Current Status and Future Direction of the Oklahoma Weather Modification Program

Nathan R. Kuhnert, Brian R. Vance and Michael E. Mathis
Oklahoma Water Resources Board
Oklahoma City, Oklahoma

Abstract. The primary focus of the Oklahoma Weather Modification Program is to suppress hail and augment rainfall. Initiated in the fall of 1996, the demonstration program is patterned after similar successful efforts underway in Kansas, North Dakota, Texas and Alberta, Canada. In 1997 and 1998, the statewide program incorporated an independent evaluation to measure results, although no randomized cloud seeding operations were conducted. Results of the evaluation are promising. Prompted, in part, by the need for additional resources to implement the program at the desired capacity, the State Legislature passed legislation in 1999 to create a cooperative, long-term funding mechanism between the state and Oklahoma's insurance industry. Potential interstate cooperation with weather modification efforts in Texas and Kansas bode well for the continuation and future growth of the program.

1. INTRODUCTION

Passage of Senate Bill No. 101 (Oklahoma Weather Modification Act, Section 1801.2 of Title 82) by the Oklahoma State Legislature in May 1999, may be interpreted as the turning point of the Oklahoma Weather Modification Program (OWMP). Initiated on August 20, 1996 and administered by the Oklahoma Water Resources Board (OWRB), the program has evolved into an operational effort fueled by a cooperative state/private insurance funding mechanism. Since inception, the program has utilized two C-band (5 cm wavelength) project radars strategically placed at municipal airports in Oklahoma City and Woodward with three Cessna 340 project aircraft (Vance and Mathis, 1997). In addition, the recent employment of the Thunderstorm Identification, Tracking, Analysis and Nowcasting (TITAN) software package allows more accurate examination for hail suppression efforts. The contractor dispenses the seeding agent, Silver-iodide (AgI), by three sources: droppable flares, end-burning flares, or wing mounted AgI acetone generators (burners).

Weather Modification, Inc. (WMI), of Fargo, North Dakota, has been contracted to conduct both hail suppression and rainfall augmentation operations during four separate periods of operation, generally conducted from March through October each year with a winter recess period. The continued partnership with a single contractor facilitates continuity from one operational period to the next. In addition, an independent evaluation of the OWMP has been performed by the Environmental Verification and Analysis Center (EVAC) of the Oklahoma Climatological Survey (OCS) on the effectiveness of seeding operations (Greene, *et al.*, 1997, 1998).

Several periods of mild to severe drought in Oklahoma, which have prevailed throughout much of the 1990s, have renewed interest in weather modification, primarily due to the enormous financial impacts that drought typically inflicts on the Oklahoma economy (Vance and Mathis, 1997). During the past year, however, there has been growing interest in the prospects of hail suppression and related potential savings to the state's crops and property. Oklahoma crop losses due to hail average approximately $2.5 million per year in loss claims alone -- not including property/casualty claims (Fisher, pers. comm.) In Alberta, Canada, where hail suppression operations have been conducted for several years and funded through the province's insurance industry, annual hail damages range from $16 to $340 million.

To direct the current activities of the OWMP, SB 101 created the Oklahoma Weather Modification Advisory Board (OWMAB). The OWMAB consists of (or the designees of) the Executive Director of the Oklahoma Water Resources Board, the Commissioner of Agriculture, the Executive Director of the Oklahoma Department of Tourism and Recreation, the Insurance Commissioner, one member familiar with the insurance industry appointed by the Governor, two members appointed by the President Pro Tempore of the

Senate and two members appointed by the Speaker of the House of Representatives.

Funding to administer the OWMP was provided through an appropriation of $1 million, although the OWMAB was provided with an additional responsibility of coordinating a mechanism that provides long-term program funding through voluntary participation by state property/casualty insurance companies and other interested persons, firms or corporations. Similar to the mechanism implemented in Alberta, voluntary assessments are based on the amount of property insurance premiums written in Oklahoma. The eventual funding goal for successive years is $3 million, collected entirely from the state's insurance companies and other interested parties.

2. INDEPENDENT EVALUATION

2.1 Phase I and II Operations

Phase I of the initial 1996 Oklahoma Weather Modification Program (Vance and Mathis, 1997) extended from August 20 through October 30, 1996. Phase II began on March 20 and ended May 31, 1997. Global Positioning Satellite (GPS) technology, utilized by WMI, coupled with the state's Mesonetwork (MESONET) and Next Generation Weather Radar (NEXRAD), provided invaluable resources with which to study the OWMP's general effectiveness and its application in Oklahoma.

The fall and spring operational phases of the OWMP were independently studied by EVAC. Green et al. (1998) set forth the proceeding conclusions on the effectiveness of the program. The key findings from Phase II (1997) are summarized below:

a. Qualitative analysis of specific rainfall enhancement seeding operations suggested that they were consistent with the seeding hypothesis. Specifically, in most cases, precipitation and increased cloud development were present after and downwind of the rainfall enhancement seeding activities. These results agreed with the existing research projects which demonstrated a seeding signature based upon long-term studies.

b. An analysis of the liquid water content (LWC) and droplet concentration based on a period in mid-May 1997, during which some seeding was randomized in conjunction with the collection of cloud physics data during a series of research flights, supports the static seeding hypothesis. The LWC decreased after seeding. The results were consistent with research efforts of other states, such as North Dakota, Kansas, and Texas, which have showed increased precipitation associated with a decrease in the LWC.

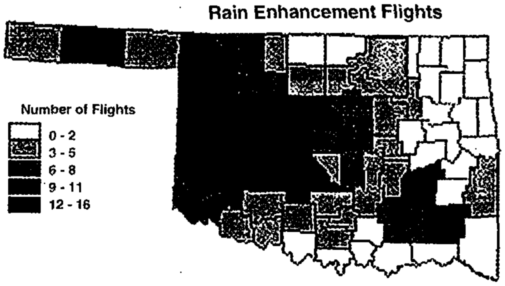
c. An analysis of the hail reports for 1997 suggested that the operator is capable of identifying the systems most likely to produce significant hail damage. Also, the methods used by the operators were consistent with efforts in other states which have shown a reduction in hail damage.

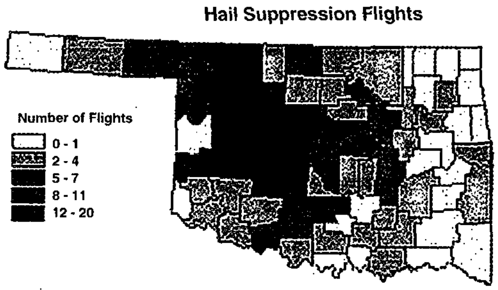
2.2 Post Phase II Operations

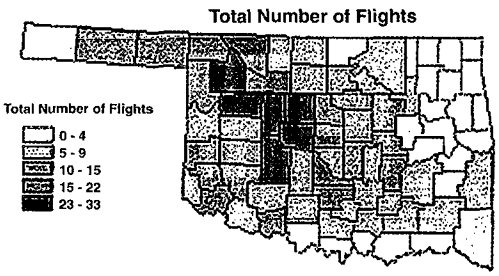
A post Phase II (1998 operational period) analysis was also conducted by EVAC. Key findings from Greene et. al. (1999) showed similar results to the 1997 analysis in that results were consistent with the seeding hypothesis.

Analysis of available hail reports again suggested that the operator is capable of identifying those systems most likely to produce significant hail damage and that the methods used were consistent with efforts in other states which have claimed up to a 40% reduction in hail damage. However, although the contractor was getting to the larger hail producing systems, an important conclusion of the analysis determined that insufficient resources were dedicated to the program. More specifically, there was an insufficient number of aircraft to provide adequate coverage of the state's 70,000 square-mile seeding area. Less than one-half of significant hail events observed in 1998 occurred in areas where clouds were seeded. The analysis also suggested that perhaps more attention should be placed on hail suppression to maximize program benefits. Quantitative analysis of the radar signatures from hail suppression showed promising results, but was not statistically conclusive.

Utilizing GPS technology, the number and location of hail suppression and rain enhancement flights were recorded. In 1998, there were 116 flights for rainfall enhancement and another 95 for the purpose of hail suppression (Table 1). The county locations and frequency of flights are depicted in Figure 1.







Monthly Flight Summary
1998 OWMP

Month	Rainfall Enhancement	Hail Suppression	Total
March	2	6	8
April	5	13	18
May	10	18	28
June	5	43	48
July	36	5	41
August	42	0	42
September	11	7	18
October	5	3	8
Totals	116	95	211

In addition to the previously discussed operation periods, a late fall 1999 program was initiated September 22, following a directive issued by the Advisory Board; operations concluded December 31, 1999. The primary impetus for conducting operations in the fall, when systems conducive for seeding are typically less numerous, was due to moderate to advanced drought conditions which developed across much of the southern part of Oklahoma during the summer and fall.

3. FALL 1999 OPERATIONS

Greene et al. (1999) also examined the potential impact of rainfall enhancement activities on the wheat yield in Oklahoma. Wheat is the largest cash crop in the state. Substantial gains in the modeled yields at two locations (Canadian County and Texas County) resulted when the precipitation totals were randomly augmented. One example assumed a 10% increase for 50% of the rainfall events, resulting in approximately $900,000 of increased revenue for these two counties, assuming current market conditions at that time.

4. DISCUSSION

4.1 Need for Expansion

Expansion of the program appears imperative in order to provide at least adequate and effective statewide coverage. During major outbreaks of storms, it is virtually impossible for three planes to reach all of the prime seeding areas. The near-future goal is to expand the program to include at least seven aircraft and three project radars. The radar image (Figure 2) captured near 20:01 CST on November 22, 1999 illustrates the current logistical constraints. Communication problems were occurring at this time from both radar attenuation and lightning. One of the planes was directly over Tulsa, which is nearly 120 miles away from the WMI radar station located at Oklahoma City Wiley Post Airport. Unsure at the intensity of the convection on the eastern side of the western-most squall line and concerned about the safety of the pilot(s), the project meteorologist directed the plane to land in Ft. Smith, Ark. A third radar located over eastern Oklahoma and additional aircraft would greatly decrease the likelihood of such problems allowing the contractor to safely stay out in front of an eastward propagating squall line where the best feeder cells are typically found.

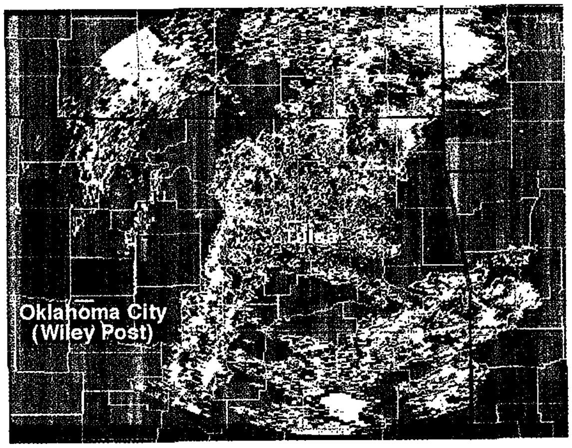


Figure 2. Radar image showing the lines of convection (20:01 CST, November 22, 1999).

4.2 Interstate partnerships

To increase the efficiency of the Oklahoma Weather Modification Program, Oklahoma is currently seeking authority and any necessary permits to conduct limited operations in the States of Texas and Kansas through which the vast majority of storm systems track prior to entering state borders. Establishment of a "buffer zone," encompassing 30 miles or more to facilitate the time limitations posed by rapidly-moving systems, would enable OWMP pilots to seed developing storms prior to their arrival in Oklahoma, thus providing maximum program benefits for the state's border counties who, depending upon the track of promising rainfall and/or threatening hail systems, often miss out on the benefits of these operations. Finalization of such agreements are imperative if Oklahoma is to establish a program which provides true statewide coverage.

Related to this effort is the exploration of potential partnerships between Oklahoma and neighboring states conducting cloud seeding operations. The potential sharing of aircraft, radar, airports, regional meteorological information and related resources would maximize aerial coverage and improve the overall efficiency of all involved programs. A cooperative, interstate program with the States of Texas and Kansas, currently under study, is especially promising due to planned expansion of Texas weather modification operations into a large area of the Texas Panhandle region, and the already established Western Kansas Weather Modification Program, adjacent to western and northwestern Oklahoma.

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