551.771.2 : 551.596.5 (547.1)

Pronounced Humidity Dip associated with thundersqualls at Colaba, Bombay

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ABSTRACT. On 30 and 31 October 1964 during the passage of thundersqualls over Colaba, Bombay, relative humidity recorded pronounced dip of 29 and 17 per cent respectively. This led to an examination of humidity changes associated with passage of squalls during the last 3 years 1962-1964. Frequency distribution of these changes in relation to rain shows that humidity dip is associated with squalls occurring before rain while a rise in humidity during squall occurred either during rain or just following the rain. A plausible explanation for the change in the humidity during the passage of the downdraft from the cumulonimbus cell is given.

1. On 30 October 1964, Colaba Observatory, Bombay recorded a severe thunderstorm activity between 1845 and 2130 IST. During this period a squall passed over the station when surface wind speed reached 56 km/hr from a northeasterly direction. The relative humidity which was 86 per cent before the thunderstorm fell by 29 per cent with the passage of the squalls. It rose again to 80 per cent after the commencement of the rain. The relevant portions of the anemogram, hygrogram and thermogram are shown in Fig. 1. The squall was not associated by any simultaneous dry bulb temperature change. Santacruz, located about 29 kilometres north of Colaba, also experienced a northeasterly squall of 49 km/hr at 2030 IST, but there was no drop in the humidity associated with the squall. Radar observations taken at Santacruz at 2030 IST showed the existence of a well developed cell over Santacruz with an area clear of any echoes to the south extending to Colaba area.

2. On 31 October 1964, there was a recurrence of the thunderstorm activity at Colaba between 2000 and 2200 IST. On this day the surface squall of speed 63 km/hr was from ESE, and humidity recorded a dip of 17 per cent. Santacruz also experienced the downdraft with maximum wind of 38 km/hr from easterly direction at 1955 IST and fall in the relative humidity of 13 per cent. The radar at Santacruz showed an extensive patch to the southeast of Colaba, with some echoes over Santacruz too.

3. On both the days, an examination of the synoptic charts shows the existence of a small vortex in the lower levels with marked convergence aloft. The thunderstorm cells formed over the Ghats to the east of the station and moving in a westerly direction drifted over this area. On 30 October 1964, the active region of the cell had passed over the central parts of Bombay City north of Colaba, where rainfall was heavier and some damage due to the squall was reported. Only the peripheral region of the cell had passed over Colaba. On 31 October 1964, as judged from the radar echoes observed at Santacruz, the direction of movement of the cells and the rainfall distribution, the outer edge of the cell which was away from the rainbelt, seemed to have moved over Colaba. Thus on both the occasions, the downdraft causing the humidity dip seemed to have originated from the periphery of the cell away from the attendant rainbelt of the cloud.

4. These observations of humidity dip gave the suggestion for carrying out a study of humidity changes associated with passage of squalls in order to find out if such changes can throw more light into the structure of the thunderstorm cell. Records of all squalls associated with or without thunder during the period of three years 1962-64 were, therefore, examined. Table 1 shows the result. The figures in brackets indicate all falls in relative humidity exceeding 15 per cent observed during these three years.

5. It will be seen that out of 173 squalls examined only a small percentage, *viz.*, 9 per cent showed accompanying falls in relative humidity. A large number of squalls was not associated with any humidity change. There is significant drop in relative humidity accompanying squalls during pre-monsoon and post-monsoon thunderstorms. The fall of 29 per cent recorded on 30 October 1964 is the highest fall observed during this period of 3 years.

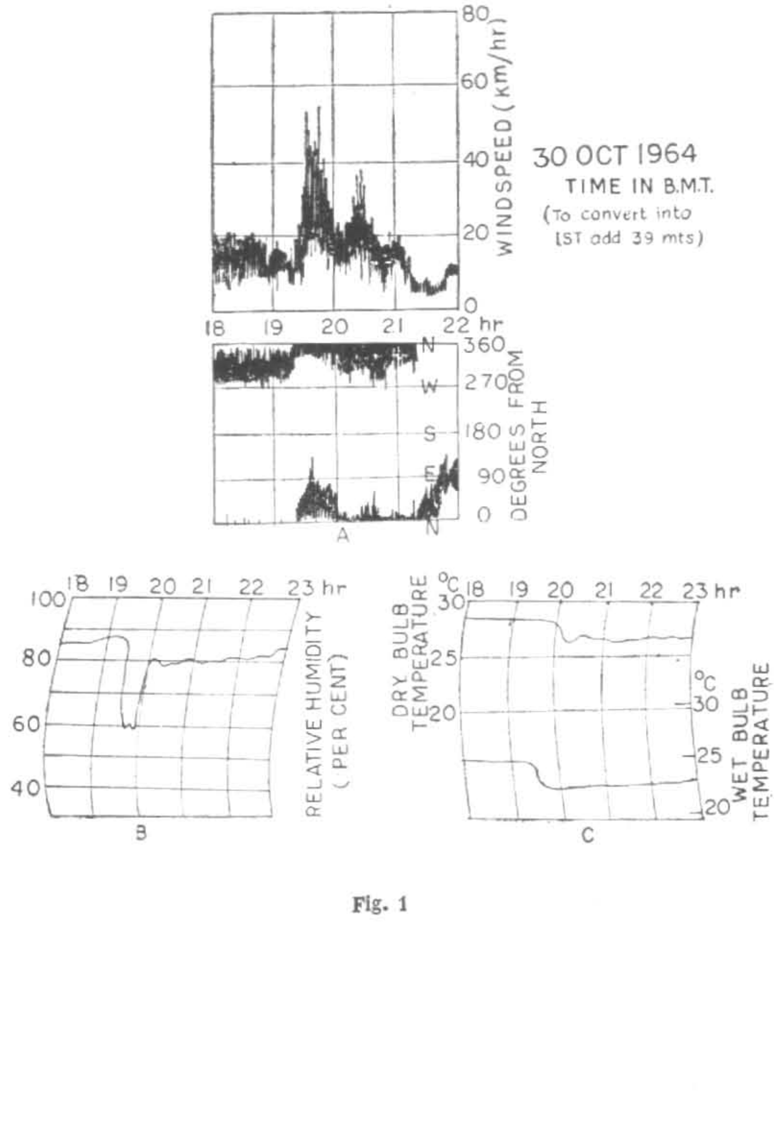
30 OCT 1964
TIME IN B.M.T.
(To convert into
IST add 39 mts)
WINDSPEED (Km/hr)
DEGREES FROM NORTH
A
RELATIVE HUMIDITY (PER CENT)
B
DRY BULB TEMPERATURE °C
WET BULB TEMPERATURE °C
C

Fig. 1

TABLE 1

Nature of humidity changes accompanying squall	1962	1963	1964
Fall	3(18) (17)	7	5(29) (17)
Rise	2	18	28
Kink	6	10	28
No change	19	7	40
Total	30	42	101

TABLE 2

Frequency distribution of relative humidity changes with occurrence of rain (1962-64)

	Nature of humidity change			
	Fall	Rise	Kink	No change
(1)	(2)	(3)	(4)	(5)
Squall before rain	8	11	6	6
Squall without any rain	2	1	12	10
Squall during rain	2	35	24	45
Squall succeeding rain	3	1	2	5

6. Table 2 gives the frequency distribution of these changes in relative humidity in relation to rain. It will be seen from col. 2 that in 10 out of 15 cases the humidity dip associated with squall occurred before any rain had commenced at the station or when there was no rain recorded at the station. On the other hand 75 per cent of the cases of rise in humidity during squall seen in col. 3 occurred either during the rain or just following the rain.

7. The relative humidity of downdrafts from a thunderstorm cell can decrease although they descend in the presence of large concentration of liquid water in the cloud and this results in a humidity dip at the surface. Byers (1949) in the report of Thunderstorm Project attributes this to (*i*) Desiccation by the cold precipitation particles and (*ii*) Time lag between the rate of evaporation of water drops and increase in the saturation mixing ratio as the air descends fast to the lower levels.

Mull and Rao (1950) in explaining the origin of the downdraft in a thunderstorm cell have shown that fall of ice crystals into regions warmer than the freezing point is responsible for the cooling of the air in the downdraft. As this process is independent of evaporational cooling, no moisture is added and the downdrafts become drier than the environment.

8. From the various models for structure of cumulonimbus cell depicting the circulation inside (Met. Monogr. 1963), it is evident that the downdrafts may originate from different parts of the same cell and during the passage of downdrafts to lower levels, they pass through a portion of the cloud itself and later they may or may not pass through a lower level of rain area. A plausible explanation of the large number of downdrafts with humidity dip occurring before the rain is that these saturated downdrafts having a source region in the periphery of the cell do not pass through the rain belt, but pass directly from the base of the cloud to the surface. Other saturated downdrafts originating from the interior of the cell, pass through the rain belt below, which add to their moisture content and they, therefore, record a rise in humidity at the surface. The squall in such cases occur during the rain or just a few minutes before the rain.

9. The above picture is consistent with some of the changes in dry bulb temperature noticed in association with these humidity changes. Of the 173 cases of squalls studied here, in 157 cases fall of temperature was on account of rain. Ten downdrafts were accompanied by a rise in relative humidity and a simultaneous fall in dry bulb temperature; these were apparently due to the passage of the downdraft through a rain belt below the cloud although rain had not commenced at the surface. In 4 cases the downdrafts were accompanied by humidity dip without any change of temperature and these may be due to passage of the downdraft directly from the cloud base to the surface without moving through any rain belt. The remaining two occasions of downdrafts were accompanied by fall in humidity and dry bulb temperature as well. This may be accounted for as due to cold downdrafts moving from the source region itself without complete temperature compensation with the environment at all levels.

10. The above picture will also account for the large number of "kink" and "no change" in the humidity trace recorded in Table 2. Between the dry downdraft from the periphery of the cell and the moist downdraft elsewhere there must be a large transition zone. If this zone happens to be over the recording station apparently the humidity trace records only a "kink" or even "no change" is observed.

11. The above analysis of 3 years' data is made with humidity records of just one station, *namely*, Colaba Observatory. It serves to highlight the marked differences that can occur in the humidity traces depending on the part of the cumulonimbus cloud from where the squall comes. To get a full knowledge of the humidity variations associated with downdrafts from one cumulonimbus cloud, one should have a synoptic study of these squalls and humidity records by having a good network of hygrographs below the cumulonimbus cell. A meso-scale study of a thunderstorm cloud as carried out at Poona (Staff Inst. Trop. Met. 1964) might reveal the actual distribution of saturated and unsaturated downdrafts in the cloud. In the case of the study at Poona the meso-meteorological network consisted of only autographic raingauges and microbarographs. It is suggested that in any similar study in future the network should include hygrographs also in order to enable us to understand the space and time distribution of downdrafts and their characteristics.

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