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AN EXPLORATORY STUDY BY RADAR OF THE EFFECT OF SEEDING TWO MARITIME CUMULUS CLOUDS

Following enunciation and demonstration by Woodcock *et al.* (1963, 1967) of the effect of seeding humid air over sea by massive doses of giant hygroscopic nuclei, a case study was undertaken at Bombay towards the end of 1973 monsoon season for exploring the effect of salt seeding on maritime cumulus using radar facility. This study formed a part of the programme of Poona cloud seeding experiment (Krishna *et al.* 1974).

The X-band, BEL weather radar of the Meteorological Office, Bombay airport and the S-band surveillance radar (ASR-3, CA-3100) of the airport Air Traffic Control, made available with the generous cooperation of the respective authorities, were used for the study. Seeding was performed

TABLE 1

Visual and radar observations of seeded and not-seeded clouds

	Seeded				Not seeded
	Cloud A	Cloud B_1	Cloud B_2	Cloud B (B_1+B_2)	Cloud C
I. Location					
1. Azimuth (degree)	300	..	..	280	335
2. Range (km)	46	..	..	26	35
3. Cloud base (km)	1·5	..	..	1·3	..
4. Cloud top (km)	3·0	..	..	2·4	..
II. Seeding time (IST)					
1. Commencement	1655	1745	1810	..	..
2. Termination	1722	1805	1825	..	..
III. Seeding level (km)	1·7—2·0	1·7—1·9	1·7—2·0	..	..
IV. Number of seeding traverses	7	6	3	..	
V. Areal echo coverage PPI (sq. km.)					
1. When first observed	100·0	5·5	16·6	..	266·7
(time in brackets)	(1625)	(1738)	(1738)		(1658)
2. When seeding commenced	68·9	13·0	44·4	..	..
3. When seeding ended	77·8	43·9	a	124·4	
4. When largest	155·6	..	..	133·3	366·7
(time in brackets)	(1842)			(1817)	(1730)
5. When last observed (time in brackets)	77·8	..	..	122·2	177·8
	(1932)			(1828)	(1932)
VI. Vertical echo coverage RHI (km)					
1. When seeding commenced	2·0	a	a	1·6	..
2. When seeding ended	4·3	a	a	2·1	
3. When largest	6·9	a	a	2·5	3·9b
(time in brackets)	(1836)			(1810)	(1731)
VII. Visual observation of rain	c	d	e	..	..

a—Not available separately for B_1 and B_2.

b—Only observation available.

c—Rain noted in the beginning of third traverse ; it intensified in the course of sixth and became more marked in the seventh traverse. On flying below the level of cloud base, it was confirmed that rain was falling from the cloud.

d—Rain noted at the beginning of fourth traverse ; it intensified in the fifth and became more marked in the sixth traverse.

e—Rain noted towards the end of second traverse; it intensified in the third traverse.

using the same DC-3 aircraft and the same technique as in the Poona experiment.

Of the three isolated clouds A, B and C, located within 50 km off Bombay coast on 30 Sept, A and B were seeded and C was left unseeded. The radar and visual observations made on these clouds are given in Table 1. The development of the areal and vertical extent of the echoes are given in Fig. 1. The units used are the ratio of the values of the area (height) shown on PPI (RHI) at the times given, to the maximum value observed on PPI (RHI).

2. The echo of the cloud A was decreasing in areal extent during at least half an hour before and 5 minutes after the time of commencement of seeding. Thereafter, it picked up growth and eventually the areal extent increased by more than two times and the vertical extent by more than three times. Fig. 2 (a, b, c) shows precipitation developments of the cloud A at three selected stages.

The seeding operation of the cloud B was accomplished in two phases. There were two echoes

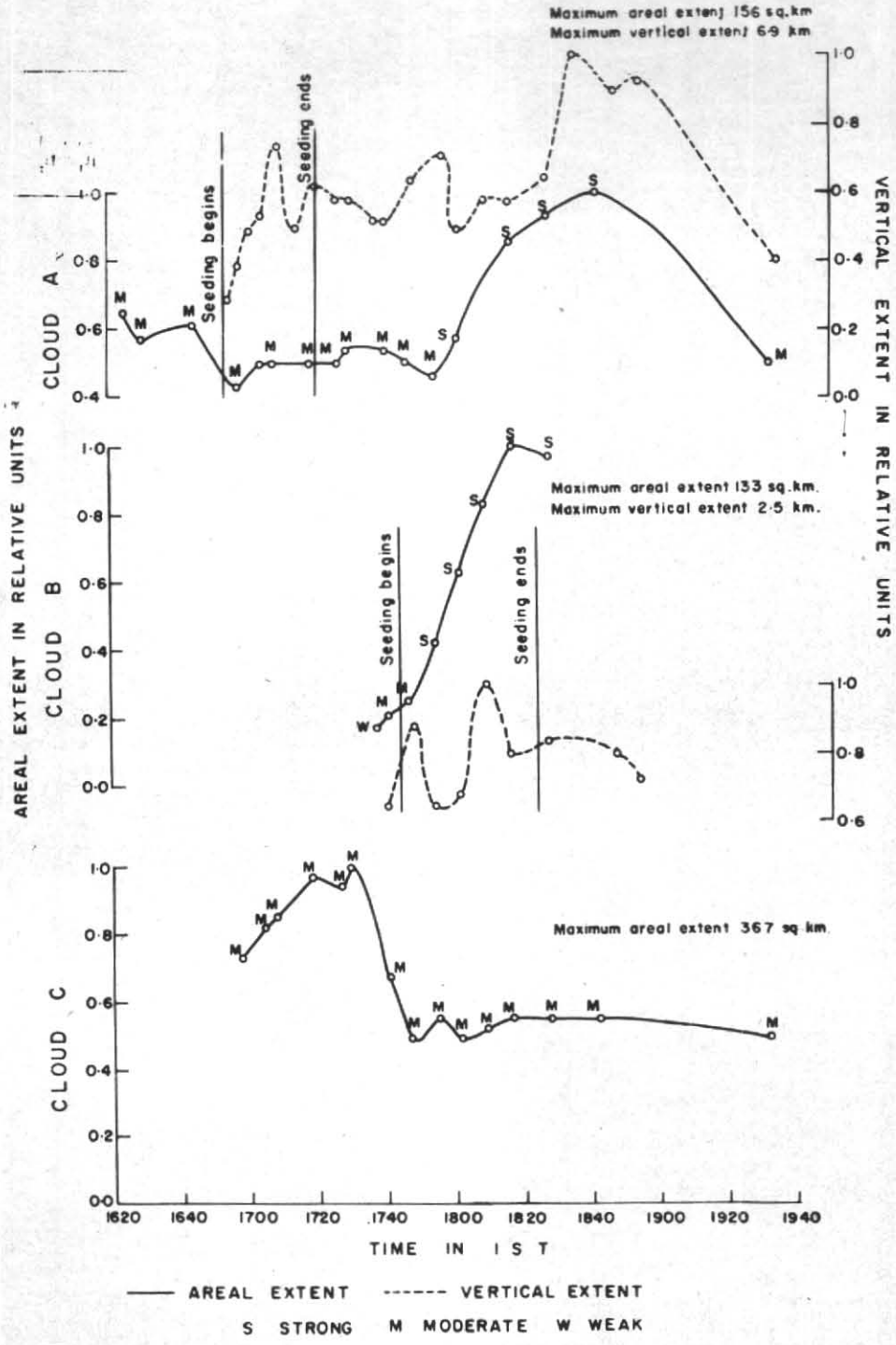

Fig. 1. Development of areal and vertical extent of the echoes of the clouds, A, B, and C

B_1 and B_2 from this cloud separated distinctively. In the first phase, seeding was done in an echo free region south of B_1. As the seeding progressed a distinct new echo appeared and merged with B_1. In the second phase, the seeder aircraft was directed to seed in the echo free region between B_1 and B_2 in the north-south direction. The seeding party could not see the gap between B_1 and B_2 although there was echo free region as seen through the radar. The aircraft was guided by the surveillance radar through radio link and seeding was carried out. When three seeding traverses were completed the echoes B_1 and B_2 merged together and formed into a large echo B (Fig. 2 f).

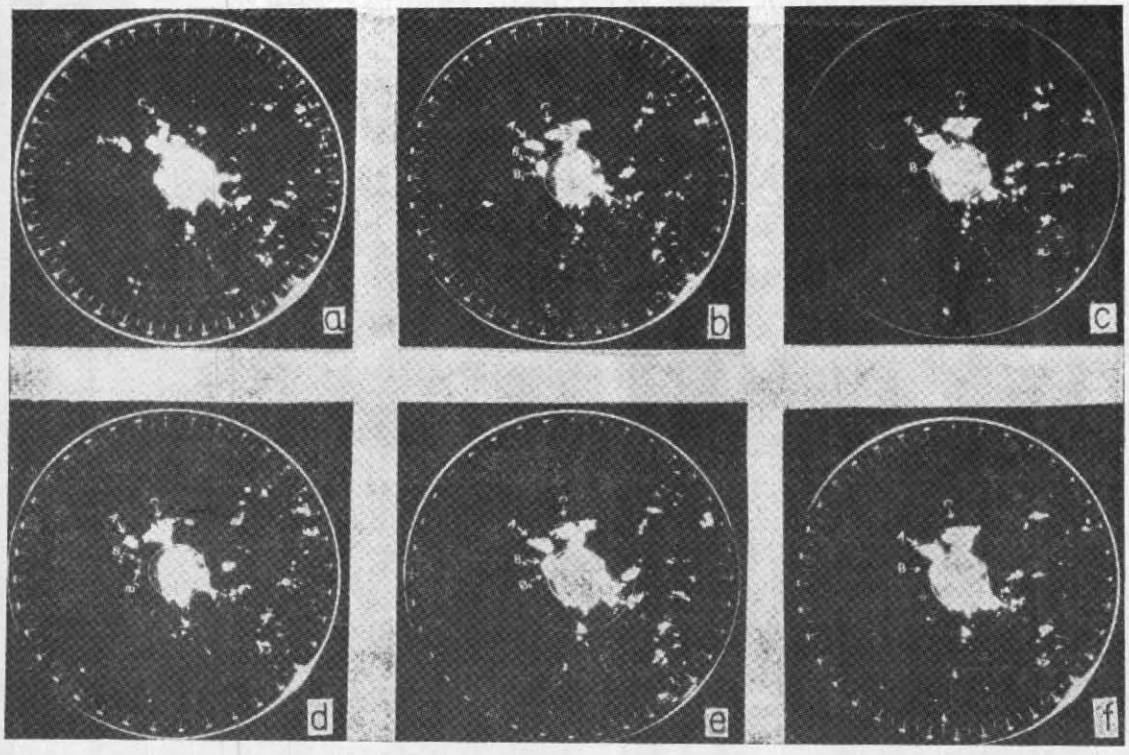

Fig. 2. Radar picture of clouds, A, B and C
(elevation : 1° ; range : 100 km; gain : maximum of the radar. Timings in IST of — a : 1658 ; b : 1755; c : 1828 ; d : 1738 ; e : 1801 30 and f : 1817)

The intensity of the echoes was categorised as strong (S), moderate (M) and weak (W) depending on the lowest gain at which the echo could be seen. From the observations made since their identification, it was found that the seeded clouds A and B and the unseeded cloud C grew in area, but the intensity of the echoes from A and B increased from moderate (M) to strong (S) after seeding, whereas the intensity of the echo from C remained moderate (M) throughout (Fig. 1).

The echoes from the seeded clouds attained maximum height after seeding. Also, from neither cloud seeded, was visual rain noted at the time of commencement of seeding, but rain was clearly observed sometime after seeding (Table 1, item VII). No observations of visual rain were available, for comparison, from the unseeded cloud.

3. While the features noted above do not establish the effect of seeding maritime warm cumuli by common salt, the trend of the results obtained from the present study is encouraging.

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