

A STATE PERSPECTIVE ON THE DEVELOPMENT OF  
WEATHER MODIFICATION: THE CASE OF ILLINOIS

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**Abstract.** The Illinois Precipitation Enhancement Project/Precipitation Augmentation For Crops Experiment (PEP/PACE) illustrates some of the more important issues requiring consensus-building in weather modification. PEP/PACE shows how project leaders can build support among key interests within a state. In terms of debate and differing perspectives, it points up disagreements between proponents of basic and applied science, and between federal and state perspectives in developing a new technology. There are lessons for how administrators of large-scale R&D projects must seek to balance scientific and political values generally, if those projects are to run the gauntlet of pressures they face over years. This essay is written from the state perspective, since the moving force for PEP/PACE over the years was a state science organization. The problems faced by those seeking to forward weather modification in Illinois illuminate issues in developing and applying the technology generally at the state level. To the extent there were mistakes made, proponents of weather modification can learn lessons. But there are lessons also from the achievements, particularly in keeping a program going many years under sometimes adverse circumstances.

1. BACKGROUND AND SETTING

The most important fact about PEP/PACE has been that it has had a consistent advocate. The moving force for weather modification in Illinois for the past two decades has been the Illinois State Water Survey (SWS). Established in 1896, SWS is a long-term research organization that is part of state government, under the Department of Energy and Natural Resources. It is also closely affiliated by law with the University of Illinois (through facilities, funding, and joint appointments) and is located on the university campus in Champaign-Urbana. This helps provide a unique arrangement (from the standpoint of state government) for stable conduct of research.

One of its missions is to assist the state agricultural industry through research on various water-related issues. SWS receives a base level of funding from the state and whatever additional funds it can acquire from federal and industrial sources. In 1987, its budget was \$6.3 million (\$3.0 million state, \$3.3 million federal). It had a staff of 250, of which 148 were scientists and engineers from a variety of disciplines, including atmospheric sciences.

The existence of SWS points up the degree to which organized science and technology have been linked with this most important industry to Illinois. The industry is big -- it is agribusiness -- and technically advanced. It looks to science and technology as a helper, not a threat. It also has long looked to the University of Illinois and the three scientific surveys as major sources of information on science and technology.

The involvement of SWS in weather modification goes back to 1947, 1 year after the first cloud-seeding experiments by Schaefer and Langmuir, in New York. At the urging of local agricultural

interests, SWS began looking into the new technology and became sufficiently interested to hire its first group of atmospheric scientists. However, the interest could not be sustained by the results obtained or resources available. During the 1950's, for the most part, weather modification was on the backburner of the SWS research agenda.

2. ORIGINS OF PEP: THE VANDALIA EXPERIENCE

If one were to point to any specific event or set of events that triggered renewed interest in weather modification in SWS it was the Vandalia experience of 1964. In that year, a commercial seeding organization was proposing to become active in Vandalia, a small rural area in Fayette County in southern Illinois. The county agent serving Vandalia came to SWS and asked for advice. SWS did not believe the particular methods to be used would work, and so advised the agent.

The agricultural interests of Vandalia decided to believe the commercial seeder, not SWS, and went ahead with a program of localized summer seeding. Money was raised and a 1-month program run. Heavy rains did fall. While SWS did not believe the commercial seeder had anything to do with the rains, the commercial seeder probably took credit.

SWS atmospheric scientists decided then and there, that if weather modification was going to take place in Illinois, SWS had not only to be part of the process (as sources of disinterested scientific advice), but also participate in advancing the technology through scientific research. Limited research attention to innovative means of purposeful cloud changes had occurred (Semonin et al., 1962), and further assessments of how to evaluate rain changes resulted (Huff, 1966).

It is important to note, even at this early point, the mix of scientific and institutional interest driving weather modification. Also it should be noted that there was conflict between scientists in SWS and commercial seeders, and that this conflict was played out before a constituency absolutely critical to SWS.

### 3. PLANNING FOR A PROJECT: INTRA-AGENCY CONFLICT

There were not many weather scientists within SWS, but they were able, professionally active, and vigorous. They included Richard Semonin and Floyd Huff, and were led by Stanley Changnon, then 36, a meteorologist and geographer, who was becoming increasingly interested in weather modification through his individual research and professional activities outside Illinois (Semonin and Huff, 1967). He saw weather modification as a technology emerging nationally. This was a time when NSF was originating the National Hail Research Experiment (NHRE), for example. A man with institutional instincts as well as scientific curiosities, Changnon and his co-horts saw weather modification as an opportunity for SWS to move forward.

SWS scientists began becoming more active in the national weather modification movement including hail suppression (Changnon, 1969). They began talking about a project with the Bureau of Reclamation (BuRec). BuRec had a large research program in several states including mountain cloud seeding under way in Colorado and one in cumulus clouds to make rain in South Dakota. It was interested in testing and diffusing the technology it was developing in the West to the Midwest. Its primary interest was precipitation enhancement.

Changnon became head of the atmospheric sciences group at SWS in 1968 and obtained agreement with the director of SWS, William C. Ackermann, that the SWS would move strongly into weather modification. Changnon was now more than a researcher: he was becoming an institutional advocate for weather modification, and had discovered that advocacy would mean conflict. The chief of SWS was supportive -- especially if the atmospheric scientists could bring additional funds from the federal government into his agency.

### 4. ADOPTION OF PEP

It took two years for SWS to work out details of a project with BuRec, which had its own ongoing commitments. In this period (1969-70), the SWS received a contract with BuRec to study rainfall-crop yield relations in Illinois and the method developed pointed to the great value of added rain in July and August to Illinois' two primary crops, corn and soybeans (Changnon and Huff, 1971). There were no particular disagreements between SWS and BuRec at this point. There were just the usual delays in getting two organizations -- one federal, one state -- to synchronize their bureaucratic gears. In 1970, BuRec told SWS it would fund the proposed Precipitation Enhancement Project. A major proposal was written, submitted, and a contract awarded in early 1971. SWS leaders were told by BuRec in 1969-70 that its interest in SWS was due to the high quality of SWS scientific staff and because it wanted to expand east from their traditional efforts in the 17 western states. Changnon and Lambright (1987) have noted that this was a

period of agency expansion and "territorial/subject matter" expansion to be the top agency.

The project that was accepted was to last approximately 10 years and cost \$15 million. BuRec's initial commitment was \$300,000 for the first year. BuRec indicated it would fund the effort 1 year at a time, but that there was good reason to believe the funds would be available. While BuRec's major emphasis in the west was snow-pack enhancement, through winter seeding, and SWS's orientation was summer rain seeding, the goal of both organizations was precipitation enhancement. With the first year funds, SWS was able to hire additional research staff, as well as obtain needed equipment. The team now numbered twelve.

BuRec and SWS agreed that PEP would have four phases (Changnon, 1973a):

Phase I: Phase I included a preliminary investigation and establishment of good hypotheses. Here, SWS wanted to look at the atmosphere and its impacts. Basic studies would be undertaken to determine appropriate milestones in the project, so that success or failure would be clear. Seeding would not necessarily take place. Phase I would consist of a series of studies and activities aimed at finding out the likelihood of success of enhancing summer rain in Illinois and surrounding states. The inner characteristics of many summer clouds produced by varying weather conditions (cold fronts, warm fronts, stationary fronts, etc.) would be measured to discern the frequency of potentially modifiable clouds (Changnon 1972).

Phase II: If Phase I showed there were enough suitable clouds that could be feasibly seeded, then Phase II could be launched at a suitable site in Illinois. This would be a multiyear field project involving actual cloud seeding experiments, using airplanes, based on knowledge gained in Phase I.

Phase III: Phase III would provide time to analyze the data and interpret it. This was thus an evaluating phase.

Phase IV: In Phase IV, there would be a final analysis and the knowledge and results acquired above would be transferred to all interested users.

As noted, the original time frame for the total project was ten years, with the most time given to the field experiments. These experiments would be scientifically designed, and randomized. The experiment's goal was to establish the efficacy of weather modification in Illinois and further refine the technology (Changnon, 1973a).

At the time SWS and BuRec reached agreement in 1970-71, there seemed to be commonality of interest. With BuRec paying for the actual project and the state funding salaries of several SWS staff, it appeared to be a model federal-state scientific project. BuRec thereby would extend its domain beyond the western states into the Midwest, while SWS would establish itself as the principal weather modification group in the Midwest, and a major force in the field nationally. Everybody would gain, or so it seemed.

## 5. IMPLEMENTING PEP: THE ILLINOIS FRONT

SWS had observed other weather modification projects. It was cognizant that many had run into trouble because their scientific leaders had not understood the importance of building a base of support among the people who would be affected by the project. As Myron Tribus, former Assistant Secretary of Commerce for Science and Technology wrote in 1970: "A scientist can bombard a nucleus with neutrons without asking permission of the nucleus. He cannot engineer the environment without consulting the people who will be affected" (Tribus, 1970).

SWS was acutely conscious of the need to take time to prepare the public for the field experiment. That was one reason for Phase I. Not only did SWS have to better understand the clouds it wished to seed but also it needed to make sure the affected publics and their elected representatives would be receptive to altering the physical environment (Changnon and Huff, 1979).

Hence, the early implementation (or Phase I period) took place on two fronts: the federal scientific front, which involved SWS-BuRec interactions; and the state-public, which entailed SWS-Illinois relations. SWS knew it had to have both fronts working in tandem to have a successful project (Changnon, 1979).

The leader of PEP spent time on both focal points; one day talking with scientists, another day dealing with political interests. PEP was not the only weather modification project SWS had in the mid-1970's (it became involved in NHRE, for example). But it was the centerpiece of SWS efforts. Unlike so many other weather modification efforts, which were examples of top-down or federal science imposed on a particular site, PEP was to be an example of grass-roots science, in which the project derived from scientific and public interests in the state and the site would be fully supportive in every way.

Also, what SWS had going for it was a "state culture" in which the dominant economic interest (agribusiness) was pro-technology. This cultural attitude translated generally into political receptiveness from the legislature for SWS. As a man who had grown up in Illinois, Changnon as PEP leader had been educated at the University of Illinois, and worked for SWS his entire professional career, he was sensitive to how to present technology in an Illinois setting. He dealt comfortably with farmer groups, and his research had often focused on weather and agricultural issues like crop insurance and irrigation. As a scientist and quasi-state bureaucrat, he was willing to labor hard and "work the system" in behalf of weather modification.

To build a state support system for weather modification and to head-off possible "people problems," SWS therefore engaged in the following strategies in the period 1971-73:

1. Changnon, Ackermann, and other colleagues spent a great deal of time going to agricultural meetings around the state, speaking to farmers about weather modification and what SWS wished to do (Ackermann et al., 1974).

2. In addition to attending meetings and giving talks, SWS prepared literature that would inform non-scientist readers about weather modification, in general, and PEP, in particular (Illinois State Water Survey, 1971).

3. SWS did a de facto "market survey," hiring a sociological group from Colorado to study attitudes in the relevant potential sites for the experiment. The results indicated a willingness to give weather modification a try. This was a homogeneous agricultural economy. The common interest of the farmers was more water. Man had already altered the land environment substantially to produce more crops. Why not extend man's capability to the atmosphere? There was a sense in Illinois agribusiness that man, nature, and technology could work in harmony (Krane and Haas, 1976).

4. As part of the scientific work, SWS did impact and risk-benefit studies, and conveyed its conclusions, to the extent they were available, to farmer-audiences. For example, the silver iodide seeding materials would not cause harm to health; the enhanced rainfall would not alter the ecology of animals and other species, there would not be so much rain as to cause floods; cloud seeding would not rob Peter to pay Paul. These and other concerns were put at rest, as best SWS could (Changnon, 1973a).

5. In addition to dealing with farmers as individuals, SWS dealt with key leaders of the agricultural community. These were identified as the county agricultural commissioners. Each county had five elected officials. These individuals presided over county agricultural programs. SWS scientists went to meetings of these commissioners and explained what PEP was all about, and how it could ultimately benefit Illinois (Achermann et al., 1974).

6. SWS decided it needed a general policy framework in Illinois within which PEP could be carried out. When PEP was conceived, it was seen as a long-term venture that had to be protected in various ways from "contamination" by indiscriminate seeding activity. SWS therefore hired an expert lawyer to draft a weather modification law for Illinois, making use of the best thinking and "model laws" in states available at the time. It allied itself with the powerful Illinois Farm Bureau. As a consequence, in 1973, a regulatory regime was enacted in Illinois for weather modification (Ackermann et al., 1974).

Thus, in a variety of ways, SWS eased the way for weather modification on the home front. The result was that those who were most directly affected by PEP gave support, rather than opposition, to the project. There was legitimacy, a sense of public consent. PEP was to be an example of grass-roots technology.

But the time SWS took in building a state political base for weather modification contributed to problems on its other front -- that of the federal government.

## 6. IMPLEMENTING PEP: THE FEDERAL FRONT

BuRec was growing unhappy. Phase I was not moving into cloud seeding trials fast enough. While it could certainly understand the need for

political constituency-building in Illinois, it was increasingly restive. It was uncomfortable with the overt rationale for Phase I, namely the need for additional scientific planning, measurements, and feasibility testing of clouds in Illinois. This was seen as too basic a research orientation. BuRec could not see why SWS had to reinvent so much of the wheel -- with BuRec's money. After all, argued BuRec, the federal government had sponsored all this convective cloud research in South Dakota and elsewhere. Would not the methods and findings there be transferable to Illinois, without all this additional extremely fundamental site-specific work?

In 1972, BuRec and SWS staffs crossed-swords over PEP at a project review at the BuRec headquarters in Denver. BuRec project monitors indicated to SWS what they expected SWS to do. SWS had its own views, and tempers flared. A while later, Changnon sat down with Archie Kahan, head of the BuRec weather modification program (who had not been present at the confrontational meeting). While loyal to his subordinates, Kahan indicated he understood the SWS position. Both felt there had been an accommodation.

#### 7. PEP TERMINATED

In 1973, SWS was informed that BuRec would not provide any more money for PEP. The state of Illinois could fund the project if it wished, but BuRec was pulling out. The reason given for the decision was that BuRec was having budget troubles and it had to retreat to its "core program." This was in South Dakota and the West. The Midwest (especially Illinois) would be nice to have as part of its program, but it was not essential.

While budget problems clearly were key, the reasons for the termination were complex. There was indeed a federal budget reduction in 1972 in weather modification, and this forced BuRec re-programming (Changnon, 1973b). But SWS might have fought more strongly to keep its place in the program, as other states did. The Chief of SWS was unwilling to seek support from Illinois congressmen for funds for PEP (add-ons to BuRec), either before the budget cut or when it occurred. SWS Chief Ackerman did not want to get the SWS involved in the "federal political process." So SWS lost out when BuRec "made adjustments" in the wake of the budget crunch of 1972.

Also, in retrospect, it appears that different views (SWS vs. BuRec) about how fast to move into actual cloud seeding trials hurt the SWS cause. These pointed up a basic difference between BuRec and SWS. BuRec was applications-oriented and believed that weather modification was a technology already in a developmental (perhaps even transferable) mode. SWS, although applied in tone generally, was relatively basic science-oriented when it came to weather modification. It held that there had to be more site-specific fundamental research on cloud physics and dynamics before sending airplanes up to seed. Thus, for various reasons, the BuRec-SWS marriage came to an end.

PEP ran 3 years. BuRec spent approximately \$700,000. Illinois, through SWS salaries, contributed approximately another \$400,000. But when the million dollar plus project ended in early 1974, it had never gone beyond Phase I (Changnon, 1979).

#### 8. DOLDRUMS: KEEPING CAPABILITY ALIVE

For SWS, going to the state government to sustain PEP was not seen as a viable option. First, Illinois had been sold on PEP as a cooperative federal-state effort in which the federal government would bear most of the costs. Second, SWS wanted PEP to be a federal project in part because it wanted the project recognized as having wide-spread significance. SWS saw PEP as a national research project, based in Illinois and representative of the Midwest (Changnon, 1973a). It was a source of pride of place in weather modification. In addition, there was no guarantee the state would not take an even more applied emphasis than BuRec. Hence, SWS decided to put PEP on hold, and seek alternative federal funds.

SWS did make the decision to stay in the field. While keeping alert to the potential of alternative funding for PEP, SWS now had to maintain the capability painfully constructed to gear up for the BuRec project. Semonin and Changnon (1974) used results from studies of how St. Louis accidentally alters the weather to infer what it meant for applied weather modification. SWS personnel were used on small projects of various kinds. Project head Changnon himself sometimes had to go far afield from his "hard science" under-pinnings. For example, he became head of a major technology assessment of NHRE, a project that linked him (and several SWS staff members) with social scientists, lawyers, and ecologists. Such contacts undoubtedly broadened Changnon and his staff, making them more capable of supplying leadership and dealing with the public in terms of a large-scale weather modification project. All that was needed was a large-scale project to which to apply their skills.

The SWS weather modification group, meanwhile, stayed busy and employed through various efforts funded by NSF and other agencies. In 1975, SWS even became a part of the BuRec team again. BuRec was planning a new effort in the high plains of Montana, Texas, and Kansas (HIPLEX project). Would Illinois help BuRec design the project, as a credible "outside" group? SWS said yes (Ackerman et al., 1978). This effort provided several key staff with the experience of planning an entire large experiment in great detail.

But these and other activities, which maintained SWS capability, were holding actions at best. What SWS still wanted was to resurrect PEP at the first opportunity.

Toward that end, SWS continued to nurture the Illinois political support base (Changnon, 1975a). Changnon was in a good position to do so. From 1974 to 1986, he served as chairman of the Illinois State Weather Modification Board, which issued licenses for seeding activities under the 1973 law. This body was highly attentive to the quality of the operational projects in Illinois. Weather modification had a somewhat sullied reputation in other states. SWS wanted to protect its status in Illinois.

In 1976-77, a moderate drought afflicted the Midwest, including Illinois. Commercial seeders made their case and farmer-users listened. While providing funds for limited operational seeding, these users were not sure what they were buying. SWS took the occasion to convene a meeting of Deans of Schools of Agriculture in Illinois, Indiana,

Michigan, and Ohio. It obtained agreement from these leaders that the role of weather modification in enhancing rainfall was still uncertain, and there was the need to carry through on PEP, to determine the efficacy of weather modification in the Midwest. A plan for a long-term midwestern experiment was jointly developed by the SWS and these four state universities (Illinois State Water Survey et al., 1978).

In 1977, following up on the meeting with the Midwest Deans, Changnon began adapting the original PEP design to incorporate a larger and more diverse number of scientific participants. However, the basic four-phase plan was not altered. While keeping his staff busy with bits and pieces of weather modification activity, keeping active and visible himself in national weather modification affairs, and shoring up support in Illinois, he intensified his hunt for funds from agencies at the federal level (Changnon, 1975b, 1977; Changnon et al., 1978).

The U.S. weather modification community was small and relatively tightly-knit. The federal scientist-administrators who sought to maintain and enhance their programs needed performers of the credibility of SWS. Having potential political support in the Midwest, through SWS, was an added benefit. Hence, if Changnon was looking for a sponsor, there was -- sooner or later -- a sponsor who could use SWS.

In 1977, the National Oceanic and Atmospheric Agency (NOAA) and SWS began talking seriously. NOAA had a weather modification program whose primary project then was the Florida Area Cumulus Experiment (FACE). This was a major project involving precipitation enhancement. Its orientation was more one of scientific understanding than actual precipitation production, as was the case with the BuRec effort. For a variety of reasons, NOAA was at this point anxious to continue its work -- but not necessarily in Florida (Weather Modification Advisory Board, 1978).

#### 9. PEP REVIVED AS PACE

SWS wrote two proposals during late 1977 and early 1978 to NOAA. Meanwhile, SWS used in-house funds to launch some basic meteorological studies (Phase I work previously begun under PEP). Scientists at the four schools of agriculture (Illinois, Indiana, Michigan, and Ohio) also wrote proposals to be part of the new project that was concerned with impact studies. What was being proposed was called PACE, for Precipitation Augmentation for Crops Experiment. As a natural extension of PEP (SWS) and FACE (NOAA), PACE fit the needs of two organizations.

SWS was thinking in terms of a long-term (10 to 15 years) experiment costing from \$20 million to \$30 million. This would allow SWS to begin where it left off in PEP, taking advantage of new knowledge that had accumulated since 1973. Because of inflation and other reasons, the costs would inevitably be greater than in PEP. In 1977, FACE officially began through a combination of NOAA funds and reprogrammed SWS monies. As in the past, SWS had begun promoting PACE in the scientific community (Changnon and Ackerman, 1979), and had begun re-educating the constituency in Illinois about the "new" PEP (Changnon and Ivens, 1979). This was important since the use of operational

cloud seeding was moderately heavy in 1976-80 and the justification for a major scientific experiment had to be recognized by the promoters of these projects, as well as those who were skeptical.

However, the funds from NOAA for PACE were way below what had been anticipated. The reason was that between the time of initial planning by SWS and NOAA, and the actual decision by NOAA to fund, NOAA's priorities changed. The agency made a decision to have a FACE II project, to try to confirm what had been done previously in Florida, rather than to move immediately to a new site and project in Illinois. This was also counter to the strong national recommendations of an independent assessment of the entire field (Weather Modification Advisory Board, 1979).

When SWS found out about this change, it had to drastically curtail its own plans. The result was that PACE proceeded with minimal federal funding. Over the 1977-80 period, all that SWS received from NOAA was \$500,000.

This meant none of the impact studies from the four universities could be funded, and PACE would have to hold in Phase I until NOAA could finish FACE once and for all, and/or redirect its priorities. The carefully constructed coalition among SWS and Midwest universities gradually fell apart, amidst great frustration at SWS. Evaluation by SWS scientists of the eight cloud seeding projects in Illinois during 1976-80 revealed little evidence of success in making rain (Changnon and Hsu, 1981), and this helped cause disillusionment in the technology among the agricultural community.

#### 10. A TROUBLED IMPLEMENTATION

Given this shaky beginning, implementation was bound to be difficult. From the SWS perspective, NOAA never fully and properly informed SWS of its change in priorities.

NOAA did send promised weather aircraft, for a 2-day period in 1977, and another brief period (10 days) in 1978. But in 1978, the NOAA crew and SWS scientists became engaged in a dispute over which clouds to enter and when. In addition, SWS priorities in radar support were not what NOAA wanted and felt were needed. The question was raised as to who was in charge of what in this project. NOAA ultimately decided it needed the planes in other weather research projects than in Illinois.

SWS did try to continue on, with the modest funds it received from NOAA, as well as those available in-house. In 1981, the Reagan Administration came into power and looked for ways to trim the non-defense federal budget. Noting that FACE II "failed" to confirm FACE I, the administration drastically curtailed NOAA's weather modification project, forcing termination of even the "stretched-out" and previously reduced PACE effort (Changnon and Lambricht, 1987).

#### 11. A SECOND HIATUS

Now began a second period in which there was no focused weather modification project around which SWS could mobilize personnel and other resources. This was a difficult period. In 1980, Changnon had become Chief of SWS, and thus his responsibilities broadened well beyond weather research and modification. He was as personally

committed to the field as ever, but now he had to champion an institution as a whole, rather than a particular group and program. There was no one under Changnon with his same combination of scientific enthusiasm for weather modification and willingness to enter the political thicket. The Illinois Weather Modification Law was scheduled to be ended in 1981 under Illinois sunset law on all regulations, and sustaining the law for weather modification required extensive negotiations with state government staff.

Moreover, the internal and external constituencies were becoming more dispersed. A number of the SWS senior scientists who had been involved with weather modification were retiring or shifting their interests. The overall budget for weather modification at the federal level was down. Hence, it was not possible to maintain capability by moving elsewhere for funding within the field. Externally, there were problems not only with the diminished federal constituency, but also with a less interested state constituency.

During the early 1980s there was plenty of rainfall in Illinois. Indeed, Lake Michigan was overflowing its shores at times. Operational seeding was accordingly cut back. Economic times had also toughened for Illinois farmers and this coupled with the lack of evidence of rain enhancement in the operational projects of 1976-80 (Changnon and Hsu, 1981) led to cessation of further operational projects (none since 1980 in Illinois). With no federal projects after 1981, the relative absence of activity led to a diminution of attention and thus support. Weather modification research in Illinois was in trouble.

Yet Changnon remained convinced that there was a need to resolve whether weather modification in Illinois could be accomplished, if only he could get a substantial scientifically-based project restarted and, most importantly, maintained. He kept trying. The state was developing a water plan. Changnon, as Chief of SWS, was in a position to influence that plan and did so. The result was that, as issued in 1983, the plan included weather modification as a potential technology that had to be researched and possibly applied in the context of Illinois water policy (Changnon and Semonin, 1982).

## 12. A LAST STAND FOR PACE

In 1983, Merlin Williams, head of weather modification in NOAA, contacted Changnon. As the latter knew, Williams had been engaged in a last-ditch effort to save weather modification research in NOAA. He had designed a federal-state cooperative program in 1978, having made an end-run around his own agency and the Carter and then Reagan Administrations to do so. Under the program, states would provide some funds for weather modification activities of interest to them (e.g., research or operational seeding). NOAA would in turn provide additional money specifically for piggyback research.

NOAA and the administration (especially OMB) strongly opposed this program. But Congress required NOAA to participate, and pass-through monies went to NOAA and made available in a grants program. Williams had had North Dakota and Utah involved since 1978, then Nevada in 1981. He now wanted Illinois to become part of the program.

Changnon agreed to see what could be worked out. He spoke with some key Illinois agribusiness and political leaders (including the governor's staff). They told him to go ahead. Their view was that if the federal government would put up most of the money for weather modification, Illinois would do its share, and together they would try to influence NOAA and the administration to go along.

In 1984, Congress awarded to NOAA \$380,000 to pursue weather modification research in Illinois. The SWS contributed about \$150,000 in staff salaries. PACE was alive again.

## 13. IMPLEMENTATION UNDER DURESS

PACE was reborn, but for how long? It could not look beyond 1 year of funding at a time. Also, it became clear to SWS that NOAA would not be an easy partner with which to work. Williams was gone, and weather modification appeared to have no strong support inside the agency from senior managers. The man who replaced Williams, William Woodley, was bequeathed a program that was embattled, to say the least.

Funding did come to SWS from NOAA and the state. Over the 4-year fiscal period, 1984-88, through congressional interest, NOAA provided a total of about \$2 million in response to four proposals from SWS. An additional \$0.6 million came from Illinois.

But, from the SWS perspective, implementation has been tortuous. In its view, NOAA has often not cooperated.

NOAA undoubtedly felt it was doing the best it could in a horrendous budgetary environment. It naturally wanted to control its budget and priorities.

In 1986, the Inspector General's Office of the Department of Commerce investigated PACE, the three other state research programs, and NOAA management of the federal/state program. It was critical of NOAA management and recommended that the federal/state program in NOAA be shifted to BuRec (Office of Inspector General, 1987). In response to this report, NOAA management indicated they were against loss of the program (Mack, 1987). Ultimately, the federal/state program was left with NOAA.

The adverse setting inevitably hurts the conduct of science, leading to pressures on researchers to show quicker payoffs. Thus, federal NOAA was perceived as unsympathetic. But a new factor was operating in Illinois. Commercial cloud seeders had been telling user-farmers that the technology was "readier" than the SWS scientists stated. These seeders wanted commercial contracts, but they were undermining SWS credibility with its farmer constituency and Illinois legislature. The state government, continuing to put substantial sums into weather modification research, and hearing from commercial seeders, wanted returns on its investment. Under the circumstances, Changnon decided SWS had no choice but to move into Phase II if the Phase I results were promising. He had to take some heat from his scientists for what they regarded as bowing to "political" pressure. The issue was one of balancing scientific and political values, in order to keep a project going.

Meanwhile, the long struggle for weather modification in Illinois had taken its toll. While SWS still had able scientists on its staff, it had lost many of the early experienced people to other areas of research. The instabilities and uncertainties proved too much for them. Changnon himself retired in 1986 as Chief of SWS, and now works part-time as a senior scientist in his former agency. Much of his time for PACE is devoted to managing, defending, and securing resources for weather modification. Even he sometimes despairs of maintaining PACE as a viable scientific project in a hostile federal-funding environment.

The new head of SWS has many priorities to address other than weather modification. Given the dilution of staff talent at SWS noted earlier, and all the other changes taking place, there are harbingers for the future of weather modification in Illinois that are not good after 16 years of struggle.

An observer of the Illinois scene cannot help but wonder whether PACE will ever be completed. There are many factors working against implementation, and few that are favorable. How many lives can a project have, before its time runs out?

#### 14. CONCLUSION

The major purpose for reviewing the above history of weather modification in Illinois is to illuminate the kind of debates that impact on "big science" projects in a state public environment, and to indicate the mechanisms that are used directly or indirectly to resolve such conflicts. The purpose is not to study disagreement for its own sake, but to try to understand its place in the advance of a new technology, such as weather modification.

Debate can sometimes be healthy in terms of ventilating issues that otherwise fester. But it can also cause problems. The development of weather modification has been hindered by the absence of a stable federal policy and sufficient funding.

The principal project that aimed at focusing scientific R&D in behalf of weather modification was that which was known as PEP in its first incarnation, and PACE in its latter. (Since it was truly the same project throughout, we will refer to it here as PEP/PACE, unless a point specific to PEP or PACE is intended.)

PEP/PACE was established as a 4-phase project. Begun in 1971, it took 15 years to reach Phase II. There was disagreement among scientists over whether it was "ready" to move to Phase II when it finally did make that transition. The original design called for PEP/PACE to be completed in approximately a decade. It is thus many years behind schedule, and may never be completed.

The debates -- scientific and intergovernmental -- are at the root of the slippage. They have caused innumerable project delays. Twice, the project has had to be put on hold. While there have been many scientific papers produced by individuals under project auspices, the project per se has not yet achieved its goals. Survival has been so much at issue that it has had only limited success in achieving its objectives.

That PEP/PACE has survived in spite of all its trouble is itself significant and in some ways remarkable. That it has succeeded in making scientific progress in understanding clouds and how they function, as well as impacts of weather changes on agriculture and water is even more noteworthy. In understanding why PEP/PACE has survived and achieved what it did, the key factor has been SWS. It has been an island of stability in a sea of change. Its greatest political success -- and this has contributed to PEP/PACE's survival and technical advance -- has been in avoiding disabling debate in Illinois and instead creating a substantial base of support for weather modification within that state.

There are many reasons PEP/PACE has created relative consensus in Illinois. First, and foremost, SWS, early on, sold weather modification as an aid to agriculture. Even though SWS aimed at scientific research, it advocated weather modification as another tool the agricultural community could turn to practical advantage. As a state agency, with university linkages, SWS had credibility with many quarters in Illinois when it spoke up for weather modification.

Significantly, SWS did not advocate weather modification as a tool available for immediate use, as did the commercial seeders. Rather, it spoke of developing a new technology for possible use.

When field work was undertaken, it was carried out in an area where attitude surveys indicated support for what was being done. There was consent from the affected publics and their elected representatives, so much so that SWS was able to spearhead a new law protecting the well-designed programs from indiscriminate seeding. Even though this law was later adapted, it remained a symbol of a state that took the development and regulation of weather modification seriously and an organization within the state that could get things done scientifically and politically.

SWS actively and continually worked to minimize conflict within its Illinois domain. It managed controversy with a skill that illustrates what a state-based scientific organization can do in behalf of a new technology. By building a consensus within Illinois, SWS made it possible for PEP/PACE to survive and make substantial contributions despite many adversities. But to do more technically, SWS has needed more politically than Illinois. It has needed the federal government, for PEP/PACE was and is a national project with wide regional applications and requiring large and steady expenditures over a long time. To be a national project, it required a larger constituency -- and consensus.

SWS thus illustrates the limits as well as strengths of state-based advocacy of weather modification. SWS proved unable to manage the larger debates that bedeviled weather modification at the federal level.

The division of labor among federal agencies is such that there have been only two agencies that have supported applied science in precipitation enhancement (BuRec and NOAA). If SWS could have gotten sustained support from either of these sponsors, it might have achieved its goals. It

did not get that support. Part of the reason has lain with budget cuts which forced BuRec and NOAA to make choices. But the scientific disagreements SWS had with those agencies did not help its cause.

Ironically, it is noteworthy that NOAA actively sought to resurrect PACE only when FACE had died and the strength of SWS -- its state constituency support -- became essential to retaining any NOAA program at all. What made for relative independence -- a technically strong organization backed by affected publics and their elected representatives at the state level -- then became an asset rather than problem for the federal sponsor.

Then, NOAA priorities changed, and problems came again to the fore in the federal-state relationship.

PEP/PACE thus points up what a technically strong and politically astute state agency can do to keep a major weather modification effort going in the face of uncertainty. SWS molded consensus within its state domain. The PEP/PACE experience also reveals the limits of state administrative power, where state science requires federal resources and those resources are not available due to differing perspectives between state and federal governments. The consensus PEP/PACE needed to achieve its goals was never consummated.

Any future "national" weather modification policy will have to learn from the above experience. Proponents of weather modification must work harder to establish mechanisms by which to facilitate scientific, political, and intergovernmental cooperation in this field. In this way, they can complete the coalitions of support needed to advance the technology and put it to useful work.

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#### REFERENCES AND RELEVANT DOCUMENTS

- Ackerman, B., Achtemeier, G., Changnon, S., Hildebrand, P., Schickedanz, P., and R. Semonin, 1978: Illinois Precipitation Enhancement Program (Phase I) and Design and Evaluation Techniques for High Plains Cooperative Program. Contract Report 210. Illinois SWS, Urbana, 316 pp.
- Ackermann, W.C., S.A. Changnon, and R.J. Davis, 1974: "The New Weather Modification Law for Illinois." Bull. Amer. Meteor. Soc., 55: 732-737.
- Changnon, S.A., 1969: "Hail Measurement for Evaluating Suppression Projects," J. Appl. Meteor., 8: 596-603.
- Changnon, S.A., 1972: "Feasibility Studies of Precipitation Enhancement in Illinois," Proceedings of Southern Plains Region Cloud Conference. U. of OK, Norman, pp. 101-109.
- Changnon, S.A., 1973a: "Precipitation Enhancement Program for Illinois," J. Irrigation and Drainage, Amer. Soc. Civil Eng., pp. 215-226.
- Changnon, S.A., 1973b: "Weather Modification in 1972: Up or Down?" Bull. Amer. Meteor. Soc., 54: 642-646.
- Changnon, S.A., 1975a: "Changing the Weather: Implications for Illinois," IL Issues, 1: 195-7.
- Changnon, S.A., 1975b: "The Paradox of Planned Weather Modification," Bull. Amer. Meteor. Soc., 56: 27.
- Changnon, S.A., 1979: "History of Planned Weather Modification Activities and Research at the Illinois State Water Survey," J. Weather Mod., 11: 156-165.
- Changnon, S.A., 1986: "Program Management and Funding Issues," Precipitation Augmentation for Crops Experiment: Pre-Experimental Phase Studies. Contract Report 404, Illinois SWS, pp. 1-10 to 1-11.
- Changnon, S.A. and B. Ackerman, 1979: "A New Weather Modification Experiment Designed for Midwestern Agriculture," Proc. 14th Conf. on Agricultural and Forest Meteorology, Amer. Meteor. Soc., Boston, pp. 44-46.
- Changnon, S.A. and C.F. Hsu, 1981: Evaluation of Illinois Weather Modification Projects of 1976-1980: A Summary. Circ. 148, Illinois SWS, Urbana, 31 pp.
- Changnon, S.A. and F.A. Huff, 1971: Evaluation of Potential Benefits of Weather Modification on Agriculture. Final Report, BuRec Contract No. 14-06-D-6843. Illinois SWS, Champaign, 77 pp.
- Changnon, S.A. and F.A. Huff, 1979: Review of the Societal, Environmental, and Legal Aspects of Weather Modification in Illinois. Contract Report 203, Illinois SWS, Champaign, 79 pp.
- Changnon, S.A. and J.L. Ivens, 1979: PACE - Precipitation Augmentation for Crops Experiment. Information Brochure, Illinois SWS, 4 pp.
- Changnon, S.A. and W.H. Lambright, 1987: "The Rise and Fall of Federal Weather Modification Policy," J. Weather Mod., 19: 1-12.
- Changnon, S.A. and R.G. Semonin, 1982: "Atmospheric Issues Identified in State Water Resource Planning," Bull. Amer. Meteor. Soc., 63: 399-06.
- Changnon, S.A., B. Farhar, and E. Swanson, 1978: "Hail Suppression and Society," Science, 200: 387-394.
- Huff, F.A., 1966: "The Effects of Natural Variability in Verification of Rain Modification Experiments," Water Resources Research, 2: 791-801.
- Huff, F.A. and S.A. Changnon, 1967: "The Effect of Natural Rainfall Variability in Verification of Rain Modification Experiments," Proceedings of 5th Symposium on Mathematical Statistics and Probability, 5: 177-197.
- Illinois State Water Survey, 1971: Precipitation Enhancement in Illinois. Champaign, 8 pp.



Illinois State Water Survey, University of Illinois, Michigan State University, Ohio Agricultural Research and Development Center, and Purdue University, 1978: Overview and Plan of Precipitation Augmentation for Crops Experiment. Urbana, 26 pp.

Krane, S. and E. Haas, 1976: "The Public View Toward Weather Modification in Illinois: A Social Assessment." In Design of Experiment to Suppress Hail in Illinois, Bull. 61, Illinois SWS, Champaign, pp. 146-172.

Mack, J., 1987: NOAA Response to IG Draft Audit Report. Memorandum, NOAA, Washington, DC, 4 pp.

Office of Inspector General, 1987: Centralizing the Cooperative Programs in Weather Modification Could Improve Program Management. Draft Audit Report No. D-118-7X, Dept. of Commerce, Washington, DC, 11 pp.

Semonin, R.G. and S.A. Changnon, 1974: "METROMEX: Lessons for Precipitation Enhancement in the Midwest," Proceedings, 4th Conf. on Weather Modification. Amer. Meteor. Soc., Boston, pp. 353-357.

Semonin, R.G., J. Bulloch, D. Staggs, W. Bradley, B. Vonnegut, and C. Moore, 1962: "Effect of Atmospheric Space Charge on Initial Electrification of Cumulus Clouds," J. Geophys. Res., 67: 3909-3922.

Tribus, "Physical View of Cloud Seeding," Science, April 10, 1970.

Weather Modification Advisory Board, 1978: The Management of Weather Resources: Proposals for a National Policy and Program. Dept. of Commerce, Washington, DC, 229 pp.