551.551.4:551.596.5(541.2)

# On the variations of pressure and temperature associated with Nor'westers at Dum Dum

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ABSTRACT. Thunderstorms occurring at Dum Dum Airport have been classified into four categories based on pressure and temperature variation. In majority of cases, pressure rises and temperature falls were observed. Occasions with other combinations of pressure and temperature also existed. Representative cases have been presented and discussed. Hailstorms accompanied by pressure rise have also been presented.

## 1. Tetrachoric correlation coefficient

Nor'westers occur frequently in West Bengal and neighbouring areas during the premonsoon season (March to May). It is generally observed that pressure rises and temperature falls in association with these thunderstorms. But on rare occasions there are also other combinations of pressure and temperature. It is, therefore, proposed in the present paper to investigate the relationship between like and unlike changes of pressure and temperature associated with Nor'westers at Dum Dum Airport utilising the autographic charts for the years 1963 to 1966. For the purpose of obtaining a statistical relationship the tetrachoric correlation coefficient (Brookes and Carruthers 1953) has been employed in analysing the data in this paper.

The tetrachoric correlation coefficient can be calculated where both variables are divided into only two classes. Supposing the pressure changes associated with the squall are divided into rises and falls, accompanying the rises there may be rises and falls in temperature which may be denoted by $a$ and $b$. For the falls of pressure there may again be rises and falls in temperature which may be denoted by $c$ and $d$. The frequencies of like and unlike changes of pressure and temperature associated with Nor'westers are given in Table 1.

The tetrachoric correlation coefficient $R_T$ is then given by $R_T = \cos \{(\pi \sqrt{bc})/(\sqrt{bc} + \sqrt{ad})\}$ which can also be expressed in the form —

$$R_T = \sin \left[ \frac{\pi}{2} \cdot \frac{\sqrt{(ad)} - \sqrt{(bc)}}{\sqrt{(ad)} + \sqrt{(bc)}} \right]$$

It is readily seen from this that if all the changes correlated are out of phase then $a=d=0$ and $R_T = -1$. If, however, they are all in phase $b=c=0$ and $R_T = +1$. In the present case the value of $R_T$ came out to be $-{\cdot}32$. The sign of the coefficient indicates that either pressure rise with temperature fall or pressure fall with temperature rise is more favoured than that of either pressure rise with temperature rise or pressure fall with temperature fall. The low magnitude of correlation coefficient is primarily attributable to the fact that cases of pressure rises accompanying temperature fall account for 47 out of 66 available cases in the period of study while cases of pressure fall associated with temperature rise are only three in number.

## 2. Examples of four types

Examples are cited below to illustrate the four typical types described in Table 1.

### 2.1. *Type I* : *Pressure rise — temperature rise* (*16-4-1963*) — Fig. 1 (a)

At 0430 IST the radar indicated the presence of line formation in the northwest within 40 km approaching the station. Under its influence, squally winds from northwest/north prevailed over the station during 0440 and 0450 IST, maximum speed in gust reaching about 65 km at 0450 IST. Temperature also rose by about 2·5°C during 0440 and 0445 IST.

Earlier, squalls and showers at Dum Dum near about 1740 IST on the same day resulted in pronounced fall of temperature bringing it from 29° to 20°C. Later the temperature rose by 2°C but started falling from 0200 IST and remained in the neighbourhood of 20·5°C at the time of commencement (0440 IST) of the second squall. It is interesting to note that humidity which was about 90 per cent dropped by about 6 per cent with the commencement of this squall. It is seen that the air in the lower layer was already at its lowest temperature and maximum saturation because of an earlier squall and subsequent radiation cooling. Downdrafts from the second squall arrived at the station at somewhat higher temperature and lower saturation resulting in upward and downward traces in

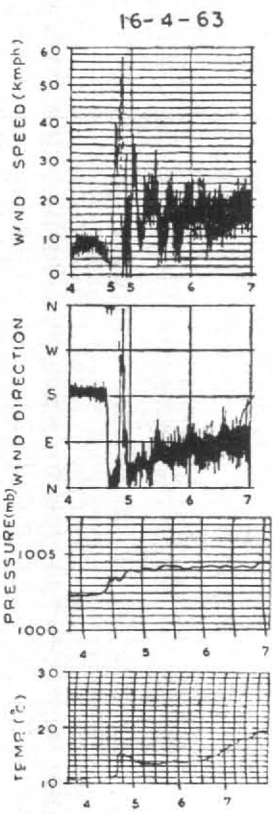


Fig. 1 (a)

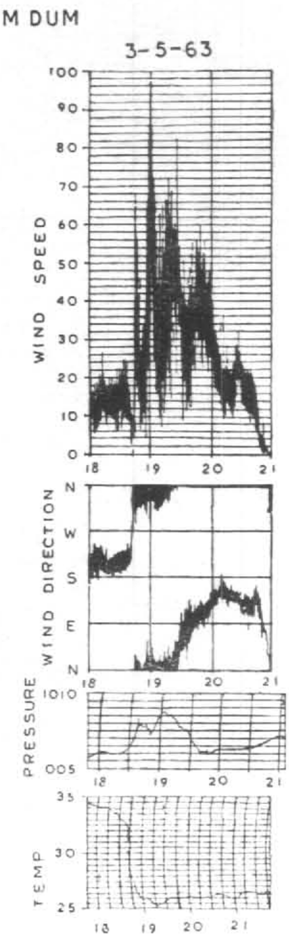


Fig. 1 (b)

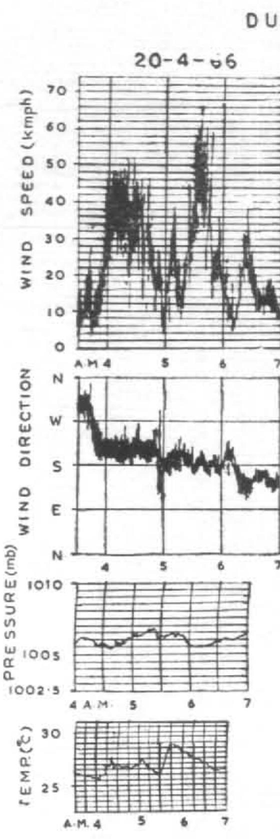


Fig. 2 (a)

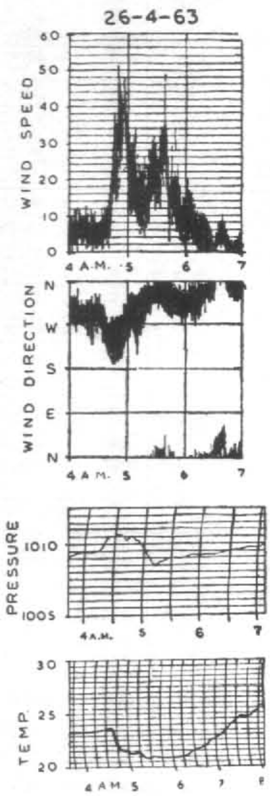


Fig. 2 (b)

**TABLE 1**

| | Temperature rise | Temperature fall |
|---|---|---|
| Pressure rise | $a = 10$ | $b = 47$ |
| Pressure fall | $c = 3$ | $d = 6$ |

the station barograms and hygrograms respectively.

2.2. *Type II: Pressure rise — temperature fall (3-5-1963)* — Fig. 1 (b)

Majority of thunderstorms fall under this category. The radar on this day indicated the presence of a squall line extending from southwest to north within 80 km of Dum Dum at 1830 IST. Under its influence and because of its subsequent movement towards the station, squally winds from northwest/north prevailed over Dum Dum during 1845 and 1925 IST, maximum speed in gust reaching 100 km at 1900 IST. A well-defined temperature break by about 6°/5°C between 1840 and 1900 IST resulted because of the cold downdraft.

2.3. *Type III: Pressure fall — temperature rise (20-4-1966)* — Fig. 2 (a)

Radarscope observations indicated the presence of a *Cb* cell, tops extending up to 12·5 km in the westnorthwest (290°) direction at a distance of 50 km at 0330 IST. This moved in the southeast direction and was located at a distance of 20 km at 0430 IST.

During the same period, another cell, tops extending up to 10·5 km was observed to lie in the southeast between 30 and 40 km of Dum Dum without appreciable movement. At 0530 IST a broken line extended from 245° to 060° through the station suggesting that the cell in the westnorthwest in course of its southeast movement resulted in two squalls under discussion—first from the westsouthwest and the second from the southwest direction.

Squally winds and showers at Dum Dum earlier during 1930 and 2000 IST of 19 April 1966 resulted in pronounced fall of temperature bringing it from 29° to 24°C. It remaining steady till 2315 IST, when it started rising. At 0400 IST of 20 April it was about 25·5°C. With the commencement of

**TABLE 2**

| Date | Duration of squall (IST) | Direction/speed (kmph) of squall | Duration of hailshowers (IST) | Average diameter (mm) of hailstones | Pressure changes |
|---|---|---|---|---|---|
| 11-3-63 | 1622—1632 | NW/50 | 1620—1637 | 6–8 | The pressure was 1000·6 mb at 1620 IST, rising to 1002·5 mb at 1622 and 1002·8 mb at 1627 IST |
| 4-4-63 | 1517—1527 | NE/76 | 1525—1532 | 5-6 | 1003·7 mb at 1517 IST rising tendency; at 1525 IST 1003·9 mb, rising gradually at 1527 IST to 1004·7 mb |
| 7-4-65 | 1805—1813 | NE/50 | 1805—1808 | 4 | 1006·3 mb at 1805 IST, 1006·5 mb at 1810 IST, rising tendency |

the first squall of the day (20 April) the temperature reached 27·5°C between 0415 and 0430 IST when the squall from westsouthwest reached the peak value of 52 km/hr The temperature then fell gradually to 26°C at 0530 IST.

The second squall reached the station shortly after 0530 IST. The sudden rise of temperature by about 3°C between 0530 and 0545 IST with the commencement of this squall from southwest and attaining a peak velocity of 66 km is interesting.

Examination of the microbarogram reveals that (*a*) pressure rose by about 1·5 mb between 0400 and 0500 IST covering the duration of first squall and (*b*) pressure suddenly fell by about 1 mb between 0520 and 0545 IST covering the period of second squall. Humidity dropped by about 10 per cent with the starting of both the squalls.

Whereas the first squall comes under Type I, *i.e.*, pressure rise—temperature rise, the second squall, characterised by pressure fall and temperature rise comes under Type III. This is the rarest case of all because as will be shown in Section 4, it necessitates the development of cells all round or in opposite quadrants as well as the occurrence of an earlier squall. Rise of temperature associated with the secondary squalls is favoured during night or in the early morning.

2.4. *Type IV* : *Pressure fall — Temperature fall* (*26-4-1963*) — Fig. 2(b)

From the radarscope observations of 0400 and 0500 IST, it is seen that *Cb* cell (220°—top 9 km) lay in SW and a growing *Cu* lay in the NE (050°) quadrants of Dum Dum. Squally winds from SSW/SW due to the effect of the *Cb* prevailed over the station during 0450 to 0500 IST, maximum speed in gust reaching 52 km/hr at 0400 IST. Pressure fell by about 0·5 mb during that period and was still falling. Temperature started falling from 0437 IST and dropped by 2·5°C at the time of squall thus characterising temperature fall in association with pressure fall.

**3. Hailstorm situations**

Greater percentage of thundersqualls are characterised by sudden rise of pressure at the station (Byers 1951, Byers and Braham 1949, Ramakrishnan and Ganapathiraman 1953, Bhalotra 1954, Mull and Rao 1950). Instances are also there, although few, when surface pressure fell during thundersqualls (Ramakrishnan and Ganapathiraman 1953, Bhalotra 1954, Asnani 1958). While the causes of pressure rise are easily understood, reasons for the pressure fall are still in debate. Asnani (1961) theoretically suggested that severe hailstorms may sometimes be accompanied by pressure fall. Interesting cases of hailstorms at Alipore (Calcutta) are given in Table 2.

**4. Discussion; cases of temperature rise with squalls**

Associated with changes of pressure in thunderstorms like and unlike changes of temperature were observed in the present study. It is common experience that great majority of thunderstorms show abrupt temperature fall in association with a squall. The temperature breaks have been found to occur either simultaneously with or slightly earlier or later than the occurrence of squalls. In certain cases, slight temperature rise also is observed (13 in 66 cases). It is generally seen that rise of temperature is associated with second or third squall in the series provided the antecedent squall or shower has considerably reduced the surface air temperature. Another interesting feature is that all these squalls occurred at night or early morning. The humidity changes associated with squalls show that unaccompanied by precipitation, eight resulted in drop, four in no appreciable change and only one followed by showers resulted in rise. While the first squall and shower bring down the surface air temperature to a low value with consequent saturation or near saturation, the subsequent squalls arrive at a higher temperature and lower saturation.

*REFERENCES*


| | | |
|---|---|---|
| Asnani, G. C. | 1958 | *Indian J. Met., Geophys.*, **9**, 2, pp. 117–132. |
| | 1961 | *Ibid.*, **12**, 1, pp. 21–28. |
| Bhalotra, Y. P. R. | 1954 | *Ibid.*, **5**, 4, p. 315. |
| Brooks, C. E. P. and Carruthers, N. | 1953 | *Handbook of Statistical Methods in Meteorology*, H.M.S.O., London, p. 238. |
| Byers, H. R. | 1951 | *Compendium of Meteorology*, Amer. met. Soc., pp. 681-693. |
| Byers, H. R. and Braham, R. R. | 1949 | *The Thunderstorms*, Washington D.C., U.S. Dep. Commerce. |
| Mull, S. and Rao, Y. P. | 1950 | *Indian J. Met. Geophys.*, **1**, 2, pp. 116–136. |
| Ramakrishnan, K. P. and Ganapathiraman, G. V. | 1953 | *Ibid.*, **4**, 1, pp. 103-104. |
| Venkiteshwaran, S. P. and Ramakrishnan, S. S. | 1954 | *Ibid.*, **5**, 4, pp. 343–348. |