

A premonsoon thunderstorm with tornadic characteristics at Calcutta

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ABSTRACT. The unusual damage caused by a thundersquall with some tornadic characteristics, which passed over the southern parts of Calcutta on 21 May 1959 are described. The autographic charts at Calcutta (Alipore and Dum Dum) are presented and their special features discussed. The barogram at Alipore recorded pronounced "pumping" during passage of the thundersquall over the station. The sequences of development of thunderstorm with squalls from NW/N at first over the northern parts of Calcutta (Barrackpore and Dum Dum) followed by fresh thundersquall from the southwest which caused severe damage over a localised area in south Calcutta, are discussed with reference to the synoptic situation and relevant observations recorded at Barrackpore, Dum Dum and Alipore.

1. Introduction

On the evening of 21 May 1959, southern part of Calcutta was hit by a thundersquall, which appeared to have some characteristics of a tornado. The thundersquall, which was accompanied by hail and heavy shower, developed a peak wind speed of 61 mph at Calcutta (Alipore) and came from the southwest. It lasted for about half an hour and affected a very localised area, roughly about 4 miles (in the east-west direction) by 2 miles (in the north-south direction). Even though the maximum wind speed recorded by Alipore Observatory was appreciably less than the previous records (highest maximum wind speed on record being 80 miles per hour), this thundersquall caused unusual damage and was far more destructive than the severe nor'westers that affected Calcutta during the past twenty years or more. Of course, the speed of the squall might have been appreciably greater in the immediate vicinity of Alipore. Full-grown trees, some with trunks two feet in diameter, were uprooted and many hutments and *bustees* collapsed like pack of cards. Sheets of corrugated iron were lifted up and carried away as far as 200 yards. Telephone and telegraph poles were broken, dislocating traffic and communications over the southern parts of the city. Considering the fury of the thunderstorm and the nature of the damage it caused, it appears that the

thundersquall was associated with unusual characteristics, somewhat of the nature of a tornado, which is of rare occurrence in this part of the world.

While the thundersqualls of the premonsoon season (nor'westers) usually come from the northwest, it was interesting that this tornadic thundersquall came from the southwest, and that again within two hours of the occurrence of an earlier thundersquall from NW/N, which passed over the northern parts of the city—Barrackpore and Dum Dum recording a maximum wind speed of 67 mph and 54 mph respectively. Though the maximum wind speed recorded at Barrackpore caused by the northwesterly thundersquall was greater than that caused by the subsequent southwesterly thundersquall at Calcutta (Alipore), the latter with its tornadic characteristics was by far more destructive than the former.

Previous studies (Desai 1950) on nor'westers have revealed that spreading of the cold air from the downdraft in a thundersquall provides trigger for development of fresh thunderstorm. In the present case, the northwesterly squall over northern parts of Calcutta at about 4 P.M. followed by the southwesterly tornadic thundersquall over southern parts of Calcutta at about 6 P.M. provides an interesting study of the sequence of development and the influence of one thundersquall

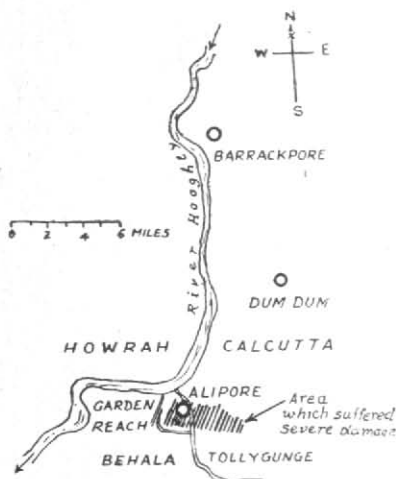


Fig. 1. Relative locations of Alipore in south Calcutta and of Dum Dum and Barrackpore to the north

on the generation of fresh thundersquall. The autographic records at Alipore and Dum Dum and the radar observations made at Dum Dum have been utilised to study the sequence of development leading to the tornadic type thunderstorm at Calcutta.

2. Sequence of observed weather and the trail of destruction

In Fig. 1, are shown the relative locations of Alipore in south Calcutta and of Dum Dum and Barrackpore to the north, and also the localised area which suffered severe damage from the tornadic thundersquall from the southwest.

Till early afternoon on 21 May 1959, the sky over Calcutta was practically clear as observed from each of the observatories at Alipore, Dum Dum and Barrackpore. Barrackpore recorded a thundersquall from northwest at 1615 IST. This was followed by thundersquall from NW/N at Dum Dum at 1625 IST. Alipore observed *Cb* cloud appearing on the northern sky at about 1430 IST, which spread rapidly and by 1600 IST, the sky was overcast. There was mammato cumulus with *Cb* after about 1630 IST. At about 1630 IST, there was a sharp change in wind direction from south to north without appreciable change in wind speed, but with appreciable drop in temperature and rise in pressure (Figs. 2,

3 and 4). These changes were obviously the result of the cold downdraft spreading southwards from the thundersquall over Dum Dum area. The wind speed apparently died down by the time it reached Alipore. Thunder with light rain started at Alipore after about 15 minutes. Thereafter, the sky rapidly became very dark and cloud base came down very low. Heavy shower started at about 1735 IST which was subsequently accompanied by small hail. Within 15 minutes of the commencement of the heavy shower, a severe squall came from the southwest. Some persons residing around Alipore, who watched the approach of the dark cloud, reported that a mass of cloud, somewhat brownish in shade (presumably due to lifting of dust), approached from SW/S with its base lowering very fast towards the ground. Their description is suggestive of the passage of a funnel shaped cloud, such as usually precedes a tornado. The squall continued for about half an hour when the wind direction gradually backed from WSW to SE and a peak wind speed of 61 mph from some south-westerly direction was recorded at Alipore at 1750 IST.

The squall from the southwest caused unusual damage over a localised area in south Calcutta as shown in Fig. 1. A few extracts from the press reports, describing the unusual destruction caused by this thundersquall and providing evidences of objects being lifted up and thrown aside with great violence are reproduced below—

“A tornado swept over Calcutta and suburbs on Thursday evening. South Calcutta suffered worst, with the result that awful scenes of devastations were witnessed there after the tornado had subsided. Trees were tossed and twisted and finally uprooted in large numbers. Broken twigs, metal pieces, corrugated tin roofs lifted from huts and buildings, were flown adrift in all directions in air. *** most of the *bustee* huts were unroofed. A corrugated iron roof was tossed high in air and brought crashing down on * * *. A newly

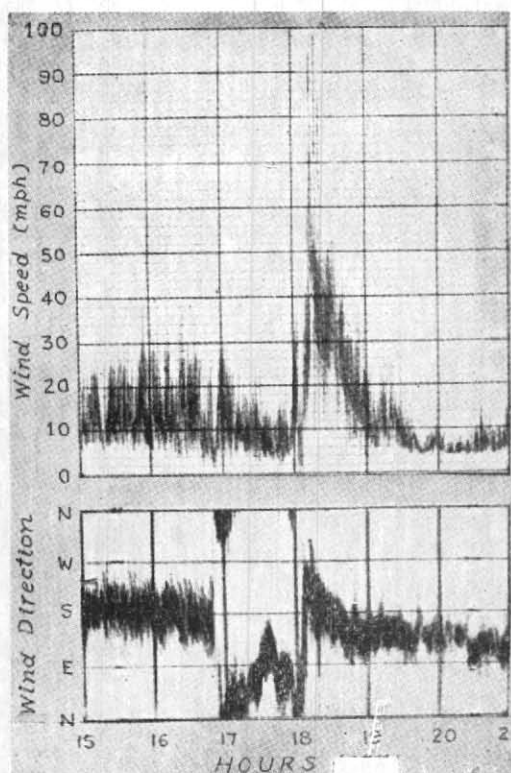


Fig. 2(a). Alipore

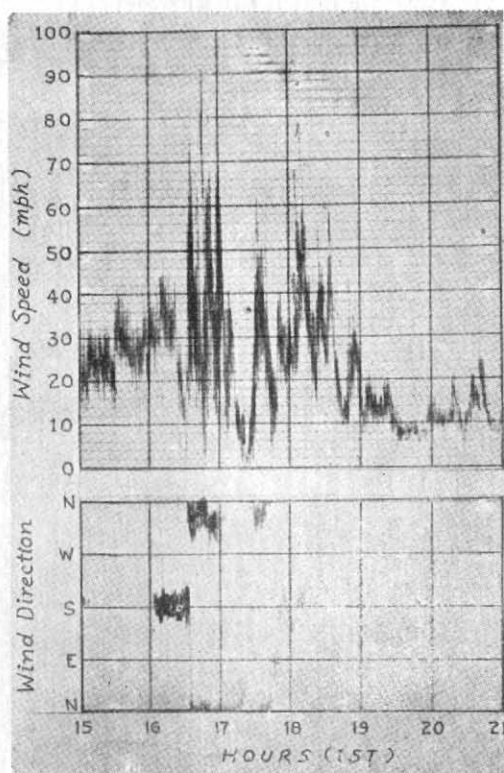


Fig. 2(b). Dum Dum

Fig. 2. Anemograms of Alipore and Dum Dum of 21 May 1959

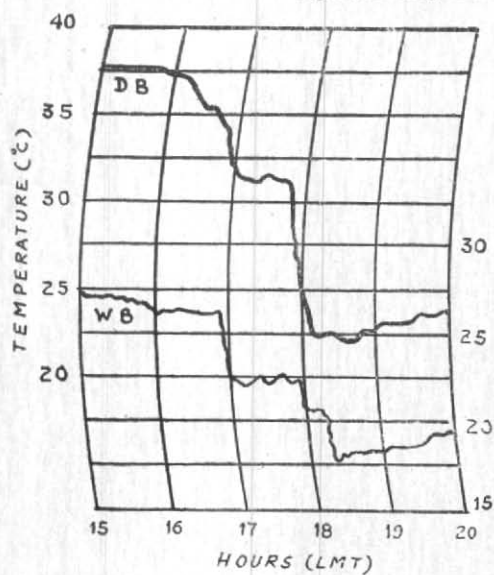


Fig. 3(a). Alipore

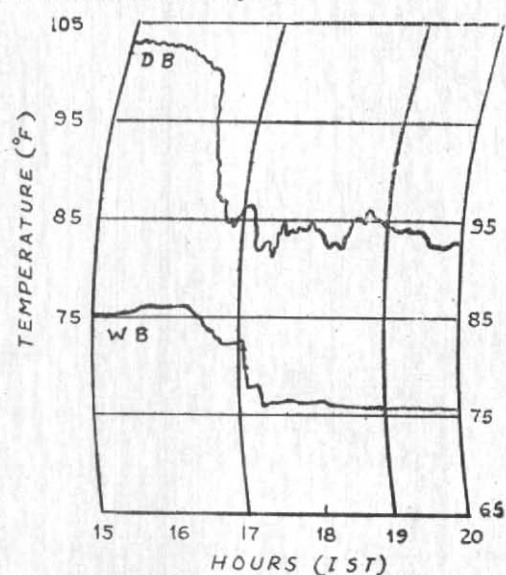


Fig. 3(b). Dum Dum

Fig. 3. Thermograms of Alipore and Dum Dum of 21 May 1959

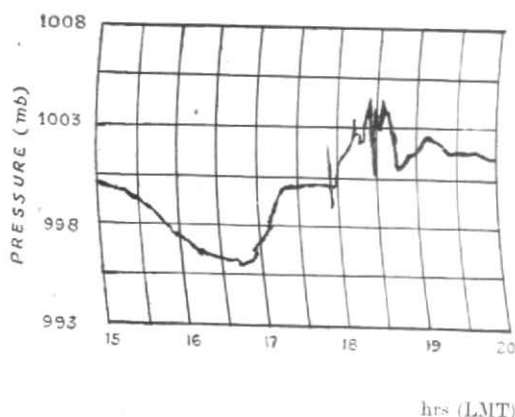


Fig. 4(a). Alipore

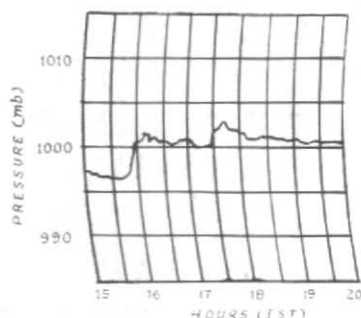


Fig. 4(b). Dum Dum

Fig. 4. Microbarograms of Alipore and Dum Dum of 21 May 1959

erected 600 gallon capacity water tank on 40 ft. high wooden structure was thrown down * * *. Most of the trees were either uprooted or broken. Near the Alipore bridge a huge tree was felled and a corrugated iron sheet was lifted from the roof of a tin-shed, blown across the road and got wrapped up around a telegraph post. Near Kalighat tram depot a 60 ft long asbestos roof over the fourth floor of the Christian College was blown to a distance such that it could not be traced even the next day. * * * A large portion of the C. I. roof in the Lake Market was whirled into the air for over 200 yards before it came crashing on Parashar Road. * * * Corrugated iron roofs of three sheds each 150 ft by 150 ft dimension were blown away. * * * Dhakuria lake area was almost unrecognizable. Majestic Rain trees lay prostrate on the ground. The refugee camp in the same area presented a scene of total devastation—almost all the roofs of the camps being blown away. * * * According to modest estimate 500 trees were uprooted, and 350 small houses were unroofed or damaged. Eleven persons including two children were killed, more than one hundred persons received minor or major injuries and 10,000 people were affected in one way or the other²².

3. Autographic records at Alipore and Dum Dum

The relevant portions of the anemograms, thermograms and barograms of Alipore and Dum Dum of 21 May 1959 are reproduced in Figs. 2, 3 and 4.

A scrutiny of the anemograms at Alipore and Dum Dum will reveal that the NW/N squall which commenced at Dum Dum at about 1625 IST had reached Alipore at about 1630 IST causing sharp change in wind direction to NW/N. After the passage of the squall over Dum Dum, the wind direction returned to normal southerly flow with reduced speed. After the south-westerly squall over Alipore at 1750 IST, wind at Dum Dum also changed to south-west and became gusty.

At Alipore, sharp fall in dry bulb temperature by 3.5°C at 1650 IST and sharp rise in pressure by about 4 mb near about the same time confirms the spreading of the cold air over Alipore in association with the NW/N squall over Dum Dum area.

4. Pressure field beneath the thunderstorm

The barograms at Alipore and Dum Dum revealed certain interesting features. Between 1500 and 1630 IST, pressures fell by about 4 mb at Dum Dum and by about 5 mb at Alipore. The magnitude of pressure

fall was no doubt appreciably more than that can be accounted for by the diurnal factor. This fall in pressure might be associated with the spreading of the anvil cloud over Dum Dum and then over Alipore. Ludlam (1957) explains in a paper on "Cumulonimbus" that during the transition from immature shower clouds to mature cumulonimbus with the production of expanding anvil cloud, the anvil cloud may occupy the whole upper half of the troposphere and in consequence of the release of latent heat of freezing and due to negligible evaporation, the entire mass of the anvil may be several °C warmer than its environment and that under these circumstances, a pressure fall of several mb could occur beneath such a massive anvil cloud. It is noteworthy that whereas at Dum Dum the minimum pressure value was reached at about 1545 IST, pressure at Alipore continued to fall thereafter till it reached minimum value at about 1625 IST. Ludlam also explains that any heavy precipitation in the lower parts of the cloud would cause rise in pressure, which may swamp any fall which might be due to the growing anvil. As such, only when wind shear tilts the cumulonimbus, so that the anvil projects on one side beyond the rain area, we might look for traces of surface pressure fall. It is significant that the pressure falls at Dum Dum and Alipore were recorded well before the rain started at the stations. The fall in pressure was, however, checked when the cold air in association with the northwesterly squall had spread introducing sharp rise in pressure. It appears that the fall in pressure which extended from Dum Dum to Alipore and apparently beyond Alipore towards the south, might have contributed towards development of a "tornado-cyclone" to the southwest or south of Alipore where the tornadic thunder-squall had its origin moving from southwest over the southern parts of Calcutta.

Another interesting feature observed on the Alipore barogram was the rapid oscillations of atmospheric pressure, somewhat

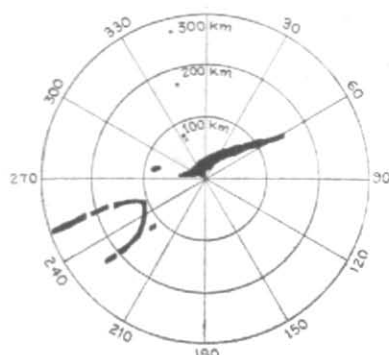
similar to 'pumping' observed in tropical cyclones, when the southwesterly tornadic squall was passing over the station. According to Dunn (1951), such oscillations in barogram may be due to strong rhythmic gusts of winds. At about 1805 IST there was a very sharp pressure drop of about 4 mb. The actual atmospheric pressure oscillations might have been greater because the pressure changes inside the buildings are sluggish. Further, Alipore might not have been in the exact centre of the path of the tornadic squall, where more violent pressure oscillations might have occurred. It is noteworthy that the barogram at Dum Dum, only 12 miles north of Alipore, did not record any corresponding sharp fall in pressure nor such oscillations in pressure near about that time.

5. Radar observations at Dum Dum

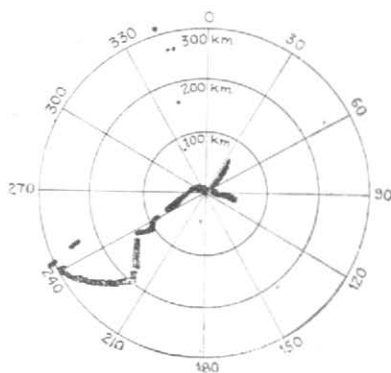
Radarscope P.P.I. observations recorded at Dum Dum at hourly intervals by means of a high-powered 3-cm storm detecting radar are schematically presented in polar diagrams in Fig. 5 for the period 1500—1900 IST. It will be seen that at 1500 IST radar clouds were observed over NW/NE sector at distances ranging from 50 to 175 km including a line-type echo at 100/175 km to the NNE. The R.H.I. of the radar indicated heights of the *Cb* clouds to be 10—16 km. There were also another patch of broken line echoes to the SW at 150/200 km with tops of *Cb* cloud reaching only 8 km. By 1600 IST, the echoes to the north developed into more pronounced line-type echo and had moved south coming within 20 km of Dum Dum and extending northeastwards upto about 150 km. R.H.I. indicated further vertical growth of the *Cb* clouds reaching 20 km. By 1700 IST, this line echo crossed Dum Dum after giving the NW/N-ly squall there during 1630-1730 IST. The echo to the SW changed in pattern but did not show appreciable movement. It disappeared by 1800 IST. The line echo associated with the NW/N-ly squall over Dum Dum moved further south



At 1500 IST



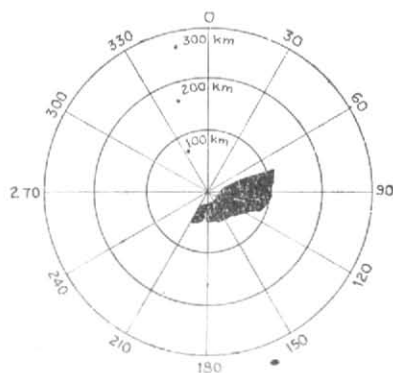
At 1600 IST



AT 1700 IST



AT 1800 IST



At 1900 IST

Fig. 5. P.P.I. presentation of Storm Detecting Radar at Dum Dum on 21 May 1959

and by 1800 IST showed fresh development within 50 km along the entire south sector. By 1900 IST, there was a wide patch of echo about 30 km to the south of Dum Dum extending in a SW-NE direction with length exceeding 120 km. It is apparent that the southwesterly tornadic thundersquall over south Calcutta was associated with the echoes observed between 1800 and 1900 IST to the south of Dum Dum. Unfortunately radar observations in between 1800 and 1900 IST were not made, which could have given further details of the development of the tornadic squall.

6. Synoptic situation

On 0300 GMT surface chart, there was a deep depression in the central Arabian Sea, which later intensified into a cyclonic storm. In association with the cyclonic storm, incursion of relatively moist southwesterly current in the lower levels was taking place into Gangetic West Bengal across the Peninsula. By evening, there was fresh incursion of southerlies from the Bay of Bengal and a sharp wind discontinuity between the moist SW/S-ly air and dry northwesterly air from north India was running between Calcutta and Asansol, extending in a SW-NE direction across coastal Orissa towards north Bengal and adjoining Assam. This wind discontinuity in this month was suggestive of favourable condition for occurrence of nor'westers in the neighbourhood of Calcutta. By 0600 GMT a feeble low was noticeable on the surface chart to the west of Calcutta, which made the situation still more favourable for such occurrence. However, analysis of the available upper air data, including vertical time-section of wind over Calcutta did not show conclusive evidence of upper divergence associated with passage of any jet maxima or upper trough in the westerlies across north India.

On the 00 GMT tephigram of Dum Dum, it is seen that lapse rate of temperature upto 700-mb level was almost moist adiabatic, and in the layer between 700-mb and 620-mb levels lapse rate was super-adiabatic with moist adiabatic rate aloft. With the maximum temperature reaching 38°C and with the fresh incursion of moist southerlies in the lower layers, the tephigram indicated considerable instability over Calcutta on the day.

7. Discussions

Studies on the trajectories of tornadoes (Brooks 1951) have shown that 90 per cent of all northern hemisphere tornadoes move in a direction from between south and southwest because they are embedded in and consequently move with the warm moist air. The tornadic thundersquall which passed over Calcutta on 21 May 1959 also moved in a direction from the southwest. The analysis presented above shows clearly that the tornadic thundersquall originated to the south or southwest of Calcutta after the passage of a NW/N-ly squall. The analysis also suggests that the tornado cloud had formed in the lee of the squall head as a result of vigorous lifting of warm moist air by influx of cold air spreading from the NW/N-ly squall. The tornado whirl moved roughly in the direction of flow of the moist air and opposite to that of the motion of the cold air. It is of interest that the observed sequences are found to agree with the mechanism suggested by Das (1933) many years ago for the formation of tornadoes in Bengal in association with the premonsoon thundersqualls.

Garbell (1947) mentioned that a tornado may follow a combination of (i) strong vertical motion indicated by a rapidly growing cumulonimbus cloud, and (ii) cyclonic circulation. These conditions are found to be present in the case reported in this paper.

Possible formation of a microcyclone beneath the expanding anvil of the *Cb* cloud by mechanism suggested by Ludlam (1957) might have provided the initial cyclonic circulation required for the development of the tornado cloud.

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