

North Delhi tornado of 17 March 1978

H. N. GUPTA and S. K. GHOSH

Meteorological Office, Safdarjung Airport, New Delhi

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ABSTRACT. A tornado occurred in northern parts of Delhi at 1805 IST on 17 March 1978 lasting for about three minutes. It caused death of 28 persons and injuries to 700 others. Damage to property was estimated to be more than Rupees 10 million. The study gives an account of the details of the areas affected and the synoptic situation resulting in its occurrence. The tornado is classified as F2 P2 of Fujita Pearson (FPP) Tornado scale (Fujita 1973).

1. Introduction

A tornado occurred at about 1805 IST on 17 March 1978 over the Delhi University area in north Delhi. A detailed survey was undertaken by one of the authors (H. N. Gupta) immediately after the occurrence of the tornado. The survey showed that it caused severe damage in a stretch of about 5 km in length and about 50 metres in width from Roshanara Gardens northward. The tornado moved almost parallel to the Najafgarh drain and lasted for about three minutes. Almost all the damage was confined to the east of the drain. Twentyeight persons lost their lives and about 700 sustained injuries. Property worth more than Rupees 10 million was destroyed. As far as the authors are aware this is the first case of a tornado in the capital of India.

1.1. Track of the tornado

As has already been stated the tornado originated near the nursery in Roshanara Gardens. It then moved northwards through Kamla Nagar and hit the Birla Spinning and Weaving Mills. Continuing to move northwards it reached Maurice Nagar chowk. It moved further north along Patel Road, through Khalsa College, petrol pump on the Mall Road, AIR transmitting station and the military barracks on Probyn Road. Subsequently it took a northwesterly course across the Najafgarh drain and moved over to the DTC workshop on Banda Bahadur Marg. It rose and then went over the Najafgarh drain and travelled northwards for about 500 metres. The track of the tornado is given in Fig. 1.

1.2. Nature of the tornado

According to an eye witness two *cb* cells from south (from slightly different directions) met each other and combined into one; suddenly

a funnel cloud emanated from its base. A ball of fire was also seen. The tornado was associated with cyclonic winds as is clear from Fig. 2. It can be seen from the figure that one light post towards the right fell away from the observer whereas the other to the left fell towards the observer. A loud explosion resembling the sound of moving military tanks was heard. The tornado lifted a bus with 70 passengers and a few other vehicles. This indicates suction associated with the tornado. Thus it exhibited almost all the characteristics usually associated with a typical tornado.

1.3. Details of damage caused

In the Roshanara Fire Station a fire engine was forced out of the shed and it dashed against the Police Station. At Kamla Nagar the hands and glass of the clock on the south side of the Clock Tower were broken. A roof of the Blow Room and the Automatic Weaving Section of the Birla Spinning and Weaving Mills came crushing down resulting in injuries to a few workers. The boundary wall of the Birla Higher Secondary School crashed and killed a boy.

At Maurice Nagar chowk a bus of the Delhi Transport Corporation was pushed by a great force and it banged into another bus behind. A few passengers in both the buses were injured. Three other DTC buses turned turtle. Daulat Ram College for Women suffered severe damage to its building, equipment and furniture. An old man in a tea shop outside the college was killed and many persons were injured. The boundary wall of Sri Ram College of Commerce collapsed. The roof over the stair case of the college hostel was blown away. A three wheeler scooter was bodily lifted off the ground. The passengers were crushed to death under the vehicle. At the Patel Chest Institute walls in

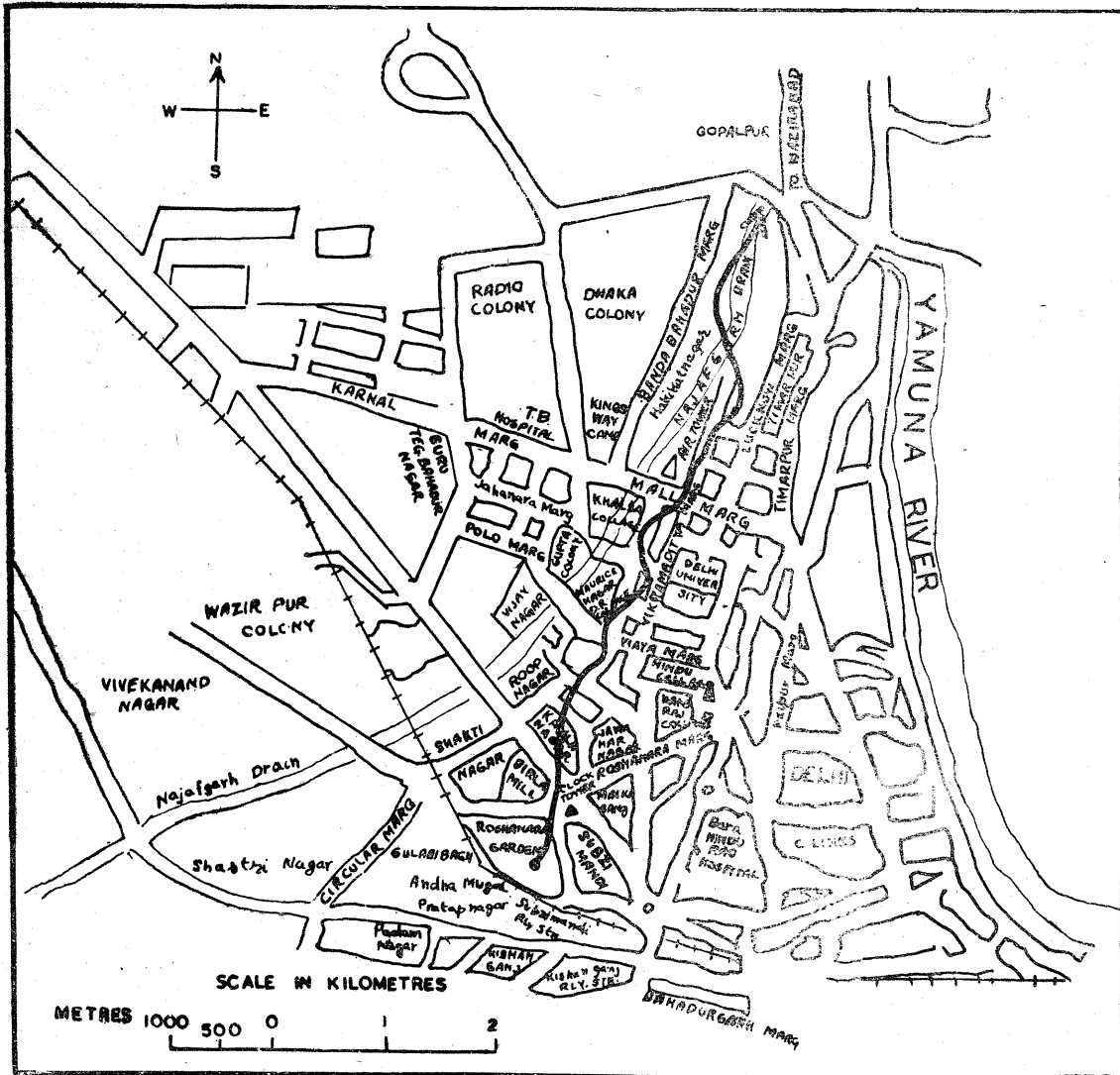


Fig. 1. Track of the tornado

front caved in and the window panes were smashed. Steel fencing was blown off and desert coolers and medical equipment were destroyed. At the students' hostel, named, Patel Niwas, doors, windows and walls came tumbling down. The roof of the 'Monkey House' at Patel Chest Institute was blown off. The loss at the institute was estimated around Rupees 1.5 lakh. The roofs of the Karamchari barracks and the Basic School behind Law Faculty were blown off. Staff quarters in the Law Faculty and the Central Institute of Education suffered substantial damage. The compound walls of Miranda House and the S.G.T.B. Khalsa College collapsed. The roofs of the out houses of 'Miranda House' were blown off. The damage to the college was estimated to be nearly Rupees thirty thousand. At Khalsa College all glass panes were damaged, metal grills wrenched out of the walls, water coolers flung into the compound

and laboratory equipment severely damaged. The college suffered an estimated financial loss of Rupees 10 lakh. The total loss of property in the university was estimated to be over Rs. 70 lakh.

A private bus with about 70 passengers proceeding to Panipat along Mall Road was lifted off the road and deposited nose down in a nullah about 20 metres off the road. The body of the bus was twisted and two of its passengers were killed. Another bus near Khalsa College standing on the road was turned through an arc of 90° in an anticlockwise direction. A scooter rickshaw was lifted and thrown against the trunk of a tree. A few cars were taken off the road side and placed inside Khalsa College. A tea stall near the petrol pump in front of 'International Students Hostel' was lifted up. A tempo was lifted from the petrol pump and



Fig. 2. Damages showing anticlockwise movement of winds associated with the tornado



Fig. 3. Damage caused by the tornado showing roofs blown off

flung about 100 metres away. A cash box belonging to the petrol pump was also lifted and deposited a few hundred metres away.

The medium wave transmitter tower installed about 40 years back on the transmitter building was felled. The top portion of another transmitter tower was severely damaged.

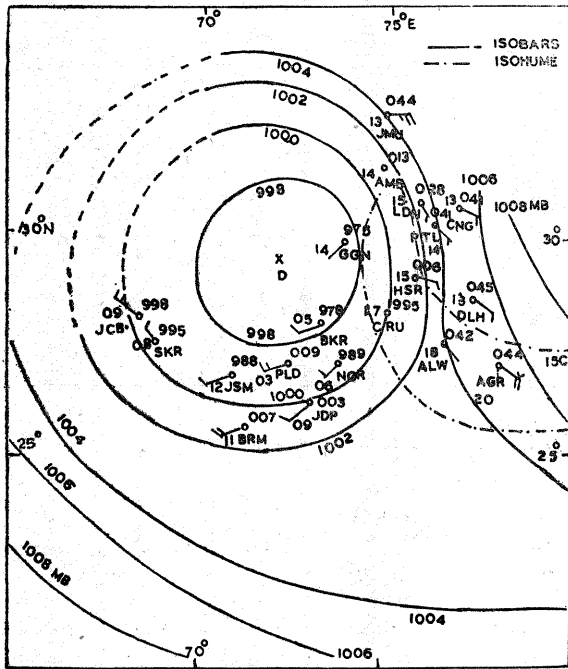
The roofs of almost all the house of the military barracks on Probyn Road were blown off (Fig. 3). The death toll in these barracks was 12. On the western side of the Najafgarh drain the DTC workshop on Banda Bhadur Marg suffered substantial damage. The entire roof of Seva Kutir, an orphanage in Hakikat Nagar, collapsed trapping many children under the debris. The headless body of a man was found lying in a ditch. All the hutments numbering about 80 along the southern boundary wall of DTC Workshop were destroyed injuring many occupants. The total damage to property was estimated to be a little over Rs. 10 million.

The damages as detailed in the foregoing paragraphs and Fig. 3 point to F2 of Fujita Scale for damaging wind (Fujita 1973). Thus an indirect estimate of the maximum wind speed associated with the tornado appears to be between 113 and 157 m.p.h. (181–251 km p.h.). The path length of the tornado was about 5 km and the path width about 50 metres. Hence the tornado under study may be classified as F2-P2 P2 in terms of Fujita-Pearson (FPP) Tornado scale (Fujita 1973).

2. Synoptic situation

Although tornado is a meso scale phenomenon and occurs in a very small area and for a brief period, we give below the main features of the synoptic situation resulting in the occurrence of the tornado.

A trough of low pressure area lay over southwest Rajasthan and adjoining south Pakistan at 0300 GMT on 13 March 1978. The associated upper air cyclonic circulation extended upto 900 metres asl. On the following morning it concentrated into a low pressure area with its central region near 28° N, 71° E but the upper air cyclonic circulation continued upto 900 metres asl. During the next two days the low remained stationary but the upper air cyclonic circulation extended upto 2.1 km asl tilting northwards with height on 16th morning. On the same day in the upper troposphere between 500 and 250 mb a trough in the westerlies lay with its axis roughly along 60° E north of 30° N. The isallobaric field showed a pressure fall of 6 mb and more in an area extending from north Rajasthan to Jammu and Kashmir. Negative pressure departure greater than 6 mb occurred over northwest Rajasthan. At 1200 GMT on 16th the low pressure area further concentrated into a depression centred near 29° N, 72° E with the associated upper air cyclonic circulation extending upto 2.1 km asl (Fig. 4a). Significantly very strong southeasterly winds of the order of 50 knots were reported in the lower troposphere over Punjab (Fig. 4b). The trough in the westerlies had a northwest-southeast orientation extending from 40° N, 60° E to 30° N, 66° E. Pressure fall was more than 8 mb in the area extending from north Pakistan to Jammu and Kashmir. Negative pressure departure greater than 12 mb lay over north Rajasthan. Continuing to move northeastwards the depression was centred near 30.5° N, 73° E on the following morning. A trough extended from the depression southeastwards to southwest Uttar Pradesh and adjoining north Madhya Pradesh (Fig. 5). The trough was also seen at higher levels upto 2.1 km. The lower tropospheric strong winds continued to prevail over Punjab. They exhibited characteristics of low level jet stream with very strong horizontal and



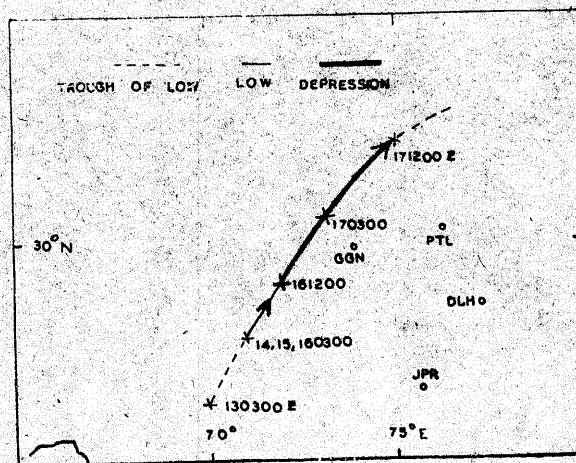


Fig. 7. Track of depression/low.

Uttar Pradesh. The negative pressure change was confined to only Himachal Pradesh and was of the order of 4 mb. Negative pressure departure of the order of 8 mb also lay over Himachal Pradesh. On 18th morning the former system broke up over Himachal Pradesh whereas the upper air cyclonic circulation continued to move away eastwards. The track of the depression/low is given in Fig. 7.

From the above it is clear that the intensification of the major system took place between the morning and evening of 16th mainly because of the positive vorticity advection associated with the trough in the westerlies over the pre-existing low level system over west Rajasthan and adjoining Pakistan. Thus the intensification took place in accordance with the classical model of Bjerknes and Holmboe (Hess 1959).

But the most significant fact that emerges is that the westward tilt of the upper tropospheric westerly trough in relation to the low level low pressure area was very large. Similar large tilt was found to be necessary in cases of intensification earlier reported (Haltiner and Martin 1957, Ghosh and Veeraraghavan 1975, Veeraraghavan and Gupta 1977). When the trough in the westerlies came closer to the low level disturbance the latter did not intensify further although the former was still to its west.

3. Discussion

As has been stated earlier the tornado developed over the trough which extended southeastwards from the centre of the depression and which had a large wind shift across it. It occurred at a distance of about 450 km southeast of the centre of the depression. The above two features of the synoptic situations are exactly the same as those in the United States for occurrence of tornadoes (Brooks 1951).

The other factors which are found to be favourable for tornado development in U.S.A., which is the only country tornadoes are mainly confined to * (Godske *et al.* 1957), are:

- (i) A thin stable layer separating moist air in the lower levels from dry air aloft (Brooks 1951).
- (ii) The horizontal distribution of wind aloft must exhibit a maximum of speed along a relatively narrow band at some level between 10,000 and 20,000 ft with maximum speed exceeding 35 knots.
- (iii) In situations preceding tornado development, a distinct dry tongue is usually present in the middle levels and provided other criteria are satisfied the development will occur where the upper dry tongue crosses the lower moist wedge.
- (iv) The horizontal moisture distribution within the moist layer must exhibit a distinct maximum along a relatively narrow band on the windward side of the inception area.
- (v) A trigger mechanism (Miller 1959).

Let us now see whether the above conditions were satisfied in the case under study.

A stable layer of about 30 mb thickness is seen in the form of an isothermal layer just above 500 mb (Fig. 8). From the same figure it can also be seen that a narrow band of very strong winds of 85 knots was observed at 500 mb showing jet characteristics whereas just below and just above this level, *viz.*, 600 and 400 mb the winds were 45 and 35 kt respectively. The vertical shear works out to be as high as 30

*However, Fujita (1973) states tornado data in other parts of the world suggest that the U.S. tornado frequency is no more than that of industrial countries in middle latitudes. The major difference seems to be in the occurrence of extremely large and intense tornadoes in the U.S.A.

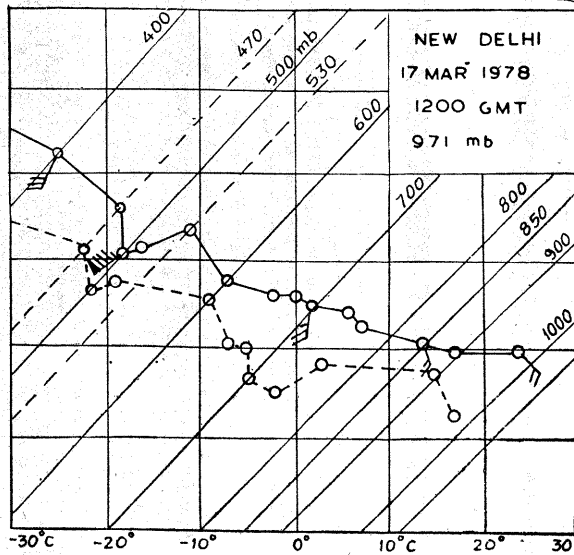


Fig. 8. New Delhi tephigram of 1200 GMT on 17 Mar 1978.

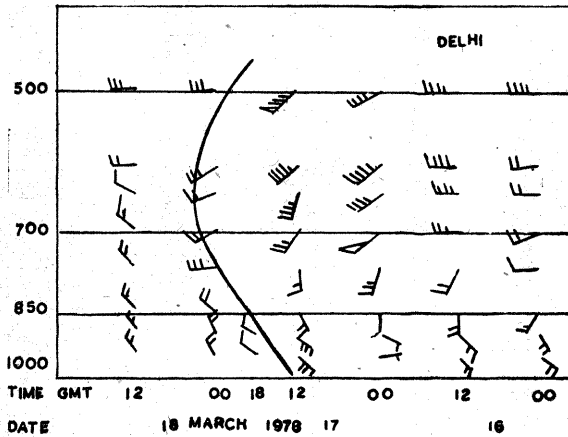


Fig. 9. Vertical Time Section of Delhi.
(Solid line indicates trough)

kt/km. Also to be noted is the presence of super adiabatic lapse rate between 530 and 500 mb. The rate of fall of temperature with height was 13.6°C/km in this layer. The horizontal moisture distribution at the sea level shows a moist wedge greater than 15° C isohume.

However, dry air in the mid tropospheric levels was not found in the present case. On the contrary a very deep moist layer extending from the surface upto mid troposphere was present. The trigger mechanism in the present case was most likely provided by the trough in the lower troposphere which moved from west to east across Delhi between 1200 GMT and 1800 GMT of the 17th (Fig. 9). In addition the area of formation of tornado lay to the left entrance of the low level jet (Fig. 6). This also could have acted as part of the trigger action.

3.1. Radar observations

Photographs of radar observations taken at Delhi Airport (Palam) by a B.E.L. radar at 1235, 1236, 1237 and 1238 GMT on 17 March 1978 are reproduced in Fig. 10. Although the intensity of the echoes was very high, no special characteristics such as hooks etc usually associated with tornadoes were seen.

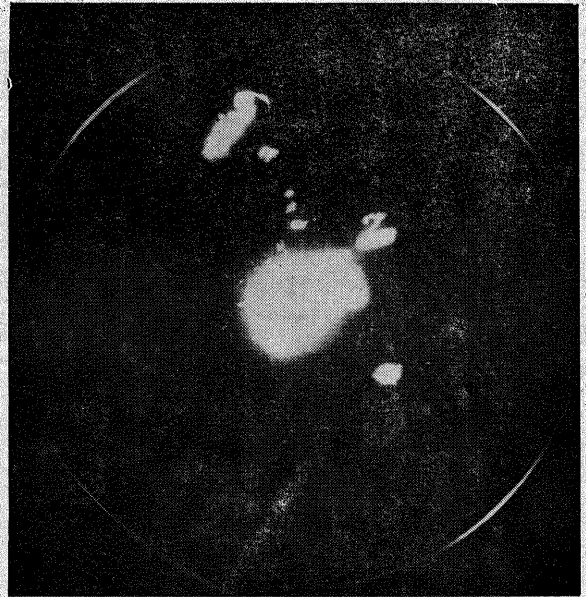
4. Conclusion

Three of the conditions favourable for the occurrence of tornadoes in the U.S.A. are found to be associated with the occurrence of the tornado under study. They are:

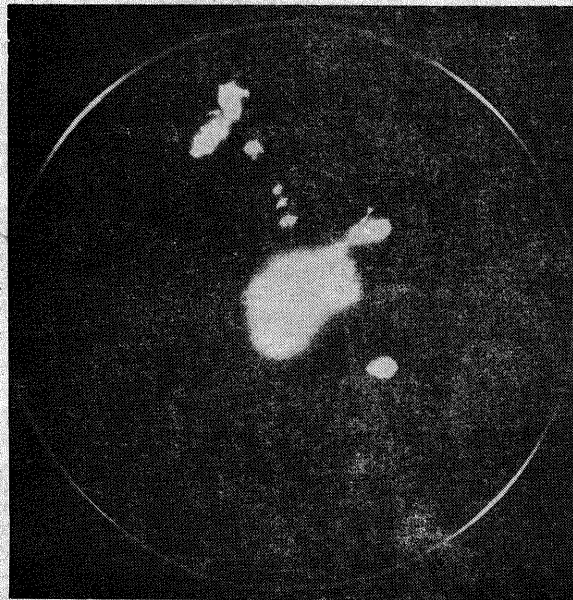
- (i) The tornado occurred on a trough extending southeastwards from the centre of the main synoptic disturbance,



Range : 200 km : Elevation 0.0°
(a) 1235 GMT



Range 200 km, Elevation 1.0°
(b) 1236 GMT



Range : 200 km, Elevation 2.0°
(c) 1237 GMT



Range: 20 km, Elevation 3.0°
(d) 1238 GMT

Fig. 10. Photographs of radar observations on 17 March 1978

namely, a depression. It occurred at a distance of 450 km southeast of the centre of the parent depression.

- (ii) A middle level jet wind was present over the area of the tornado.
- (iii) The horizontal moisture distribution in

the lower layers exhibited a distinct maximum along a relatively narrow band on the windward side of the area of occurrence of the tornado.

However one condition, namely, the presence of a distinct dry tongue at the middle levels was not satisfied.

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