3.5–4.0	4.5 (15.4)	5.9 (23.5)	6.2 (36.3)	8.8 (28.7)	8.2 (26.7)	4.1 (18.1)	1.0 (2.5)	—	1.9 (4.3)	3.4 (11.9)	9.6 (23.0)	15.2 (44.8)
4.0–4.5	8.2 (10.9)	4.4 (17.6)	4.4 (30.1)	10.3 (29.9)	7.8 (18.5)	5.2 (14.0)	0.3 (1.5)	0.4 (0.8)	—	4.0 (8.5)	2.7 (13.4)	12.9 (29.6)
4.5–5.0	0.9 (2.7)	2.9 (13.2)	11.9 (25.7)	6.8 (19.6)	2.0 (10.7)	2.6 (8.8)	0.5 (1.9)	0.4 (0.4)	1.2 (2.4)	1.7 (4.5)	4.6 (10.7)	2.0 (16.7)
5.0–5.5	0.9 (1.8)	1.5 (10.3)	3.5 (13.8)	3.6 (12.8)	2.1 (8.7)	5.2 (6.2)	—	—	0.6 (1.2)	1.1 (2.8)	1.4 (6.1)	8.3 (13.7)
5.5–6.0	—	3.7 (8.8)	1.3 (10.3)	2.4 (9.2)	0.8 (5.6)	0.5 (1.0)	—	—	—	—	1.8 (4.7)	1.5 (5.4)
6.0–6.5	—	0.7 (5.1)	3.5 (9.0)	2.4 (6.8)	1.6 (4.8)	—	0.5 (0.5)		0.6 (0.6)	—	—	1.5 (3.9)
6.5–7.0	—	2.2 (4.4)	3.5 (5.5)	1.2 (4.4)	1.2 (3.2)	—				—	—	0.3 (2.4)
7.0–7.5	—	—	0.4 (2.0)	1.6 (3.2)	1.6 (2.0)	0.5 (0.5)				1.1 (1.7)	—	—
7.5–8.0	—	—	0.4 (1.6)	0.4 (1.6)	0.4 (0.4)					—	1.4 (2.7)	—
8.0–8.5	0.9 (0.9)	1.5 (2.2)	0.4 (1.2)	0.4 (1.2)						0.6 (0.6)	—	—
8.5–9.0		0.7 (0.7)	0.4 (0.3)								0.5 (1.5)	—
9.0–9.5			—	0.4 (0.8)							0.5 (1.0)	
9.5–10.0			—	—							—	—
10.0–10.5			—	0.4 (0.4)							—	—

*Each range is inclusive of the upper limit value, but not the lower limit.

TABLE 2 (*contd*)

Range* of windchill (in °C)	Percentage number of days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10.5–11.0			0.4 (0.4)								—	—
11.0–11.5											0.5 (0.5)	—
11.5–12.0												0.8 (1.6)
....												
....												
....												
14.0–14.5												0.8 (0.8)

*Each range is inclusive of upper limit value but not the lower limit

TABLE 3

Windchill on maximum temperature and percentage number of days (Figures in brackets are cumulated percentages. Values of 50% and 25% frequency classes are shown by full and dotted underlines)

*Range of windchill (°C)	Percentage number of days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
—ve values												
0.0–0.5	54.1 (100.0)	24.5 (100.0)	13.5 (100.0)	6.7 (100.0)	6.8 (100.0)	19.7 (100.0)	53.9 (100.0)	65.5 (100.0)	46.8 (100.0)	18.3 (100.0)	18.3 (100.0)	42.8 (100.00)
0.5–1.0	—	—	0.8 (86.5)	7.8 (93.3)	9.0 (93.2)	21.1 (80.3)	26.2 (46.1)	19.1 (34.5)	25.6 (53.2)	26.7 (81.7)	2.3 (81.7)	—
1.0–1.5	10.1 (45.9)	23.7 (75.5)	15.8 (85.7)	5.7 (85.5)	11.9 (84.2)	21.7 (59.2)	13.3 (19.9)	8.1 (15.4)	12.1 (27.6)	18.6 (55.0)	27.6 (79.4)	16.4 (57.2)
1.5–2.0	18.4 (35.8)	11.9 (51.8)	6.2 (69.9)	11.7 (79.8)	14.4 (72.3)	11.7 (37.5)	5.8 (6.6)	5.3 (7.3)	6.0 (15.5)	14.2 (36.4)	8.2 (51.8)	12.7 (40.8)
2.0–2.5	—	10.4 (39.9)	15.9 (63.7)	15.5 (68.1)	17.3 (57.9)	8.5 (25.8)	0.4 (0.8)	0.5 (2.0)	6.5 (9.5)	8.9 (22.2)	19.8 (43.6)	9.8 (28.1)
2.5–3.0	2.8 (17.4)	11.1 (29.5)	13.6 (47.8)	12.8 (52.6)	10.4 (40.6)	7.5 (17.3)	—	1.0 (1.5)	1.5 (3.0)	6.5 (13.3)	8.2 (23.8)	3.0 (18.3)
3.0–3.5	3.7 (14.6)	4.4 (18.4)	11.2 (34.2)	11.7 (39.8)	10.4 (30.2)	7.5 (9.8)	0.4 (0.4)	0.5 (0.5)	1.0 (1.5)	1.6 (6.8)	6.7 (15.6)	4.5 (15.3)

*Each range is inclusive of the upper limit value, but not the lower limit.

TABLE 3 (*contd*)

Range* of windchill (in °C)	Percentage number of days											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3.5–4.0	4.6 (10.9)	3.0 (14.0)	5.4 (23.0)	9.6 (28.1)	9.0 (19.8)	2.3 (2.3)			0.5 (0.5)	2.4 (5.2)	4.1 (8.9)	4.5 (10.8)
4.0–4.5	0.9 (6.3)	3.7 (11.0)	6.2 (17.6)	8.5 (18.5)	3.2 (10.8)					0.4 (2.8)	0.7 (4.8)	0.8 (6.3)
4.5–5.0	—	1.5 (7.3)	1.9 (11.4)	2.8 (10.0)	4.3 (7.6)					0.8 (2.4)	1.5 (4.1)	—
5.0–5.5	—	—	3.1 (9.5)	1.8 (7.2)	1.1 (3.3)					0.4 (1.6)		0.8 (5.5)
5.5–6.0	0.9 (5.4)	0.7 (5.8)	1.6 (6.4)	1.1 (5.4)	1.8 (2.2)					0.4 (1.2)	0.7 (2.6)	0.8 (4.7)
6.0–6.5	0.9 (4.5)	2.2 (5.1)	1.2 (4.8)	1.4 (4.3)	0.4 (0.4)					—	0.4 (1.9)	0.8 (3.9)
6.5–7.0	—	1.5 (2.9)	0.4 (3.6)	0.7 (2.9)						—	0.4 (1.5)	0·8 (3.1)
7.0–7.5	0.9 (3.6)	0.7 (1.4)	0.4 (3.2)	1.1 (2.2)						0.4 (0.8)	1.1 (1.1)	1.5 (2.3)
7.5–8.0	—	—	0.4 (2.8)	0.7 (1.1)						—		—
8.0–8.5	—	—	—	—						—		—
8.5–9.0	1.8 (2.7)	—	0.4 (2.4)	—						0.4 (0.4)		—
9.0–9.5	—	0.7 (0.7)	0.4 (2.0)	0.4 (0.4)								—
9.5–10.0	—	—	—									—
10.0–10.5	—	—	0.4 (1.6)									0.8 (0.8)
10.5–11.0	—	—	0.4 (1.2)									
11.0–11.5	—	—	0.4 (0.8)									
11.5–12.0	—	—	—									
12.0–12.5	0.9 (0.9)		0.4 (0.4)									

*Each range is inclusive of the upper limit value, but not the lower limit

values during the months of March to April and again in November is seemingly controlled by the wind factor.

In this study, average wind-speeds during the periods 1730 to 0830 IST and 0830 to 1730 IST are used to evaluate windchill effect on the minimum and maximum temperature epochs respectively. In the bottom of a valley area at Leh Lakshminarayanan (1979) observes a marked diurnal variation with strong winds in the afternoon and the first portion of night. Considering this variation the magnitude of windchill should be smaller at the epoch of minimum temperature than those obtained in the present study and larger at that of maximum temperature and early night, at such locations.

7. Conclusion

(*i*) At Leh, the epoch of maximum temperature experienced windchill most frequently than the epoch of minimum temperature. The highest frequency of days in the case of former is in October (92 per cent of the days) and in the case of latter it is in August (78 per cent). Even in January, the month of least frequency, the value is still high, being about 36 per cent for the minimum temperature epoch and 40 per cent for the maximum temperature epoch.

(*ii*) While the frequency of occurrence of windchill on maximum temperature is higher than on minimum temperature, the actual magnitudes are

larger on minimum temperature. The mean value varies between —0.6 and —2.5 °C in the case of the minimum temperature. But, in the bottom of valleys, the detailed study on the diurnal variation of wind speed by Lakshminarayanan (1979) suggests that colder windchills are likely to be experienced much earlier to the epoch of minimum temperature, may be in the early night.

(*iii*) On individual occasions, windchill can be as high as —14° C (Table 2) on minimum temperature and —12° C on maximum temperature (Table 3).

(*iv*) In the annual variation, the coldest windchill periods are controlled by the wind factor and the least windchill period by the temperature factor.

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