Hail Suppression up in the Air

Nearing the end of a 5-year hail research program, investigators at Colorado's National Center for Atmospheric Research (NCAR) find they know an awful lot more about hailstorms than they did, but how to suppress hail still remains a mystery.

The National Hail Research Experiment (NHRE), funded at $2.5 million a year by the National Science Foundation (NSF), has therefore been undergoing a lengthy reexamination spurred by its director, David Atlas, who convened a conference of world-renowned atmospheric scientists last fall. In December, during the course of this reexamination, Atlas resigned because of "differences" with the management "on the optimum direction toward hail suppression research." Atlas was apparently among the first to conclude that the hypotheses on which suppression experiments were based didn't hold water. Now it seems just about everyone agrees that resumption of the cloud-seeding experiments that were conducted over three summers would be fruitless until existing data are further analyzed and more basic research is done on the nature of hailstorms.

Summer hailstorms are quite a problem in western states, causing an estimated $600 million in crop damage and another $150 million in property damage a year. The idea for the hail research program evolved in the early 1960's when the Russians reported spectacular successes in hail suppression using rockets and heavy artillery to bombard storm clouds with lead iodide crystals. Thinking the Russians were onto something (it is now not at all clear that they were) the Interdepartmental Committee on Atmospheric Sciences, composed of 12 federal agencies, asked the NSF to plan a national experiment to find out how hailstorms work and determine the efficacy of cloud seeding.

The NCAR in 1972 set about to conduct the first statistically controlled randomized seeding experiments, using silver iodide. Between 1972 and 1974 the NCAR monitored about 30 storms a year (seeding half of them and leaving the rest as the control population) in "hail alley," a 625-square-mile area in the lee of the Rockies along the Colorado-Nebraska border.

Hail Theory Cast in Doubt

No statistically significant reduction of hail was produced, and the results have contributed to the belief that hypotheses about hail formation, borrowed from the Russians, were wrong. The central concept was that hail is formed in a zone in the middle of a storm cloud where there is a heavy accumulation of supercooled liquid droplets. When particles are introduced, either naturally or artificially, they supply nuclei for the water to crystallize around. The purpose of seeding is to augment the number of particles so the hail will come down in many little pieces—hopefully to melt before landing—rather than in big chunks. The NHRE researchers have found, though, that the supposed liquid accumulation zones do not necessarily exist, and they believe that hail formation is not a one-step but a two-step process occurring in different parts of a cloud, all of which makes the results of seeding unpredictable. The research has also confirmed that in the Rockies there are at least two types of hailstorms—supercell and multicell (referring to single or multiple shafts of upwardly moving air)—which may respond very differently to seeding.

So, hypotheses that 5 years ago seemed "crystal clear," says NCAR executive director John Firor, have now "evaporated." There now even exists the possibility, not particularly encouraging for commercial cloud seeders, that seeding has actually increased the hail from some storms. Although there are differences of opinion on the interpretation of data, Atlas believes there is a case to be made that seeding increases hail in the case of supercell storms because the silver iodide supplies nuclei for the crystallization of water that otherwise might have blown harmlessly out of the top of the cloud.

Instilled with fresh awe for the complexities of atmospheric phenomena, the NHRE people, now under the direction of Donald L. Veal from the University of Wyoming, plan to stay away from random seeding for a while and concentrate on finding just what does go on inside those storms. This they do with the aid of ground-based radar, an armored plane for penetration into the heart of storm clouds, and sailplanes. Meanwhile the floor is wide open for new hypotheses.—C.H.

expanded energy sources as quickly as possible. Only fanciful relations—speculations about the possibility of "muon fusion" and "quark reactors"—have ever been suggested between high energy physics and practical power, although some of its peripheral technology can be helpful in energy research. A year ago many scientists worried about the health of high energy physics under ERDA (*Science*, 6 June 1975), but the fears have proved unfounded.

In fact the purity of high energy physics seems to have brought it special status. According to James Kane, director of physical research at ERDA, "We are essentially the custodians for high energy physics. We don't justify it in the same terms" as other types of basic research. The result is that in fiscal 1977, the science of the largest accelerators and the smallest particles will receive an 11 percent budget increase from ERDA, to $163 million. The National Science Foundation support will be $20 million. High energy physics did considerably better than the rest of the physical research activities at ERDA which were not put in any special category, and were only boosted by 8 percent.

The increment for basic research at ERDA was less than at other agencies, and it pales beside the 40 percent rise in the overall ERDA budget. But what has aggravated nuclear scientists most is that they did not even get a share of the modest increase. In the operating budget alone, the nuclear science funding fell from $79 to $77 million. Combining categories, support for molecular, materials, and geoscience research rose from $103 to $133 million in fiscal 1977, while nuclear sciences fell from $107 to $93 million (figures are budget authorizations, including capital equipment). Spokesmen from many areas of physics have been quick to condemn this shift in basic research as "severe," a "crisis," and a decision with dire consequences in the future.

"I think it is a disaster," says Victor Weisskopf of MIT, whose career includes ample contributions to both nuclear and high energy physics. "If they wanted to cut all basic science, that would at least be consistent," he says, "but they haven't. Of course, I would disapprove such a cut." The same sentiment is reflected by John Schiffer, nuclear physicist at Argonne National Laboratory and of the head of the nuclear division of the American Physical Society (APS). "I very much hope the things reflected in the 1977 budget can be reversed," he says, noting that overall funding for nuclear physics has been going down steadily since 1969. By now, according to Schiffer, the United States is spending less on nuclear sciences than West Germany, and if the expenditure is measured