

EFFECT OF AFTERNOON HEAT LOWS ON WINDS AT LOWER LEVELS

S. L. MALURKAR
(Poona)

THE question of diurnal variation on surface winds has been discussed elsewhere.¹ Mention was made of the large variation of winds at Ahmedabad on many days in winter even in upper air. On many mornings in late winter, the upper winds at Ahmedabad are N.W. or N.E., and have a speed of nearly 30 m.p.h. up to about 1.5 km. above m.s.l. But in the afternoon the wind speed drops down to as low a value as 5 m.p.h. An explanation can be easily given once the fact is known. When one of the low pressure areas of a western disturbance is approaching Kathiawar or south Rajputana, the seasonal high pressure area to the west of Ahmedabad gets intensified and gives rise to strong winds with some northerly direction. The strength of the seasonal high diminishes with height at the place. The more northerly low pressure areas of the western disturbance also limit the extent of the high pressure area. The vertical extent of the strong winds is, therefore, limited by the above considerations to about 1.5 km. The intensification of the high pressure leads to clear afternoon skies giving full play to solar heating. A low pressure area due to this solar heating is superimposed in the afternoons diminishing the strength of the high pressure area, and consequently the strength of the upper winds. The vertical extent of the heat low is also of the same order as 1.0 to 1.5 km. so that the diurnal variation of upper winds is most marked in this layer.

An equally remarkable diurnal variation can be observed at Mandalay in Upper Burma, in the clear season, i.e., in the non-monsoon months. The upper winds up to about 1.5 km. show in the mornings large southerly components. But in the afternoons the southerly com-

ponent diminishes very considerably. Sometimes even a small northerly component may actually be seen. The following table is based on an average of five to six years.

TABLE I
Components from South (miles per hour)

Height	March		April		May		October	
	M	A	M	A	M	A	M	A
0.5 km.	12.3	-1.3	16.5	2.7	21.4	5.8	7.8	-1.1
1.0 km.	5.6	-0.2	12.8	2.9	18.0	5.6	5.6	+0.2

M—Morning. A—Afternoon.

The approximate location of the semi-permanent low pressure areas was derived from considering the fact that the low pressure areas are regions of upward convection. In the sunny afternoon near the hills or uplands, instead of the Katabatic winds uphill currents of Anabatic winds occur.¹ In the uplands or near the hills, the afternoon convection or upward air motion is greater than in the neighbouring plains. In other words, the uplands or hills behave as areas of low pressure. It is well known that the reduction of barometric pressure to the sea level or the neighbouring plain level shows on sunny days a relative low pressure area over the hills or the uplands. It may be thought that the effect of this has little significance. The winds at upper levels are determined not only by the pressure gradient but by the density of air which is dependent on the temperature distribution. The apparent low introduced by reduction of barometer is also

due to the deviation of the temperature distribution from an assumed value. When it is possible to work out these equations more rigorously, one can confidently expect that these apparent low pressure areas in the afternoon have their value in determining the winds.

Because of the orography of Upper Burma, there should be a semi-permanent low pressure area west of Mandalay as a feature in the dry season. As an afternoon effect a low pressure area should be superimposed due to Shan Hills. This superimposed low pressure area would be to the east of Mandalay, and would give rise to northerly winds which diminish the southerly components found in the mornings.

A further application of the afternoon low pressure areas over the hills can be made to explain the "Sea Breeze" to the east of Western Ghats in Peninsular India. Rice, in the *Gazetteer of Mysore*, mentioned long ago that sea breeze blows at Shimoga. It is known to occur in Hassan and Belgaum districts. Ramnathan³ studied the sea breeze at Poona, but gave no explanation for its penetration so far from the coast.

It is generally considered that the sea breeze is due to differential heating of coastal land and sea. It is supposed to flow across the isobars for a distance not exceeding 15 to 20 miles inland. The depth of the sea breeze is also not great. But the places east of the Western Ghats are much farther away. There is a high range of hills with an average height of 2,000 to 3,000 feet between the sea and these places. One would have thought this as an obstruction across which the sea breeze would not penetrate. The sea breeze does not penetrate so far inland in the flat coast north of Bombay.

The author pointed out¹ that the wind at a place near the sea or hills is the resultant of the synoptic wind, i.e., wind due to the prevailing circulation of the day and the effects of sea and land breezes, Katabatic (down hill) and Anabatic (up hill flow) winds. The sea breeze which flows across the north Konkan coast is accelerated by the heat low lying adjacent to the Ghats. Once the isobaric picture has been drawn carefully and completely, the idea of orography or the hills obstructing the flow should not again be considered. At the obstacle, the equations may not prove correct. But on either side of the obstacle or the range of hills, the wind given would be correct (cf. barrier equations in hydrodynamics and other similar subjects). The sea breeze which is accelerated by the heat low would blow much further inland than if the low did not exist. Because of momentum gained the wind would cross the central axis of the low due to the Western Ghats, until friction and pressure gradient against it wipe it out.

For the occurrence near the hills, it may be argued also in a slightly different and more easily understandable way. The sea breeze that reaches the foot of the hills on the western side of the Ghats is carried along with the uphill wind (Anabatic wind) to a higher height and allows the stream to cross the Ghats. As the time of maximum temperature is usually past by the time the wind reaches the top of the Ghats, the resultant wind flows down on the eastern side till its momentum is exhausted. There is absolutely no difference between this and the statement in the last paragraph, except that of a physical picture.

It is possible that the above offers an explanation to the strong westerly winds which blow in the summer afternoons in the plains of the United Provinces and the adjoining regions. At other hours, the wind strength dies down considerably. The morning isobaric picture is an increase of pressure to the north extending to the plateau of Tibet. Even in the afternoon charts, the pressure increases towards the north in the plains of the United Provinces. In fact, there is an afternoon heat low over the Peninsula. Due to the latter, one should have expected the winds to have some easterly direction. The fact that the winds blow W. or W.N.W. shows that in the summer afternoons, an apparent low must be forming and being superposed to the north of the United Provinces. As in the case of the Shan Hills, the apparent low must be forming over the Himalayas and the Tibet. The reasons for the formation of the low must be the same as before. The uphill currents must give the effect of a low, or the pressure and temperature distribution must both be responsible for the effect on the wind. The reduced barometer readings of Roorkee show a higher pressure than the corresponding values for Dehra Dun on summer afternoons though, in the mornings, the opposite is the case. The stations are chosen near each other so that only diurnal effects are shown up. An analysis may be made to divide the winds into one due to pressure gradient and the other due to the temperature gradient (Thermal winds) after laborious investigations. The picture in this paragraph is simple and can be applied in other similar cases. A confirmation of the above can be seen when there is a western disturbance passing at a more northerly latitude, the afternoon winds in the United Provinces are stronger than usual.

1. *Tech. Note No. 19, Indian. Met. Dept., 1945.*
2. —, No. 20, *Ibid.*, 1945. 3. *Sci. Notes, Indian. Met. Dept., 1931, 3, 131.*

Note.—The cost of printing this article has been met from a generous grant-in-aid from the Indian Council of Agricultural Research, New Delhi.