ANNUAL EVALUATION REPORT 2007 **State of Texas**

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Cloud seeding operations 2007 began over Texas Weather Modification target area in March. This annual report is a compilation of the evaluation reports already made and published for five local projects. As in 2006, the SOAR and Trans-Pecos projects did not provide any data during 2007. Therefore, this annual report serves as a summary of the results obtained over Panhandle, WTWMA, STWMA, and SWTREA target areas (EAA target area is included in the last two). A total of **228 clouds** were seeded and identified by TITAN in **110 target area operational days**. Table 1 in page 1 summarizes the general figures:

Table 1 Generalities

First operational day: **March 28th, 2007 (WTWMA and SWTREA)**
Last operational day: **October 8th, 2007 (STWMA and SWTREA)**

Net Number of operational days: 110
(Most active months May to August: ~ 70 % of the operation days,
Less active months: March: ~ 3 % of the operation days)
October: ~ 2 % of the operation days)

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

Forty-seven with excellent performance
Thirty-nine with very good performance
Twenty with good performance
Three with fair performance
One with poor performance

Additionally, nine days with non proper data

One experimental day

Number of seeded clouds: 228
(75 small seeded clouds, 75 large seeded clouds, 78 type B seeded clouds, and 6 npf))

Missed Opportunities: 6 (~ 3 % of the seedable conditions)

Small Clouds

Table 2 shows the results from the classic TITAN evaluation for the 75 small seeded clouds which obtained proper control clouds.

Table 2: Seeded Sample versus Control Sample (72 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	65 min	45 min	1.44	44 (**35**)
Area	65.9 km^2	45.4 km^2	1.45	45 (**29**)
Volume	193.0 km^3	119.6 km^3	1.61	61 (**43**)
Top Height	8.4 km	7.7 km	1.08	8 (**3**)
Max dBz	53.2	51.3	1.04	4 (**2**)
Top Height of max dBz	4.2 km	4.3 km	0.98	- 2 (**0**)
Volume Above 6 km	45.0 km^3	22.2 km^3	2.03	103 (**76**)
Prec.Flux	520.2 m^3/s	313.3 m^3/s	1.66	66 (**55**)
Prec.Mass	2314.3 kton	997.6 kton	2.32	132 (**107**)
CloudMass	156.0 kton	91.6 kton	1.70	70 (**42**)
η	14.8	10.9	1.36	36 (**45**)

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 **368 flares** were used in this sub-sample with an excellent timing (**86 %),** for an effective dose near **115 ice-nuclei per liter,** which might have reached slightly higher levels in some individual cells. An excellent increase of 107 % in precipitation mass together with an increase of 42 % 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 (35 %), area (29 %), volume (43 %), volume above 6 km (76 %), and precipitation flux (55 %) are notable. There are slight increases in maximum reflectivity (2 %), and in top height (3 %). The seeded sub-sample seemed 45 % more efficient than the control sub-sample. Results are evaluated as **excellent** for this sub-sample.

An increase of 107 % in precipitation mass for a control value of 997.6 kton in 75 cases means:

Δ_1 = 75 x 1.07 x 997.6 kton = 80 057 kton = 64 927 ac-f

Large Clouds

The sub-sample of 75 large seeded clouds received a synergetic analysis. In average the seeding operations on these large clouds affected 58 % of their whole volume, with an excellent timing (94 % of the material went to the clouds in their first half-lifetime). A total of **1096 flares** were used in this sub-sample for an effective dose near **95 ice-nuclei per liter**.

Also in average, large clouds were 30 minutes old when the operations took place; the operation lasted about 40 minutes, and the large seeded clouds lived 195 minutes (3 hours and 15 minutes).

Table 3 shows the corresponding results:

Table 3. Large Seeded Sample versus Virtual Control Sample (75 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	195 min	155 min	1.26	26
Area	1025 km^2	839 km^2	1.22	22
Volume	4030 km^3	3185 km^3	1.27	27
Volume Above 6 km	1208 km^3	904 km^3	1.34	34
Prec.Flux	10958 m^3/s	8502 m^3/s	1.29	29
Prec.Mass	96 205 kton	65 952 kton	1.46	46

An increase of 46 % in precipitation mass for a control value of 65 952 kton in 75 cases may mean:

Δ_2 = 75 x 0.46 x 65 952 kton = 2 275 344 kton = 1 845 304 ac-f

Type B Clouds

The sub-sample of 78 type B seeded clouds also received a synergetic analysis.
In average the seeding operations on these type B clouds affected 26 % of their whole volume with a very good timing (71 % of the material went to the clouds in their first half-lifetime). A total of **1372 flares** were used in this sub-sample for an effective dose near **95 ice-nuclei per liter.** .

Also in average, type B clouds were 140 minutes old when the operations took place; the operation lasted about 40 minutes, and the type B seeded clouds lived 295 minutes (4 hours and 55 minutes)

Table 4 shows the results:

Table 4. Type B Seeded Sample versus Virtual Control Sample (78 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	295 min	270 min	1.09	9
Area	2343 km^2	2191 km^2	1.07	7
Volume	8289 km^3	7581 km^3	1.09	9
Volume Above 6 km	2161 km^3	1896 km^3	1.14	14
Prec.Flux	19801 m^3/s	18250 m^3/s	1.08	8
Prec.Mass	162 303 kton	140 714 kton	1.15	15

An increase of 15 % in precipitation mass for a control value of 140 714 kton in 78 cases may mean:

Δ_3 = 78 x 0.15 x 140 714 kton = 1 646 354 kton = 1 335 193 ac-f

The total increase: $\Delta = \Delta_1 + \Delta_2 + \Delta_3$ = 3 245 424 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 Seeding	Initial Seeding	Extended (increase)	Acre-feet (increase)	Inches (increase)	Rain gage (season value)	% (increase)
Armstrong	**13**	**21**	**177 900**	**3.65**	**17.7 in**	**20.6**
Carson	**12**	**22**	**195 500**	**3.97**	**14.3 in**	**27.8**
Donley	**6**	**10**	**126 100**	**2.54**	**21.0 in**	**12.1**
Gray	**10**	**18**	**141 800**	**2.86**	**19.6 in**	**14.6**
Potter	**9**	**12**	**174 000**	**3.58**	**15.1 in**	**23.7**
Roberts	**2**	**8**	**84 700**	**1.72**	**17.9 in**	**9.6**
Wheeler	**4**	**6**	**41 600**	**0.85**	**21.1 in**	**4.0**
Hemphill		3	70 600			
Hutchinson	3	6	79 000			
Moore	1	2	37 800			
Randall	2	5	69 000			
Glascock	**12**	**16**	**140 700**	**2.93**	**23.20 in**	**12.6**
Sterling	**15**	**19**	**134 200**	**2.72**	**22.70 in***	**12.0**
Reagan	**15**	**22**	**167 000**	**2.66**	**18.89 in**	**14.1**
Irion	**16**	**31**	**248 300**	**4.43**	**20.80 in**	**21.3**
Tom Green	**10**	**22**	**193 800**	**4.78****	**28.57 in**	**16.8**
Crocket	**9**	**17**	**123 200**	**0.81**	**28.40 in**	**2.8**
Schleicher	**10**	**17**	**102 600**	**1.47**	**26.49 in**	**5.5**

Sutton	**8**	**15**	**76 400**	**0.99**	**26.65 in**	**3.7**
Coke		4				
Medina	**8**	**9**	**14 600**	**0.21**	**30.26 in**	**0.7**
Frío	**3**	**5**	**17 200**	**0.28**	**19.77 in**	**1.4**
Bexar	**4**	**5**	**9 600**	**0.37**	**21.84 in**	**1.7**
Atascosa	**5**	**9**	**13 200**	**2.04**	**21.41 in**	**9.5**
McMullen	**1**	**4**	**3 400**	**1.32**	**21.66 in**	**6.1**
Wilson	**4**	**6**	**15 400**	**1.02**	**20.19 in**	**5.1**
Karnes	**8**	**11**	**30 300**	**2.70**	**17.52 in**	**15.4**
Live Oak	**5**	**7**	**50 500**	**0.91**	**21.24 in**	**4.3**
Bee	**2**	**3**	**3 800**	**0.81**	**15.05 in**	**5.4**
Goliad		2	2 000			
Uvalde	**6**	**8**	**40 200**	**0.48**	**19.72 in**	**2.4**
Zavala	**6**	**8**	**20 100**	**0.29**	**16.94 in**	**1.7**
Dimmit	**5**	**11**	**19 000**	**0.27**	**19.19 in**	**1.4**
La Salle	**9**	**10**	**50 400**	**0.62**	**21.26 in**	**2.9**
Webb	**3**	**7**	**30 000**	**0.17**	**16.70 in**	**1.0**
Total	**228**	**381**	**2 740 600**			
Average				**1.77 in**	**20.87 in**	**9.2 %**

Final Comments

Results are evaluated as **excellent** despite the relative scarcity of seedable conditions (see last comment in this page). The main problem detected was the loss of radar data (5 operational days did not get proper files);

The micro-regionalization analysis showed increases per county; the average increase in precipitation, referred to an average seasonal value, is slightly above **9 %**;

Radar estimations of precipitation should be considered as measurements of trend. Nevertheless, **seeding operations appeared to improve the dynamics of seeded clouds**.

Season 2007 was very atypical over the target areas in Texas due to an anomalous location of the sub-tropical jet stream during the early spring which in turn produced strong Pineapple Connection of Pacific Ocean moisture, whereas, in June, the long presence of an Upper Level Low over North Texas added even more atypical conditions. Tropical Storm Erin (August), in dissipation, also was an important factor. These patterns explain why the seedable conditions were relatively scarce in comparison with season 2006 (details in **"2007 Midseason Cloud Seeding Briefing"**: **The Texas Weather Modification *Courier***, Volume 1, Issue 2, August 15, 2007, page 4).