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# A tornado over Orissa in April 1978

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सार – 16 अप्रैल 1978 को उड़ीसा के कानझार एवं कटक जिलों के अनेक भागों में आए बवंडर का विश्लेषणात्मक अध्ययन किया गया है। इस बवंडर में भारी मात्रा में सम्पत्ति की क्षति हुई और अनेक व्यक्तियों एवं जानवरों की जानें गई। इस शोध पत्र में इसके बनने के लिए उत्तरदायी सिनॉप्टिक परिस्थितियों का विवेचन किया गया है।

ABSTRACT. An analytical study of a tornado which struck parts of districts Keonjhar and Cuttack in Orissa on 16 April 1978, causing large scale devastations of property and loss of human and animal lives, has been made. Synoptic situation responsible for its formation have been discussed.

## 1. Introduction

It was 1630 IST on 16 April 1978 when a tornado struck the village of Purunabandhaguda in district Keonjhar, Orissa and wiped it out completely. All together eleven villages in the districts of Keonjhar and Cuttack suffered losses due to the impact of the storm covering an area of about 50 sq. km and having a population of 6000. According to the State Government about 90 per cent inhabitants in seven villages in Ghasipura block of Anandpur sub-division of Keonjhar district and four villages in Dangadi and Korai blocks of Jaipur sub-division of Cuttack district were affected. It is stated that ill-fated village of Purunabandhaguda suffered losses of 141 human lives and 231 heads of cattle (Figs. 1 & 2).

On record there is only one other tronado which occurred in Orissa on 12 May 1976 (Gupta and Ghosh 1978) in which seven villages in Balasore district were affected. This, also caused loss of human and animal lives and damage to property.

### 1.1. *General description*

According to the accounts of the eye witnesses, prior to the tornado, a big ball shaped dark cloud with luminous red band around it suddenly appeared in the sky in the northwest direction. This was followed by darkness and a terrific sound of thunder bolt and of whirling wind that churned the area. Funnel cloud was visible and the tornado moved from northwest to southeast for a distance of about 16 to 17 km. On its path, it destroyed everything, shattering houses, slashing and uprooting trees and sucking up cattle or whatever came on its way. The water of a pond in the village Purunabandhaguda was sucked out and fishes and mud thrown out. The debris was thrown to the northeast corner of the village. The branches of trees were found to be twisted at a height of 6 to 8 feet and those that were uprooted fell in the modal direction of east to south. The wind speed has been estimated to be 150 to 200 kmph and duration 16 to 17 minutes.

A newspaper report relates weird and fearful stories. A ten months old baby was suddenly lifted up some 20 feet into air as though by diabolical hand and propelled forward some 30 yards and then suddenly and mysteriously gently put down on a thick heep of straw so that she did not get a scratch on her body. A 25 year old woman was also lifted up from the same spot and at the same time, taken some distance and dashed violently against a tree so that she lost an eye. A man of the same place had fist size hail hit his waist with a stunning blow. While he sat down in pain he saw another hail hit his bullock and break its neck.

From the size of the hail as described above a rough estimate can be made about the probable updraft by using the equation (Wichmann 1951).

$$W = \left[ \frac{2\, \rho_1\, dg}{3\, \rho_2\, k} \right]^{\frac{1}{2}}$$

where, $W$=updraft velocity required to support the hail of diameter $d$,

Fig. 1. It was a cemented building belonging to village headman (sarpanch) of Purunabandhaguda

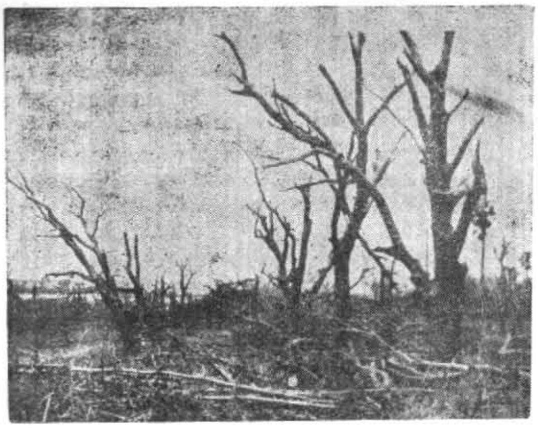

Fig. 2. Trees uprooted and completely denuded in the affected village

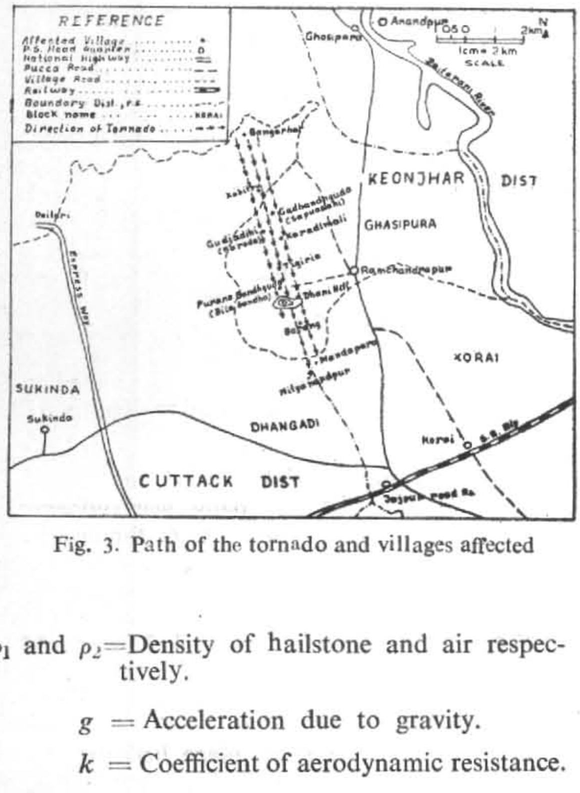


Fig. 3. Path of the tornado and villages affected

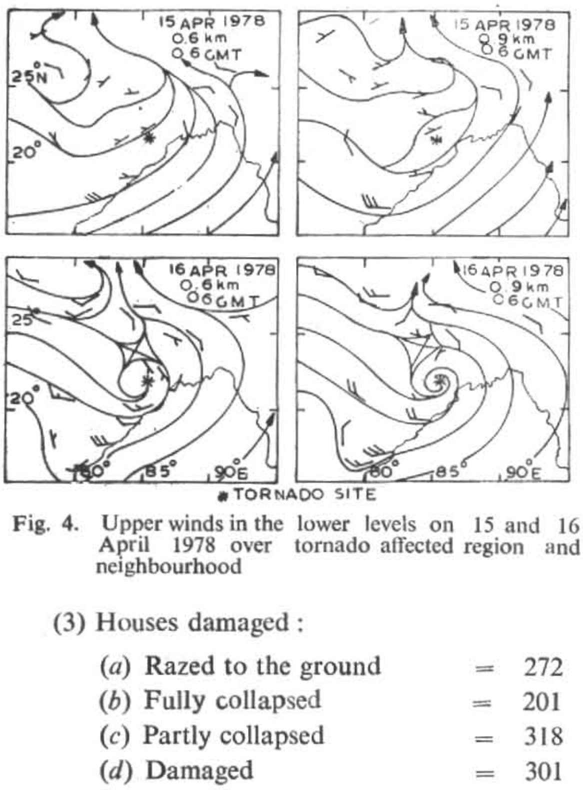


Fig. 4. Upper winds in the lower levels on 15 and 16 April 1978 over tornado affected region and neighbourhood

$\rho_1$ and $\rho_2$=Density of hailstone and air respectively.

$g$ = Acceleration due to gravity.

$k$ = Coefficient of aerodynamic resistance.

Taking $d$ = 6 cm, $\rho_1$=0.9 gm/cc

$\rho_2 = 1.2 \times 10^{-3}$ gm/cc, $g$=10 m/sec$^2$

$k$ = 0.1 (for a spherical body at high Reynolds number)

we get $W \sim 54$ m/s or 194 km/hr.

According to estimate given by the State Government, the total loss of life and damages caused are as follows :

(1) Human lives lost = 173

(2) Cattle perished = 1,176

(3) Houses damaged :

(*a*) Razed to the ground = 272

(*b*) Fully collapsed = 201

(*c*) Partly collapsed = 318

(*d*) Damaged = 301

(4) Estimated loss of private and public property = Rs. 1,77.46 lacs.

### 1.2. *Track of the tornado*

The path of the tornado and the villages affected are shown in Fig. 3. The first village to be affected was Bangarkot. From there the tornado moved southeastwards to Kobitru, Godbandhgoda, Gudiadili, Koradimall, Tigria and then the fateful village of Purunabandhaguda. From there it crossed Dhani hills reaching

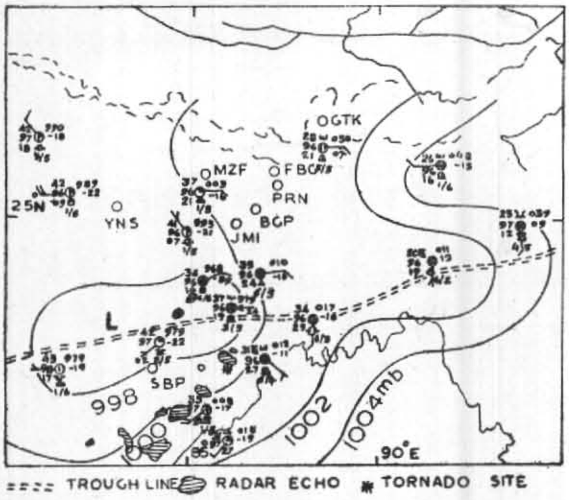


Fig. 5. 09 GMT synoptic chart of 16 April 1978

Barang, Mandapara and finally dissipating at Nityanandpur.

**2. Synoptic situation**

The morning chart of 16 April showed a low pressure area over northeast Madhya Pradesh and adjoining south Uttar Pradesh. From the centre of the low a trough line passed through Satna, Champa, Keonjhar, Kalaikunda and Calcutta. The associated upper air trough extended upto 0.6 km asl. At 0.9 km asl a wind discontinuity passed through Darbhanga, Kanker, Arogyavaram and Tuticorin. The low level winds over Orissa were mainly southsouthwesterly 15 to 20 kt. In contrast 00 GMT sea level chart of 15th did not indicate any low pressure area closeby though on the 03 GMT chart a feeble low could be seen. This low, however, did not persist subsequently. The surface wind at Pendra clearly brings out this point. On 15th at 00 GMT, 03 GMT and 06 GMT they were S/02, S/02 and WSW/02 respectively whereas on 16th they were calm, NE/05, N/05 for the same synoptic hours. The low pressure area present on 16th was accentuated as the day progressed is brought out by the low level upper winds at 06 GMT on 15th and 16th (Fig. 4). Thus the morning synoptic situation indicated that a zone of low level convergence lay close to the place of occurrence of tornado which gradually became accentuated as the day progressed. The 09 GMT synoptic situation which is close to the time of occurrence of the tornado is shown in Fig. 5.

Superimposed on this chart are shown the radar echoes which were observed at the same synoptic hour from Bhubaneswar. The formation and orientation of the echoes along the isobars are worth noting. This area is clearly a meeting place of the warm moist maritime air and relatively drier air from land. The place of occurrence of the tornado is shown with an asterisk mark on the figure. A convective cell is seen just north of this site. The height of the cell was observed to be 10 km. It may be inferred from the closeness of the cell to the site of occurrence of tornado and in absence of any other cell in vicinity, that this convective cell was responsible for breeding the tornado some time later. The cell moved from northwest to southeast roughly at the rate of 40 km per hour.

The other significant feature that was observed was a general fall of pressure of about 2 mb over the region at 03 GMT over the past 24 hours. The pressure departure from normal was below 5 mb. Such large pressure departure are uncommon except in association with cyclonic system close by.

The upper air flow at 300 mb did not show any jet stream in the area. Jet strength wind was, however, observed over Bhubaneswar at 200 mb in the 12 GMT chart overlying the affected area (Fig. 6).

### 2.1. *Stability and moisture*

The presence of potential instability is an essential prerequisite for development of a thunderstorm as also a tornado, the latter being invariably associated with it. A potentially unstable airmass is characterised by a decrease of wet bulb potential temperature (WBPT) (Brunt 1952). The 160000 GMT upper air sounding of Bhubaneswar, which is the nearest radiosonde station to the tornado affected area was examined. The WBPT profile showed a sharp decrease upto 850 mb and then a slower fall upto 500 mb.

The vertical time section of Bhubaneswar from 12 to 18 April (Fig. 6) indicates that flow of moisture on the 16th in the coastal regions was more than on other days.

The horizontal moisture distribution near the surface was analysed with the help of dew point temperature at 03 and 12 GMT (Fig. 7). In the morning chart there is no distinct moisture wedge. The moisture is found to be uniformly distributed along the contour of the coast. However, in the afternoon hours there is sharp fall in the dew point temperatures towards the southwest sector of the place of occurrence of the tornado. A hot dry tongue of air from northwest penetrates from northwest. This causes a wedge of moisture to penetrate north of it overlying the affected site.

### 2.2. *Thermal structure*

An examination of 00 GMT tephigram (Fig. 8) of Bhubaneswar indicates an inversion layer between 950 and 900 mb, overlain by a deep layer of steep lapse rate upto 600 mb. The layer from surface to 950 mb has a high moisture content. Thus it is found that a layer of warm moist air near the surface is overlain by a deep

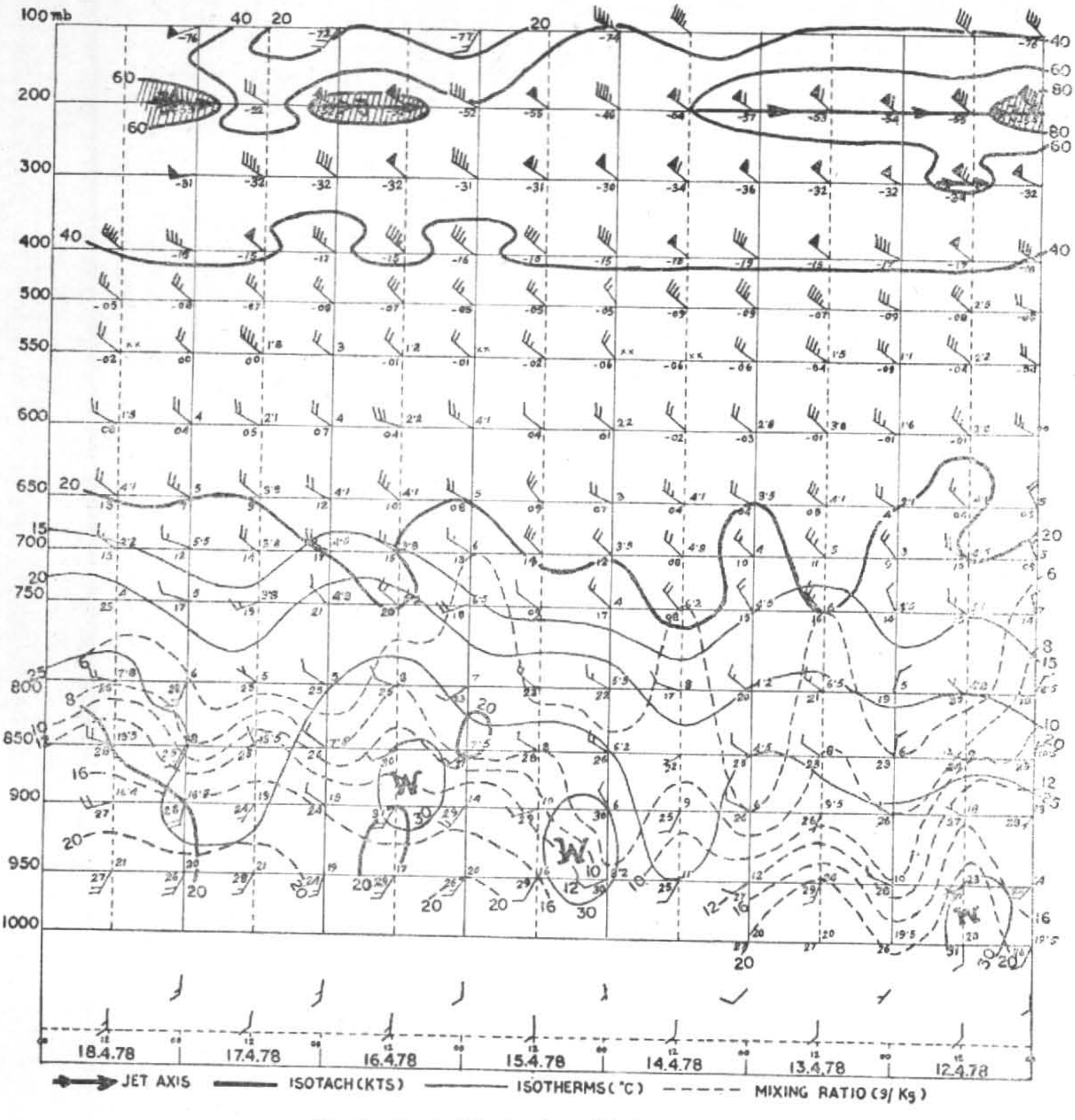


Fig. 6. Vertical time section of Bhubaneswar

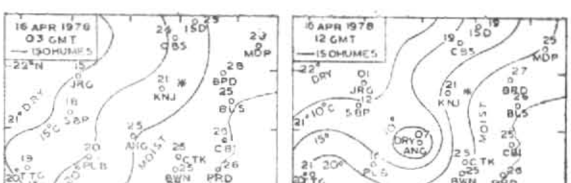


Fig. 7. Distribution of dew point temperatures on 16 April 1978 at 03 & 12 GMT

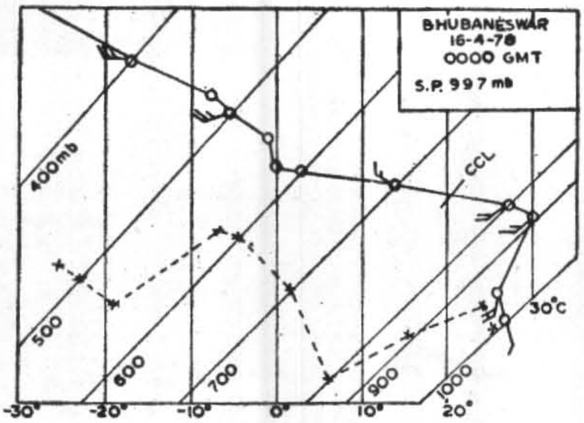


Fig. 8. Bhubaneswar tephigram of 00 GMT on 16 April 1978

layer of cold dry air with inversion layer in between.

The wind also shows a marked veering with height upto 700 mb indicating a low level warm advection.

2.3. *Vertical wind shear*

Another constituent thought to be associated with tornado development is strong vertical wind shear (Browning 1969). Ludlam (1963) has found in the cases of five severe local storm in Western Europe that the vector wind shear between surface and 500 mb was between 40 and 60 kt. In the cases of two recent tornadoes in India, one in Punjab (Mandal and Basandra 1978) and other over Delhi (Gupta and Ghosh 1980), vertical wind shears were very marked. However, in this case the vector wind shear from surface to 500 mb is in the order of 32 kt only.

**3. Discussion**

For an organised convective development the air should be potentially unstable. This is possible when cold dry air overlies a warm moist layer near the surface. If an inversion lies at the top of moist layer, the release of energy is delayed. On collapse of the inversion the intensity of release of energy is greater. In such a situation an ascending parcel is greatly accelerated upward which results in explosive type of convection. This situation was realised in this case.

The presence of strong wind shear and pronounced veer of wind with height assists development. However, an Australian tornado is reported to have developed even when the wind backed with height (Peterson 1979). The divergence associated with wind shear is supposed to be an important factor in causing a marked reduction in pressure inside the vortex column (Saha 1966). It also helps the storm to organise in such a manner that the updraft and downdraft are fed continuously over long periods (Browning 1969). However, in the case of a tornado at Malta (Dean 1969) no strong wind shear was present. Origin of the tornado was attributed to downdraft from the storm causing a pattern of convergence and divergence which was reinforced by wave motion at the inversion or stable layer and it was suggested that this could be an alternative to wind shear as prime cause. Hence, the occurrence of tornado even with a shear of 32 kt in the lower levels, as found in this case is also likely. There was also veering of wind with height.

Another point of interest is that the temperature at the intersection of surface isobar and the dry adiabat drawn from convective condensation level (CCL) was found to be 43 deg. C. This temperature was exceeded in the inland area (Jharsuguda reported maximum temperature of 44 deg. C). Thus the surface was sufficiently heated to act as a trigger mechanism for rapid lifting of moist air. Heated ground may also help formation of a tornado. According to Goldie (1969), the outer part of a downdraft from a thunderstorm becomes unstable while flowing over a heated ground. If the downdraft is deep and its lapse rate unstable, the divergence in the horizontal wind field near the top of the downdraft initiates an upward motion from below and if a cyclonic wind shear is prepresent a tornado is likely to form.

It has been further found that tornado occurred close to a trough extending southeastwards from centre of low. This synoptic scale system proved favourable for generation of mesoscale conditions necessary for tornado formation.

**4. Conclusion**

In conclusion it may be said that the following synoptic situation was present which lead to the formation of tornado :

(*a*) A warm moist layer close to the surface, overlain by a deep layer of cold dry air with steep lapse rate.

(*b*) Moist and dry layer separated by an inversion.

(*c*) Veering of wind with height in the lower levels.

(*d*) Existence of synoptic scale system in the neighbourhood.

(*e*) Excessive heating of ground which acted as trigger mechanism to release energy.

(*f*) Vertical wind shear.

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