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Hailstorm at Poona on 16 March 1954

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1. Frequency of hailstorms at Poona

Hailstorms at Poona have been practically confined to the pre-monsoon months of March to May, when they may occur occasionally in some years in the afternoons. The dates of occurrence of hail at Poona since 1938 are given below—

Year	Date	Year	Date
1938	16 April	1950	26 April
1940	25 April	1950	27 May
1942	9 April	1951	23 May
1943	3 May	1952	14 April
1946*	15 February	1954	16 March

*A hailstorm occurred also in September 1946

A fairly severe hailstorm occurred at Poona at about 1800 IST on 16 March 1954. The storm came over the station from the north. From enquiries made from parties at different points in the neighbourhood, it was ascertained that hail was experienced over a strip about 6 miles in the N-S direction and about 4 miles in the E-W direction. The Meteorological Office was about 2 miles to the south of the central region. The maximum size of hail reported was about $\frac{3}{4}$" diameter in the Meteorological Office at Poona and in the Central Agricultural Meteorological Observatory, about half a mile to the north, the most predominant size was about half inch in diameter.

2. Damage due to the hailstorm of 16 March 1954

This hailstorm was particularly injurious to the crops of the season and in the Agricultural College Farm the vegetable garden was severely affected—Figs. 1(a) to (d)*. The mangoes dropped from the trees partly due to the wind and partly due to the direct hit of the hailstones. Those that were hit by the hail, but did not fall, started rotting at the place where they were hit and dropped a day or two later. Fig. 1(d) illustrates such an effect on vegetables in the Meteorological Office gardens. The force of the hail even split some of the mangoes. Nine soil and radiation thermometers were broken at the Central Agricultural Meteorological Observatory.

*Figs. 1(a) to (c) have been kindly loaned by the Agricultural College, Poona

3. Number of hailstones per square foot

At the Central Agricultural Meteorological Observatory, one of the research students, Mr. Raschke had set up an experiment to study the effect of varying solar radiation on plants by spreading thin aluminium sheets 34 S.W.G. over a square area, each of size about 10 feet. There were three such plots about 40 feet from each other. Every hailstone that fell made its mark on the aluminium sheet as a dent. There were a few which pierced the sheet also. Fig. 2 shows a photograph of the impressions made on the sheets. Four areas, each of one square foot, were taken at random in each of the three plots covered with aluminium sheets and the number of dents due to the hailstone was counted. The number of dents in each square foot area was as follows:

	Plot (1)	Plot (2)	Plot (3)
	393	354	328
	391	403	357
	382	496	424
	366	394	387
Average	383	412	374

If we assume that hailstones have not fallen on the same spot more than once, the distribution seems to be fairly uniform and is of the order of about 390 per square foot during the whole storm. If we assume that on the average, hail fell at this rate over the whole area of about 24 square miles, the total number of hailstones associated with the storm was approximately 2×10^{12}.

4. Extent of the storm from radar pictures

Fig. 3 shows the radar picture of the hailstorm. It shows the echo received with the antenna rotating in the north to south plane, with the axis of rotation horizontal in the east-west direction. Fig. 3(a) shows the echo at 1805 IST when the hailstorm just started. The maximum height of the rain echo was 10·7 km (35,105 ft) above sea level where the temperature was of about —40°C. The rain echo was nearly 9 km (29,528 ft) wide in the north to south direction. Fig. 3(b) shows the radar echo at $18^h\ 27^m\ 30^s$, when the original storm over the station had nearly dissipated and a second cell was just forming to the south. Thus, from $18^h\ 05^m$ to $18^h\ 27^m\ 30^s$, it decreased in vertical extent from 10·7 km to 5·5 km, which correspond to a rate of 13·9 km hr^{-1}, *i.e.*, 13 ft sec^{-1}, a value which is of the same order as that observed in the Thunderstorm Project in America (Byers 1949).

Figs. 3(c) and 3(d) show the radar pictures of the second cell which moved from the south and caused the rain at 1945 IST. It will be seen from Fig. 3(b) that the formation of the second cell was just detected in the radar at a height of approximately 5·5 km (18,045 ft), *i.e.*, about 1219 metres (4,000 ft) above the freezing level (14,108 ft above sea level) observed during the radiosonde flight at about 2100 IST on 16 March 1954. Byers (1951) has reported from his investigations, a mean height of approximately 2,200 ft above the freezing level as the altitude of the tops of the initial echo and the concurrent height of the freezing level.

At 1940 IST, the maximum height of the second rain cell over the station was about 7 km (22,966 ft), while at $19^h\ 47^m\ 30^s$, it was nearly 8·6 km (28,215 ft). The rate of upward growth of the rain echo in the second cell was about 12 ft sec^{-1} (nearly 13 km hr^{-1}), as compared with that of a mean of 18 ft sec^{-1} observed by Byers (1951).

5. Autographic Records—Rainfall

Figs. 4 (a) to (g) and (l) show the records of temperature, humidity and rain at the Central Agricultural Meteorological Observatory. Temperatures and humidity observations in stevenson screens were available on the ground and at heights of 4, 15 and 30 ft above the ground. The records of some of the instruments at the Meteorological Office are shown in Figs. 4(h) to (k). The height of the anemograph head was 127 feet above ground. All the autographic records indicate that the station was affected by two thunderstorm cells, one at about 1800 and the other at about 2000 IST.

Precipitation occurred in two instalments; all the hail occurred with the first. During the first spell, about 1·40″ of the rain fell from 1745 to 1815 IST at the Central Agricultural Meteorological Observatory which was nearer the hailstorm centre; at the Meteorological Office, however, only about 0·90″ fell from 1800 to 1830 IST. This was followed by light rain or drizzle till 1945 IST when due to the second spell, 0·20″ fell between 1945 to 2000 IST at the Agricultural Meteorological Observatory and 0·35″ at the Meteorological Office. The intensity of the rain in the first spell at the Meteorological Office went up to 3·8 inches per hour as recorded on a tilting bucket raingauge coupled to a Bibby impulse recorder; it is likely that this does not represent the true intensity, as the hailstones might have been collected in the funnel and taken some time to melt and fall into the tilting bucket. However, the intensity during the second spell reached approximately 6 inches per hour. A feature of the thunderstorm was that within about half an hour of the

Fig. 1(a)

Fig. 1(b)

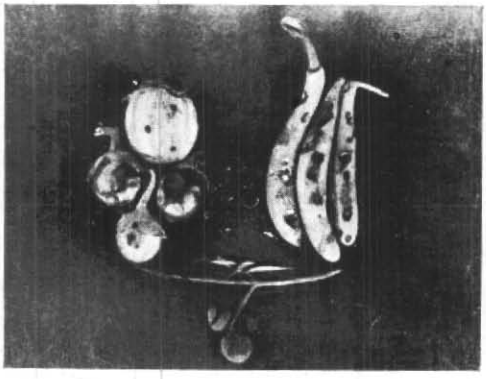

Fig. 1(c)

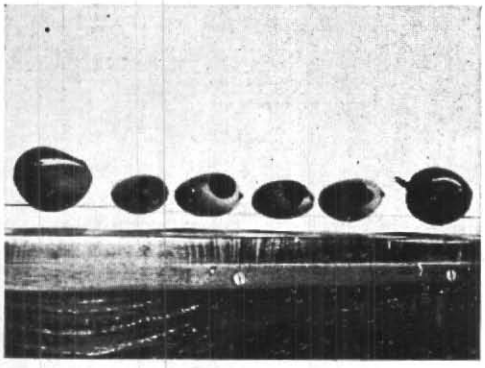

Fig. 1(d)

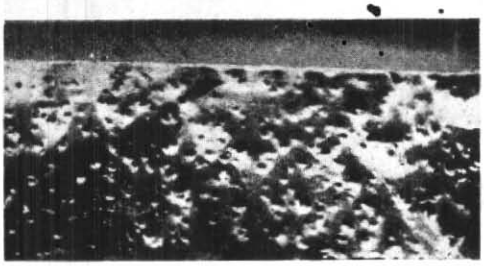

Fig. 2

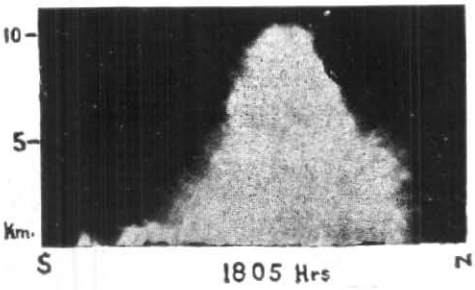

Fig. 3(a)

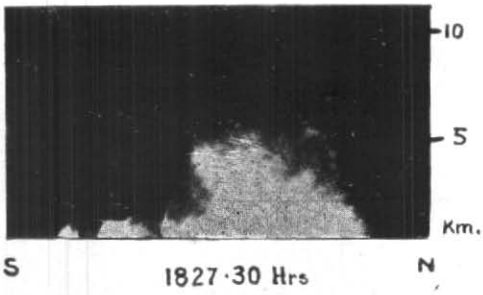

Fig. 3(b)

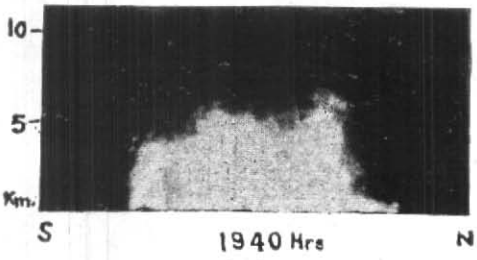

Fig. 3(c)

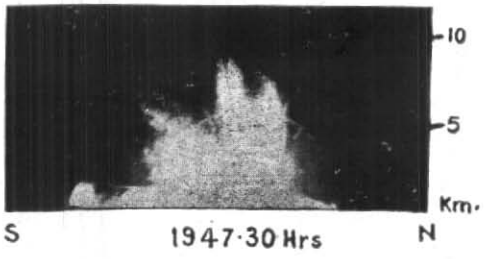

Fig. 3(d)

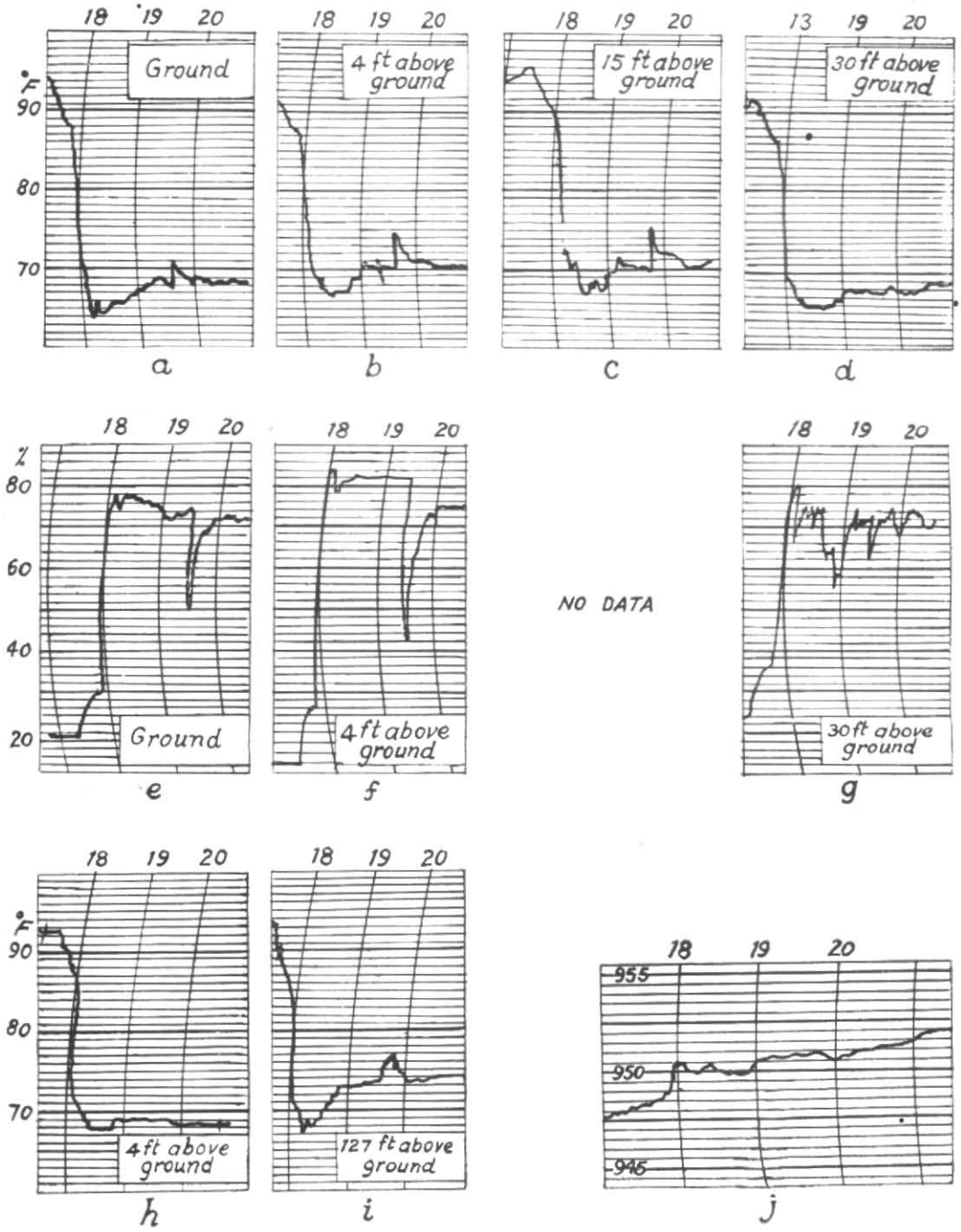
18 19 20
Ground
°F
90
80
70
a
18 19 20
4 ft above ground
b
18 19 20
15 ft above ground
c
13 19 20
30 ft above ground
d
18 19 20
%
80
60
40
20
Ground
e
18 19 20
4 ft above ground
f
NO DATA
18 19 20
30 ft above ground
g
18 19 20
°F
90
80
70
4 ft above ground
h
18 19 20
127 ft above ground
i
18 19 20
955
950
945
j

Fig. 4

second spell, the thunderstorm dissipated and the sky cleared up appreciably.

6. Wind Records

There were two squalls at the station. The first one which arrived at about 1800 IST reached a maximum velocity of about 48 miles per hour and came from the north. The second one at about 1945 IST was a very weak one and came from the south reaching a maximum speed of only about 20 miles per hour.

7. Barogram

The barogram (Fig. 4 j) also seems to indicate two pressure surges; the one with the first cell being strong and that with the second, very feeble.

8. Hygrograms and Thermograms

The hygrograms and thermograms are interesting. The hygrogram at all the three levels at the Central Agricultural Meteorological Observatory showed an increase in humidity from about 20 per cent to about 80 per cent on the onset of the hailstorm, the corresponding fall in temperature being about 25°F. At the time of the onset of the strongest squall of 48 miles per hour, there was a small decrease of humidity in all the three hygrographs, the decrease being largest and about 14 per cent at the 30-ft level. Associated with this, there was only a very slight rise of temperature of the order of about 1°F. At the Meteorological Office, the thermograph on the tower (127 ft above ground) showed a rise of about 1°F while the one at 4 ft showed no change. During the second squall at about 1930 IST, there was an appreciable and sharp decrease in the humidity and increase in temperature at the Agricultural Meteorological Observatory. It was more prominent at the lower levels. The approximate changes in temperature and humidity at the different levels were as shown on next page.

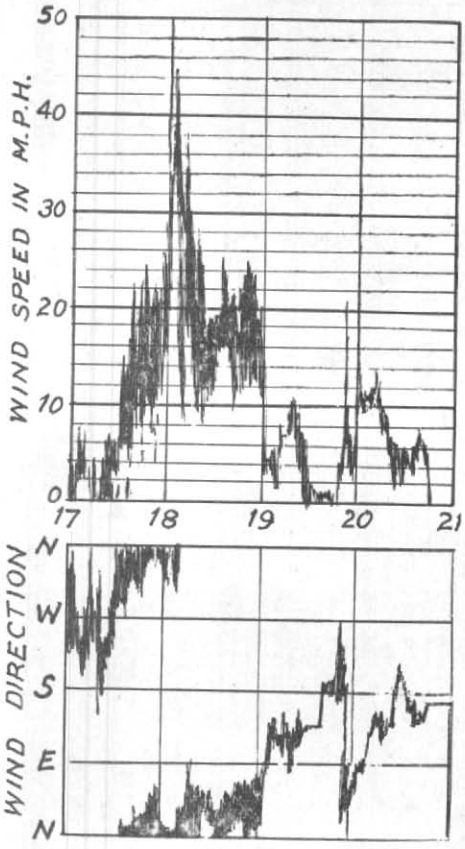

Fig. 4(k)

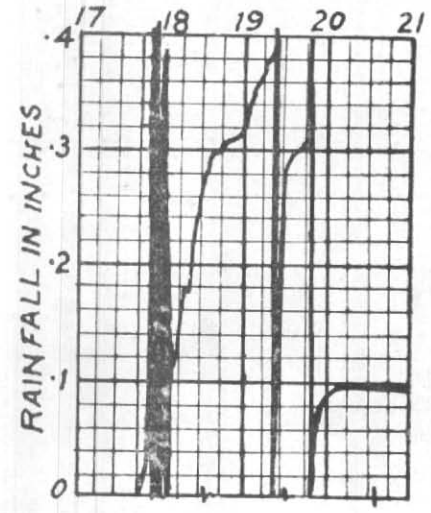

Fig. 4(l)

	(Temp. rise) (°F)	(Humidity) (fall)
	Central Agrimet. Observatory	
Ground	4	25
4 ft	4·5	40
15 ft	5	No hygrograph
30 ft	1	10
	Meteorological Office	
127 ft	3·5	No hygrograph
4 ft	No change	

Decrease of relative humidity associated with a rise in temperature has been often observed in thunderstorms. This feature has been discussed by many workers including Byers and Braham (1949), who have termed this type of fluctuation as "humidity dip" and is associated with the out-going downdraft. However, the changes recorded in the thunderstorm of 16 March 1954, appear to be unique.

The larger temperature rise and humidity fall associated with the second squall are presumably due to the lowest temperature and highest humidity having been reached near the ground due to the first rain spell. It is not clear why the thermographs at 4 ft in the Meteorological Office did not record any rise in temperature during the second squall–probably, the descending air did not reach this level at the Meteorological Observatory, while travelling towards the north it reached the ground and began spreading as a thin layer by the time it reached the Agricultural Meteorological Observatory.

REFERENCES

Byers, H.R. (1951). *Thunderstorms, Compendium of Meteorology.*

Byers, H. R. and Braham, R. Jr. (1949). *The Thunderstorm*, Washington D.C., U. S. Department of Commerce.