

The Daily Variation of Wind in the Lower Atmosphere over Ahmedabad

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(Received 10 April 1952)

ABSTRACT. The lower atmospheric wind structure over Ahmedabad has been studied from a detailed analysis of one complete year's observations. It is found that the local winds introduced by the orographical peculiarities of the surrounding country are (1) the katabatic wind that comes as a northeasterly current extending to a depth of about 0.15 to 0.25 km in the months of October to January and (2) the sea breeze that reaches from the Gulf of Cambay in the hot months just prior to and after the local monsoon. A seasonal examination of the pilot balloon winds shows that the nature of the diurnal variation of wind is governed mainly by the amount of turbulence in the frictional layer. This variation is confined to about 3000 ft in winter and extends to a greater height in summer. It is also shown how, in the winter months, both the wind and temperature distributions help in the formation of a very stable layer just above 3000 ft limiting the upper reach of surface turbulence.

1. Some interesting features of the wind structure over Ahmedabad that emerged from a day to day analysis, for one complete year (1950), of the pilot balloon data obtained from the Indian Daily Weather Report, and of the additional information available from observations made in this laboratory, are discussed in the present note.

2. The topographical details of Ahmedabad are brought out in Fig. 1. The direction of the rivers indicates the general slope of the land towards southwest. The position of the city on the banks of the Sabarmati influences, to a considerable extent, the development of local winds. Here we deal with—

(a) The strengthening of the northeasterly wind that occurs on many days at night and in the early morning hours in the period October-January. This *strengthening* is likely to be due partly to katabatic effect.

(b) The sea breeze that penetrates from the Gulf of Cambay. This is most pronounced in the hot months of the year when steep temperature gradients between land and sea are common.

3. Since the dip of the land is very gentle, the katabatic effect is not strong. But the strengthening of the northeasterly wind in the cloudless, anticyclonic weather that generally prevails between October to January is clear. During this period, the

number of days on which the effect could be proved from an examination of the pilot balloon charts (kindly lent by Dr. B. N. Desai on behalf of the India Meteorological Department) are given in Table 1. To bring out the development of the phenomenon more clearly, each month has been divided into two fortnightly periods.

The nature of the wind variation on such occasions can be seen from the windspeeds and directions given in Fig. 2 for six selected days. Observations are available at 0, 0.5, 1, 2, 4 and 6 minutes after the release of the balloon whose normal rate of ascent at 02 and 07 hrs was 9 km hr^{-1} . From these, the winds were calculated at sufficiently short intervals of height for the wind structure at low altitudes to be determined with enough detail. The katabatic effect was found to extend to a height of 0.15 to 0.25 km in November, the month with the maximum number of days of occurrence of the phenomenon.

On a comparison of the winds at 0200 and 0700 IST on 5 November 1950, we find that (a) close to the ground the winds are light and of nearly the same strength at both the hours; (b) the windspeed increases rapidly with height in the first 100 or 200 metres above ground. It attains a higher maximum at 0700 IST. The layer of maximum wind speed is also higher at that hour. These show clearly how the katabatic flow, which

has started at 0200 IST, thickens in the period between 0200 and 0700 IST. Already at 0200 IST the cold air gliding down from greater elevations has lodged itself stably at the bottom, and the additional current that comes with the greater development of the effect runs smoothly over this stable base. Since it requires a strong vertical gradient of wind to disturb a stable stratification near the ground, the base is not appreciably accelerated by the increased motion of the upper parts. Sudden increases in windspeed, however, can disturb the stable regime temporarily.

4. The sea breeze arrives at Ahmedabad from the Gulf of Cambay (distance nearly 50 miles) as a cool, gusty wind, generally between 1700 and 2000 IST. At the time of onset, it can be quite strong. Its decay at midnight is marked by a veer of wind from the south to the west or southwest. The deep penetration of the sea breeze in this region is primarily due to the flat nature of the land. As far as Ahmedabad is concerned, the Sabarmati river valley probably exercises a tunnel effect in guiding the wind.

The anemogram of 15-16 May 1950 is presented in Fig. 3 along with the temperature and humidity records of the same day. The welcome drop in temperature and the sudden increase of relative humidity at the onset of the phenomenon (1800 IST) are noteworthy. The number of days on which there was a similar sudden fall of temperature accompanied by a rise in humidity in the evening hours of April, May, June and October 1950 are presented in Table 2. The phenomenon is found to be most frequent in June and in October, the month just prior to and after the local monsoon respectively.

5. In Fig. 4 histograms showing the number of days of occurrence of different group of windspeed, 0-4, 5-9, 10-14, 15-19, 20-24, 25-29 and 30-34 knots are given for three times a day, night (0200 IST), morning (0700 IST) and afternoon (1400 IST) for the three heights 1000, 2000 and 3000 ft for the months of January and May (1950) which are taken as representative of the cold and hot seasons respectively. In the diagram points representing the mean values of wind speed for the different groups, viz., 0-4, 5-9, 10-14 etc knots are marked.

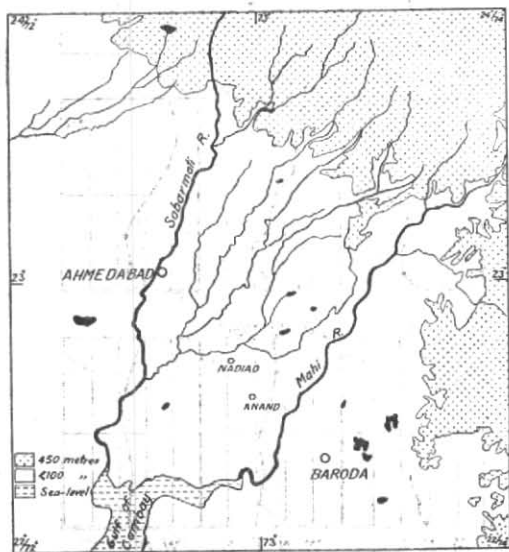


Fig. 1. Orographical Map of Ahmedabad and the surrounding country

TABLE 1

Number of days on which northeasterly or easterly winds showed marked strengthening in the morning hours

Period	October		November		December		January	
	1	2	1	2	1	2	1	2
No. of days of occurrence	7	10	13	12	13	6	4	5

TABLE 2

Number of days on which the sea-breeze effect was prominent in Ahmedabad

	April	May	June	October
No. of days of occurrence	7	18	21	22

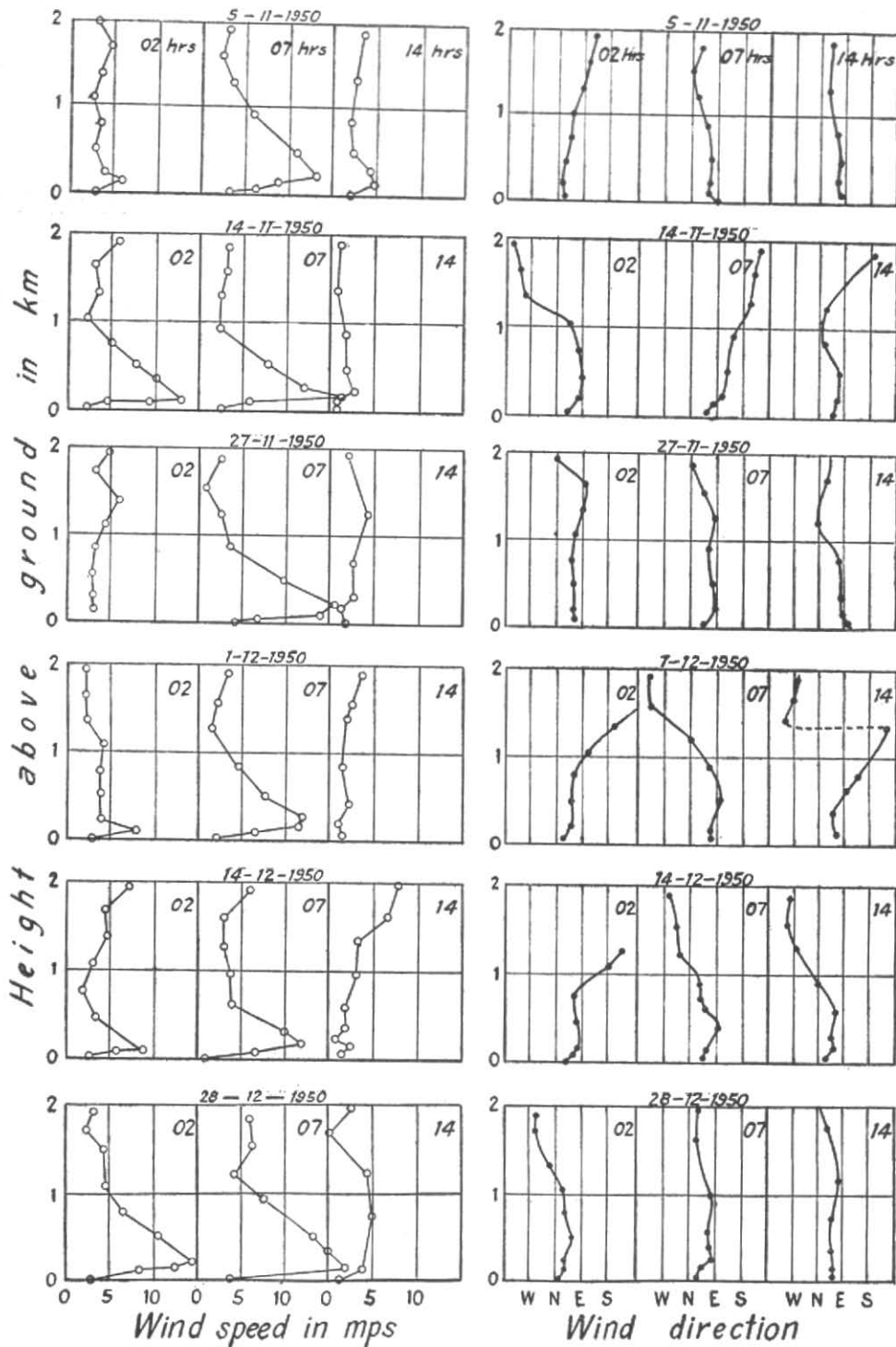


Fig. 2. Winds in the first two kilometres over Ahmedabad on six selected days of katabatic effect

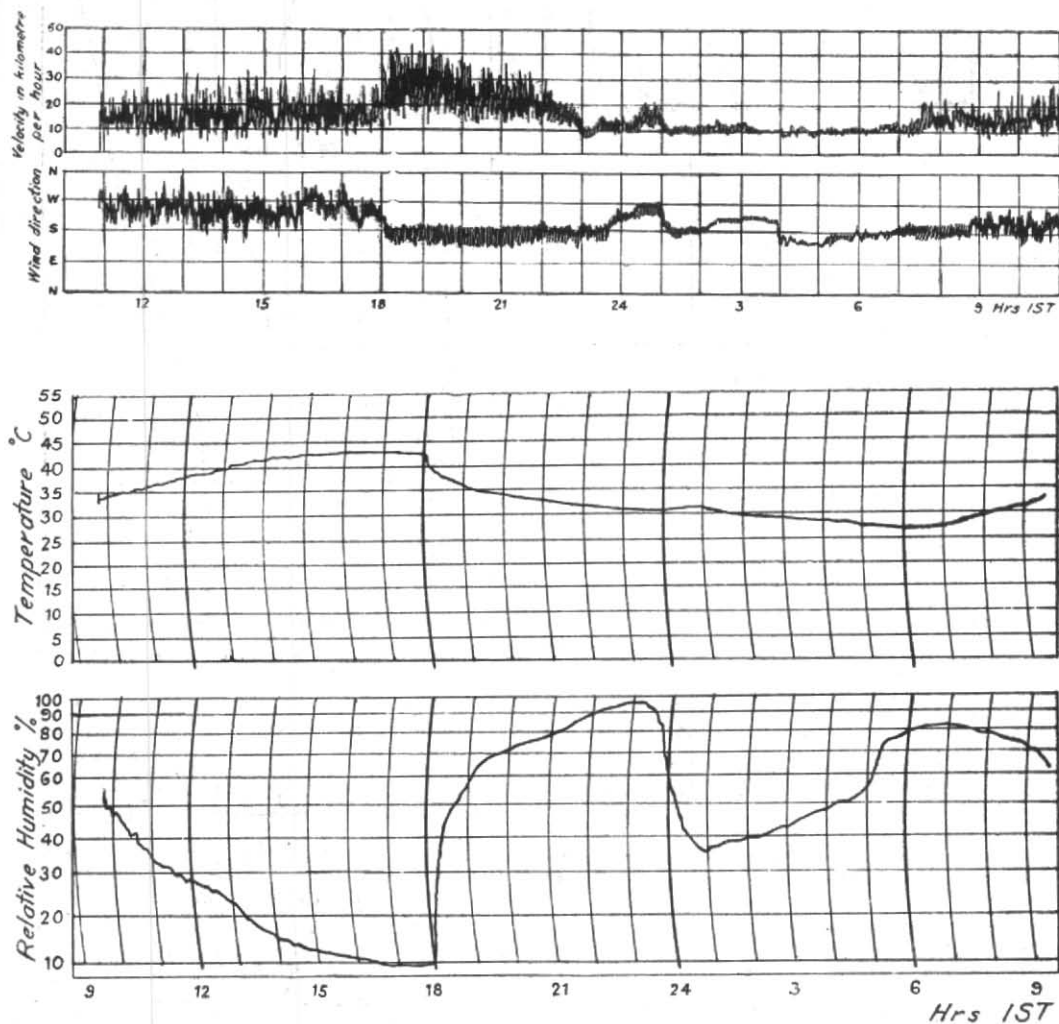


Fig. 3. Autographic records of 15-16 May 1952 illustrating onset of sea breeze at 1800 IST

Considering first the month of January we see that—(a) At 1000 ft at 0200 IST the most frequent speed group is 10-14 knots, at 0700 IST it is 15-19 knots and at 1400 IST it is 5-9 knots. The speed grouping at 2000 ft is essentially the same except that at night and in the morning it is shifted one step towards the lower wind-side. (b) At 3000 ft the most frequent wind group is 5-9 knots. The geostrophic wind level may be considered to be reached at approximately this height in this season.

In May, on the other hand, the wind speed even at 3000 ft shows marked diurnal variation. The maximum speed is now obtained at night instead of in the morning. This is due to the fact that, in this season of earlier sunrise, at the time of morning observations (0700 IST), turbulence has already started transporting momentum from these layers to the ground. Moreover, the sea breeze effect sometimes persists far into night, and affects the night observations.

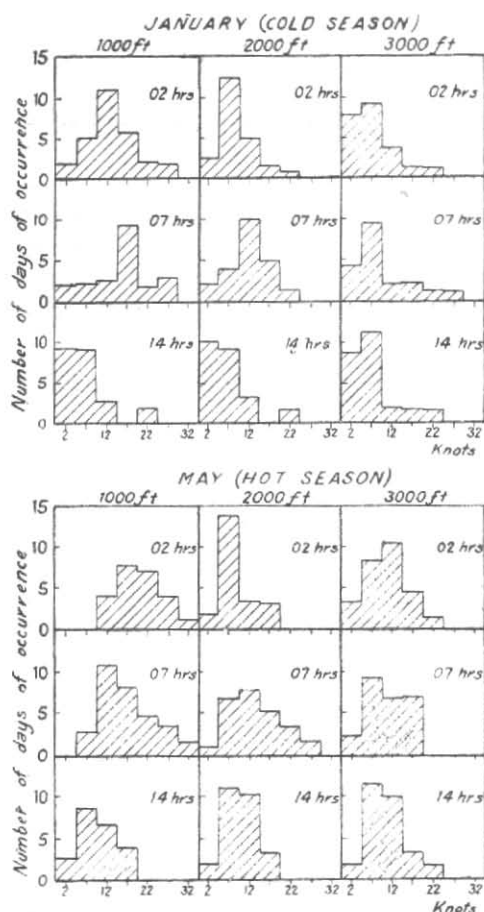


Fig. 4. Frequency distribution of different groups of wind speed over Ahmedabad

6. Fig. 5 (a) gives the average speed-height curve for the month of December. The corresponding curves for the other winter months are similar. Of special interest is the comparatively stable stratum of air just above 3000 ft revealed by these curves. We have seen that the geostrophic wind level is reached near 3000 ft in these months. Thus this stable layer is seen to act as a boundary limiting the upper reach of turbulence.

In Fig. 5 (b) potential temperature is plotted against height from values obtained from regular radiosonde ascents made between 1800 and 1900 IST. ABCD is the

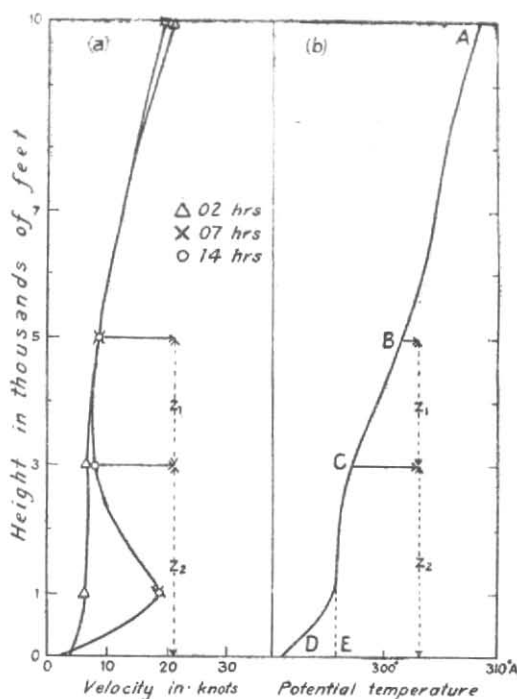


Fig. 5. Pilot balloon windspeeds and potential temperatures over Ahmedabad in December

experimental curve and ABCE is extrapolated as approximating to midday conditions. It can be seen that (a) above 5000 ft. (portion AB) the temperature distribution is that of an initially stable atmosphere. With no turbulence the temperature-height curve will be roughly given by ABC; (b) The layer between 3000 and 5000 ft (ht Z_1) has a larger value of $d\theta/dz$ (θ = potential temperature) than the layers immediately above or below it. Also in this region dv/dz (V = wind speed) is small. Thus the stability of the layer between 3000 and 5000 ft is due both to a large value of $d\theta/dz$ and a small value of dv/dz which together give a large value of Richardson's number. This excessively stable layer, though itself caused by turbulence in Z_2 , prevents the influence of the latter to higher levels.

I wish to acknowledge my indebtedness to Prof. K. R. Ramanathan for very helpful discussions and criticism.