Comments on Silver Iodide Seeding and Hailfall Damage Suppression[1]

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In a recent paper published in this JOURNAL, Schleusener (1968) presents summaries of the results of hailstorm seeding projects and offers certain generalizations. Various aspects of his report are likely to mislead readers who are not familiar with the details of cloud seeding techniques and hail suppression attempts.

In his Table 1, Schleusener gives the results of experiments and projects involving the silver-iodide seeding of potential hailstorms. The projects are listed in order of increasing "maximum seeding rate in grams per hours per storm" in an effort to support one of the main conclusions of the paper namely, "Evaluation of experience to date supports the hypothesis that seeding at rates less than 1000 gm hr^{-1} per storm may stimulate convection and increase the number of individual hail events, but that heavier seeding at rates of 2000–3000 gm hr^{-1} per storm is effective in reducing hail damage by reducing the total impact energy from hailfalls." It is not at all clear that the evidence on hand supports this conclusion.

First of all, it should be noted that silver iodide can affect the development of hail only if the substance enters the cloud in the form of ice nuclei. The quantity of silver iodide consumed does not directly measure the concentration of nuclei entering the cloud. It is well known that the number of nuclei per gram of silver iodide depends on the technique of nuclei production. The number of nuclei at a temperature of −10C, for example, may vary over one or two orders of magnitude (see Fletcher, 1962).

A second complication in predicting the concentration of nuclei in a cloud is introduced by uncertainties in knowing diffusion rates and deactivation rates of nuclei. Even if the output of a particular generator is known precisely, it is impossible to accurately determine the concentration of nuclei entering a cloud. This is particularly true when using ground-based generators but it also applies when airplane generators are operated outside the cloud. The uncertainties certainly exceed a factor of two and in many instances probably exceed a factor of ten.

In view of the differences in nuclei generation and dispersal techniques used in the projects listed in Table 1, it is difficult to accept conclusions that a factor of 2 or 3 in silver-iodide seeding rate (gm hr^{-1} per storm) can account for the reported successes or failures of past hail modification activities.

There are various other aspects of this article which need more elaboration. The significance of the quantity called the maximum silver iodide seeding rate per storm (column 13 in Table 1) needs clarification. Footnote 5 states that it is "Calculated as the sum of the use rates from a maximum of 3 aircraft plus 3

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ground generators." This definition would indicate that it is some fictitious seeding rate determined, as noted by the author, by some arbitrary formula.

In the Argentina project there were 97 ground units each of which consumed 36 gm hr^{-1} of silver iodide. This yielded a maximum rate for all units of 3500 gm hr^{-1} (column 12, Table 1). No aircraft generators were employed. According to the formula for maximum rate per storm (3 airplanes plus 3 ground generators) the Argentina project was assigned only 100 gm hr^{-1} as a maximum seeding rate per hour per storm (column 13, Table 1). As a result, instead of ranking as one of those where heavy seeding was practiced, the Argentina project appears to be one which seeded at a very small rate. According to the Schleusener formula regardless of the number of ground-based generators employed in the Switzerland or Argentina projects, their maximum seeding rates per hour per storm would remain at 25 and 100, respectively.

Obviously, the ranking of projects in Table 1 is governed to an important extent by the formula for calculating maximum seeding rate per storm. The use of the formula must be justified, if possible. It is not adequate merely to mention it.

Incidentally, according to information supplied to me, during 1961 and 1963 Sulakvelidze most often used about 500 gm of AgI per cloud rather than 1000 gm (Battan, 1965). Sulakvelidze (1966) states that in 1964, 50–500 gm were used in each experiment and this averaged about 20 gm km^{-3} of cloud.

Table 1 fails to include a very important piece of information which is needed in order to interpret the results of past experience. The table should indicate the number of seeded clouds or the number of days on which seeding was carried out. The so-called "Time Unit" (column 6) does not give enough information. For example, the Switzerland project was a carefully designed, randomized experiment which ran for seven years, involving a total of 292 test days of which about half were seeded and hail was observed on 61 days (Schmid, 1967).

On the other hand, the four entries under Project Hailswath involved a total of 10 days of field operations with hail observed on six days. It would be difficult to argue that the same weight could be given to the Switzerland and Hailswath projects in attempting to infer the efficacy of silver iodide seeding on hail formation. The lack of information about the number of experiments also makes it difficult to weigh the value of the other projects.

Summary

The conclusion that greater quantities of silver iodide are more efficacious than small quantities in suppressing the fall of damaging hail seems possible, but Schleusener does not make a good case supporting it. The suggestion that whether or not hail is decreased depends on seeding at 2000 gm hr^{-1} per storm rather than 900 is not proven by the data presented in Schleusener's paper on his analysis thereof. Interestingly, Sulakvelidze (1966) initially seeded at rates of about 500 gm km^{-3} of cloud but as he states, "The results of the first experiments showed, however, that this amount could be reduced by a factor of about 10, and further study showed that the maximum amount of the agent required to produce the desired modification was about 20 gm km^{-3} of hail center."

Finally, it is relevant to note that in a yet unpublished report presented at the Irrigation and Drainage Division Specialty Conference in Phoenix, Ariz., in November 1968, Schleusener discussed a "massive cloud seeding project" conducted in the summer of 1968. He states the following:

"The Grand River Project was conducted from 16 May through 31 August 1968. The result was disappointing in that it was not possible to stop all hailstones with heavy seeding. The area experienced several damaging hailstorms in spite of heavy seeding."

"While it is not possible to stop all hail damage under existing seeding techniques, data from the Rapid Project gives cause for some optimism that moderate seeding rates are effective in reducing hailfall damage."

It appears that before drawing overly optimistic conclusions about the efficacy of hail suppression techniques, it is necessary that more experimental evidence be obtained.

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