State Water Survey Division
ATMOSPHERIC SCIENCES SECTION
AT THE
UNIVERSITY OF ILLINOIS

Illinois Institute of Natural Resources

MISCELLANEOUS PUBLICATION 56

ASSESSMENT OF SUMMER 1979 RAINFALL IN SOUTHEASTERN ILLINOIS WITH SPECIAL REFERENCE TO WEATHER MODIFICATION EFFORTS

Stanley A. Changnon, Jr., and Chin-Fei Hsu

APRIL 1980

URBANA, ILLINOIS

ASSESSMENT OF SUMMER 1979 RAINFALL IN SOUTHEASTERN ILLINOIS WITH SPECIAL REFERENCE TO WEATHER MODIFICATION EFFORTS

Stanley A. Changnon, Jr., and Chin-Fei Hsu
Illinois State Water Survey

Introduction

In 1978, during a dry summer period, a group of citizens in the Saline and Gallatin County area of southeastern Illinois became interested in the possibility of obtaining additional rainfall through the use of a weather modification program. By the latter part of the summer, in August and early September, they had formed a corporation called Southeastern Rain Incorporated; they had raised funds; and they then launched a cloud seeding project carried out by a weather modification firm. No scientific assessment of this hurriedly assembled effort could be attempted. The regional interest in this endeavor, and the potential for agriculture benefits deriving from additional summer rainfall in this area of Illinois, led the group to plan for a second summer season project in 1979.

During the spring of 1979, a local fund raising program was conducted. Interactions involving the local county cooperative extension advisors and staff of the Illinois State Water Survey, which was providing scientific and technical information relating to weather modification, led to the decision that the State Water Survey would plan and perform an assessment of the rainfall during the 1979 project. To this end, Survey officials met and discussed the needs for rainfall data with the extension advisor in Saline County. This discussion and subsequent correspondence between other area county advisors led to the establishment of a network of raingages in a 6-county area embracing the 1979 "target area." The target area was defined as that area in which funds were raised and was identified as the site for cloud seeding operations, based upon the contract between Southeastern Rain Inc., and Atmospherics Incorporated, the company contracted to do the 1979 cloud seeding project. Plastic raingages were obtained, and farmers who were to serve as observers of daily rainfall amounts were contracted and given raingages. The target area was about 1000 square miles.

Data

By the middle of June 1979, a reasonably dense network of 92 non-recording raingages had been installed, largely within the target area, as shown in figure 1. The target area embraced most of Saline and Gallatin Counties, as shown, and parts of Franklin, Hamilton, White, and Williamson Counties. Although the 92 raingages in the raingage network were not evenly distributed, the network represents a much denser sampling of rainfall than would be obtained without the network. Please note that the official raingages of the National Weather Service in the area are shown on figure 1, each denoted by a

small triangle, Typically, there is only one such station per county in this region of Illinois and Kentucky, not a good density for measuring the highly variable rainfall of one summer.

Rainfall data at these National Weather Service stations and at the 92 raingages operated by the local volunteer observers in the special network were based on measurements made once daily, typically at 0700 or 0800, Data were collected in the special raingage network from the middle of June (prior to the start of the cloud seeding operation) until late August (several days after the cloud seeding operations had terminated). The daily rainfall observations of the cooperative observers were entered on postcards mailed to the county extension advisors, who in turn transmitted the data to the Illinois State Water Survey. The daily rainfall data of the National Weather Service observers in the area were available in the published records of that agency. These two data sets then became the principal basis for assessing the summer 1979 rainfall distribution in the target and surrounding areas.

Analysis

It is *important* to appreciate that this assessment of the summer rainfall, which involved comparisons of. the rainfall pattern and amounts in the target (seeded) area with those in the surrounding (non-seeded) regions, is not to infer that the rainfall in the target was either increased or decreased because of seeding. We stress that it is impossible, due to the great natural variability of summer rainfall in southern Illinois, to decide whether cloud seeding during a period of a few weeks altered the rainfall.

Rather, these statistics are presented with these *cautions* to fulfill our goal which is-; to describe the rainfall in and around the target area. From a scientific standpoint,, these data will hopefully become a part of a larger package of data, including radar echo data and cloud seeding operational data for 1979 (and subsequent years and other projects), which ultimately may provide sufficient information to allow some assessment of whether cloud seeding in Illinois actually 1) altered clouds and their behavior, and 2) altered rainfall *with some high degree of certainty*-.

For example, whether the target area had more or less rainfall in 1979 could be construed in several different ways. If the target area had more rainfall in 1979 one might be willing to claim a positive seeding effect. Other claims might be that 1) the target rainfall might have been more *without* cloud seeding (that is, the seeding might have decreased the rainfall), or 2) the seeding increased the rainfall in the target at the expense of the rainfall in the surrounding areas (which might have been made less),

Thus, *we urge caution in interpreting the 1979 rainfall results as any evidence of a seeding effect. They are oust numbers out of several weeks of typically diverse summer rainfall.*

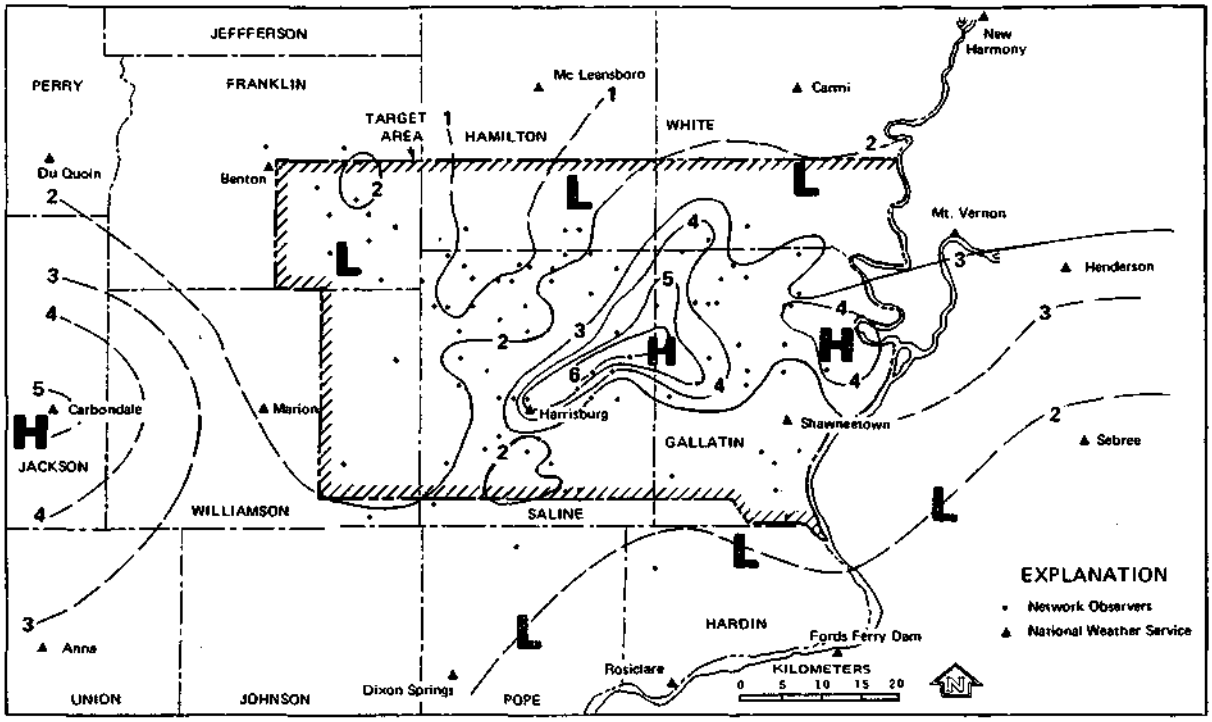


Figure 1. Rainfall (inches) from rains when cloud seeding occurred

The Water Survey collected rainfall in a dense network of raingages in Franklin and Williamson County for 10 years (1958-1967), and the 1979 rainfall pattern, with the great local differences, was typical of those found in earlier years. Results from this Survey network in years when cloud seeding was not in progress are presented later to help illustrate the great natural variability of summer rainfall in southern Illinois.

The cloud seeding company was available and ready to seed clouds from 23 June through 26 July 1979, and then, after a pause because local conditions were too wet with lowland flooding, the operations were available again from 10 August through 15 August 1979. Thus, cloud seeding could have been conducted, if suitable weather conditions were available, for a period of 40 days within this 23 June-15 August period.

The basic rainfall data were in daily values. These were classified according to three types of operational decisions by the weather modification group which operated its radar and seeding aircraft at the Marion Airport. Rainfall data from the group of days when cloud seeding occurred during all or a portion of the rain in the target area, became the "seeded rainfall amounts." These included six rainfall periods: 23-24 June, 29 June, 30 June, 8-9 July, 10 July, and 12-13 July. The rainfall at each of the observer gages and at the National Weather Service gages for these six periods were totaled and identified as the "seeded rains only."

It is important to realize that it rained on other days during the period of 23 June through 15 August. There were 17 rain periods identified in our analysis that were classified as "non-seeded rain" periods. The reporting forms from the cloud seeding operations indicated that these could be further subdivided into two classes. First was those when there was no cloud seeding but when the seeding airplanes flew to observe and measure clouds to see if they were amenable to seeding. This inferred that the project meteorologists believed atmospheric conditions suitable for successful seeding existed, and had the pilots go aloft to monitor conditions. However, the pilots concluded in these cases that the clouds were not right. The second class comprised eight rain periods when there was no cloud flying. These were situations in which the project meteorologists thought the conditions were totally unsuitable for rainfall modification.

In summary, the rain analysis was based on these three categories of the rainfall during the 1979 "operational" period. These were then developed into five classifications of the 1979 rainfall.

1) Rainfall from these rain periods when cloud seeding occurred (6 rainfall periods).

2) Rainfall from the non-seeded events but when aircraft cloud observations occurred (9 rain periods).

3) Rainfall from the non-seed rain periods with no cloud observations (8 rain periods).

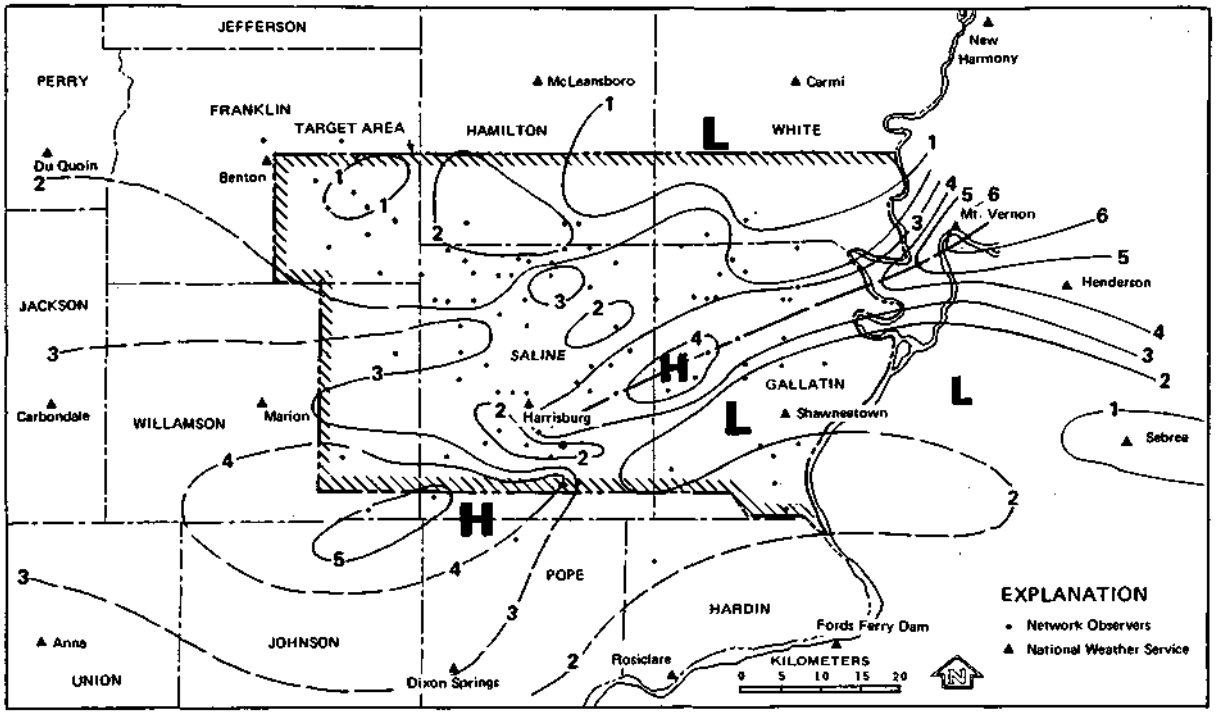


Figure 2. Rainfall (inches) from rains when no cloud seeding occurred but with aircraft cloud observations

4) Rainfall from both of the no-seed rain periods (a total of 17 rain periods).

5) Total rainfall for the 40-day operational period (23 rain periods in 23 June-26 July and 10-15 August 1979).

Results Based on Isohyetal Patterns

The total rainfall pattern from the rains in the six periods with cloud seeding is shown in figure 1. A small but well-defined high rainfall area occurred in the center of the target area. Low rainfall values are shown in the northern and western parts of the target area. Rainfall almost as high as that found in the center of the target area is shown to the west, centered at Carbondale. The area embraced by the 3-inch isohyetal line extends from near Harrisburg eastward well beyond the target area into southwestern Indiana and western Kentucky.

Figure 2 presents the isohyetal map of the rainfall from the rains when no cloud seeding occurred *but* when aircraft cloud observations were made. These periods included 2-3 July, 4 July, 5 July, 13-14 July, 15 July, 22 July, 25-26 July, 10-11 August, and 11 August (late). The rain from these periods, which seemed aloft as unsuitable for cloud seeding, shows a pattern similar to that of the seeded rainfall (figure 1). A rainfall high is in the center of the target area and it extends eastward beyond the target. However, greater rainfall highs are found to the southwest of the target. In general, the pattern is remarkably similar to the seeded-period pattern (figure 2), and the rainfall totals, in general, are comparable at many locations to those for the seeded periods.

Figure 3 presents the pattern of rainfall from the eight rains which were not seeded and had no airborne cloud measurements. These reflect atmospheric conditions that were considered totally unsuitable for cloud seeding well before the rain began. The periods of these eight rains included 28-29 June, 1 July, 7 July, 9 July, 14 July (late), 23-24 July, 24 July (late), and 14-15 August. The pattern of these no-seed rainfall events is somewhat similar to those of the seed and the other no-seed class with cloud observations. A generalized west-east high crosses the target area, but in this instance it is farther south. Rainfall values in the center of the target are much lower than they were in the seeded category, although rainfall values in the northern part of the target area (Franklin, Hamilton, and White Counties) are higher in this no-seed category than in the seed category or in the no-seed/cloud observation category.

Combining the values from the three categories of rain events gives the total rainfall for the 40-day operational period. The total rainfall pattern is presented in figure 4. The basic features of this rainfall pattern reflect a west-east oriented ridge of heavy rainfall running from Carbondale to the southwest corner of the target and then ENE across the center of the target. It reaches a maximum of 11 inches between Harrisburg and Shawneetown, and then extends on eastward into Indiana and Kentucky where amounts greater than

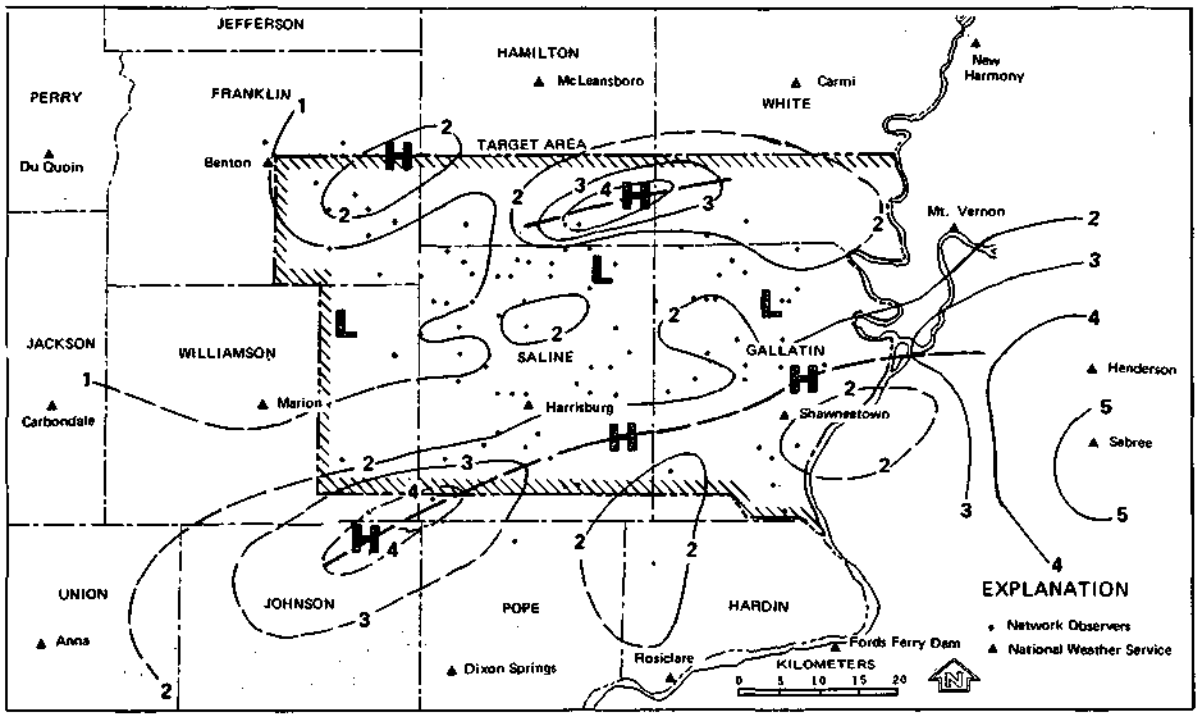


Figure 3. Rainfall (inches) from rains not seeded and with no cloud measurements

11 inches also occurred. Rainfall values in the target area ranged from less than 3 inches in one locale between Benton and Harrisburg, to as much as 11.22 inches.

The danger of making claims for cloud seeding from inspection of rainfall patterns alone is easily revealed by considering figure 4. One might wish to claim that the heavy rainfall centered in the target area was a result of cloud seeding. However, one finds rainfall totals as high or higher outside of the target area to the southwest and east. One also finds within the target area, in the northwest, the northern, and southeastern portions, relatively low rainfall amounts, which are as low or lower than those anywhere else in the area surrounding the target.

One should not be surprised by the variation in the rainfall demonstrated in this figure for the period from late June through mid-August 1979. To help illustrate this, two past rainfall patters (from July-August 1958 and July-August 1965) were selected for figure 5. These were based on data from a network of 50 raingages operated in portions of the 1979 target and control study area. One notes in these two summers (with no cloud seeding) considerable space variations typical of those found in Saline and Gallatin Counties in 1979.

These maps are included to help illustrate the considerable natural variability of midsummer rainfall in southern Illinois and to serve as a warning about making conclusions relating to cloud seeding from the results from 1979. One could look at the map for 1958 and claim that there was cloud seeding to enhance rainfall near Benton, or in 1965 that cloud seeding near Marion and Carbondale had altered the rainfall. Obviously there was no cloud seeding at those times in those areas.

Results Relating to Study of National Weather Service Data

One of the problems in assessing the rainfall data for seeding effects utilizing the excellent dense raingage network established for the project area relates to the fact that there was *not* a comparable raingage network and rainfall data from the surrounding areas. This becomes a problem when one wishes to evaluate the target area rainfall by comparing it with that in surrounding regions to derive conclusions as to its relative magnitude. That is, was the target rain higher or lower than one might have expected? A time-honored approach to rainfall evaluation of a specific area has been to compare the rainfall in the area of interest with that in regions surrounding it. The surrounding regions are typically called "control areas" for comparison with the "target area."

In order to make an unbiased comparison (unbiased by different raingage densities), the rainfall data from only the available National Weather Service raingages in and around the target area were used. One notes from figure 1 that there were very few such gages. For example, the only National Weather Service gages in the target area were at Harrisburg and Shawneetown. Although

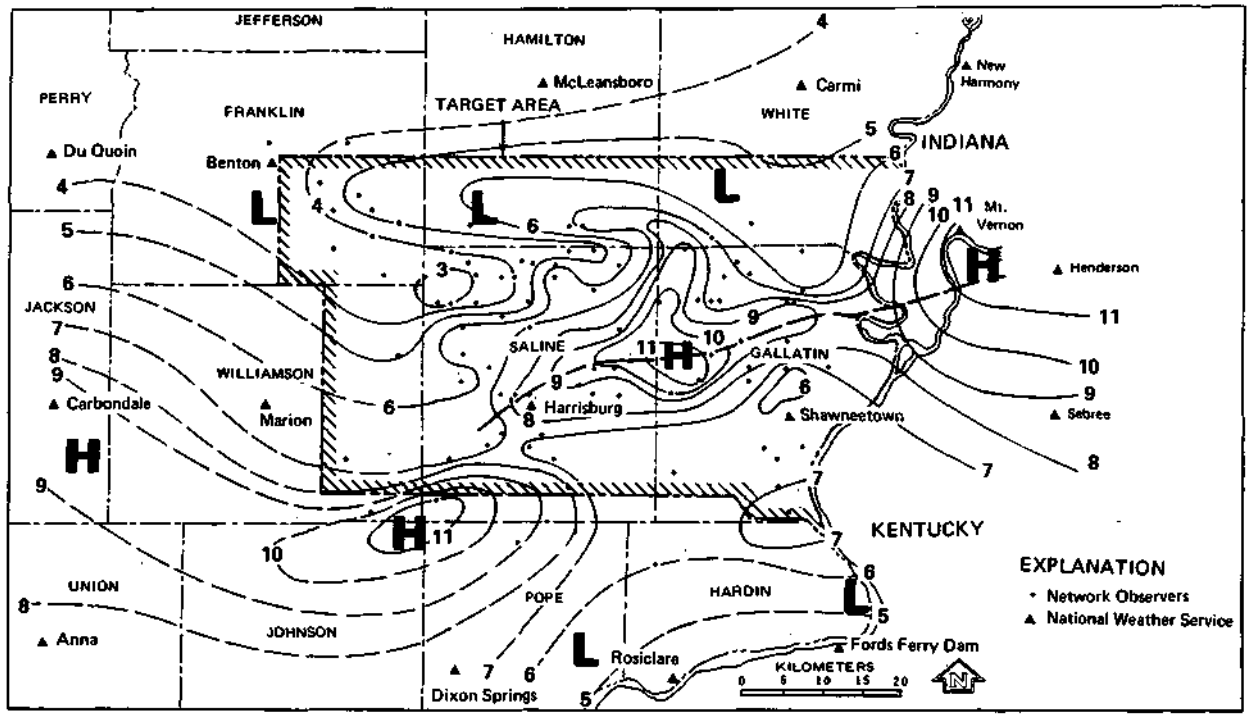
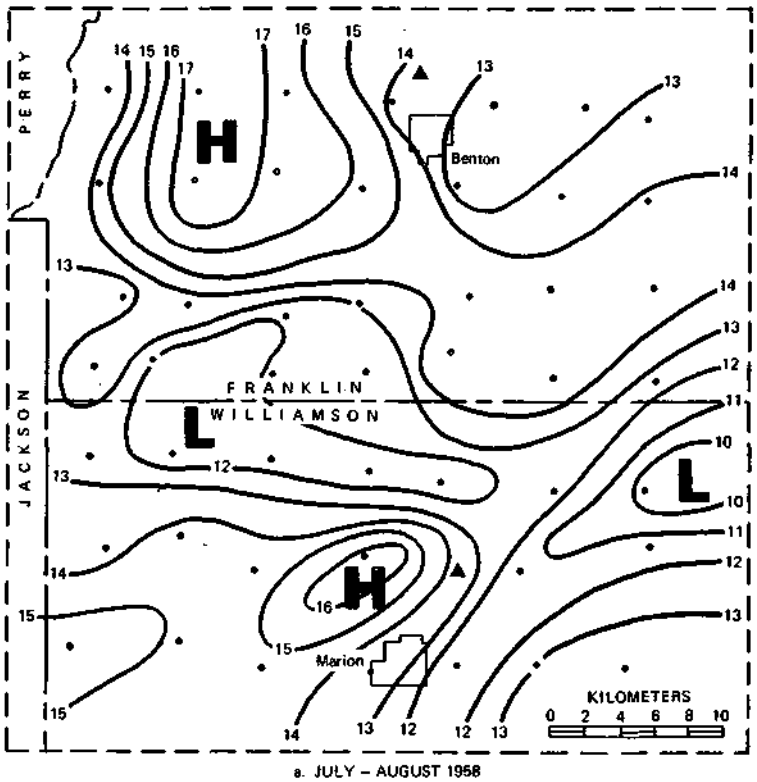
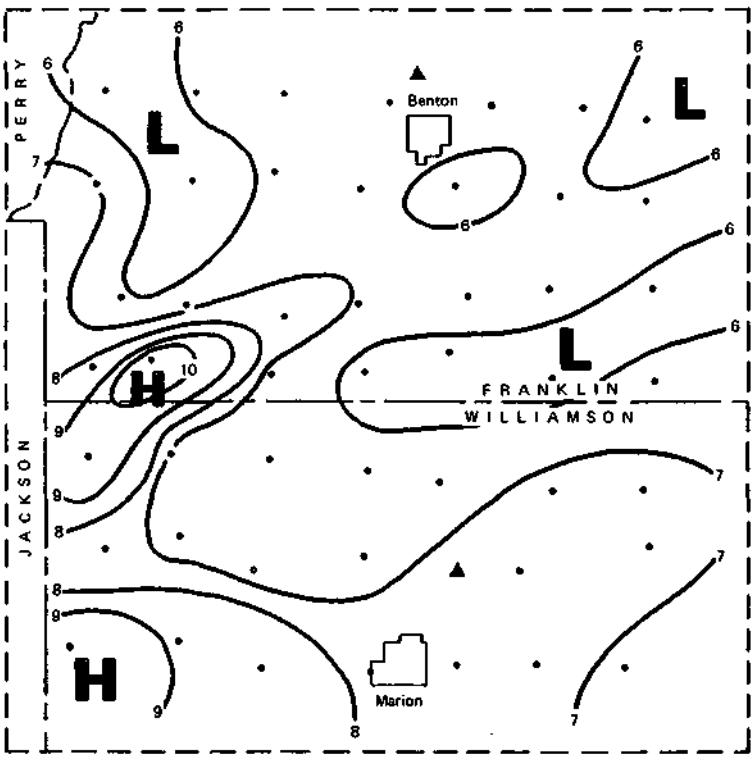


Figure 4. Total rainfall (inches) in 1979 period of weather modification



a. JULY – AUGUST 1958



b. JULY – AUGUST 1965

Figure 5. Rainfall patterns in two years in southern Illinois

the density of gages is poor, it is relatively uniform in the target and control areas. Prior to the seeding project (in early June 1979), we defined control areas to the north, west, south, and east of the target area that were approximately the same size, and each included two or three National Weather Service gages. The groupings of these gages according to the various controls are shown in table 1. For example, the north control area comprised the rainfall values from the station gages at McLeansboro and Carmi. In essence, the four control areas surrounding the target area are shaped, at least conceptually, as shown by the four boxes in figure 6. They are areas of a size equivalent to the target area, and each has the same general raingage density of approximately one gage in 500 square miles.

Results for 1979 Target-Control Comparisons. Shown in table 1 are the total rainfall values at each of these stations for the five classifications of rainfall that were derived. For example, in the seeded periods, Harrisburg had 4.35 inches of rainfall. The station values under the five rain categories, in the target and in the four control areas, were combined to derive area averages as shown in table 1. For example, the average in the target area for the seeded periods was 3.50 inches.

The area averages are plotted in the map portrayals, as shown in figure 6. These map portrayals allow one to more easily compare and assess differences between regions. For example, in figure 6a, based on the seed rains only, one finds the target area average of 3.50 inches with lesser area averages in all of the 4 surrounding control regions. Shown beside figure 6a is the average of all 4 control areas, a value of 1.91 inches, and the target average of 3.50 inches. Their difference, labeled T-C (or target minus control), is equal to 1.59 inches. This difference, expressed as a percent of the control area value, represents 83.2% more rainfall in the target than in the control. *Again, caution is urged.* This does not necessarily reflect any cloud seeding effect. It simply says that 83% more rainfall fell in the target area than in the surrounding control, and the cause for this is *not established.* It could be man, nature, or both.

Similar comparisons for the two no-seed rain categories appear as figures 6b and 6c. These both show that the target area received less rainfall, in both categories, than did the average of the four control areas. It was 11.4% less in the cloud observation/no-seed category, and 28.3% less in the no-seed rains with no cloud observations.

Figure 6d presents the area average rainfall values combined for both categories of no-seed conditions. One sees here that the target area received more rainfall than did the north, west, and south control areas, but noticeably less than did the east control area. The difference between the four control areas and the target represents 0.90 inch less, or 19.4% less rainfall in the target than in the surrounding control area. It is important to note that rainfalls in the east control area in both of the no-seed categories (figures 6a and 6c) were higher than in the target area.

Table 1. Rainfall Values at National Weather Service Raingages for the Operational Period of the Southeastern Illinois 1979 Cloud Seeding Project

	Seeded Periods	No Seeded Periods with Cloud Observations	No Seeded Periods with No Observations	Both No Seeded Classes	Total Rainfall
Target Area					
Harrisburg	4.35	2.79	1.13	3.92	8.27
Shawneetown	2.65	1.54	2.02	3.56	6.21
Average	3.50	2.17	1.57	3.74	7.24
North Control Area					
McLeansboro	0.63	1.47	1.21	2.68	3.31
Carmi	1.95	0.90	1.55	2.45	4.40
Average	1.29	1.19	1.38	2.57	3.86
West Control Area					
Benton	1.5l	1.19	1.00	2.19	3.70
Marion	1.87	3.57	0.87	4.44	6.31
Average	1.69	2.38	0.94	3.32	5.01
South Control Area					
Dixon Springs	2.13	3.11	2.32	5.43	7.56
Rosiclare	1.30	1.06	2.03	3.09	4.39
Fords Ferry	1.80	1.34	1.22	2.56	4.37
Average	1.70	1.84	1.86	1.70	5.44
East Control Area					
Mt. Vernon	2.96	6.89	1.84	8.73	11.69
Henderson	3.09	4.09	4.40	8.49	11.58
Sebree	1.90	0.85	5.45	6.30	8.20
Average	2.65	3.94	3.90	7.84	10.49

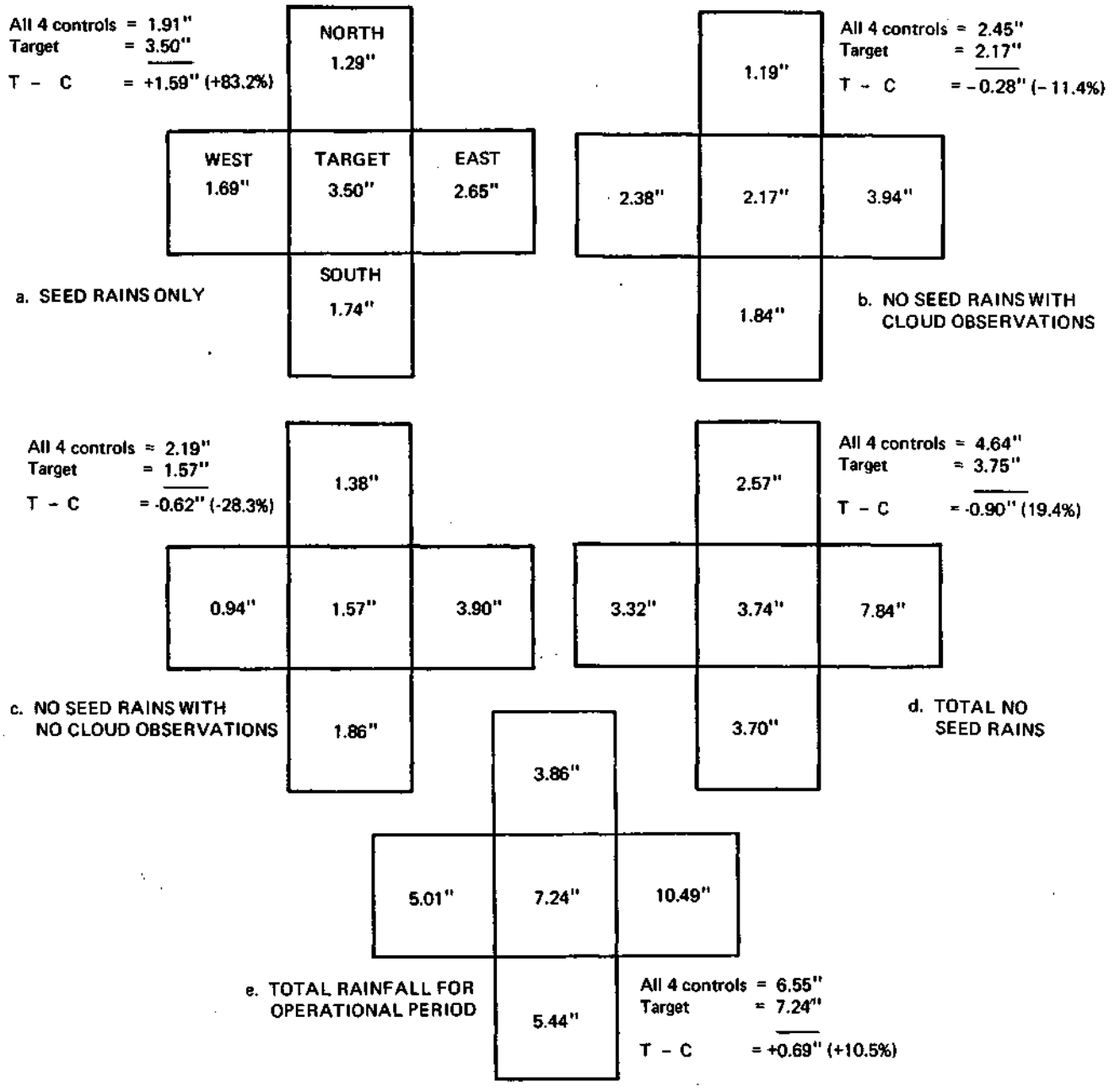


Figure 6. Area mean rainfall in target and control areas during the Southeastern Illinois Cloud Seeding Project in 1979. Values are based on NWS data.

The combination of all the 1979 rains in the operational period is shown in figure 6e. Here, the target area average of 7.24 inches easily exceeds the averages of the north, west, and south control areas but is considerably less than for the east control area. The comparison of the target with the average of the four control areas shows 0.69 inch more in the target, or 10.5% more than in the surrounding control.

Evaluation Using Rainfall Data from Surrounding Areas and Historical Period. The 1979 cloud seeding efforts were also assessed by comparing target area rainfall and control area rainfall from the past 31 years. Rain totals were defined to be that total during the period of June 23-July 26 and for August 8-15, which was the cloud seeding operational period in 1979 as agreed upon between the operator and the contractors. Total rainfall values of the stations in the target and in each control area were averaged to form area averages for each year from 1949 to 1979. These averaged totals are the units used in the subsequent analyses.

In 1979, the target area had a precipitation of 7.24 inches (table 1), while the average of the four control area was 6.20 inches. The target/control ratio is thus 1.17, a crude indication of a positive seeding effect. However, this ratio cannot be used alone as indication of a seeding effect, as it will undoubtfully introduce "selection" bias in favor of the days chosen to be seeded. More reliable and more bias-free evaluation involves use of the historical target-control comparison.

The areal-averaged precipitation values from 1949 to 1978 were used as historical observations. A principal component analysis for the four control areas using 1949-1978 data was performed and three components were retained, which were used in turn as independent variables to run a regression on the target. This (historical) principal component regression was used to forecast 1979 precipitation in the target area, which was compared to the observed 1979 target precipitation to assess the seeding effect.

The choice of principal component regression as the method to evaluate the present cloud seeding project was largely due to our NSF-sponsored research findings. These indicate that principal component regression is a more powerful statistical evaluation technique than other comparable techniques used under circumstances similar to those of the present project. The choice of using three components in the regression is also due to findings from the same research.

The resulting forecasted precipitation for the 1979 target area using 1949-1978 principal component regression, is 5.19 inches. The difference between this and the observed (7.24-5.19) value results in a rainfall increase of 2.05 inches, or 39 percent.

To assess the significance of this rainfall increase, a re-randomization (repetitive) principal component regression was performed. One year from 1949 to 1978 was randomly selected as a hypothetical seeded year, and all other years (including 1979) were used as historical "control" years.

Table 2. Re-Randomization Distribution of Precipitation Increases Using all Surrounding Control Areas

Stem	Leaves	Cumulative No.	Cumulative %
-2.00	00, 04, 09	3	9.7
-1.00	08, 09, 19, 60, 67, 70	9	29.0
-0.00	11, 23, 42, 47, 57, 58, 74, 95	17	54.8
0.00	10, 19, 23, 43, 48, 48, 68, 69, 88	26	83.9
1.00	55, 75	28	90.3
2.00	05*	29	93.5
3.00	03	30	96.8
4.00	12	31	100.0

* 1979 value

Then a principal component regression was performed on this seeded-historical setting, and a forecasted precipitation was obtained as described above, from which a rainfall increase was calculated. This process was repeated by selecting another year as "seeded" and so on, until a distribution of rainfall increases was obtained. For the present project, 31 rainfall increases were obtained and are shown in a "stem and leaf" distribution in table 2. Among these rainfall increases, two are larger (3.03 and 4.12) than the 1979 (indicated by an asterisk in the table), and the significance is thus 0.0968. That is, the chance that this sizable increase is due to nature (rather than to cloud seeding) is about one out of ten. Because of the very short duration (one year) of the present project, the seeding effect, if any, is usually more difficult to detect than in longer projects, even using powerful evaluation techniques.

Evaluation Using Historical Data and Excluding East Area. Figure 6e shows that the target area has more rain than the control areas except the east control. There, the average of 10.49 inches in 1979 is much above the other areal rainfall values. To find out whether this large value occurred naturally or extremely (in other words, was an outlier), frequency distributions of the rainfall for each area were studied. They are shown in table 3, and the 1979 rainfall values are marked by an asterisk. It is obvious that among the four control areas, the precipitation values of 1979 in the north and south control areas are fairly close to their respective median; whereas the precipitation values in the west and east control areas are above normal (compared to their medians).

Table 3. Distribution of Areal Precipitation

	Target	North	West	South	East
1	1.70	1.57	1.60	1.21	2.93
2	1.91	1.83	1.86	1.24	3.23
3	2.33	1.96	1.90	2.66	3.34
4	2.44	1.97	2.47	3.07	3.37
5	2.97	2.58	2.61	3.69	3.46
6	3.23	2.81	2.87	3.69	3.49
7	3.77	2.83	2.97	3.76	3.53
8	3.80	2.88	3.20	3.81	3.61
9	3.88	2.98	3.48	4.21	3.74
10	4.19	3.06	3.63	4.30	3.82
11	4.23	3.51	3.67	4.57	4.15
12	4.39	3.55	4.00	4.72	4.18
13	4.73	3.66	4.05	4.81	4.33
14	4.82	3.82	4.18	4.92	4.56
15	4.88	3.83	4.25	5.08	4.58
16	4.92	3.86*	4.28	5.42	4.87
17	4.93	4.01	4.49	5.43	5.00
18	5.06	4.18	4.54	5.44*	5.20
19	5.21	4,24	4.60	5.61	5.32
20	5.38	4.27	4.89	5.75	5.85
21	5.57	4.72	5.01*	5.78	6.32
22	5.61	4.95	5.05	6.22	7.11
23	5.71	5.13	5.08	6.61	7.31
24	6.49	5.13	5.13	6.69	7.88
25	7.01	5.64	6.08	6.89	7.94
26	7.24*	5.67	6.64	6.91	8.34
27	7.80	6,15	6.84	7.19	8.46
28	8.08	6.19	7.23	7.99	8.53
29	8.86	7.89	7.32	8.28	9.43
30	10.20	10.83	11.86	9.10	10.49*
31	10.62	12.37	.12.01	13.08	11.30

The deviation is especially large in the east control area, whose 1979 precipitation is the second largest in a 31-year period. This raises a question of possible extra-area seeding effects in the east control area. Without looking extensively into the detailed seeding operations and the corresponding meteorological conditions, this question of extra-area effect cannot be resolved. Even though information regarding seeding operations and the meteorological conditions are available, they might not be sufficient to tackle this difficult question. Therefore, it was decided to exclude the east control area from the control data and to perform another evaluation. One point to bear in mind about this second evaluation is that it does not render the above first evaluation invalid, rather it only serves as an auxiliary piece of information to supplement the first evaluation regarding the question of extra-area seeding effect.

Double ratio was the evaluation technique used for these data, rather than principal component regression, because the small number of independent variables (3) made it unrealistic to use principal component regression. A double ratio is calculated as follows:

$$DR = TsCns/TnsCs$$

where Ts is the precipitation of the target area in the selected seeded year, Tns is the averaged precipitation of the target area in the non-seeded years, and similarly for controls Cs and Cns. Table 4 shows the re-randomization distribution of double ratio obtained as described above. The 1979 double ratio is 1.4269, which has a significance level of 0.0968. Interestingly, this significance level using the double ratio is identical to that using the principal component regression. However, the estimated precipitation increase in 1979 is 43% using three control areas, compared to 27% using four control areas.

Table 4. Re-Randomization Distribution of Double Ratios Using Surrounding Control Areas except East Control Area

Stem	Leaves	Cumulative No.	Cumulative %
.600	16, 71	2	6.5
.700	26, 85, 96	5	16.1
.800	06, 14, 19, 25, 52, 65, 91	12	38.7
.900	00, 02, 22, 33, 42, 56, 97	19	61.3
1.000	54, 56	21	67.7
1.100	50, 80, 87	24	77.4
1.200	65, 78, 90	27	87.1
1.300	82	28	90.3
1.400	37*	29	93.5
1.500	79, 93	31	100.0

* 1979 value

Summary

The results indicate that the target area received more rainfall (based on only two gages to determine an area average) during the 40-day operational period than did surrounding areas. This was particularly true when one compared the rainfall based solely on the rain periods which were seeded. Investigation of the rainfall (isohyetal) pattern within the target, based on the detailed dense raingage network data, shows that there were wide extremes, from very low to very heavy rainfall in the target.

The rainfall data alone cannot be construed as evidence of any cloud seeding effect. The differences, however, when one compares the seeded rainfall -values with the no-seed values, particularly as revealed in figure 6, do suggest that a localized high in the target occurred in the seeded rain conditions and was not present there in the no-seed conditions. However, as one final caution, one would expect that cloud seeding in the target would be attempted under conditions that were locally favorable for heavier rainfall there, again warning against an interpretation that the 1979 target-control comparisons reflect any enhancement of rainfall due to cloud seeding.

Evaluation using surrounding control areas and historical data shows that there is a significant precipitation increase in the target area in 1979 with a 39% precipitation increase during the 1979 cloud seeding period. If the question of the east control (extras-area effect) is considered, then evaluation using the other control areas also shows a 43% precipitation increase. In both cases, the probability that this is due to chance is 1 in 10.

Acknowledgments

This assessment of rainfall could not have been possible without the considerable efforts of the Cooperative Extension Advisors in the six counties of the target area. We wish to thank in particular Bob Edgar for his considerable assistance in establishing the raingage network and in getting the data assembled and transmitted to the Water Survey. We also wish to thank the 92 persons who served faithfully as rainfall observers during the summer of 1979. We wish to acknowledge the considerable assistance of Kathy Eckstein and Phyllis Stone who meticulously and carefully compiled the rain data and segregated it into discrete rain periods. John Brother aided with the drafting of the rainfall figures. We also wish to acknowledge the interest and cooperation of the members of Southeastern Rain Inc. who supported the cloud seeding program and the concept of a rainfall evaluation effort.