Letters

Everybody Talks about the Weather, but . . .

The report by Neyman, Scott, and Smith (28 Mar., p. 1445) on the effect of cloud seeding in the Whitetop Experiment is of great interest to me for both official and personal reasons. Officially, in my new post as Assistant Secretary of Commerce for Science and Technology, I find myself involved with the weather modification efforts of the Environmental Science Services Administration (ESSA). On the personal side, nearly 25 years ago I had the good fortune to be the military officer at Wright Field who initiated contracts under which the first cloud seeding experiments were conducted by Langmuir and Schaefer.

I well remember Langmuir's constant admonitions against overseeding if one wished to produce rain. Once when we were talking about the potentialities of seeding, Langmuir suggested that by properly placing generators in Canada it might be possible to overseed the winds which regularly bring heavy snowfalls into the northern U.S. He speculated that perhaps we could decrease the snowfall, and by converting the supercooled clouds to tiny ice crystals, release the heat of fusion and raise the mean winter temperature 10 degrees Fahrenheit! Later, as a resident of New Hampshire, waiting for good skiing conditions, I viewed the Langmuir proposal differently. In 1946, Langmuir and Schaefer were also claiming to observe the effects of seeding in Mexico on rainfall halfway across the continent. As is the case with almost everything done in this field, their claims were hotly contested, particularly by statisticians.

My views regarding the relationship of statistics to experimentation may be summarized in the statement: "If experimentation is the Queen of the sciences, surely statistical methods must be regarded as the Guardian of the Royal Virtue." We should be grateful that a statistician of the reputation of Neyman has taken an interest in this important activity, and we may be assured that the methods used are properly employed. On the other hand, the conclusions drawn from statistical inference which go beyond the data might well be questioned without in any way detracting from the accuracy of the analysis. As is well-known, statistical formalism reflects in its output only what is in the input. The statistical analysis of the report used only the data from rainfall gauges and was designed to answer two questions: (i) Did seeding have an effect on the precipitation measured at the ground? and (ii) If an effect exists, how large is it?

The conclusion for (i) is "Yes" and for (ii) is "From minus 9 to minus 30 percent." These results apply to *the given data.* To draw generalizations which go beyond the data is to go beyond the duties of the "Guardian of the Royal Virtue." The conclusion by Neyman *et al.* that decreases in rainfall on a vast scale have not been contemplated is a case in point. The statement that "The situation is aggravated by the absence of an intelligible theory, even a hypothesis, on the mechanism through which cloud seeding conducted as a 'local measure' could have large effects some 150 miles away," is not true. Langmuir once described these mechanisms. He visualized overseeding as producing very small ice crystals which would rise to higher levels (the heat of fusion causing local warming), and drift for many miles until they would be caught in a down draft and mixed with another cloud, thus providing new seeding.

In a trip report rendered to me (in connection with the early contract) describing his visit to Russia in World War II, Langmuir reported his observation of rain appearing in a cloud below his airplane. He wondered how the lower cloud might have been seeded from the ice cloud above it. This report preceded by about one month his request for additional funding to undertake cloud seeding and persuaded me to go ahead with the project, despite the advice to the contrary which I had received from the "experts."

When discussing cloud seeding in general, and not merely one set of experimental data, *all* known data should be admitted as evidence, not merely the frequency distributions for amounts of rainfall in gauges. Numerous reports have not only shown that man can affect the weather, but also have given us insights as to the mechanisms. For example, I have examined the movies of a radar screen, and seen rain deposited in the hills east of Santa Barbara in three plumes from three silver iodide generators placed on the islands to the west. The radar screen showed that *no precipitation occurred outside the plumes.*

The knowledge we have of cloud physics should not be discounted, either. If, for example, the freezing nuclei were more abundant during that year (by reason of more industrial activity or more seeding to the west) the nuclei count might already have been high enough for rain-making and the addition of more nuclei would, on the average, have decreased the rainfall.

The conclusion of Neyman *et al.*, that man can affect the weather, is valid—but is not to be considered as derived solely from the data from Whitetop. I believe that in the Whitetop experiment there was overseeding.

Recently I flew over some of the flood-stricken areas of the North Central States. Looking down on feverishly built levies, and on farms turned to lakes, I could not help but wonder if overseeding could have helped to lessen or prevent the flooding.

The important issue facing us is whether we have enough information on hand to attempt to schedule opertional weather modification activities. I believe we are much closer to this state of knowledge than Neyman indicates. I am hopeful that, in the not too distant future, we shall be able to prepare a plan of action to be approved by the Congress and the people. I see no Utopia ahead. If the historical controversies in this field, when only the scientific community was involved, are any guide as to how people feel about weather modification, I wonder what will happen when everyone gets into the act and decides what kind of weather we wish to have.

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