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Cold Waves in Northwest India

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ABSTRACT. During the winter months, northwest India experiences cold waves after the passage of western disturbances across the same area. These cold waves may be broadly classified under two categories, *viz.*, (1) dry cold waves and (2) moist cold waves. When the area is in the grip of a dry cold wave, there is no deterioration in the morning visibility and the aviation activity is not affected in any way. On the other hand, widespread fog occurs in the area when it experiences moist cold wave and this dislocates air traffic very badly. In the note, the conditions favourable for occurrence of dry fog as well as moist fog have been discussed and illustrated. The typical instances included in the note will be found useful to forecaster in predicting for occurrences of widespread fog of persisting type in NW India.

During the winter months, northwest India experiences cold spells after the passage of western disturbances across the same area. On some such occasions, the night temperature at the surface falls appreciably below normal (4°C or more) and the area is said to be in the grip of a cold wave. A study of the cold waves in northwest India suggests that these may be broadly classified under two categories, *viz.*, (1) dry cold waves and (2) moist cold waves, the occurrence of the former type being more frequent. The dry cold waves are due to the cold air mass that sweeps over northwest India in the wake of an active western disturbance. This cold air usually extends upto 20,000 to 30,000 ft above ground level and contains very small quantity of moisture. In the cold sector of a western disturbance, the wind is also strong and gusty; therefore, the conditions are not favourable for formation of fog in an area in the grip of a dry cold wave. All western disturbances are not followed by a surface cold wave. The cold air that advances into northwest India in the rear of such disturbances is generally more marked in the higher levels and may sometimes move away eastwards, without appreciably affecting the surface temperature. This usually occurs when the disturbances are not very active. A cold wave may also be produced, rather in an indirect way, by a western disturbance which has not actually brought in sufficiently cold air at the surface from the west. The air cooled by widespread snow and rain in the Punjab Kumaon hills caused by such a disturbance, may occasionally spread over the plains of northwest India and reduce the surface temperature appreciably. A low level anti-cyclonic circulation over the northwestern districts of West Pakistan facilitates such spreading of cold air from the hilly regions. The air being moist and the wind field weak, a cold wave of this type, termed as moist cold wave in this note, causes widespread fog which may sometimes continue for days together. The vertical extent of a moist cold wave is naturally smaller than that of a dry cold wave.

Three instances, namely (1) a well-marked dry cold wave, (2) a dry cold wave affecting the higher levels but not the surface and (3) a well-marked moist cold wave are discussed below by way of illustrations. The movement and vertical extent of the above cold waves, as indicated by the upper air data of Delhi, a central station in northwest India, have also been examined and discussed in this note along with low level wind circulations over the same area.

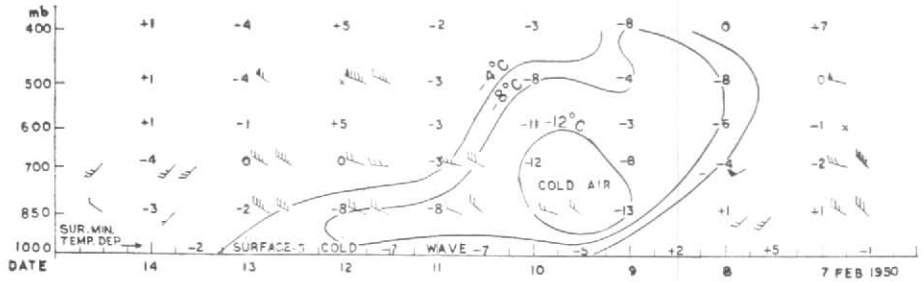

Fig. 1(a). Temperature anomalies at various levels—New Delhi, 7-14 Feb 1950
(Upper air temperatures refer to 1500 GMT data)

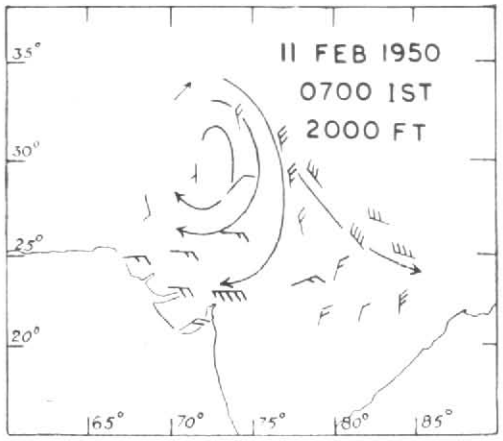

Fig. 1(b)

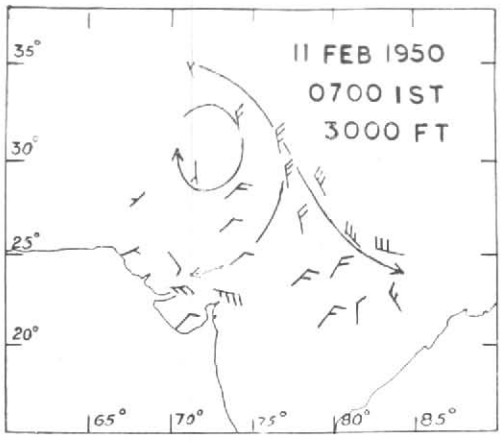

Fig. 1(c)

Case I : A well-marked dry cold wave (February 1950)

On the morning of 8 February 1950, a very active western disturbance was located over northwest Punjab (P) and it was moving away eastnortheastwards. A cold wave developed in West Pakistan on 9th and was moving eastwards. On 10th and 11th, northwest India was in the grip of a very intense cold wave, many stations having reported temperature near or below freezing point. On 11th, Sriganganagar recorded —3°C, Bikaner —2°C and Hissar —2°C; on the above two dates, night temperatures in the Punjab, Rajasthan and U.P. were generally 6—11°C below normal; later the cold wave commenced to abate. During the above cold spell, no fog occurred in the area except at one or two stations near the hilly regions on 10th.

The vertical time-section of the atmosphere over Delhi for the period concerned is shown in Fig. 1(a). The temperature anomalies and winds at different levels are plotted in this diagram. It is seen that the cold front passed over Delhi at the surface on the 9th night. In its rear, a large mass of cold air extending upto 400 or 300-mb level was sweeping over the area. The coldest air (below normal) was located between 850 and 700-mb levels and was passing over Delhi on 10th morning. The lowest surface temperature was reached only on 11th and 12th morning, *i.e.*, after one or two days.

Winds at 2000 and 3000 ft on 11th morning (the coldest day) are shown in Figs. 1 (b) and 1(c). It is seen that the winds in the area were strong and blew from some NW'ly

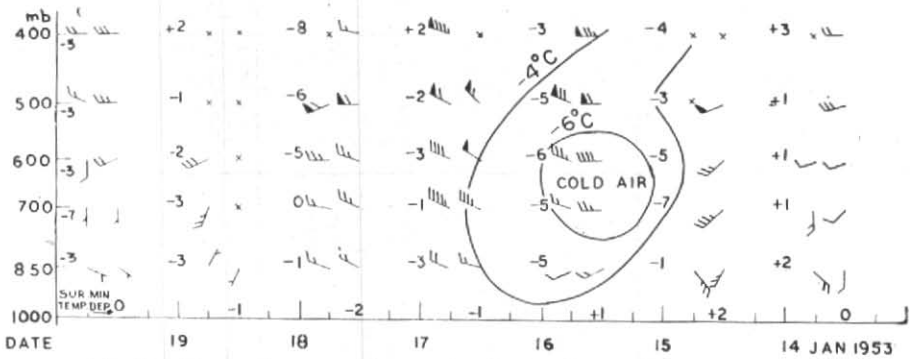

Fig. 2 (a). Temperature anomalies at various levels—New Delhi, 14-20 Jan 1953
(Upper air temperatures refer to 1500 GMT data)

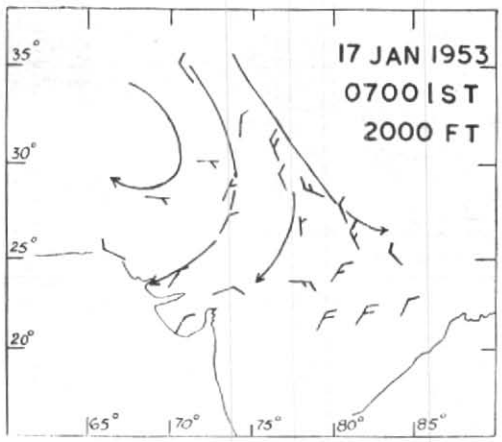

Fig. 2(b)

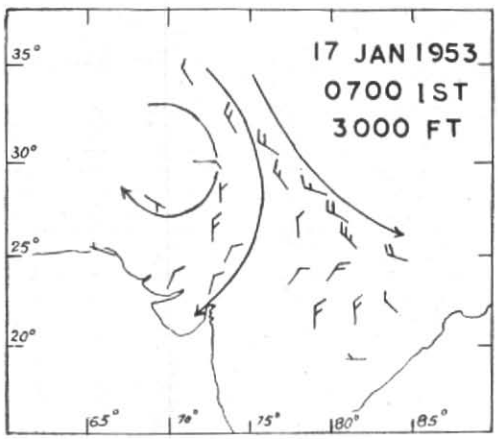

Fig. 2(c)

direction, bringing in dry cold air from the northern districts of West Pakistan. It may be mentioned that the dew point temperature at Delhi during the period of the above cold wave was very low, varying from —3° to —13°C.

Case II : A cold wave affecting the higher levels but not the surface (January 1953)

A western disturbance lay over northwest Rajasthan and adjoining Punjab (P) on 14th morning and moved away eastnortheastwards during the course of the next few days. It caused fairly widespread rain and thunderstorms in the Punjab (I) and Uttar Pradesh on 15th and 16th, but no surface cold wave followed the above weather spell. The maximum fall in night temperature over the area occurred on 17th and 18th when the departures from normal were only —2° to —4°C. During the period, no fog occurred in the area except at one or two isolated stations on 17th.

The vertical time-section (Fig. 2a) shows that the cold front passed over Delhi at the surface on 15th night. The mass of cold air extended upto 400-mb level, the coldest part being located between 700 and 600-mb levels. The coldest air aloft passed over Delhi on 16th morning while the lowest surface temperature was reached at this station on the 18th morning, *i.e.*, about 48 hours later. The wind patterns at 2000 and 3000 ft during the period in question were similar to those in Case I and the surface dew point temperature was also low. The wind patterns at 2000 and 3000 ft on 17th are shown in Figs. 2(b) and 2(c).

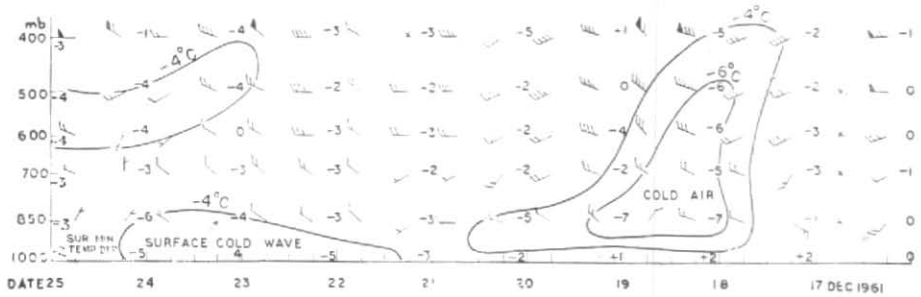

Fig. 3(a). Temperature anomalies at various levels—New Delhi, 16-25 Dec 1961
(Upper air temperatures refer to mean of 0001 and 1200 GMT data)

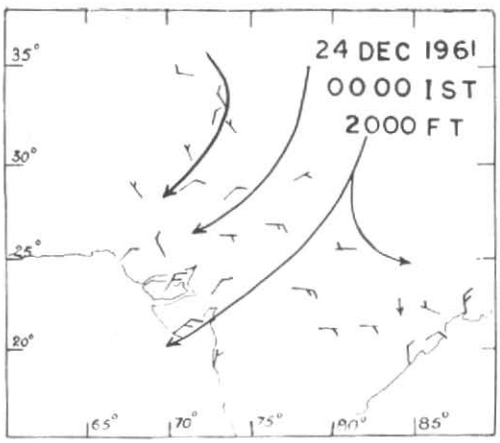

Fig. 3(b)

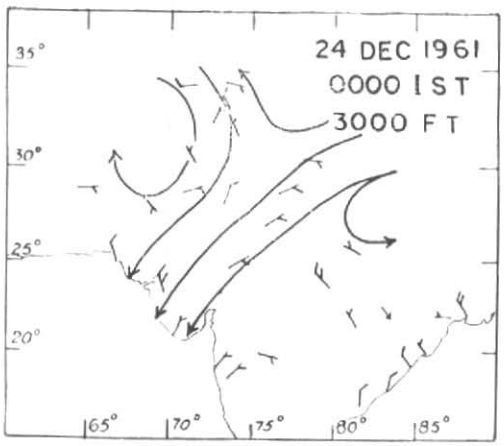

Fig. 3(c)

The above two cases are essentially similar, the only difference being that the air coming from northwest in the second case was not very cold and did not affect the surface temperature appreciably. These two instances of dry cold air and also other similar instances (not included in this note) show that the cold air is more marked and moves faster in the higher levels and the lowest surface temperature is reached after 24 hours or more. Thus, the vertical time-section chart of a station may be of interest to a forecaster to predict roughly the intensity and time of occurrence of a surface cold wave at the same station.

Case III : A well-marked moist cold wave (December 1961)

Under the influence of a western disturbance moving across northwest India, local to widespread rain or snow occurred in Kashmir, Himachal Pradesh and the hills of the Punjab and of west Uttar Pradesh during the period 16th to 19th. A very intense cold wave was experienced in the plains of northwest India during the period 20th to 28th. Some stations in Rajasthan recorded freezing point on certain days during the above period. On 26th, the night temperatures were 6—9°C below normal in the plains of Uttar Pradesh, Kanpur and Orai having

TABLE 1

Dew Point Temperature (°C)

Date	Surface		Pressure levels (mb)		
	0300 Z	1200 Z	900	850	700
		(*a*) Dry cold wave			
9-2-50	—	—12·8	— 4·6	— 7·7	— 6·3
10-9-50	— 5·0	— 7·8	—	—	—
11-9-50	— 3·9	— 8·3	—10·5	—11·6	—24·6
12-9-50	— 2·8	— 9·4	— 0·6	— 3·6	—
13-9-50	— 5·6	— 6·1	1·5	— 4·3	— 8·1
		(*b*) Moist cold wave			
21-12-61	5·0	8·0	— 8·3	—16·5	—
22-12-61	6·0	7·0	—14·2	—22·3	—
23-12-61	4·0	7·0	— 6·2	—10·2	—13·7
24-12-61	3·0	8·0	— 0·7	— 8·5	—20·9
25-12-61	5·0	8·0	— 4·9	—16·0	—

recorded —1°C. During this long period of nine days of the cold wave, widespread fog occurred daily in Punjab (I), east Rajasthan and Uttar Pradesh. At Delhi, the fog persisted upto 2 or 2-30 P.M. on certain days.

It is seen from the vertical time-section chart (Fig. 3 a) that the cold front passed over Delhi at the surface on 17th night. The cold air aloft passed over the same station during the period 18th to 20th. The surface cold wave was actually experienced at Delhi during 22nd to 24th when the wind at 2000 and 3000 ft at this station blew from directions between north and east, suggesting that moist cold air was spreading over this area in the lower levels from the Punjab-Kumaon hills. The dew point temperature at Delhi on these days was 3° to 8°C while in Case I it was as low as —3° to —13°C.

The wind circulations at 2000 and 3000 ft over northwest India on 24th, the mid-period of this cold wave, are shown in Figs. 3(b) and 3(c). It is clear from these circulations that a layer of cold and moist air upto a depth of about 3000 ft was flowing into the plains of northwest India from the western Himalayas. The winds were light and the moisture content of the air was high. These favoured the formation of widespread fog in the area under study.

The dew point temperature distribution at the surface and aloft in northwest India during the passage of the above two dry and moist cold waves (Case I and Case III) is shown in Table 1. It will be seen from this table that a mass of dry air prevailed over the area during the passage of the dry cold wave. But in the case of the moist cold wave, the air was moist below 3000 feet and dry aloft consistent with the genesis of this cold wave as explained in the note. A shallow layer of moist air is also very favourable for the formation of fog.

The two well-marked cold waves discussed above are distinctly of two different types. The illustrations may be useful to a forecaster to predict if a particular cold wave is likely to last long and give rise to widespread fog of persisting type.

In conclusion, the authors wish to record their thanks to Shri S. S. Bhondve for the preparation of the charts.