EXPERIMENTAL CLOUD SEEDING PROGRAM 1976/1977

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INTRODUCTION

Three seasons of single cloud experiments conducted in Rhodesia in 1968/69, 1973/74 and 1974/75 indicated that rainfall could be increased by seeding cumulus clouds with silver iodide, provided that the cloud-top temperatures were colder than about -10°C. The results were even more clear-cut if cloud tops were colder than -13°C. In 1968/69 silver iodide burners were used for the seeding; in the other two seasons the silver iodide was released from pyrotechnic cartridges fired from Very pistols. The reports on these experiments are given in Rhoedesia Meteorological Notes Series A, Nos. 29, 43 and 45.

In 1974/75, trials conducted with clouds failing to attain -10°C indicated that silver iodide was nearly always ineffective at these warmer temperatures. It was decided to resume these experiments on warmer clouds in 1976/77, but increasing the quantity of silver iodide used for the seeding, to see whether this succeeded in stimulating rain where the light dose had failed. Experience has shown that negligible rain is produced by the overwhelming majority of clouds warmer than -10°C. Thus, the 1976/77 warm cloud trials were all seeded occasions with no randomization, because the seeding of every cloud yielded more information than would have come from leaving half of them alone. The experimental procedure was therefore the same as that in previous seasons except that there were no non-seeded control clouds, and the number of silver iodide cartridges fired into each cumuliform cell was increased from one to two or three.

EXPERIMENTAL PROCEDURE

Isolated growing cumulus clouds were selected from the experimental Cessna 320 aircraft from about 19,000 ft. a.s.l. The cloud-top height was measured; the aircraft then penetrated the cloud and fired two cartridges simultaneously when updraughts were encountered.

After seeding, the aircraft descended below the base of the cloud to observe its behaviour. If rain was produced, then its intensity was estimated qualitatively, with help from measurements made in the rain collector. It was not possible to measure the total quantity of rain accurately, because it was necessary to return to cloud-top at least once during every experiment to check whether the initially warm cloud had in the meantime grown beyond the -10°C level.

When these warmer clouds were not available, randomized experiments continued with taller clouds colder than -13°C at their tops, using the same light dosage as in 1973/74 and 1974/75, to investigate whether the apparent successes of these two seasons could be confirmed. From 25th January 1977 onwards, these randomized colder cloud experiments were given first priority, because it was considered that by then enough had been learned from the trials with warmer clouds.

RESULTS OF EXPERIMENTS

Warm Clouds

The heights, top temperatures and rainfalls of all experimental clouds are presented in Table I. Fifteen clouds warmer than -10°C were seeded, thirteen of which produced no rain at all, or rain which was too little to measure in the collector, listed as "trace" in Table I. The other two warm clouds gave only light rain.

In addition to these fifteen, there were five seeded clouds which only just managed to penetrate beyond the -10°C level. Three of these yielded negligible or no rain, one gave light rain, and the other moderate rain. When rain was produced it was comparatively short-lived, fading out about half an hour after the first cartridge was fired. In the 1973/74 report (Series A, No. 43) it was explained that the rain resulting from seeding near cloud-top takes approximately half an hour to reach cloud-base. It therefore appears that the seeding of warm clouds with a heavier dosage in 1976/77 did not increase the rainfall significantly.

Cold Clouds

Four randomized trials were carried out with clouds colder than -13°C at their tops. One of these were seeded, and gave light rain. Two control clouds gave nil rain. The other control cloud produced moderate rain, but it was the tallest and widest of the four. This number of experiments is too low for valid conclusions to be drawn regarding cold clouds.

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I am also gateful to Mr. J. Ward for acting as Meteorologist in the aircraft on days when I was unavailable.

The aircraft was capably maintained by Rhodesia United Air Carriers during the experimental program.

TABLE I EXPERIMENTAL CLOUDS 1976/77.

Date	Seeded or not	Seeding flight level	When selected: Cloud Top FL	When selected: Temp. Top °C	When selected: Cloud Depth ft	RAIN (10^3 m^3) from x mins. after "seeding": x = 10	x = 30	x = 50	Rain duration (Mins.)	Other notes
5/11/76	S	190	194	-10,5	10 000	Mod	Light	Nil	>12	Two similar adjacent cells seeded, but only one rained.
8/11/76	S	194	198	-9	8 800	Trace	Trace	Nil	-	Two cells seeded: the first collapsed immediately, and the second grew to 20 800 ft a.s.l. Poorish bases.
9/11/76	S	193	201	-9,5	8 700	Light	Trace	Nil	5	Poorish base.
15/11/76	S	203	210	-13	11 000	Heavy	?	?	?	Base broken. Top grew at least to 21 800 ft a.s.l. Rain measurements interrupted by lightning
25/11/76	S	211	217	-15	8 200	Nil	Nil	Nil	Nil	High base. No significant updraughts during seeding. Top collapsed 2 mins. after seeding.
25/11/76	S	213	218	-15	8 300	Nil	Nil	Nil	Nil	High cloud base. Gyrocompass failure prevented proper seeding.
2/12/76	S	202	208	-10,5	10 300	Trace	Nil	Nil	2	Good liquid water content near top, but poorish base, and cloud leaning.
2/12/76	S	200	205	-10^{++}	9 000	Mod	Mod	?	?	Cloud collapsed within one minute of seeding, and then revived, becoming too vigorous for further seeding.
3/12/76	S	184/190	191	-7,5	7 100	Nil	Nil	Nil	Nil	
14/12/76	S	192	197	-9	8 200	Nil	Nil	Nil	Nil	Ice encountered during seeding.
15/12/76	S	190	195	-10	9 000	Nil	Nil	Nil	Nil	Broken base. Ice encountered during seeding.
20/12/76	S	191	194	-9,5	11 400	Nil	Nil	Nil	Nil	Very poor base
20/12/76	S	190	205	-12	12 500	Heavy	?	?	?	Only light updraughts during seeding. Lightning & fuel shortage interrupted experiment. Rain difficult to distinguish from adjacent storm.

Table I. Experimental Clouds 1976/77 - Contd.

Date	Seeded or not	When selected: Seeding flight level	When selected: Cloud Top FL	When selected: Temp. Top °C	When selected: Cloud Depth ft	RAIN (10^3 m^3) from x mins. after "seeding": x = 10	x = 30	x = 50	Rain duration (Mins.)	Other notes
7/ 1/77	S	200	206	-10	11 300	Light	Nil	Nil	>8	Light icing during seeding. Top 20 000 ft a.s.l. soon after seeding. Poor base. Initially poorer cloud nearby gave heavy rain.
7/ 1/77	S	190	196	-8	10 100	Trace	Nil	Nil	>14	Ice during seeding. Broken base. Three mod/heavy showers within 15 - 20 n. miles.
10/ 1/77	S	190	192	-7,5	8 700	Nil	Nil	Nil	Nil	Poor base.
10/ 1/77	S	188	190	-7,5	8 500	Nil	Nil	Nil	Nil	Poor base. Top collapsed soon after selection.
11/ 1/77	S	188	190	-6	8 500	Nil	Nil	Nil	Nil	Multicell, but poor base.
11/ 1/77	S	189	194	-6,5	8 900	Trace	Trace	Nil	(>10)	Ice during seeding, with good liquid water content. Top grew to 20 000 ft a.s.l. Poorish base.
13/ 1/77	S	191	197	-9,5	11 200	Light	Light	Nil	>9	Multicell, but leaning with poor base. Ice during seeding with good liquid water. Top grew to 20 800 ft a.s.l. Descent delayed.
13/ 1/77	S	189	196	-9	10 400	Nil	Nil	Nil	Nil	Good liquid water content.
19/ 1/77	S	190	198	-8	9 700	Nil	Nil	Nil	Nil	Cloud started collapsing 3 mins. after seeding.
19/ 1/77	S	202	203	-9	10 200	Nil	Nil	Nil	Nil	Grew to 20 500 ft a.s.l.
20/ 1/77	S	192	198	-10,5	10 300	Nil	Nil	Nil	Nil	Wide multicell. Ice during seeding; high water content. Rain nearby may have been ours, but stopped 30 mins. after seeding.
20/ 1/77	S	189	190	-9^{++}	9 500	Heavy	Heavy	?	>11	Ice during seeding. Grew to 20 700 ft a.s.l.

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24/ 1/77	S	191	198	-9	8 300	Nil	Nil	Nil	Nil	Similar clouds around gave moderate rain.
25/ 1/77	N+	-	230	-15	13 000	Nil	Nil	Nil	Nil	Poor base.
26/ 1/77	S	225	228	-16,5	11 800	Nil	Nil	Nil	Nil	Non-randomised. Very light updraughts - only one cartridge fired, although multicell.
26/ 1/77	N+	-	228	-16,5	11 800	Nil	Nil	Nil	Nil	Wide multicell. Abandoned after 15 mins. because of engine trouble.
27/ 1/77	S	223	226	-15	10 100	V.Light	?	?	?	Base broken. Poor updraughts - only one cartridge fired, although multicellular. Abandoned after 20 minutes - engine trouble.
2/ 2/77	N	-	225	-14,5	13 800	Heavy	Heavy	?	>23	Wide multicell member of a line along a range of hills, Grew to 24 000 ft., 5 mins. after seeding. Abandoned because of lightning.
18/ 2/77	S	225	230	-14	14 000	Mod	Light	?	>26	Multicell, but only one cell could be seeded. Top collapsed 3 mins. after seeding. Broken base.
25/ 2/77	N+	-	240	-18,5	16 200	Mod	Light	Nil	34	Wide multicell.
11/ 3/77	S+	225	230	-16,5	14 000	Light	Nil	Nil	>4	

+ Denotes randomised experiment.

++ Indicates that this cloud top grew beyond the -12°C level.