

Potential gradient patterns associated with airmass types at Poona

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ABSTRACT. The records obtained of the potential gradient at Poona have been examined *vis-a-vis* the synoptic charts showing the minimum temperature departure from normal and the wind at 1.5 km. The study has indicated that the variations noticed in the pattern of the potential gradient could be associated with the variations of the airmass over the region.

1. Introduction

The recent trend in studies relating to atmospheric electricity is towards determining the meteorological factors which control its variations (Israel 1971). The surface potential gradient for land stations within the austausch layer, is dependent on the resistance of the lowest layers of the atmosphere (Chalmers 1967). Hence the characteristics of the airmass, such as its aerosol/pollution content, stability and moisture content, influence both the fair weather and disturbed weather variations of the potential gradient.

The nature of the variation in surface potential gradient during the IQSY and IGY periods have been reported for Poona and Bombay (Chowdhuri and Gopinath 1968). Extensive observations of the seasonal variations of the electrical potential gradient in the free atmosphere over Poona have been reported and discussed (Venkiteshwaran and Huddar 1956; Venkiteshwaran and Mani 1962; Mani, Huddar, Kachare, Swaminathan, Srivastava and Venkiteshwaran 1960; Venkiteshwaran 1958). With a view to examining the influence of airmass on the potential gradient, a study has been undertaken by the present authors, at Poona (18°32'N, 73°51'E, 559 m a.m.s.l.) of the variations in surface potential gradient during the four seasons (1) Winter (December-March), (2) Summer (April-May), (3) Southwest Monsoon (June-September) and (4) Post monsoon (October-November). The features noticed on typical occasions are described.

2. Data

The source of data for the study is the daily recordings of potential gradient obtained at the station with the equipment described earlier (Selvam 1970). The recordings have been standar-

dized for the exposure and load factors of the equipment independently.

The cold and warm air advections can be detected from the minimum temperature fall or rise over the region, particularly during the winter season in Poona (Roy 1946). Charts showing (a) minimum temperature departure from normal, (b) 1.5 km wind and (c) anemogram, have been made use of for detecting large scale airmass advection.

3. Analysis and discussion

3.1. Winter (December-March)

The airmass over Poona and neighbourhood during winter, according to the classification made (Roy 1946), is usually T_c (Tropical Continental). Slight convective instability is present in the lower layers during the day. Sky is clear or partly covered with high/medium clouds with patches of cumuliform clouds locally in the afternoon. Nights are mostly clear. This type of airmass is found to give rise to a diurnal variation in potential gradient with double maximum, one in the morning (336 v/m) and the other in the evening (244 v/m), as shown by the mean 24-hour potential gradient for December 1971 in Fig. 1.

3.1.1. *Cold air advection*—The meteorological features associated with the field (potential gradient) pattern on 16 to 17 February 1971 are considered. Fig. 2 gives the charts of the potential gradient and surface wind. It also gives the isopleths of minimum temperature departure from normal and the winds at 1.5 km. The 1.5 km winds at 1730 IST on 16 February 1971 show advection of northerly air NP_c (Extra Tropical Continental) or $P_c T_c$ (Transitional Polar Continental) into the region. Night minimum has fallen by about 2° to 4°C throughout Maharashtra and adjoining areas. Examination of the anemogram and the

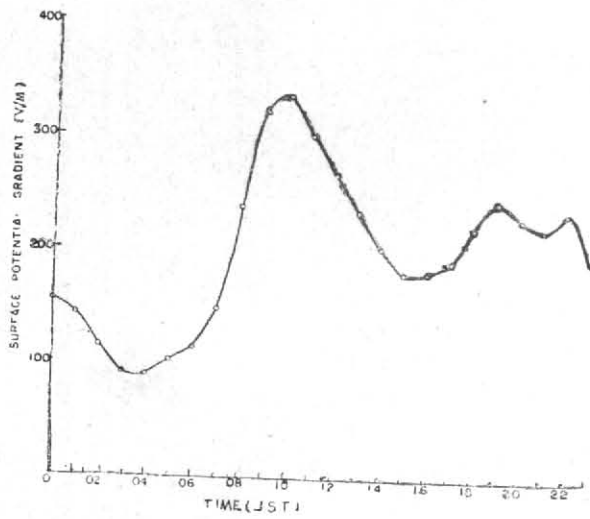


Fig. 1
Diurnal variation of potential gradient (v/m)
for December 1971

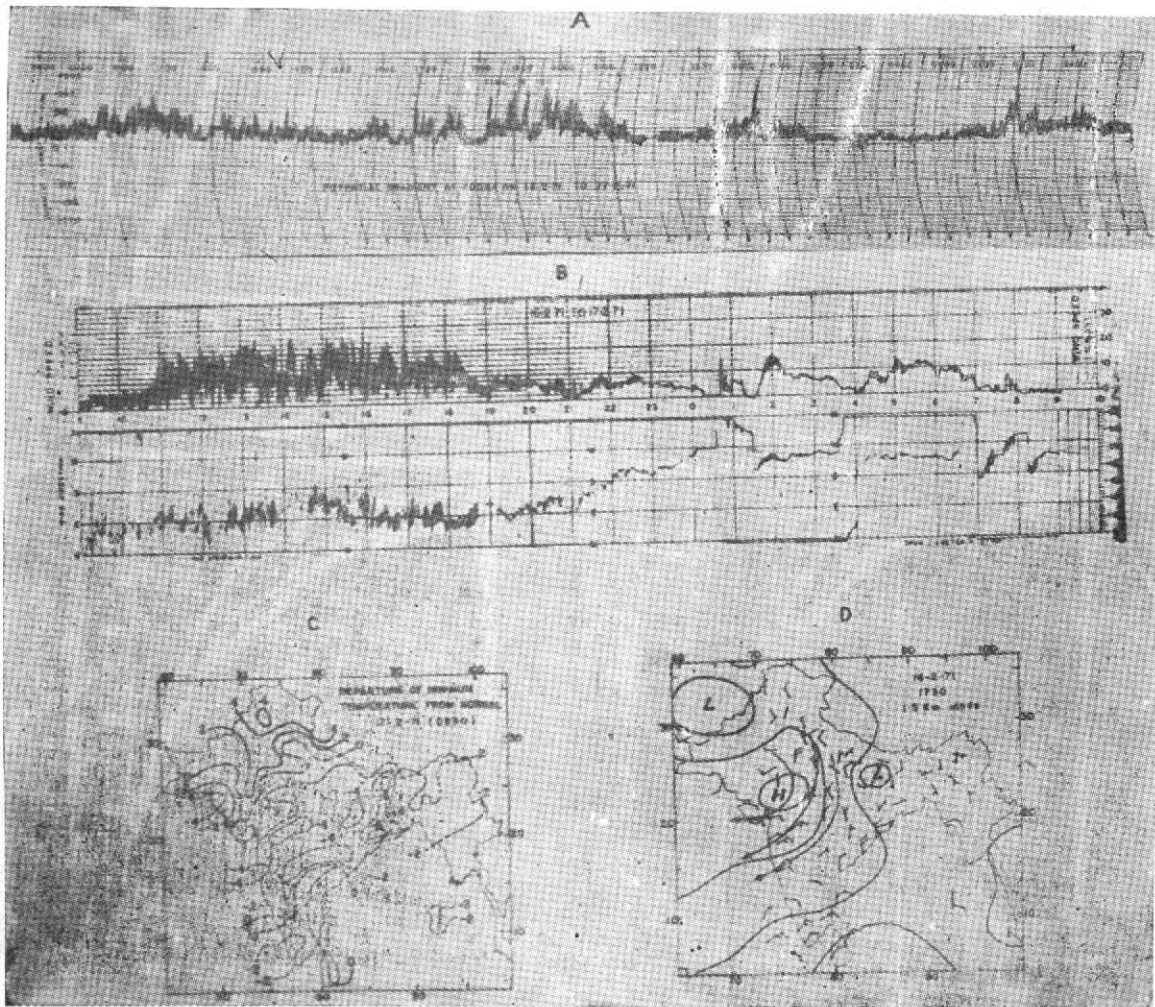


Fig. 2

- (a) Potential gradient at Poona from 16 to 17 February 1971
- (b) Anemogram at Poona from 16 to 17 Feb 1971
- (c) Isopleths of departure of minimum temperature from normal at 03:30 IST on 17 February 1971
- (d) Streamlines at 1.5 km on 16 February 1971 at 17:30 IST

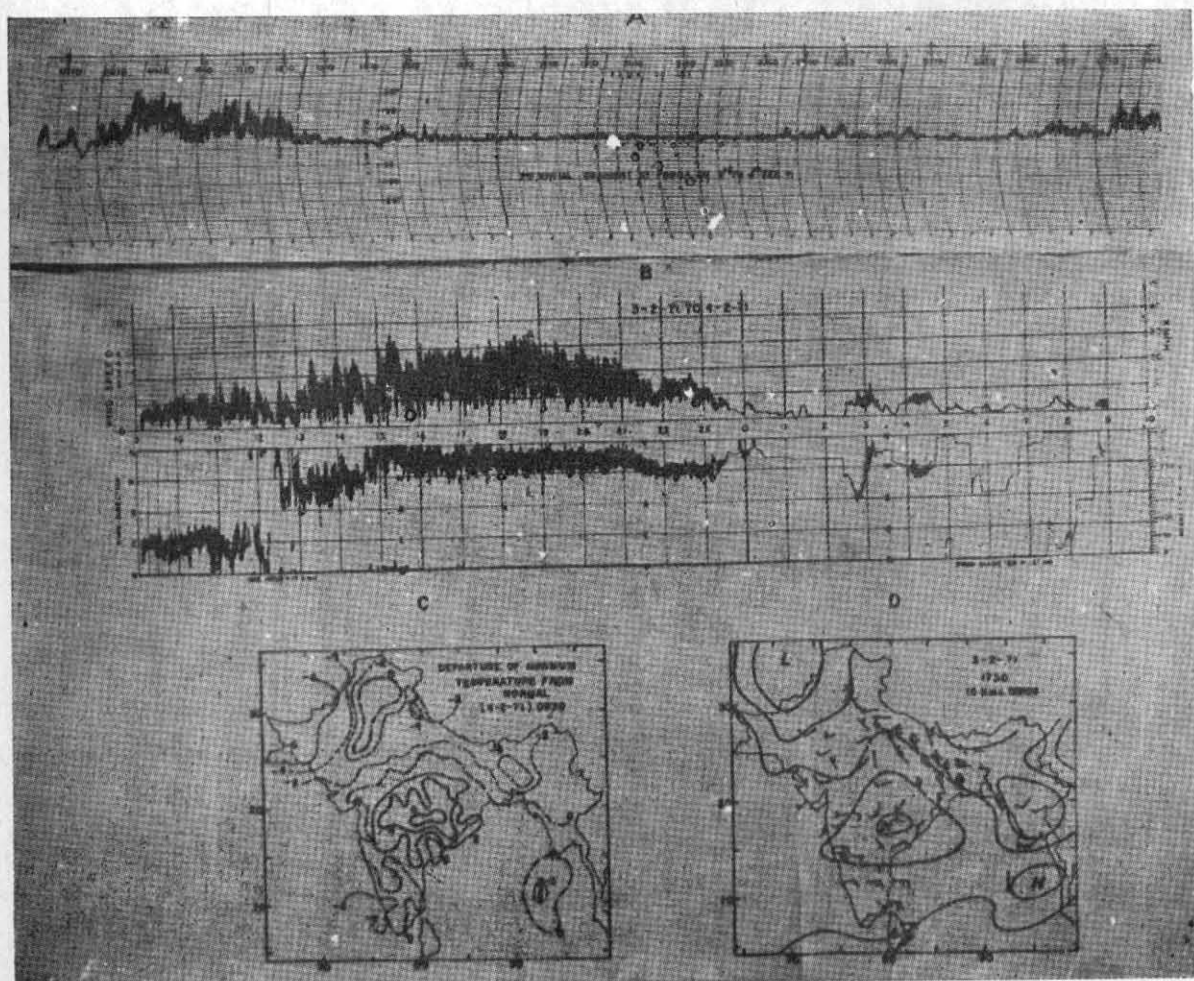


Fig. 3

- (a) Potential gradient at Poona from 3 to 4 February 1971
 (b) Anemogram at Poona from 3 to 4 February 1971
 (c) Isopleths of departure of minimum temperature from normal at 0830 IST on 4 February 1971
 (d) Streamlines at 1.5 km on 3 February 1971 at 1730 IST

potential gradient record shows that the agitation in the potential gradient pattern is associated with easterly winds. Northwesterly to southwesterly winds are associated with small values of potential gradient without much fluctuation. The change in wind from continental (before 2200 IST on 16 February 1971) to maritime (after 2200 IST) is accompanied by a decrease in the magnitude and agitation in the field. During calm conditions the field shows an increase, possibly because the suspended particulates in the atmosphere accumulate due to absence of turbulence (0015 to 0040 and 0115 to 0130 IST on 17 February 1971) thereby reducing the concentration of the small ions. The value of the hourly mean potential gradient is 143 v/m when the flow is from land (0900 to 2100 IST) and 80 v/m when the flow is from the sea (2200 to 0900

IST). The value of the hourly mean for the entire day is 117 v/m.

3.1.2. *Warm air advection*—The meteorological features associated with the field pattern on 3 to 4 February 1971 are examined. Fig. 3 shows the charts of the potential gradient, surface wind, departure of minimum temperature from normal and the winds at 1.5 km. Night minimum has risen throughout Maharashtra. 1.5 km winds at 1730 IST on 3 February show advection of southwesterly winds into the region indicating that the prevailing airmass was of the type $T_m T_c$ (Tropical Continental above with Tropical Maritime below) or $T_m NP_c$. Clouding was reported at 0830 IST (3 okta) and 1730 IST (1 okta), on 3 February 1971. The anemogram chart shows the wind to b

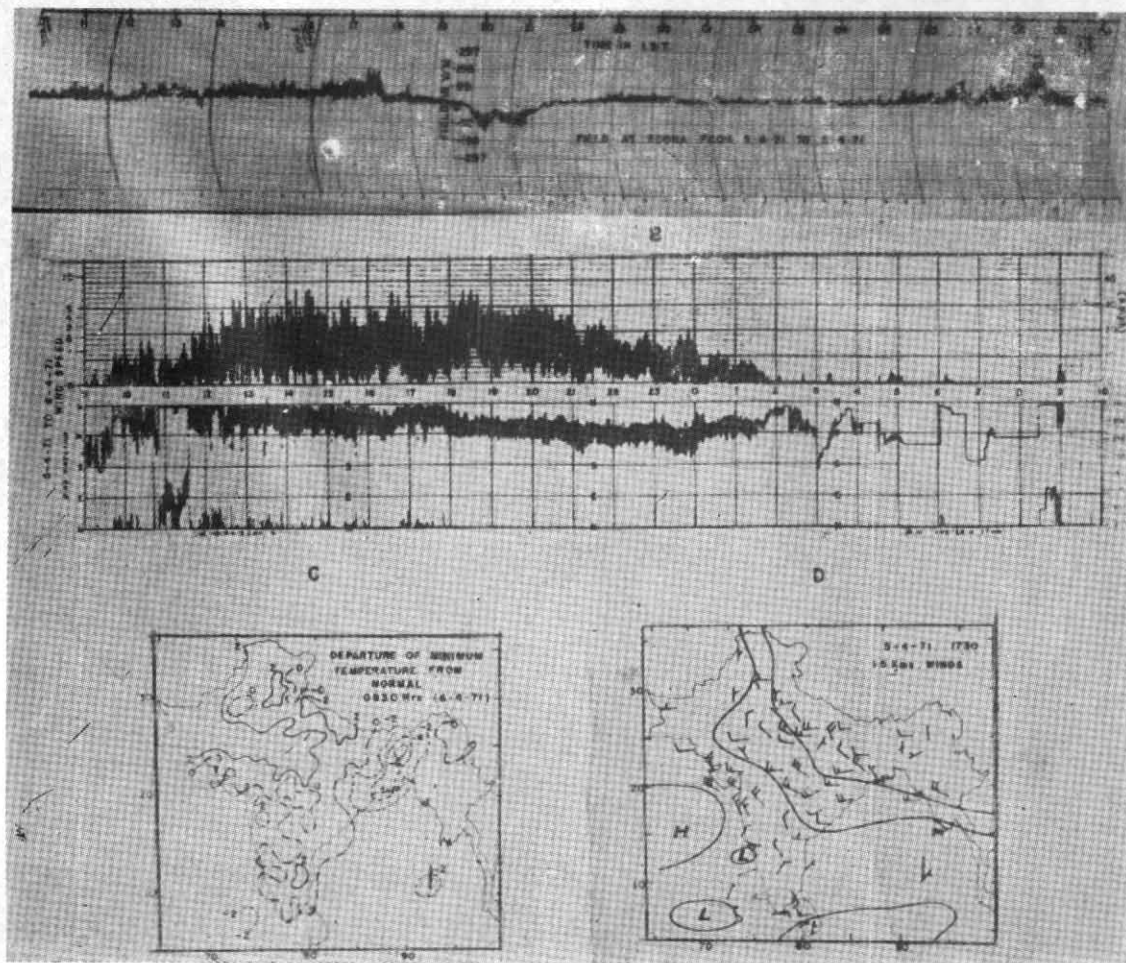


Fig. 4

- (a) Potential gradient at Poona from 5 to 6 April 1971
 (b) Anemogram at Poona from 5 to 6 April 1971
 (c) Isopleths of departure of minimum temperature from normal at 0300 IST on 6 April 1971
 (d) Streamline at 1.5 km on 5 April 1971 at 1730 IST

mostly easterly in the morning (from land), and later becoming northwesterly. The value of the hourly mean potential gradient is 205 v/m when the flow is from land (0900 to 1215 IST) and 45 v/m when the flow is from the sea (1300 to 1430 IST and 1530 to 2300 IST). The hourly average of potential gradient from 0800 IST on 3 February to 0800 IST on 4 February 1971 is 77 v/m.

Comparing the day of cold air advection (3.1.1) with the day of warm air advection (3.1.2) it is seen that the wind speed and turbulence were smaller during the former case. Sustained high speed maritime winds during the latter might have kept the air clear of pollution/aerosol particles and given rise to the observed smaller fields of that day.

From 1800 to 2200 IST on the cold air advection day, the wind was mainly easterly and the corresponding field pattern shows high values with large fluctuations (300 v/m to 60 v/m). During the same period on the warm air advection day, the wind was mainly northwesterly and the corresponding field is small (about 50 v/m) with small fluctuation. The usual evening maximum caused by subsidence at about 2000 IST is also absent. These features further illustrate the influence of wind direction on the changing pattern of the potential gradient at the station.

3.2. Summer (April-May)

During this period, which is the pre-monsoon, the airmass over the Deccan plateau (T_c) is dry and

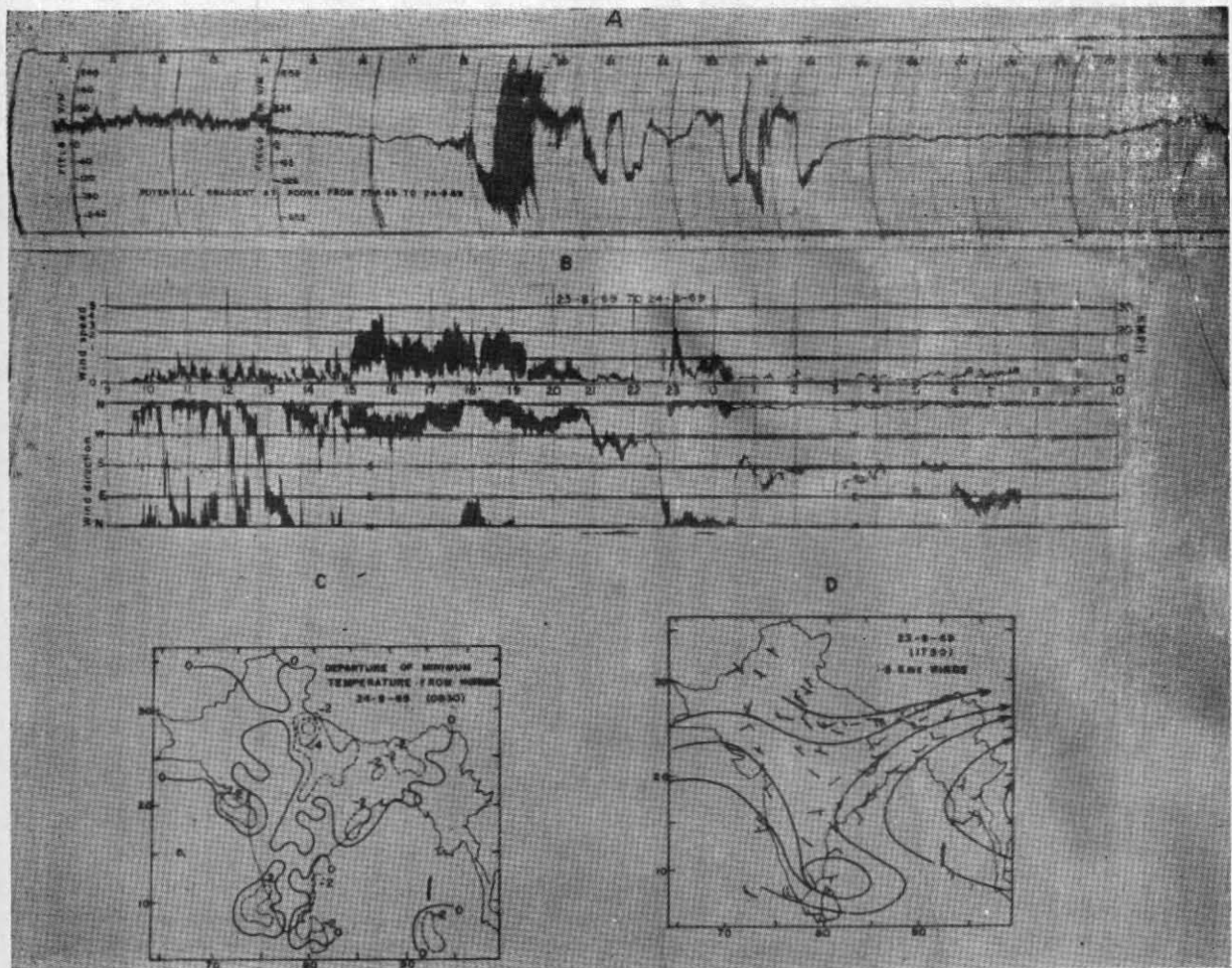


Fig. 5

- (a) Potential gradient at Poona from 23 to 24 August 1969 (Record from 1900 to 1930 IST is not genuine because of adjustments made during that period)
- (b) Anemogram at Poona from 23 to 24 August 1969
- (c) Isopleths of departure of minimum temperature from normal at 0830 IST on 24 August 1969
- (d) Streamlines at 1.5 km on 23 August 1969 at 1730 IST

highly unstable and insolation gives rise to convection. Towards afternoon and late evening, with incursion of maritime air (T_m , T_c), cumulus and sometimes cumulonimbus form and, if the moisture supply is sufficient, result in thunderstorms. The morning maximum of potential gradient during this period is smaller than during winter because of the increased convective activity. The potential gradient during afternoon/evening shows a small positive value or if there are well developed clouds, negative values.

The potential gradient chart from 5 to 6 April 1971 and the corresponding other charts are shown in Fig. 4. The field is small (average value is 60 v/m) and it shows only small agitation. At about 1800 IST there is a sudden decrease in the magnitude (from 180 v/m to 40 v/m) and in the agitation

of the field, coinciding with the change in the wind direction from northnorthwest to westerly. It seems likely that the negative field noticed at 2000-2100 IST is due to convective clouds, which had dissipated later (at 1730 IST on 5 April 1969, 6 okta low or medium clouds were reported).

3.3. Monsoon (June-September)

The airmass during the season is designated as E_m (Equatorial Maritime). This cool, highly humid and convectively indifferent or slightly unstable airmass is characterised by sky mostly covered to overcast, mainly with stratiform clouds. Instability phenomena such as thunderstorms and squalls are rare, except during the period of first advance over warmer surface when these are frequent and widespread and also occur occa-

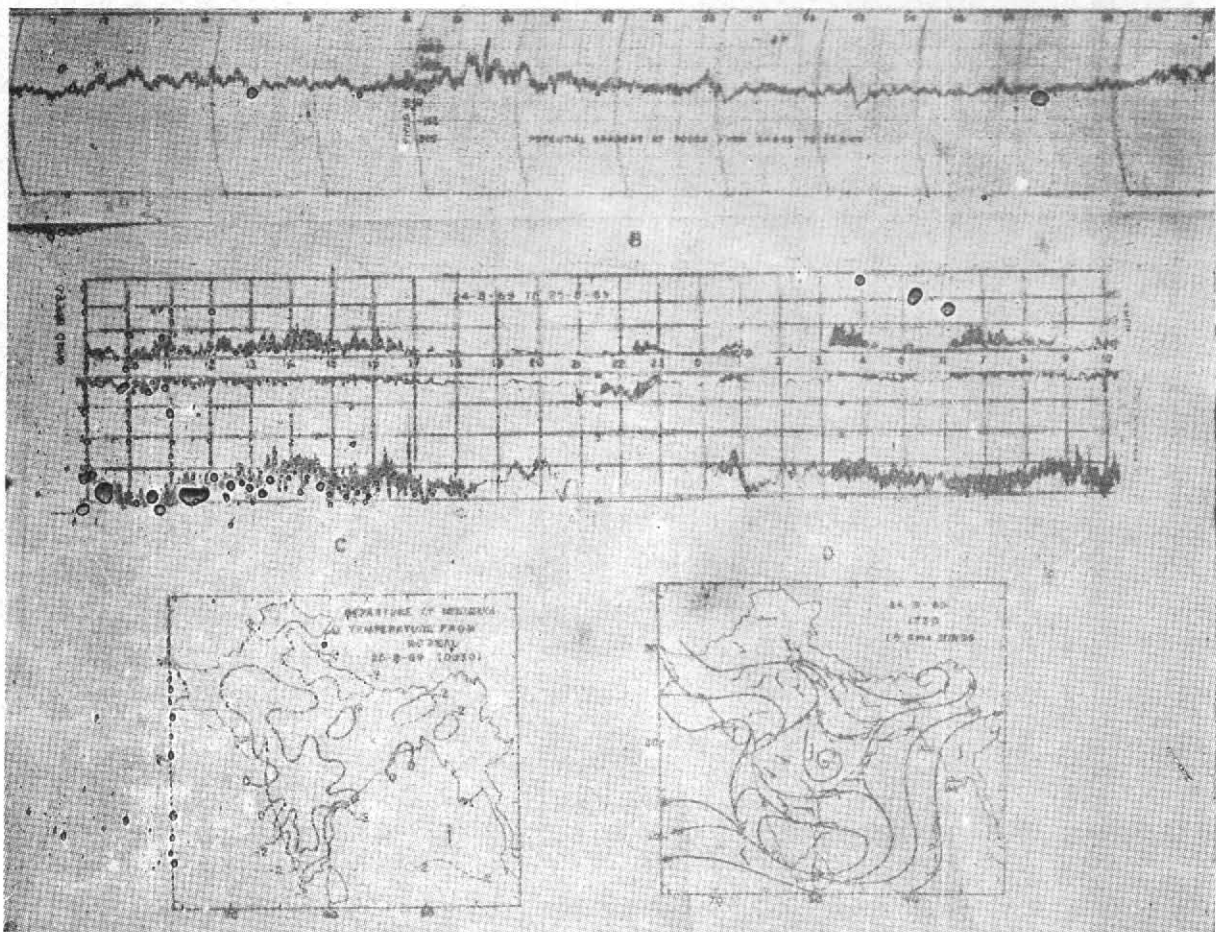


Fig. 6

- (a) Potential gradient at Poona from 24 to 25 August 1969
 (b) Anemogram at Poona from 24 to 25 August 1969
 (c) Isopleths of departure of minimum temperature from norma at 0830 IST on 25 August 1969
 (d) Streamlines at 1.5 km on 24 August 1969 at 1730 IST

sionally in inland regions when fresh surges take place after a prolonged retreat. Suspended aerosol/pollution content in the atmosphere may also be minimum during this season due to sustained strong maritime winds. The potential gradient during this period shows a small positive value which becomes negative when it rains.

The days 23 to 25 August 1969 are chosen to illustrate the influence of moist maritime air in producing fields typical of the formation of instability clouds. On 23 August 1969 (Fig. 5) the anemogram shows the wind to be small and indeterminate upto 1500 IST. There is a surge of westerly to north-westerly air from 1500 to 2200 IST. The field, which is small, is positive upto 1800 IST showing slight agitation. Subsequently there has been development of instability clouds and the field shows oscillations between positive and negative values.

On 24 August 1969 (Fig. 6) the anemogram shows very small easterly to northerly winds. The field has been positive throughout the day (average value 184 v/m) with a peak at 1900 to 2000 IST when the wind speed was nearly zero.

3.4. Post-monsoon (October-November)

The airmass in the lowest layers upto a height of 1 to 2 km in October and early November is the old E_m air which by now is virtually cut off from the source, and is named $E_m T_m$ or $E_m T$ (Transitional Equatorial Maritime) air. Above it flows the Continental Tropical air, the anticyclonic field of circulation of which extends farther south and eastwards in the upper levels than at the surface. Cu and Cb clouds develop during the afternoon. If the $E_m T$ layer extends upto 2 km or more, thunderstorms occur. Otherwise the weather clears up.

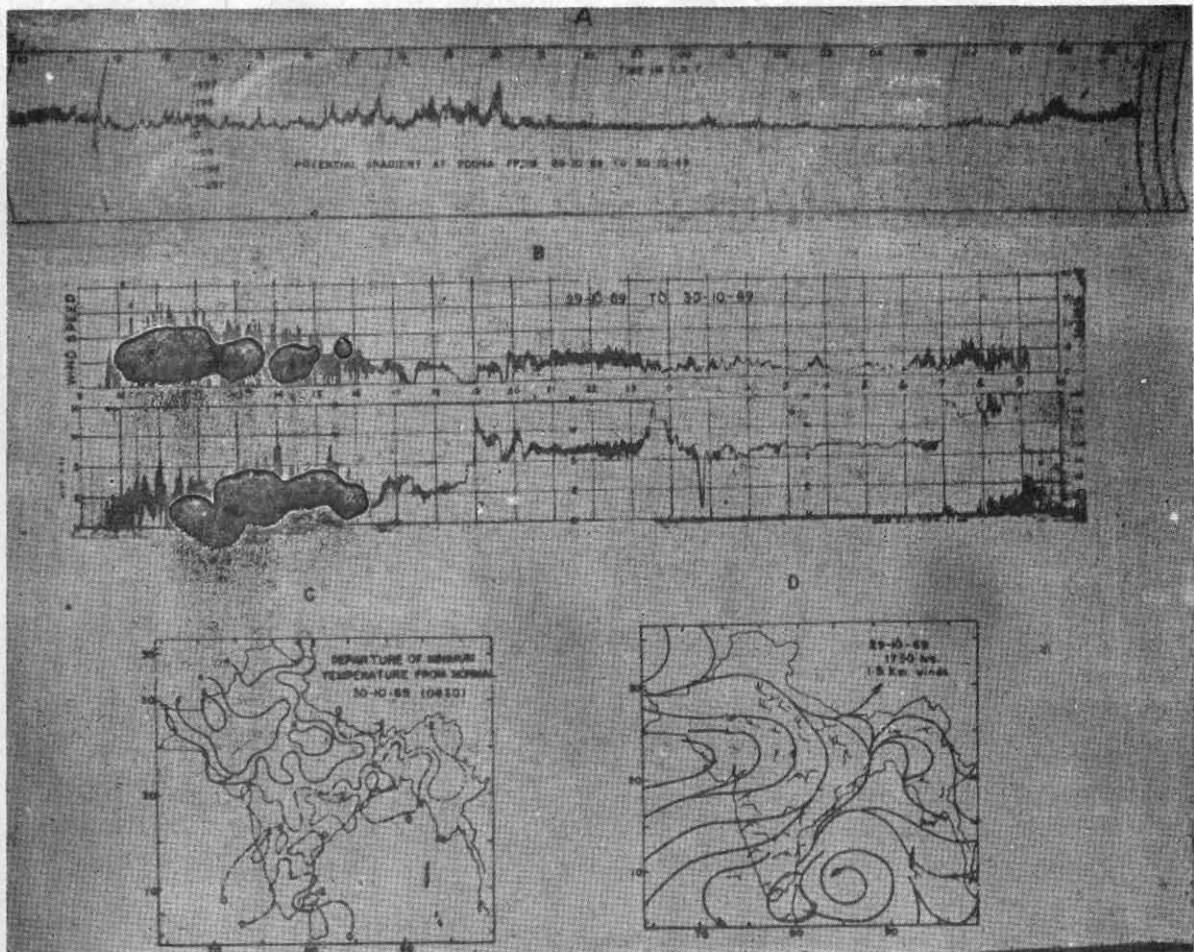


Fig. 7

- (a) Potential gradient at Poona from 29 to 30 October 1969
 (b) Anemogram at Poona from 29 to 30 October 1969
 (c) Isopleths of departure of minimum temperature from normal at 0830 IST on 30 October 1969
 (d) Streamlines at 1.5 km on 29 October 1969 at 1730 IST

Fig. 7 gives the charts for 29 to 30 October 1969. The evening maximum of the potential gradient which is 200 v/m occurs at about 2000 IST. The agitation and magnitude of the field show sudden decrease (from 180 v/m to 80 v/m) after 2000 IST on 29 Oct 1969 coinciding with the change in the wind direction from easterly to southwesterly.

4. Conclusion

The study of the effect of airmass on the potential gradient pattern at Poona has revealed the following features :

1. Maritime air gives rise to smaller potential gradients without much agitation. This is because it is sustained and strong and will be relatively free from pollutants.

2. Continental air gives rise to larger potential gradients with pronounced agitation. This is attributed to the larger content of aerosol/pollution of continental air.

3. During any season the change in the wind direction from continental to maritime is followed by a decrease in the magnitude and agitation of the field.

4. The maximum of fair weather field are found in winter and the minimum during monsoon season. Pre-monsoon and post-monsoon months show intermediate values.

5. The cold air and warm air advectations during winter are well reflected in the magnitudes of the potential gradient recorded. The warm air advection at Poona being due to unstable maritime air, produces smaller fields with less agitation. Cold air advection produces larger fields with more agitation.

The variations in the arimass over Poona region give rise to recognisable variations in the pattern of the potential gradient at the station. Similar features have also been reported by others (*viz.*, Byers 1953; Chalmers 1967; Dolezalek 1958 and Israël 1958, 1971).

The data presented are characteristic of the exact location where measurements have been made and

may not be representative of locations elsewhere in Poona.

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