CHLORIDE AND SODIUM ION INCREASES IN RAIN FROM SALT SEEDED CLOUDS

L.T. Khemani, G.A. Momin, M.S. Naik
A.S. Ramachandra Murty and Bh.V. Ramana Murty

Indian Institute of Tropical Meteorology
Poona-411005, India

Chloride and sodium ion concentrations in rainwater from warm clouds seeded with a salt-soapstone mixture were two to three times greater than in rain from non-seeded clouds east of Poona, India, during the 1974 summer monsoon. The warm cloud seeding experiment, begun in 1973 and studied intensively in 1974, 1976, 1979 and 1980, involved two 1600 sq. km experimental areas, each having 40 raingauges and separated by an intervening buffer (Fig. 1). Crossover randomization was used.

A 10:1 mixture of salt and soapstone, with particle model size 10 μm, was released at cloud base level through a special device fitted to a DC-3 aircraft. The warm stratocumulus and cumulus clouds, with average bases 1.5 km MSL, were seeded during aircraft penetrations about 600 meters above cloud base. An average of 1,500 kg of salt mixture was released in the target sector on each seeded day. Other details are given by Krishna et al. (1976).

At raingage stations at Sirur (north sector) and Baramati (south sector), stainless steel funnels 12 inches in diameter on special stands collected rainwater samples into 1-liter polythelene bottles cleaned previously with double-distilled water (Khemani and Ramana Murty, 1968). Concentrations of sodium, potassium and calcium were measured by standard flame photometric methods; chloride, sulfate, nitrate, and ammonium concentrations were measured by standard colorimetric procedures (Khemani and Ramana Murty, 1968; kapoor et al., 1972).

Of 27 samples collected during the 1974 summer season, five were on seeded days and the remaining 22 on non-seeded days. Rainwater was collected between 1400 and 2000 IST, because seeding was confined to the afternoon. Because the difference of 0.69 mg/l between chloride concentrations in the north and south sectors on non-seeded days (Table 1) is significant, by the Mann-Whitney test, at less than 1 percent level, results were evaluated by sectors.

Table 1. Average concentrations (mg/l) and standard deviations of various chemical constituents of rainwater on seeded and non-seeded days in south and north sectors of warm cloud seeding experimental areas east of Poona, India during 1974 summer monsoon season.

		Cl^-	SO_4^{--}	NO_3^-	NH_4^+	Na^+	K^+	Ca^{++}
SOUTH (16 samples)								
Seeded	MN	3.96	5.02	1.23	0.16	2.68	1.31	4.84
4 samples	SD	0.74	9.83	0.64	0.13	0.91	0.60	1.32
Not-seeded	MN	1.17	2.48	0.76	0.15	0.93	0.41	2.37
12 samples	SD	0.95	1.16	0.67	0.13	0.67	0.26	1.45
NORTH (21 samples)								
Seeded	MN	4.70	3.70	2.06	0.08	3.00	0.45	3.81
1 sample								
Not-seeded	MN	0.48	1.44	1.01	0.10	0.78	0.56	1.42
10 samples	SD	0.20	0.78	1.14	0.03	0.73	0.22	0.74

In the south sector, concentrations of chloride, sulfate, sodium and calcium are significantly higher on seeded days, the chloride and sodium values about 200 percent, agreeing with rainfall increases on seeded days of 14 to 137 percent (Krishna et a., 1976). Aerosol measurements at cloud base on one seeded day (3 Sept. 1974) suggested an increase of 34 percent in the concentration of giant particles after seeding. Giant particles released at cloud base could help in formation of raindrops through condensation and collision-coalescence processes, facilitating rain development in warm monsoon clouds.

In the north sector, the only rainwater sample available on a seeded day showed a significantly higher concentration of chloride, sulfate, nitrate, sodium and calcium. The sources of nitrate and calcium particles are not clear.

Thus, chemical analyses of rainwater collected on seeded and non-seeded days during the 1974 salt seeding experiment east of Poona suggest that:

1) concentrations of chloride and sodium in rainwater on seeded days were significantly higher, by about 200 percent than those on non-seeded days;

2) rainfall increases in the target areas varied from 14 to 137 percent;

3) concentrations of giant condensation nuclei, measured at cloud base in the target area, increased about 34 percent after seeding, consistent with the increased concentrations of chloride and sodium and suggesting that giant condensation nuclei could induce rain-formation in warm monsoon clouds.

REFERENCES

Kapoor, R.K., L.T. Khemani and Bh. V. Ramana Murty, 1972: Chemical composition of rainwater and rain characteristics at Delhi II. Tellus, 24, 575-580.

Khemani, L.T. and Bh. V. Ramana Murty, 1968: Chemical composition of rain water and rain characteristics at Delhi. Tellus, 20, 284-292.

Krishna, K., R.K. Kapoor, A.S.R. Murty, A.M. Selvam, K.K. Kanuga, L.T. Khemani, B.K. Mukherjee, S.K. Paul, R. Vijayakumar and Bh.V. Ramana Murty, 1976: A randomized cloud seeding experiment in the Deccan plateau, India-preliminary results. J.Weather Modification.8,134-144.

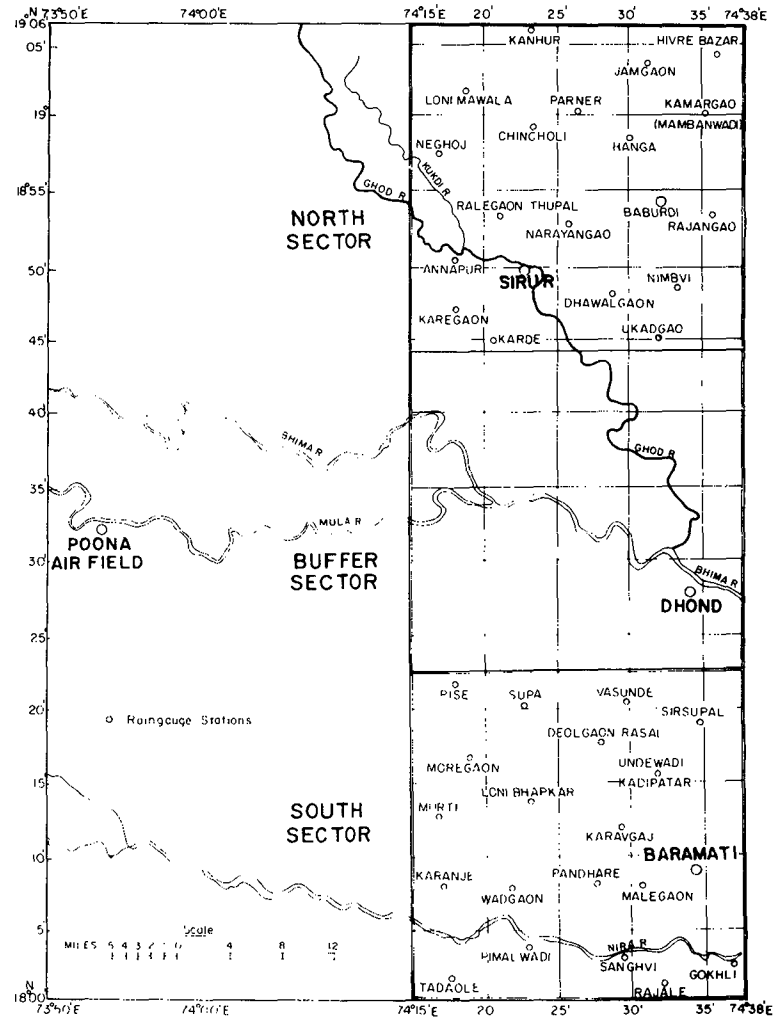

Figure 1: Location of the Experimental Area consisting of North, South and Buffer Sectors.