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Radar observation of supercooled water in thunderstorms at Poona

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From the middle of 1953, a search radar, type 717C operating on 9·1 cm was available in the Meteorological Office at Poona. The peak power of the transmitter in this radar is approximately 40 KW and the pulse duration of 1·125 sec. It operates over five ranges, *viz.*, 4, 10, 20, 50 and 100 nautical miles. With this 10-cm radar a precipitation rate of 0·02 inch per hour can be expected to be just detected at a range of 10,000 ft (Day 1953), if it is assumed that the rain storm completely fills the radar beam and has a size distribution, as given by Law and Parsons (1943). Also drops of 1 mm diameter and density 100 drops per cubic metre or those of 0·5 mm radius would just be visible at the same range of 10,000 ft if their density was 10^4 drops per cubic metre. The intensity of the radar echo decreases rapidly with increase in range.

The radar antenna, which is a dipole-fed parabaloid was so mounted that it could be adapted easily for turning about a horizontal or vertical axis. In the former type of mounting, first adopted by Bowen and his collaborators in Australia (Day 1953), the radar beam scans a path from horizon to horizon, through the zenith and this results in a representation in the cathode ray display unit of a cross-section through the atmosphere about the point of observation. In this method of scanning the range and height are maintained in true proportion and thus easier interpretation of the rain echoes immediately above the point of observation is possible.

Radar observations of rain are being made regularly at Poona since 1954 and some features have been summarised in a previous paper (Gupta *et al.* 1955). A first indication about the height to which supercooled water in thunderstorm clouds extend relating to a few instances was given in that paper. All observations of maximum heights to which supercooled water extended in radar measurements made at Poona during 1954-56 are given in this note.

Thunderstorms at Poona generally occur in the afternoons during the pre-monsoon months March to June and during the post monsoon period September to November. However, during the years 1954-56, no observation of thunderstorm echoes were recorded during November. Measurements of the maximum height reached by the supercooled water in the thunderstorm, from the echoes in each thunderstorm is given in Table 1.

When more than one cell was observed on a day, the mean of the maximum heights reached by the supercooled water in the cells was calculated.

It appears from the above table that the mean maximum heights to which supercooled water extends in the thunderstorms at Poona are nearly similar in March and April; and so also in May and June and September and October. The mean height for each of these three seasons is given below—

March–April	9500 metres
May–June	13100 metres
September–October	7500 metres

TABLE 1

Maximum height reached by supercooled water in thunderstorms over Poona

Serial No.	Date	Height a.s.l. (metres)	Date	Height a.s.l. (metres)	Date	Height a.s.l. (metres)
	MARCH		MAY		SEPTEMBER	
1	16-3-54	10200	10-5-54	10700	17-9-55	9200
2	19-3-54	9700	7-5-55	10700	20-9-55	6800
3	10-3-55	6000	20-5-55	16000	21-9-55	8100
4	22-3-55	10700	2-5-56	15000	22-9-55	9700
5	23-3-55	11900	—	—	27-9-55	7900
6	24-3-55	8700	—	—	20-9-56	7500
	Mean	9600	Mean	13100	Mean	8200
	APRIL		JUNE		OCTOBER	
1	21-4-54	9100	5-6-54	14000	6-10-53	8200
2	22-4-54	5900	2-6-55	12400	7-10-53	6000
3	23-4-55	11900	—	—	8-10-53	5500
4	10-4-56	8700	—	—	18-10-54	5600
5	16-4-56	8900	—	—	19-10-54	7800
6	18-4-56	8700	—	—	24-10-55	7300
7	9-4-57	12700	—	—	5-10-56	6600
8	—	—	—	—	8-10-56	7300
	Mean	9400	Mean	13200	Mean	6800

It is seen from the above that supercooled water in the thunderstorms in May-June reach higher levels than those in March-April, and that the height is lowest in September-October. The height upto which the supercooled water is lifted in a thunderstorm depends upon the thermal stability and the moisture supply available. Fig. 1 gives the mean tephigrams for the period March-April, May and September-October. The tephigrams represent the mean prevailing general conditions when thunderstorms occur. The data for June has not been combined with that of May as the meteorological conditions get completely altered by the onset of the monsoon by about the middle of June. The latent instability is lowest in September-October, somewhat higher in March-April and largest in May. Also, saturated air rising from the lowest layers will continue to be warmer than the environment to a higher level in May than in the remaining months considered. One may, therefore, expect the thunderstorm to reach maximum heights during May-June and least during September-October.

The mean height of the freezing level and the free air radiosonde temperature corresponding to the mean maximum height upto which supercooled water was visible in the thunderstorm are given in Table 2.

These observations give an approximate estimate of the convective vigour in each season. They also indicate upto what level above and upto what degree of cooling below the freezing level in the free air, supercooled water is lifted in the thunderstorm cell in the different seasons. The air temperature inside the growing thunderstorm cell will be higher than that in the free air till the dissipation stage,

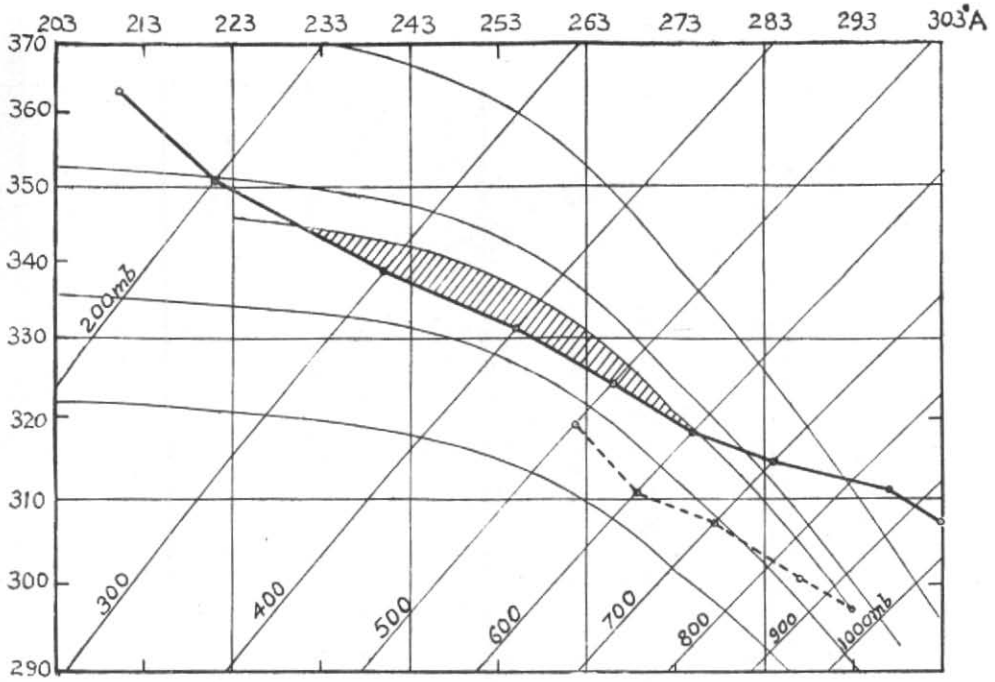

Fig. 1. Normal tephigram of Poona, March-April

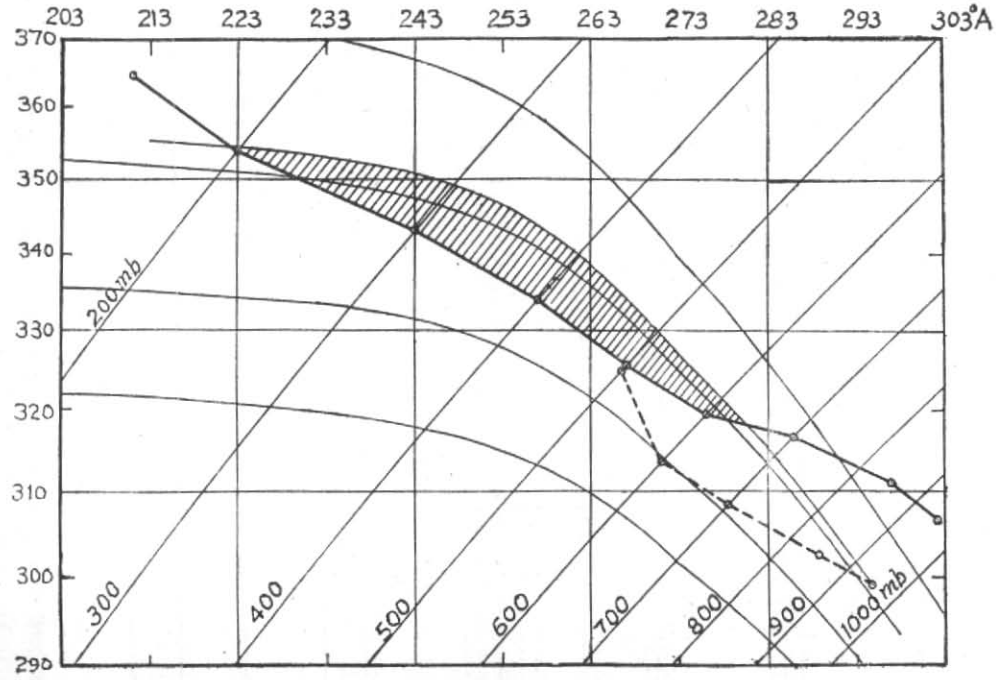

Fig. 2. Normal tephigram of Poona, May

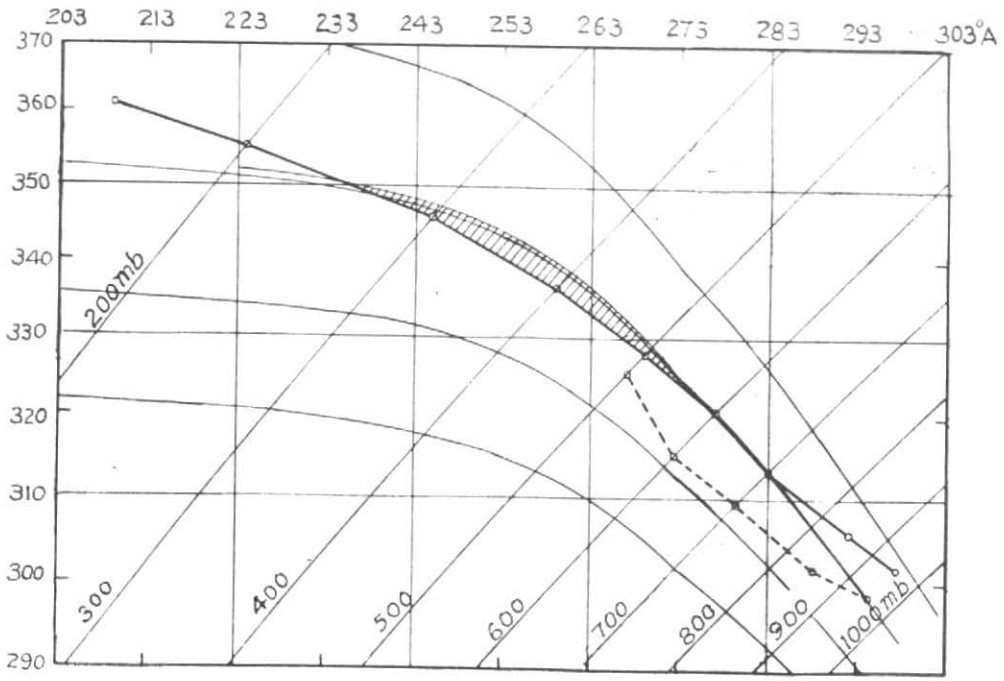

Fig. 3. Normal tephigram of Poona, September–October

TABLE 2

Month	Height of level in free air corresponding to 0°C (a.s.l.) (metre)	Mean height of top of supercooled water above 0°C level (metre)	Temp. of free air at mean max. height of supercooled water (°A)
Mar—Apr	4800	4700	241
May—Jun	4900	8200	217
Sep—Oct	5200	2300	262

Since the water carried upward will not change temperature as fast as the ascending air, the water drops will be warmer than the air surrounding them. Due to this and supercooling, water may remain in the liquid state several thousand feet above the level corresponding to 0°C. It has to be mentioned that maximum heights considered in this paper represent only the levels upto which supercooled water or wet snow is lifted as observed in the radar and does not represent the heights upto which the thunderstorm cloud has reached. This should be naturally higher.

REFERENCES

Day, G. A.	1953	*Aust. J. Phys.*, **6**, pp. 229-239.
Gupta, B. K., Mani, A. M. and Venkiteshwaran, S. P.	1955	*Indian J. Met. Geophys.*, **6**, 1, pp. 31-40.
Law, J. O. and Parsons, D. A.	1948	*Trans. Amer. geophys. Un.*, **24**, Pt. 3, pp. 452-459.