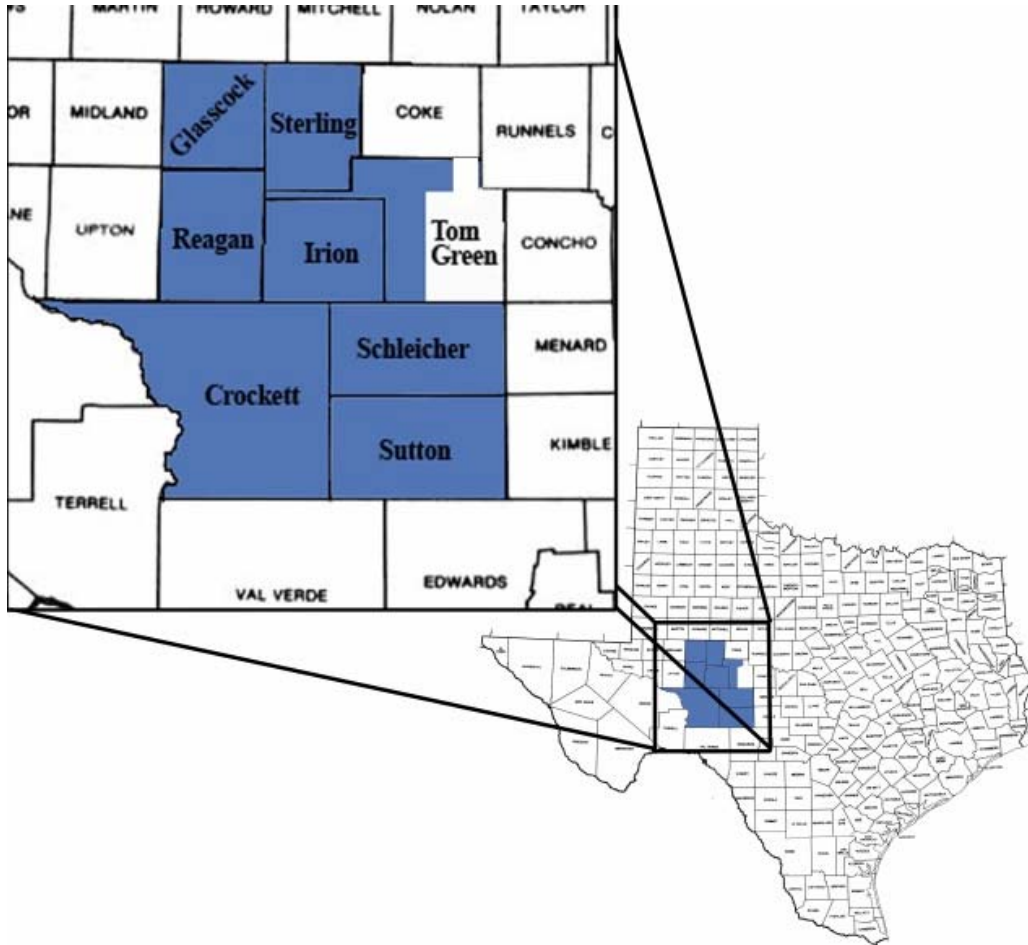


2008 ANNUAL REPORT WEST TEXAS WEATHER MODIFICATION ASSOCIATION



West Texas Weather Modification Association
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West Texas Weather Modification Association 2008 Annual Report

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Seeding operations started on March 17th and ended on September 24th with 38 operational days. Three days were classified as experimental due to the limited moisture or suppressed vertical structure which hindered sufficient inflow. 77 clouds were seeded with 1431 flares during 57 flights. 8 reconnaissance flights were flown while making an attempt to find seedable clouds on marginal days. Pilots flew 150 flight hours. Part time pilots flew for the duration of the season; pilot availability and erratic storm development throughout the season made for a few late flight initiations. A few repairs on aircraft had minor affects on operations.

TITAN software created some negative affects on operations this season. The National Weather Service Offices installed a new software package called Build-10 with super-resolution compatibilities. The software update required manipulation to the LDM data stream from which TITAN receives and processes radar data. One day (June 13) was completely lost while the new code was written. Weather Decision Technologies (WDT) worked hard to provide the new data stream through the month of June. New issues continued to crop up through the summer associated with the change. Several instances of lost radar hindered operations at various times. Curious parties may also notice a ring around both Midland and San Angelo radars on precipitation images; this ring is a false echo.

2008 was a rather dry year. As of December 1, a value (18.96) at San Angelo was under normal by 1.01 inches. Record rainfall at the San Angelo Regional airport on September 8th and several days in August where Mathis Field received plentiful rains does not show accurately the amount of rainfall seen by the majority of the target area. August was the most active this season with 15 operational days. Precipitation and percent of normal maps show that much of Texas was well below normal except for March which had mainly one rain event. Another event occurring in September west of the Pecos River and over western Crockett County is noticeable on Percent of Normal maps for September and annual. Hurricane Dolly struck the southern tip of Texas on July 21st and moved west into Mexico with very little influence on the target area. Tropical Storm Edouard made landfall over Southeast Texas August 5th and Hurricane Ike made landfall at Galveston on September 13th without any rain for West Texas.

The statistical reports conducted by Active Influence and Scientific Management shows a majority of seeding operations results were excellent or very good with an average seasonal increases to precipitation at 20%. Timing to small and large seeded clouds, (84% - 92%) was excellent. Small clouds showed increases for precipitation mass at 104%, cloud mass increases of 46%, lifetime increases at 36%, increases to cloud area at 33%, cloud volume increases of 44%, and volume above 6Km of 29%. Increases in precipitation mass by county were shown between 5.1 and 35.5%. Glasscock and Sutton Counties were at or below 10% but were a consequence of environmental circumstances that did not provide favorable seedable conditions during the season. Irion County was most favored in number of seeded clouds; this is often the case given the central geographical location. Interpolation of rainfall for Reagan County shows the superior value of rainfall increases. Total increases in precipitation for the target area were calculated at 1,270,200 acre-feet.

Robert Rhodes
Meteorologist

Arquímedes Ruiz-Columbié
Active Influence & Scientific Management

Cloud seeding operations 2008 began over the West Texas Weather Modification Association target area in March. This annual report serves as a summary of results. A total of **77 clouds** were seeded and identified by TITAN in **38 operational days**. Table 1 in page 1 summarizes the general figures:

Table 1: Generalities

First operational day: **March 17th 2008**
Last operational day: **September 24th 2008**

Number of operational days:
(One in March, two in April, four in May, seven in June, seven in July, fifteen in August, and two in September)

According to the daily reports, operational days were qualified as:

Nine with excellent performance
Eighteen with very good performance
Five with good performance
Two with fair performance
One with data corruption
Three experimental days on marginal conditions

Corrupted data: June 13th

Number of seeded clouds: 77 (35 small, 23 large, and 19 type B seeded clouds)

Missed Opportunities: 2 (~ 2.5 %)

July 8th: Cloud # 36 over Sutton County

August 18th: Cloud # 2266 over Sterling County

Small Clouds

Evaluations were done using TITAN and NEXRAD data.

Table 2 shows the results from the classic TITAN evaluation for the 35 small seeded clouds which obtained proper control clouds.

Table 2: Seeded Sample versus Control Sample (35 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	60 min	40 min	1.50	50 (36)
Area	83.5 km ²	61.0 km ²	1.37	37 (33)
Volume	234.2 km ³	159.8 km ³	1.47	47 (44)
Top Height	8.2 km	7.8 km	1.05	5 (3)
Max dBz	50.4	49.5	1.02	2 (0)
Top Height of max dBz	4.3 km	4.4 km	0.98	- 2 (0)
Volume Above 6 km	26.6 km ³	17.3 km ³	1.54	54 (29)
Prec.Flux	630.1 m ³ /s	434.2 m ³ /s	1.45	45 (40)
Prec.Mass	2374.5 kton	1127.0 kton	2.11	111 (104)
CloudMass	182.6 kton	119.4 kton	1.53	53 (46)
η	13.0	9.4	1.38	38 (40)

Bold values in parentheses are modeled values, whereas η is defined as the quotient of Precipitation Mass divided by Cloud Mass, and is interpreted as efficiency. A total of 230 flares were used in this sub-sample with an excellent timing (**84 %**) for an effective dose about **85 ice-nuclei per liter**. The seeding operation for small clouds lasted about **12.5 minutes** in average. An excellent increase of **104 %** in precipitation mass together with an increase of 46 % in cloud mass illustrates that the seeded clouds grew at expenses of the environmental moisture (they are open systems) and used only a fraction of this

moisture for their own maintenance. The increases in lifetime (36 %), area (33 %) volume (44 %), volume above 6 km (29 %), and precipitation flux (40 %) are notable. There are slight increases in top height (3 %). The seeded sub-sample seemed 40 % more efficient than the control sub-sample. Results are evaluated as **excellent**.

An increase of 104 % in precipitation mass for a control value of 1130.0 kton in 27 cases means:

$$\Delta_1 = 35 \times 1.04 \times 1127.0 \text{ kton} = 41\ 023 \text{ kton} = 33\ 269 \text{ ac-f}$$

Large Clouds

The sub-sample of 23 large seeded clouds received a synergetic analysis. In average, the seeding operations on these large clouds affected 59 % of their whole volume; with an excellent timing (92 % of the material went to the clouds in their first half-lifetime). A total of 811 flares were used in this sub-sample for an effective dose about **100 ice-nuclei per liter**.

Also in average, large clouds were 27 minutes old when the operations took place; the operation lasted about 44 minutes, and the large seeded clouds lived 220 minutes.

Table 3 shows the corresponding results:

Table 3: Large Seeded Sample versus Virtual Control Sample (23 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	195 min	165 min	1.18	18
Area	1400 km ²	1195 km ²	1.17	17
Volume	5460 km ³	5174 km ³	1.06	6
Volume Above 6 km	1588 km ³	1377 km ³	1.15	15
Prec.Flux	15748 m ³ /s	13093 m ³ /s	1.20	20
Prec.Mass	173 043 kton	120 995 kton	1.43	43

An increase of 43 % in precipitation mass for a control value of 120995 kton in 23 cases may mean:

$$\Delta_2 = 23 \times 0.43 \times 120\,995 \text{ kton} = 1\,196\,641 \text{ kton} = 970\,475 \text{ ac-f}$$

Type B Clouds

The sub-sample of 19 type B seeded clouds received a synergetic analysis. In average, the seeding operations on the type B clouds affected 25 % of their whole volume; with an excellent timing (73 % of the material went to the clouds in their first half-lifetime). A total of 390 flares were used in this sub-sample for an effective dose ~ **85 ice-nuclei per liter**.

Also in average, type B clouds were 105 minutes old when the operations took place; the operation lasted about 43 minutes, and the type B seeded clouds lived ~ 290 minutes.

Table 4 shows the results:

Table 4: Type B Seeded Sample versus Virtual Control Sample (19 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	290 min	280 min	1.04	4
Area	1232 km ²	1156 km ²	1.07	7
Volume	4674 km ³	4317 km ³	1.08	8
Volume Above 6 km	1276 km ³	1204 km ³	1.06	6
Prec.Flux	12353 m ³ /s	11470 m ³ /s	1.08	8
Prec.Mass	141 806 kton	123 742 kton	1.14	14

An increase of 14 % in precipitation mass for a control value of 123 742 kton in 19 cases may mean:

$$\Delta_3 = 19 \times 0.14 \times 123\,742 \text{ kton} = 329\,154 \text{ kton} = 266\,944 \text{ ac-f}$$

The total increase: $\Delta = \Delta_1 + \Delta_2 + \Delta_3 = 1\,270\,688$ ac-f

Micro-regionalization

Increases in precipitation mass were analyzed county by county in an attempt to better describe the performance and corresponding results. **Table 5** below offers the details:

County	Initial Seeding	Extended	Acre-feet (increase)	Inches (increase)	Rain (season value)	% (increase)
Glasscock	9	10	47 500	0.99	9.55 in	10.4
Sterling	9	15	153 400	3.12	13.75 in	22.7
Reagan	9	13	247 000	3.94	11.11 in*	35.5
Irion	16	21	166 200	2.96	11.69 in	25.3
Tom Green	3	15	126 400	3.11**	12.24 in	25.4
Crocket	14	19	287 800	1.92	12.93 in	15.0
Schleicher	8	11	189 500	2.71	12.06 in	22.5
Sutton	9	14	52 400	0.68	13.29 in	5.1
Total	77	118	1 270 200			
Average (only for the bold values)				2.43	12.08 in	20.1

(*) Missed data recreated by spatial interpolation

(**) One half of the Tom Green Area considered

(**Initial seeding** means the counties where the operations began, whereas **extended seeding** means the counties favored by seeding after the initial operations took place).

Final Comments

- 1) Results are evaluated as **excellent**; one operational day was lost due to corruption of data;
- 2) The micro-regionalization analysis showed increases per county; seedable conditions were more frequent over the central zone of the target area (Irion County); the average increase in precipitation, referred to the seasonal value, is about **20 %**;
- 3) Radar estimations of precipitation should be considered as measurements of trend. Nevertheless, seeding operations appeared to improve the dynamics of seeded clouds;
- 4) Season 2008 was about normal in rainfall amounts over the target area, but stingy in seedable conditions due to a relatively strong tropical influence, especially during the summer. A deeper synoptic analysis later will clarify this issue.

West Texas Weather Modification												
2008 Flight Summary												
March												
Date	Number	Call Sign	Takeoff	Landing	Duration	BIP	Eject.	AgI	Seeded	Pilot	Dirty Cloud ug/m ³	
17-Mar	1	6909P	21.50	0.30	2.40	27		702	CrScSu	Eggemeyer	Dust	60
SubTotal					2.40	27.00		702				
Total					2.40	27.00		702				
West Texas Weather Modification												
2008 Flight Summary												
April												
9-Apr	2	6909P	20.05	22.15	2.20	25		650	Gl, Re, St	Funke	N/A	N/A
	3	6730Y	21.40	23.20	1.70	6		156	Gl	Sleeper	N/A	N/A
17-Apr	4	6909P	23.25	1.30	2.00	0		0		Zesch	Dust	40
23-Apr	5	6730Y	22.40	0.25	1.70	0		0		Sleeper/Zesch	Smoke	1
26-Apr	6	6909P	22.05	1.45	3.50	59		1,534		Zesch	Dust/Smoke	10 / 1
SubTotal					11.10	90.00		2,340				
Total					13.50	117.00	0.00	3,042				
West Texas Weather Modification												
2008 Flight Summary												
May												
13-May	7	7924P	21.35	1.45	4.10	14		364	Sch	Baker	Dust	20
14-May	8	6730Y	20.30	23.45	2.80	31		806	Ir, Tg	Sleeper	Dust/Smoke	10 / 1
	9	6909P	20.35	22.50	2.10	26		676	Ir, Re, St	Zesch	Dust/Smoke	10 / 1
17-May	10	6730Y	14.50	16.00	1.30	3		78	Ir, Re	Sleeper	N/A	N/A
24-May	11	6730Y	21.15	23.30	2.20	21		546	Gl, St	Sleeper	Dust/Smoke	10 / 1
SubTotal					12.50	95.00		2,470				
Total					26.00	212.00	0.00	5,512				
West Texas Weather Modification												
2008 Flight Summary												
June												
Date	Number	Call Sign	Takeoff	Landing	Duration	BIP	Eject.	AgI	Seeded	Pilot	Dirty Cloud ug/m ³	
13-Jun	12	6909P	23.55	2.00	2.20	35		910	Gl, St	Zesch	N/A	N/A
21-Jun	13	6909P	18.25	21.55	3.60	24		624	Cr, Ir, Re	Eggemeyer	sulfates	0.01
	14	6730Y	20.15	23.15	3.00	13		338	Cr,Su	McClendon/Sle	sulfates	0.01

	15	6909P	22.50	1.00	2.40	40		1,040	Ir,Re	Eggemeyer	sulfates	0.01
23-Jun	16	7924P	20.30	22.20	1.90	2		52	Gl,Re	Granaghan	N/A	N/A
24-Jun	17	6909P	21.25	0.45	3.40	43		1,118	Gl,Ir,Re	Eggemeyer	N/A	N/A
27-Jun	18	6909P	0.15	2.00	1.80	18		468	Gl,Re	Eggemeyer	Dust	40
28-Jun	19	6909P	20.00	23.20	3.20	55		1,430	St,Re	Eggemeyer	Dust	20
	20	5141P	21.10	23.35	2.20	28		728	St, Re	Zesch	Dust	20
29-Jun	21	5141P	20.40	21.40	1.00	0		0	recon	Sleeper	Dust	20
30-Jun	22	5141P	20.50	23.10	2.20	9		234	Sc	Sleeper	N/A	N/A
SubTotal						26.90	267.00	0.00	6,942			
Total						52.90	479.00	0.00	19,396			

West Texas Weather Modification

2008 Flight Summary

July

Date	Number	Call Sign	Takeoff	Landing	Duration	BIP	Eject.	AgI	Seeded	Pilot	Dirty Cloud ug/m ³	
1-Jul	23	6730Y	19.15	20.40	1.25	5		130	Cr, Sc	McClendon	Dust 40	
	24	6730Y	21.20	22.40	1.20	4		104	Su	McClendon	Dust 40	
3-Jul	25	5141P	18.00	20.00	1.90	41		1,066	Ir, St, Tg	Zesch	Dust 40	
	26	6909P	18.05	20.30	2.20	9		234	Cr, Ir, Re	Eggemeyer	Dust 40	
	27	6909P	21.10	0.00	3.00	12		312	Gl, Ir, Re	Eggemeyer	Dust 40	
8-Jul	28	5141P	22.06	23.50	1.70	25		650	Ir,Tg	Zesch	N/A N/A	
	29	6730Y	22.23	0.00	2.25	16		416	Ir,Re	McClendon	N/A N/A	
17-Jul	30	6909P	20.55	22.00	1.60	6		156	St	Zesch	Dust 5	
24-Jul	31	6909P	19.55	21.20	0.60	0		0	recon	Sleeper	N/A N/A	
29-Jul	32	6730Y	23.50	2.10	2.25	26		676	Tg	McClendon	N/A N/A	
30-Jul	33	6730Y	21.15	0.15	3.00	33		858	Gl, Ir, Re	McClendon	N/A N/A	
	34	7924P	23.25	2.00	2.50	22		572	Cr, Re	Granaghan	N/A N/A	
31-Jul	35	6730Y	21.15	0.45	2.20	48		1,248	Su	McClendon	N/A N/A	
	36	5141P	21.25	1.00	2.70	6		156	Cr, Su	Zesch	N/A N/A	
SubTotal						28.35	253.00	0.00	6,578			
Total						81.25	732.00	0.00	19,032			

West Texas Weather Modification

2008 Flight Summary

August

1-Aug	37	5141P	18.45	22.30	3.70	126		3,276	Cr,Ir,Re,Sc,St,Tg	Zesch	N/A	N/A
	38	6730Y	20.45	22.45	2.00	44		1,144	Cr, Sc,Su	McClendon	N/A	N/A

4-Aug	39	5141P	22.25	23.30	1.10	0		0	recon	Sleeper	Dust	10
6-Aug	40	5141P	22.00	0.15	2.30	7		182	Ir	Sleeper	N/A	N/A
10-Aug	41	5141P	22.20	23.50	1.60	5		130	St	Sleeper	N/A	N/A
11-Aug	42	5141P	20.50	23.45	2.80	72		1,872	Cr	Zesch	N/A	N/A
	43	6909P	21.10	23.55	2.60	5		130	Cr	Sleeper	N/A	N/A
12-Aug	44	5141P	18.20	20.40	2.30	17		442	Cr, Su	Zesch	N/A	N/A
	45	5141P	22.20	1.10	3.00	47		1,222	Cr, Su	Zesch	N/A	N/A
14-Aug	46	5141P	22.20	23.50	1.50	2		52	Su	Sleeper	Sulfates	1
15-Aug	47	6909P	18.50	22.50	4.00	71		1,846	SC, Su	Zesch	N/A	N/A
	48	7924P	21.00	23.45	2.70	18		468	Cr	Granaghan	N/A	N/A
	49	5141P	23.50	1.20	1.40	8		208	Ir, Re	Granaghan	N/A	N/A
	50	6909P	0.30	1.15	0.90	0		0	recon	Zesch	N/A	N/A
18-Aug	51	6909P	17.00	20.00	3.00	95		2,470	Ir, Sc, St, Tg	Zesch	N/A	N/A
19-Aug	52	7924P	20.15	21.15	1.00	0		0	recon	Zesch	Sulfates	1
21-Aug	53	6730Y	19.25	21.30	2.00	37		962	Cr, Sc, Su	McClendon	Sulfates	1
	54	7924P	19.55	23.10	3.80	23		598	Cr, Re, Sc	Sleeper	Sulfates	1
	55	5141P	23.15	1.15	2.00	4		104	St	Baker	Sulfates	1
24-Aug	56	7924P	19.05	22.50	3.20	48		1,248	Cr, Su	Zesch	N/A	N/A
	57	5141P	20.15	23.15	3.00	6		156	Sc	Baker	N/A	N/A
25-Aug	58	5141P	20.15	22.00	1.70	0		0	recon	Baker	Sulfates	1
26-Aug	59	6730Y	19.50	23.10	3.20	32		832	Ir, Sc, Su	McClendon	Sulfates	1
27-Aug	60	5141P	22.30	23.55	1.30	6		156	Su	Zesch	N/A	N/A
29-Aug	61	5141P	19.10	21.50	2.40	28		728	St, Gl	Zesch	N/A	N/A
30-Aug	62	7924P	21.35	0.00	3.60	14		364	Ir, Re, Tg	Linderman	Sulfates	1
31-Aug	63	5141P	19.00	20.40	1.70	2		52	St	Baker	Sulfates	1
SubTotal					63.80	717.00	0.00	18,642				
Total					145.05	1449.00	0.00	37,674				

West Texas Weather Modification

2008 Flight Summary

September

Date	Number	Call Sign	Takeoff	Landing	Duration	BIP	Eject.	Agl	Seeded	Pilot	Dirty Cloud ug/m ³
23-Sep	64	6909P	21.40	24.00	2.60	8		208	Cr, Su	Eggemeyer	N/A N/A
24-Sep	65	6909P	19.40	23.00	2.20	9		234	Cr	Eggemeyer	N/A N/A
SubTotal					4.80	17.00	0.00	442			
Total					149.85	1466.00	0.00	38,116			