ANNUAL EVALUATION REPORT 2005 **State of Texas**

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Cloud seeding operations 2005 began over Texas Weather Modification target area in February. This annual report serves as a summary of results. A total of **494 clouds** were seeded and identified by TITAN in **184 target area operational days**. Table 1 in page 1 summarizes the general figures:

Table 1 Generalities

First operational day: **February 22nd, 2005 (WTWMA)**
Last operational day: **October 31st, 2005 (SWTREA and STWMA))**

Number of operational days: 184 (175 over Texas)

According to the daily reports operational days were qualified as:

Forty-five with excellent performance
Sixty-seven with very good performance
Fifty-six with good performance
Ten with fair performance
Six with poor performance

Thirty-one with non proper data

Number of seeded clouds: 494
(219 small seeded clouds, 146 large seeded clouds, 111 type B seeded clouds, and 18 npf))

Missed Opportunities: 9 (1.8 % of the seedable conditions)

Small Clouds

Table 2 shows the results from the classic TITAN evaluation for the 219 small seeded clouds which obtained proper control clouds.

Table 2: Seeded Sample versus Control Sample (219 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	70 min	45 min	1.55	55 (**57**)
Area	63.0 km^2	38.7 km^2	1.63	63 (**29**)
Volume	175.8 km^3	129.7 km^3	1.36	36 (**30**)
Top Height	7.8 km	7.4 km	1.05	5 (**3**)
Max dBz	50.0	49.5	1.01	1 (**2**)
Top Height of max dBz	4.5 km	4.6 km	0.98	- 2 (**-4**)
Volume Above 6 km	17.3 km^3	15.2 km^3	1.14	14 (**40**)
Prec.Flux	422.6 m^3/s	306.5 m^3/s	1.38	38 (**32**)
Prec.Mass	1687.7 kton	827.1 kton	2.04	104 (**88**)
CloudMass	140.6 kton	101.0 kton	1.39	39 (**35**)
η	12.0	8.2	1.46	46 (**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 865 flares were used in this sub-sample with an excellent timing **(81 %),** for an effective dose near **75 ice-nuclei per liter,** which might have reached higher levels in some individual cells. A very good increase of 88 % in precipitation mass together with an increase of 35 % 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 (57 %), area (29 %), volume (30 %), volume above 6 km (40 %), and precipitation flux (32 %) are notable. There are slight increases in maximum reflectivity (2 %), and in top height (3 %). The seeded sub-sample seemed 40 % more efficient than the control sub-sample. Results are evaluated as very good for this sub-sample.

An increase of 88 % in precipitation mass for a control value of 827.1 kton in 219 cases means:

Δ_1 = 219 x 0.88 x 827.1 kton = 159 399 kton = 129 272 ac-f

Large Clouds

The sub-sample of 146 large seeded clouds received a synergetic analysis. In average the seeding operations on these large clouds affected 65 % of their whole volume, with an excellent timing (90 % of the material went to the clouds in their first half-lifetime). A total of 1967 flares were used in this sub-sample for an effective dose near **95 ice-nuclei per liter**.

Also in average, large clouds were 25 minutes old when the operations took place; the operation lasted about 45 minutes, and the large seeded clouds lived 225 minutes (3 hours and 45 minutes).

Table 3 shows the corresponding results:

Table 3. Large Seeded Sample versus Virtual Control Sample (146 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	225 min	180 min	1.25	25
Area	940 km^2	855 km^2	1.10	10
Volume	3308 km^3	2827 km^3	1.17	17
Volume Above 6 km	1125 km^3	893 km^3	1.26	26
Prec.Flux	6923 m^3/s	5818 m^3/s	1.19	19
Prec.Mass	66 458 kton	47 133 kton	1.41	41

An increase of 41 % in precipitation mass for a control value of 47 133 kton in 146 cases may mean:

Δ_2 = 146 x 0.41 x 47 133 kton = 2 821 381 kton = 2 288 140 ac-f

Type B Clouds

The sub-sample of 111 type B seeded clouds received a synergetic analysis. However, 5 of them were seeded during their senescence periods and did not offer any reaction. In average the seeding operations on these type B clouds affected 30 % of their whole volume, with a good timing (60 % of the material went to the clouds in their first half-lifetime). A total of 1551 flares were used in this sub-sample for an effective dose near **105 ice-nuclei per liter.** .

Also in average, type B clouds were 110 minutes old when the operations took place; the operation lasted near 45 minutes, and the type B seeded clouds lived 275 minutes (4 hours and 35 minutes)

Table 4 shows the results:

Table 4. Type B Seeded Sample versus Virtual Control Sample (106 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	275 min	255 min	1.08	8
Area	1676 km^2	1566 km^2	1.07	7
Volume	5513 km^3	5105 km^3	1.08	8
Volume Above 6 km	1188 km^3	1100 km^3	1.08	8
Prec.Flux	11822 m^3/s	10846 m^3/s	1.09	9
Prec.Mass	91 678 kton	79 033 kton	1.16	16

An increase of 16 % in precipitation mass for a control value of 79 033 kton in 106 cases may mean:

Δ_3 = 106 x 0.16 x 79 033 kton = 1 340 400 kton = 1 087 064 ac-f

The total increase: $\Delta = \Delta_1 + \Delta_2 + \Delta_3$ = 3 504 476 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)
Dallam	**9**	**11**	**33 500**	**0.42**	**10.40 in**	**4.0**
Hartley	**9**	**11**	**79 900**	**1.02**	**10.34 in**	**9.9**
Oldham	2	5	51 000	0.64		
Sherman	**7**	**12**	**66 350**	**1.35**	**12.11 in**	**11.2**
Moore	**7**	**11**	**39 900**	**0.83**	**9.54 in**	**8.7**
Potter		4	24 650	0.51		
Hansford	**6**	**9**	**40 000**	**0.82**	**9.35 in**	**8.8**
Hutchinson	**3**	**6**	**12 900**	**0.27**	**16.81 in**	**1.6**
Ochiltree	**5**	**6**	**17 800**	**0.36**	**14.32 in**	**2.5**
Gray		1	4 000	0.08		
Limpscomb	**1**	**4**	**42 000**	**0.84**	**21.16 in**	**4.0**
Moore	2	2	570	0.01		
Potter	**4**	**5**	**13 450**	**0.28**	**10.34 in**	**2.7**
Randall	3	4	6 450	0.13		
Hutchinson	2	4	54 500	1.15		
Carson	**4**	**11**	**39 100**	**0.79**	**7.41 in**	**10.7**
Armstrong	**2**	**5**	**2 950**	**0.06**	**7.75 in**	**0.8**
Roberts	**4**	**7**	**66 250**	**1.34**	**10.11 in**	**13.3**

Gray	**3**	**7**	**68 750**	**1.39**	**7.16 in**	**19.4**
Donley	**2**	**2**	**48 200**	**0.97**	**7.81 in**	**12.4**
Hemphill	2	5	5 700	0.12		
Wheeler	**3**	**6**	**32 900**	**0.67**	**8.34 in**	**8.0**
Gaines	**3**	**5**	**15 600**	**0.19**	**9.0**	**2.0**
Yoakum	**3**	**3**	**5 500**	**0.13**	**13.4**	**1.0**
Terry	**4**	**5**	**7 300**	**0.15**	**11.21**	**1.3**
Cochran			4 900			
Dawson			1 200			
Hockley			1 800			
Roosevelt	**6**	**7**	**29 500**	**0.23**	**8.23**	**2.8**
Lea	**17**	**18**	**138 500**	**0.59**	**6.08**	**9.7**
Glascock	**8**	**13**	**168 300**	**3.10**	**18.69 in***	**16.6**
Sterling	**14**	**21**	**191 100**	**3.90**	**23.89 in**	**16.3**
Reagan	**14**	**23**	**163 700**	**2.61**	**15.06 in***	**17.3**
Irion	**17**	**25**	**188 700**	**3.36**	**17.92 in***	**18.8**
Tom Green	**14**	**26**	**99 600****	**2.46**	**19.82 in**	**12.4**
Crocket	**26**	**38**	**248 500**	**1.66**	**11.42 in**	**14.5**
Schleicher	**25**	**35**	**106 200**	**1.52**	**27.01 in**	**5.6**
Sutton	**13**	**20**	**82 500**	**1.06**	**20.43 in**	**5.2**
Coke	1	2	9 000			
Menard	1	1	100			
Bandera	**13**	**15**	**9 000**	**0.21**	**15.93 in**	**1.3**

Medina	**13**	**18**	**47 300**	**0.67**	**8.30 in**	**8.1**
Frío	**13**	**20**	**38 400**	**0.65**	**9.78 in***	**6.6**
Bexar	**6**	**12**	**41 200**	**0.62**	**9.48 in**	**6.5**
Atascosa	**21**	**23**	**42 600**	**0.65**	**11.35 in**	**5.7**
McMullen	**19**	**24**	**91 600**	**1.54**	**10.29 in**	**15.0**
Wilson	**11**	**16**	**30 000**	**0.70**	**9.49 in***	**7.4**
Karnes	**12**	**17**	**82 500**	**2.06**	**10.81 in**	**19.1**
Live Oak	**21**	**27**	**95 100**	**1.72**	**11.45 in**	**15.0**
Bee	**25**	**31**	**104 800**	**2.23**	**12.55 in**	**17.8**
Goliath	1	1	550	0.01		
Guadalupe	1	1	350	0.01		
Uvalde	**16**	**18**	**85 600**	**1.03**	**6.02 in**	**17.1**
Zavala	**19**	**23**	**165 500**	**2.39**	**9.64 in**	**24.8**
Dimmit	**18**	**23**	**101 000**	**1.42**	**6.54 in**	**21.7**
La Salle	**20**	**26**	**119 300**	**1.50**	**8.37 in**	**17.9**
Webb	**19**	**21**	**160 500**	**0.90**	**9.43 in**	**9.5**
Total	**494**	**696**	**3 428 120 ac-f**			
Average				**1.18 in**	**11.97 in**	**10.1 %**

Final Comments

Results are evaluated as **excellent**. The main problem detected was the loss of radar data (31 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 about **10.1 %**;

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