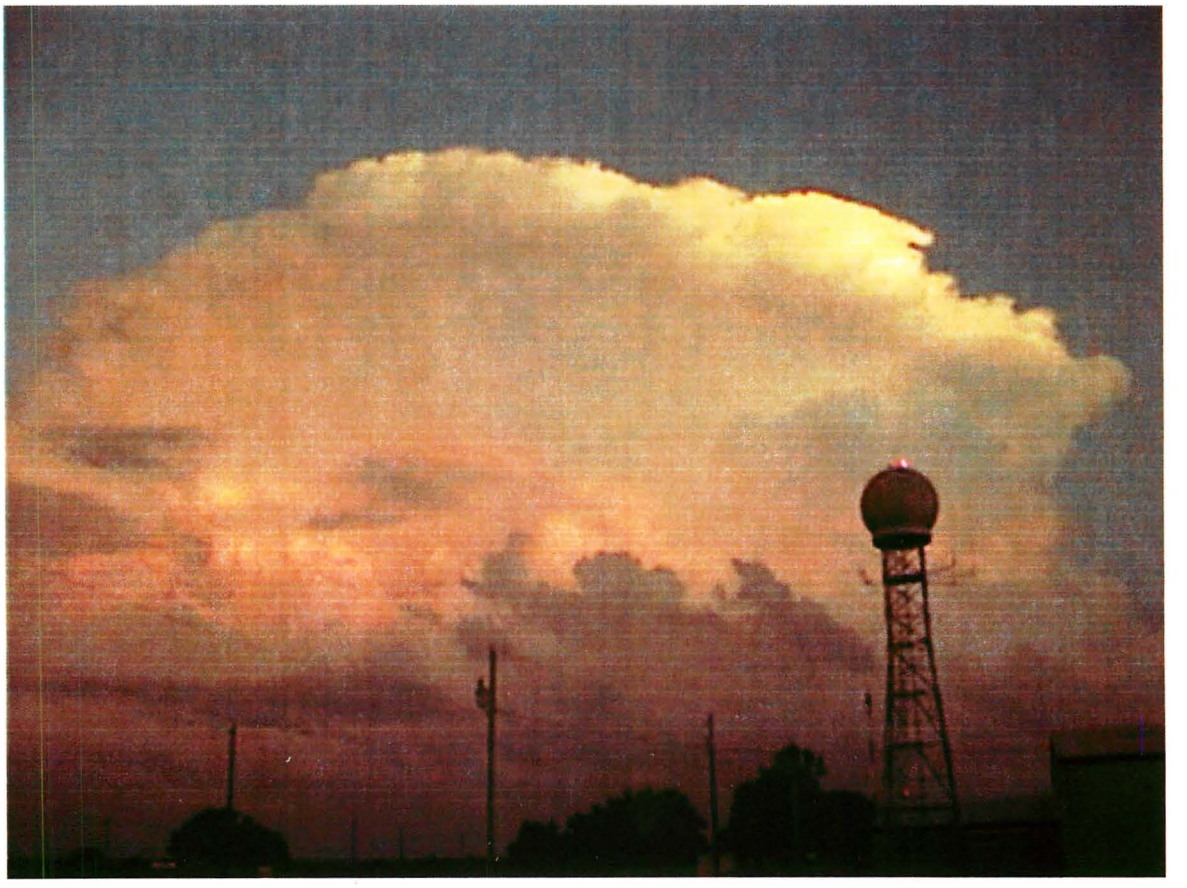
SOUTH TEXAS WEATHER MODIFICATION ASSOCIATION

EDWARDS AQUIFER AUTHORITY TARGET AREA



2004 REPORT

2004 FINAL REPORT

for the

SOUTH TEXAS WEATHER MODIFICATION ASSOCIATION

EDWARDS AQUIFER AUTHORITY TARGET AREA

by

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THE YEAR IN REVIEW

2004 marked the third year of operations for the Edwards Aquifer Authority (EAA) by the STWMA. As was the case in 2002 and 2003, one plane, N57AA, was stationed at Stinson Field (SSF) in south San Antonio. Two of our pilots, Ron Merks and Mickey Chadwell, were stationed there. They worked along with Jim Transue and Tim Pickens, stationed at Pleasanton, and Larry Dement, stationed at Kenedy. Occasionally the other pilots helped out with seeding in the EAA target area, henceforth referred to as the target area.

2004 turned out to be a good year for seeding in the target area, with 20 days of seeding. This compares with 22 days of seeding in 2003, and only 8 in 2002. May turned out to have a few convective events, none of which were seeded due either to storms occurring at night or the location of the storms over the city of San Antonio. The first seeding mission of the year took place on June 7th, when a surge of tropical moisture brought waves of showers and thunderstorms northward across the area. June ended up being a very wet month, so wet in fact, that a temporary suspension was put in place for the last few days of June due to excessive rainfall and numerous Flash Flood Warnings being issued. The remainder of the year saw some good activity with October 27th being the final day of seeding within the target area. A brief discussion on the meteorological perspective of the seeding events will be presented later in the report.

Once the season concluded, Archie Ruiz, who works for Active Influence performing radar evaluations for the Texas weather modification projects, completed the radar evaluation of the program. Once again, it appears that seeding produced favorable increases in rainfall, with apparent lifetime extensions in the seeded clouds along with other positive results. These numbers are presented and discussed towards the end of the report.

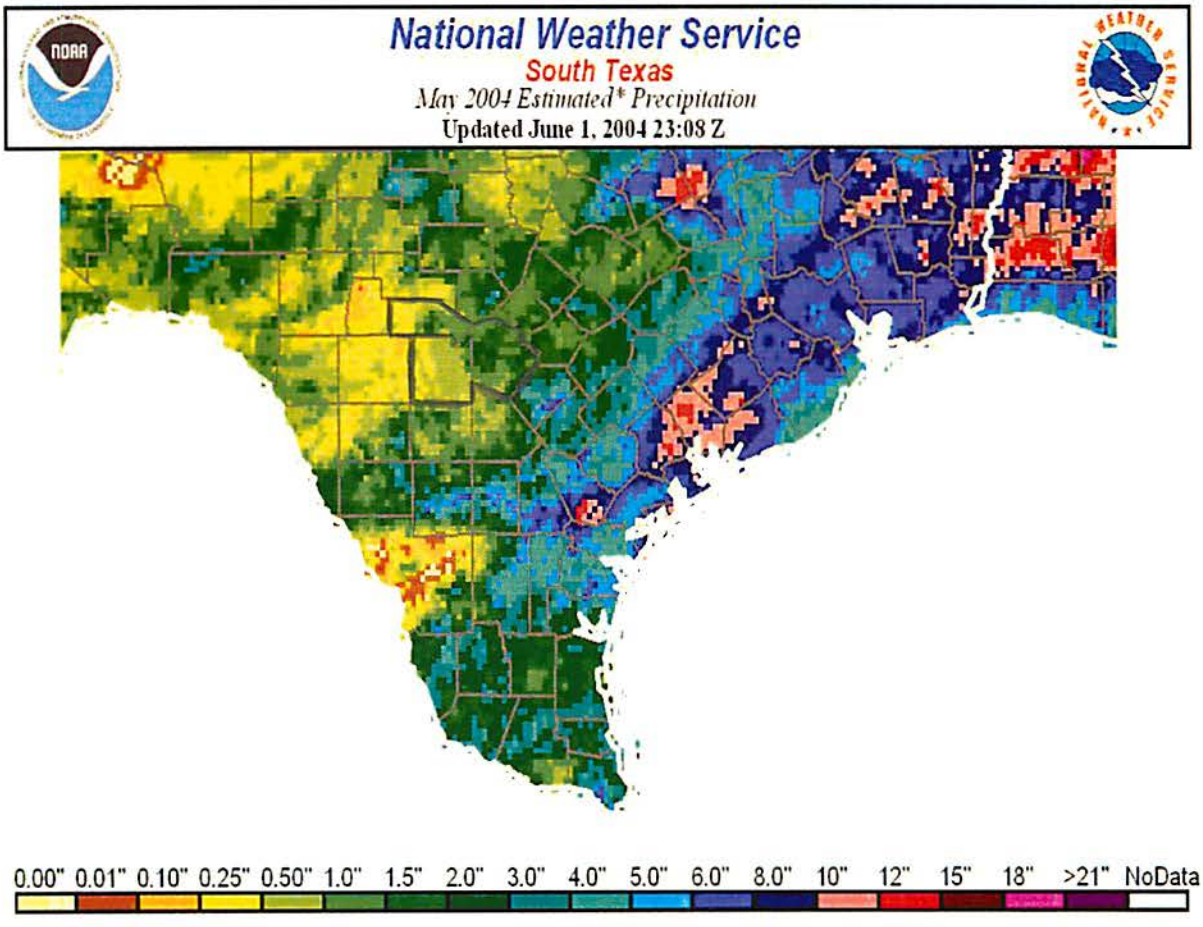
As was mentioned in the 2003 annual report, the weather modification projects in Texas now have a contract with Weather Decision Technologies, Inc., based out of Norman, Oklahoma. The company provides the projects with live NEXRAD feeds from the various National Weather Service offices nearest to their respective target areas. For the target area, a feed from the WSR-88D radar at New Braunfels (KEWX) is used. The WSR-74C radar at the Pleasanton Municipal Airport is still used in conjunction with the NEXRAD data, and this secondary radar data may be analyzed in the near future to determine any possible differences.

2004 FLIGHT LOG FOR EDWARDS AQUIFER AUTHORITY TARGET AREA

Date	Plane	Flight No.	Take Off Time	Landing Time	Total Time	No. Flares Used	Amount of Agl (g)	Flare Locations
7-Jun	7AA	1	19:45	22:26	2.7	13	520	Bandera - 4; Bexar - 2; Medina - 7
23-Jun	47P	2	22:28	1:09	2.7	5	200	Medina - 5
24-Jun	7AA	3	18:40	22:40	4	17	760	Bandera - 4; Bexar - 3; Medina - 10
26-Jun	7AA	4	21:05	22:17	1.2	8	320	Bexar - 1; Medina - 7
27-Jun	7AA	5	22:10	23:20	1.2	7	280	Medina - 7
10-Jul	7AA	6	18:20	20:20	2	9	360	Bexar - 5; Medina - 4
11-Jul	7AA	7	20:05	23:18	3.2	19	760	Bandera - 6; Bexar - 12; Medina - 1
23-Jul	60P	8	18:30	22:00	3.5	10	400	Medina - 10
25-Jul	7AA	9	20:45	23:10	2.4	4	160	Bandera - 4
29-Jul	7AA	10	21:55	22:44	0.8	-	-	Recon mission over Bandera County
2-Aug	47P	11	22:54	0:42	1.8	10	400	Bandera - 9; Medina - 1
6-Aug	7AA	12	20:20	23:06	2.8	16	640	Bandera - 2; Bexar - 3; Medina - 11
18-Aug	7AA	13	22:25	0:38	2.2	1	40	Bexar - 1
22-Aug	47P	14	20:00	23:12	3.2	3	120	Medina - 3
28-Aug	47P	15	22:20	0:21	2	11	440	Bandera - 1; Bexar - 6; Medina - 4
29-Aug	47P	16	21:30	1:08	3.6	5	400	Medina - 5
31-Aug	47P	17	19:15	21:57	2.7	9	360	Bandera - 2; Medina - 7
4-Sep	47P	18	18:05	21:43	3.6	-	-	Recon mission in STWMA area, also Medina County
22-Sep	7AA	19	20:15	22:35	2.3	8	320	Bandera - 2; Bexar - 2; Medina - 4
23-Sep	7AA	20	21:45	23:48	2.1	6	240	Bandera - 4; Medina - 2
6-Oct	7AA	21	18:45	21:22	2.6	3	200	Medina - 3
27-Oct	7AA	22	21:25	21:57	0.5	2	80	Bexar - 2
Totals:		**22 flights**			**53.1**	**166**	**7000**	**Bandera - 38; Bexar - 37; Medina – 91**

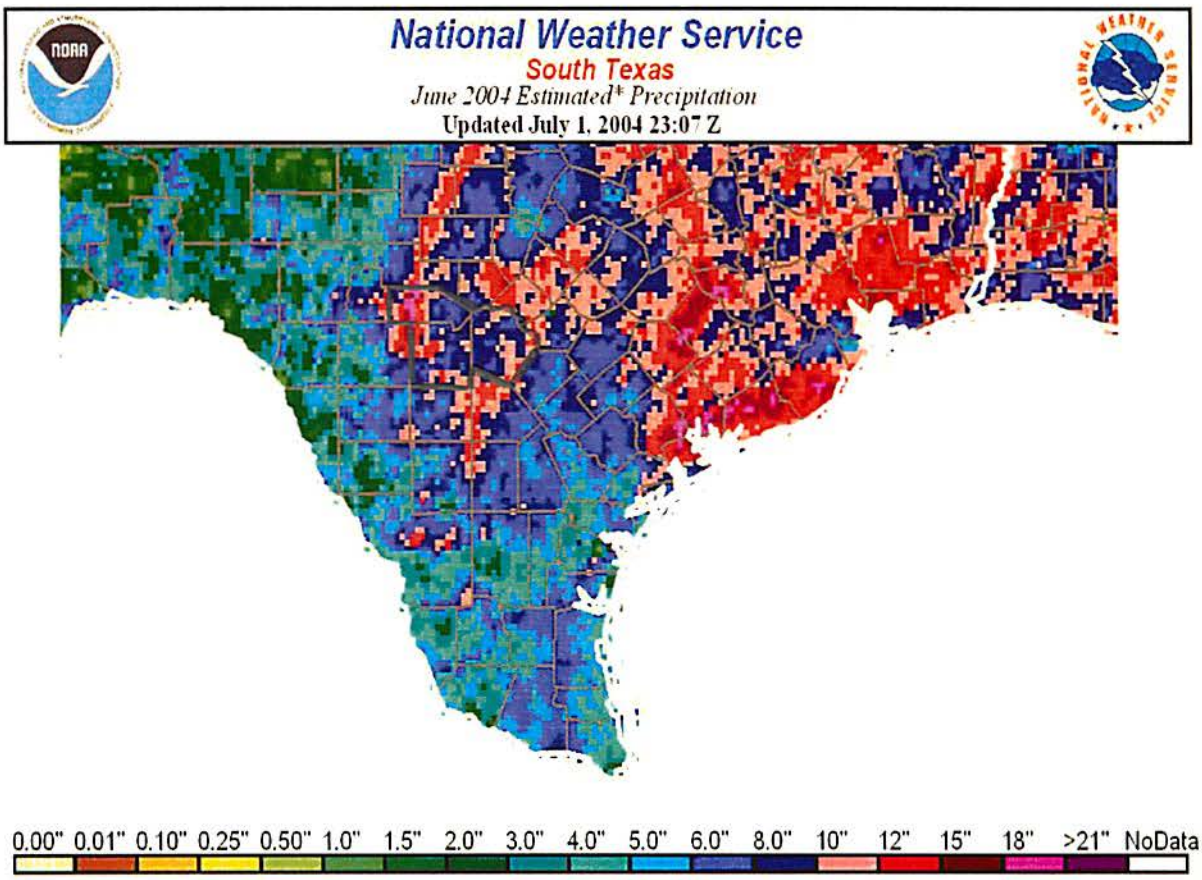
MAY 2004

May saw the end of the wet spring pattern that south Texas had been experiencing in 2004. High pressure was in control for the first week of the month, and as such, the weather remained tranquil. An upper low in the desert southwest began to impact our weather on the 7th, helping to bring in lots of low- and mid-level moisture as well as sending impulses of energy across the area. There was a bit of activity over central Bexar County on the 7th, but the storm remained within the flight pattern of San Antonio International, preventing any seeding from taking place. Additional activity occurred on the 13th, but cloud bases were extensive and very low, thus preventing flights from taking place. From mid-month on, high pressure regained control, and no precipitation occurred through the rest of the month in Bandera, Bexar and Medina counties. The month ended on a scorching note, with a dryline crossing the area, resulting in a record high of 104°F at San Antonio International.



JUNE 2004

Unlike May, June turned out to be a very wet month for the target area, particularly over the last 10 days of the month. There were plenty of seedable clouds this month; however, some situations did not permit seeding to take place. Very low ceilings on June 8th prevented flights in the target area. Flash Flood Warnings on June 9th eliminated any possibility of seeding. On June 15th, a storm sat over the Randolph airspace, which was not accessible. Then, during the last week of June, a situation set up that produced a prolonged period of excessive rainfall. Texas sat between two areas of high pressure, with a trough of low pressure over the state. With moisture coming in off the Gulf at low levels and Pacific moisture streaming in off the Pacific, all ingredients were in place for daily waves of showers and thunderstorms. Early on in this period, there was seeding, but as the ground became saturated and rivers rose, seeding operations were halted. The month ended on a wet note. Overall, 8-12 inches of rain fell across the target area, with locally higher amounts.



JUNE 7

Deep south and southeasterly flow overspread south Texas today, aided by high pressure in the Gulf and a digging trough in the western states. This allowed for a plume of tropical moisture to surge northward out of Mexico. Waves of showers and thunderstorms moved northward across the area during the afternoon hours. 7AA was launched at mid-afternoon to seed these convective cells, using 40g flares for seeding. 4 flares burned in Bandera County, 2 flares burned in Bexar County, and 7 flares burned in Medina County. Total AgI used was 520g.

JUNE 23

Unlike the past few mornings, skies were clear to partly cloudy to start. With abundant tropical moisture in place and sufficient heating to act on the moisture and various boundaries, popcorn-type showers began to develop near the noon hour, particularly in the vicinity of the circulation near Gonzales. It was not until evening before any activity would affect the target area. Just as it appeared all convection was beginning to wind down, new convection rapidly developed across the western target area about an hour before sunset, with some of this activity in Medina County being seeded. This activity lasted beyond sunset. Five 40g flares were burned in Medina County. Total AgI used was 200g.

JUNE 24

As had been the case for the past few days, south Texas was under the influence of a very warm and moist airmass, with a trough of low pressure across the central part of the state. Showers began to develop near a low-level circulation in the vicinity of Kerrville, with a general east-southeast drift. A flight was launched to investigate developing activity near Medina Lake, which eventually grew and elongated along what appeared to be an old outflow boundary. This activity was seeded, with a favorable response apparent on radar (high reflectivities, good cloud size). Additional cells developed near Stinson Field in south Bexar County, which was also seeded and appeared to respond favorably. With the loss of daytime heating, most activity diminished after 0000 UTC (7pm CDT). 40g flares and two 80g flares were used for seeding. 4 flares (two of which were 80g) were burned in Bandera County, 3 flares were burned in Bexar County, and 10 flares were burned in Medina County. Total AgI used was 760g.

JUNE 26

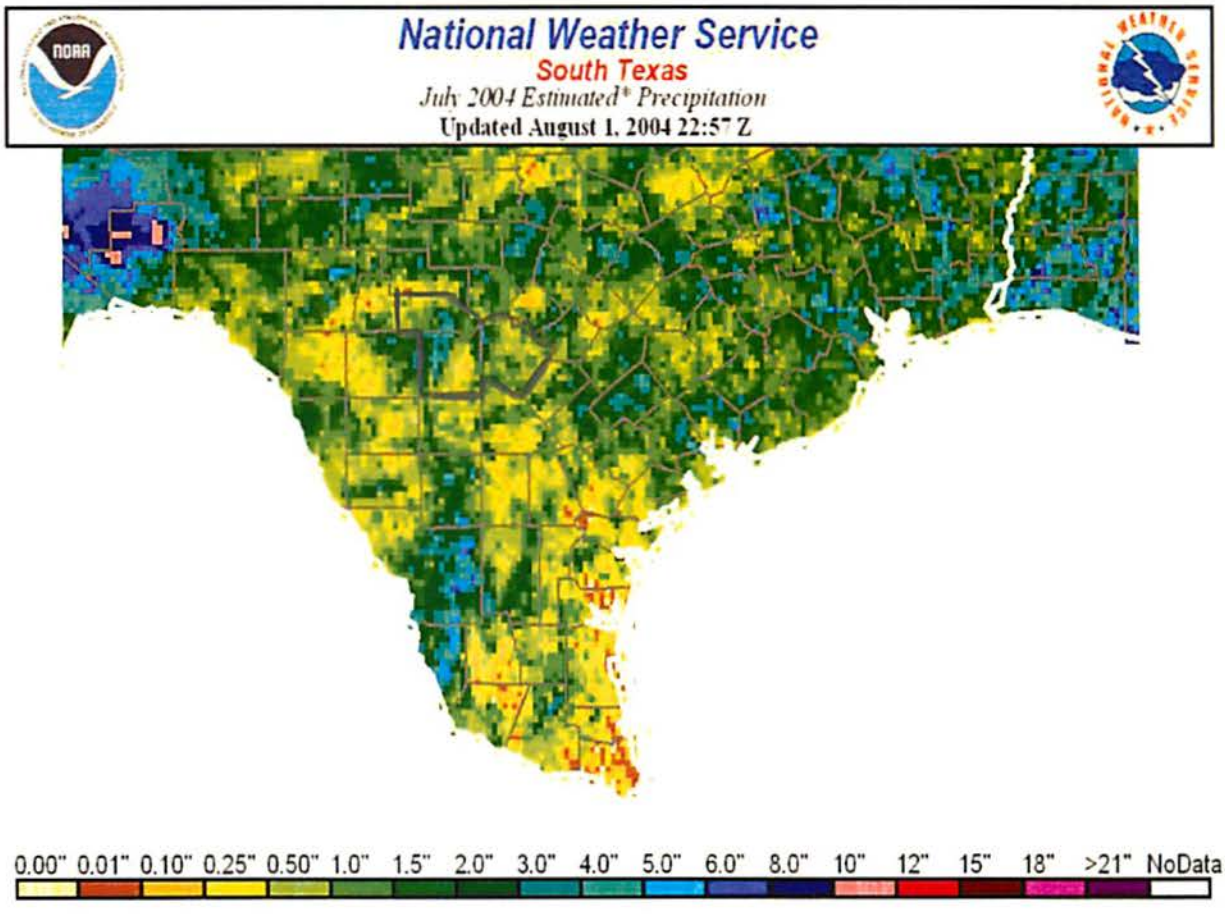
An upper level low was situated over Burnet County, north of San Antonio. Convection from the previous day left plenty of outflow boundaries across the area, as had been the case for the past few days. With some daytime heating, showers and thunderstorms began to develop near the circulation and along an old outflow boundary across the northern end of the target area. A flight was launched to investigate the activity around mid-afternoon. With good inflow located, several flares were burned. The activity increased in size and intensity, and a Flash Flood Warning was issued for all three EAA counties. As such, the mission was terminated. 40g flares were used for seeding, with one flare burned in Bexar County, and 7 flares burned in Medina County. Total AgI used was 320g.

JUNE 27

With daytime heating acting on the outflow boundaries lying around the area, a few showers and eventually thunderstorms developed south of the target area. Initial convection developed down near Cotulla and moved northward into Frio County, which was seeded. As this first shower began to dissipate, new convection developed in front of it and began to intensify, so a second flight was launched to treat the cloud. The activity developed further into Medina County, with seeding continuing. This activity eventually became part of a developing cluster of thunderstorms that went on to sustain themselves long into the night over the northwestern third of the target area. Seven 40g flares were burned in Medina County. Total AgI used was 280g.

JULY 2004

After a very wet and near record-breaking June, July almost became one of the driest on record. The first half of the month saw only a couple days with rain across the target area, with two days of seeding before mid-month. The latter half of the month was more active, mainly because of the unusual eastern trough/western ridge setup, allowing for cold fronts to make it this far south in the northerly/northwesterly flow aloft. There were plenty of days with rain, some of which occurred at night. Two more seeding missions took place during the latter half of July. Overall for the month, there were four missions plus one recon flight, with a total of 42 flares burned over the target area (Bandera - 10; Bexar - 17; Medina - 15). Total AgI used was 1680g.



JULY 10

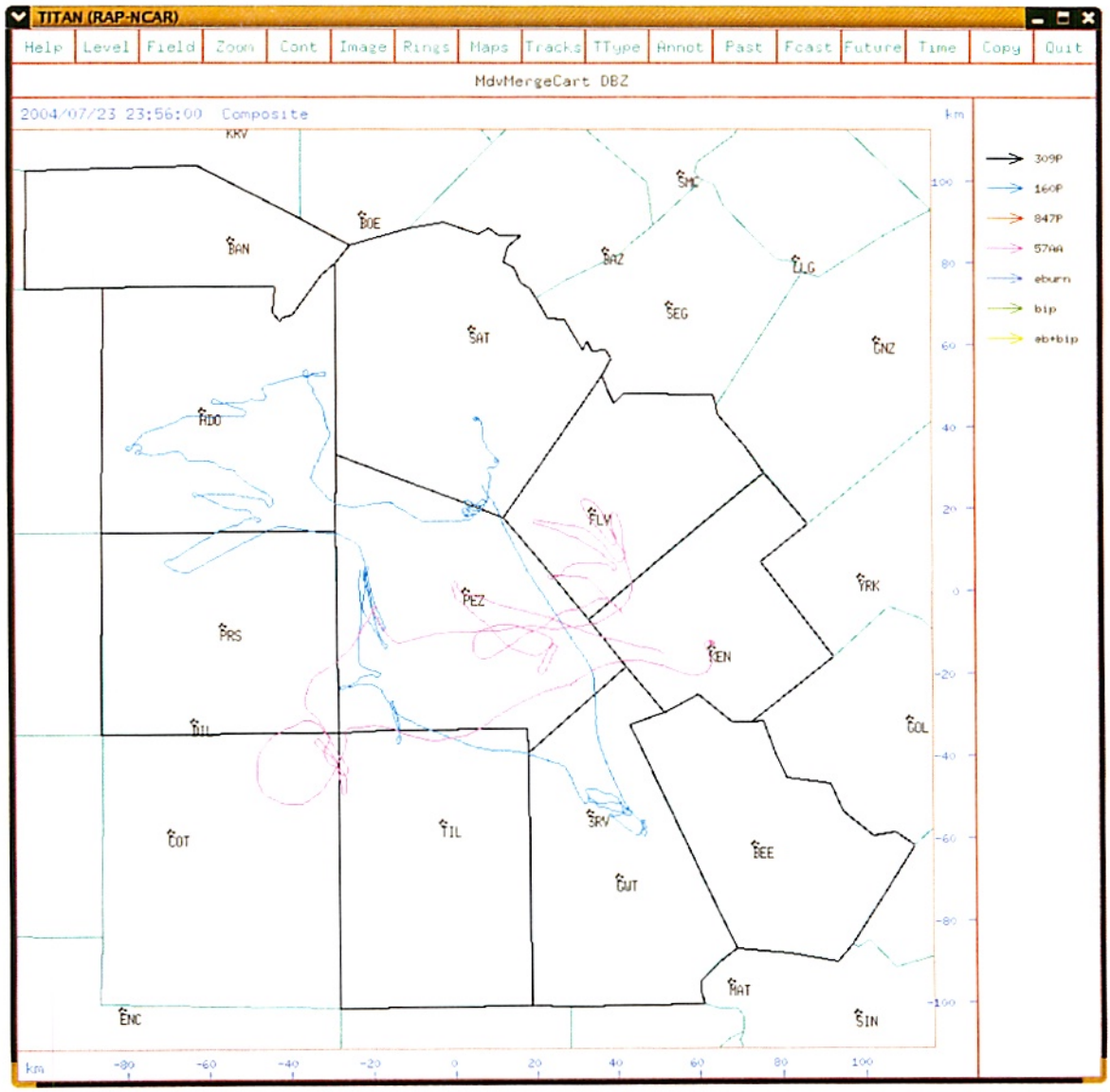
An upper level low, which originally entered the state near Houston, slowly pushed southwestward over the course of a few days, eventually making a second landfall near Brownsville. As the axis of the low/trough pushed west of the area, we began to see the influence of the ascension flank of the low, with rising motion accompanied by a surge of tropical moisture pushing in from the Gulf. This surge of moisture initiated a seabreeze-type boundary, which pushed inland to the northwest at about 25 mph. Showers and thunderstorms developed along and behind this boundary as the effects of daytime heating began to be realized. A flight was launched early in the afternoon as it began to enter the southern part of Bexar County. Seeding of this activity took place over Bexar and Medina counties. The activity appeared to react well to the seeding, which eventually exited the target area late in the afternoon. Nine 40g flares were burned (Bexar - 5; Medina - 4), totaling 360g of AgI.

JULY 11

The upper low responsible for yesterday's convection was a little further to the west, in north-central Mexico. Right behind it, a tropical wave crossed the coast in northern Mexico/southern Texas and continued to push westward, with the target area entering the more favorable east side of the trough axis by mid-afternoon. Morning showers that approached the target area appeared to die off before entering...at least until mid-afternoon, when showers began to develop with the peak in daytime heating arriving. 7AA was launched to treat several cells, albeit weak, that developed across Bexar and Medina counties during mid-afternoon. It wasn't until late afternoon before more significant cells began to develop, first in Bexar County. 7AA seeded this activity, which fared well as it pushed northwestward into eastern Bandera County. Then, additional activity began to develop in Atascosa and Wilson counties, pushing northwest into southern Bexar County. 7AA fired several flares at once in between some of these developing cells. These cells merged into one large thunderstorm, which moved across San Antonio and headed towards Medina Lake, dropping over an inch of rain in a short period of time. Nineteen 40g flares were burned over the target area (Bandera - 6; Bexar - 12; Medina - 1), totaling 760g of AgI.

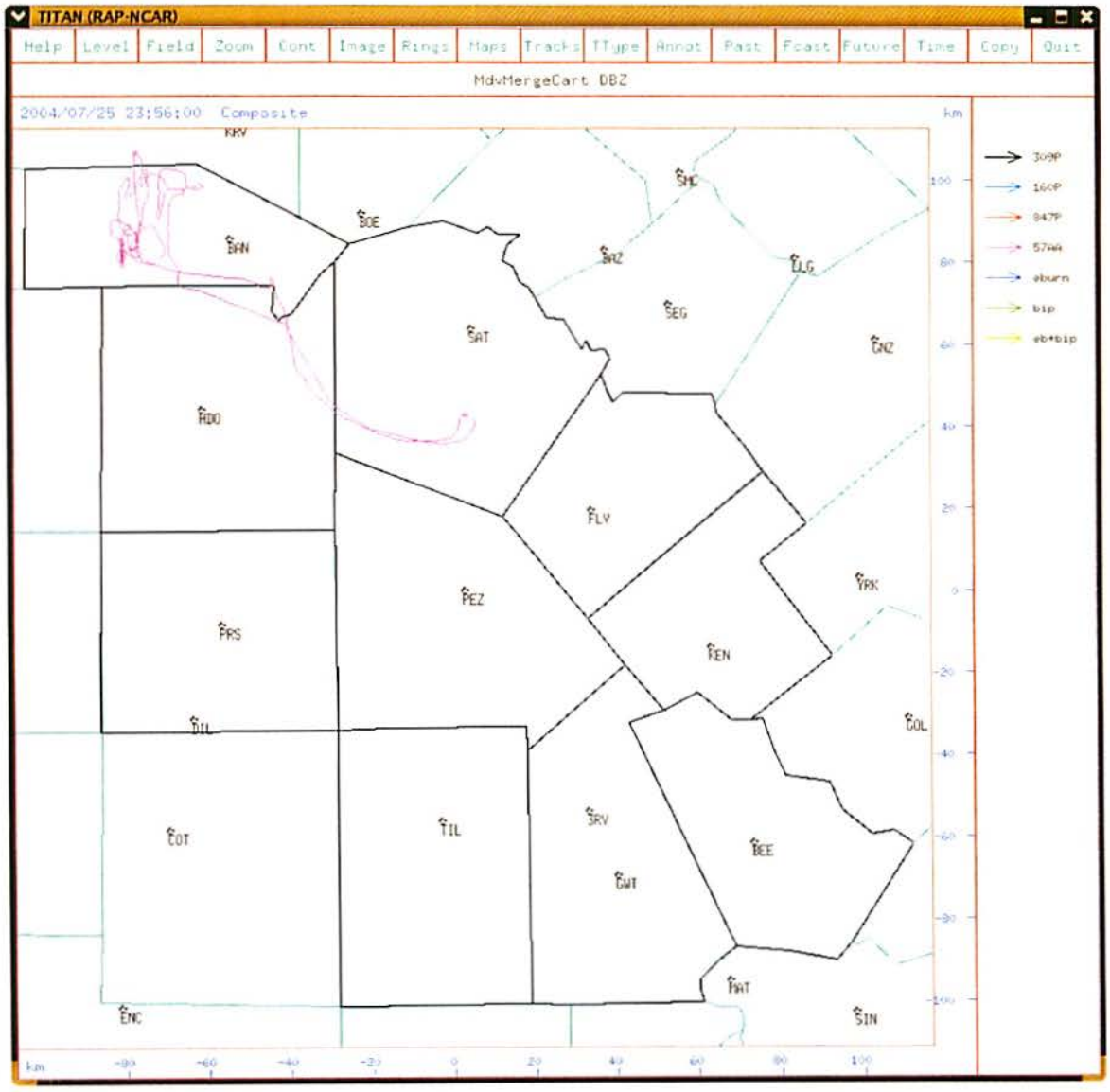
JULY 23

For the third day in a row, the slow-moving TUTT (Tropical Upper Tropospheric Trough), now near the Big Bend, continued to influence our weather. Moisture continued to move into the area from the south and southeast, pooling across areas south of the target area initially. As the atmosphere heated up, additional showers and thunderstorms began to develop, mainly in response to a weak shortwave (not really initialized by computer models) and to the pooling of moisture across the area. The showers and thunderstorms continued to fill in immediately south of the target area, with another plane being launched to help with the seeding. The activity south of San Antonio congealed into one large line of storms stretching west to east. With the aid of southerly winds, this activity pushed up into Bexar County, eventually becoming severe. Seeding of this storm terminated, but continued west and east of Bexar County. Overall, it was a good day for seeding, with the merging line of storms apparently helped along by the glaciogenic seeding. Ten 40g flares were burned over Medina County, totaling 400g of AgI.



JULY 25

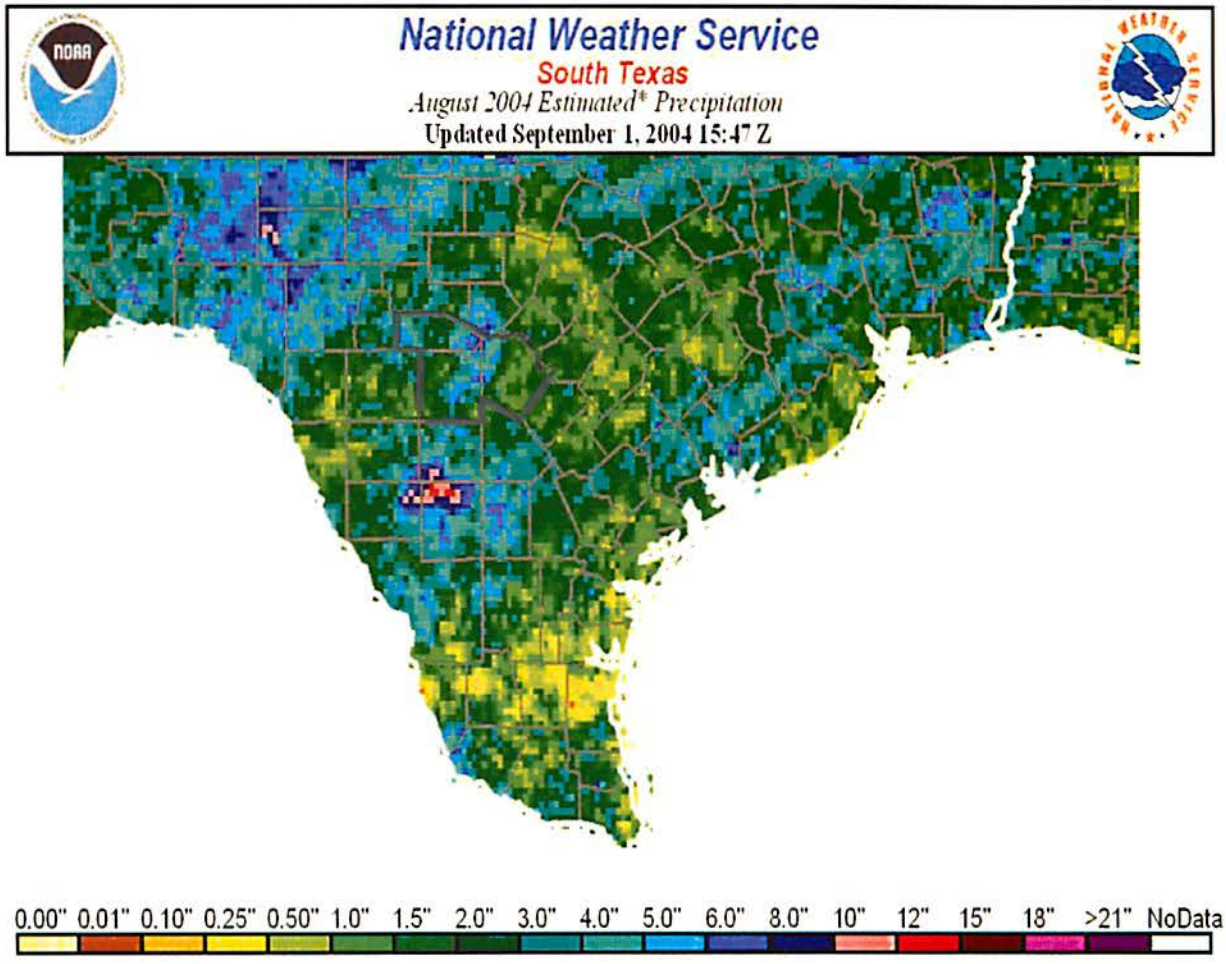
A rare July cold front was pushing south across Texas during the day, being helped by northerly flow aloft. Ahead of the front, moisture pooling interacted with daytime heating, and a few airmass showers and thunderstorms began to develop in the vicinity of Medina Lake. 7AA was launched to look at the activity, and some seeding was done as the activity pushed northwestward into Bandera County. The cells did not appear to last very long. Early in the evening, numerous showers and thunderstorms developed along the front as it ever-so-slowly continued southward, eventually getting into the target area after dark. Four 40g flares were burned in Bandera County, totaling 160g of AgI.



AUGUST 2004

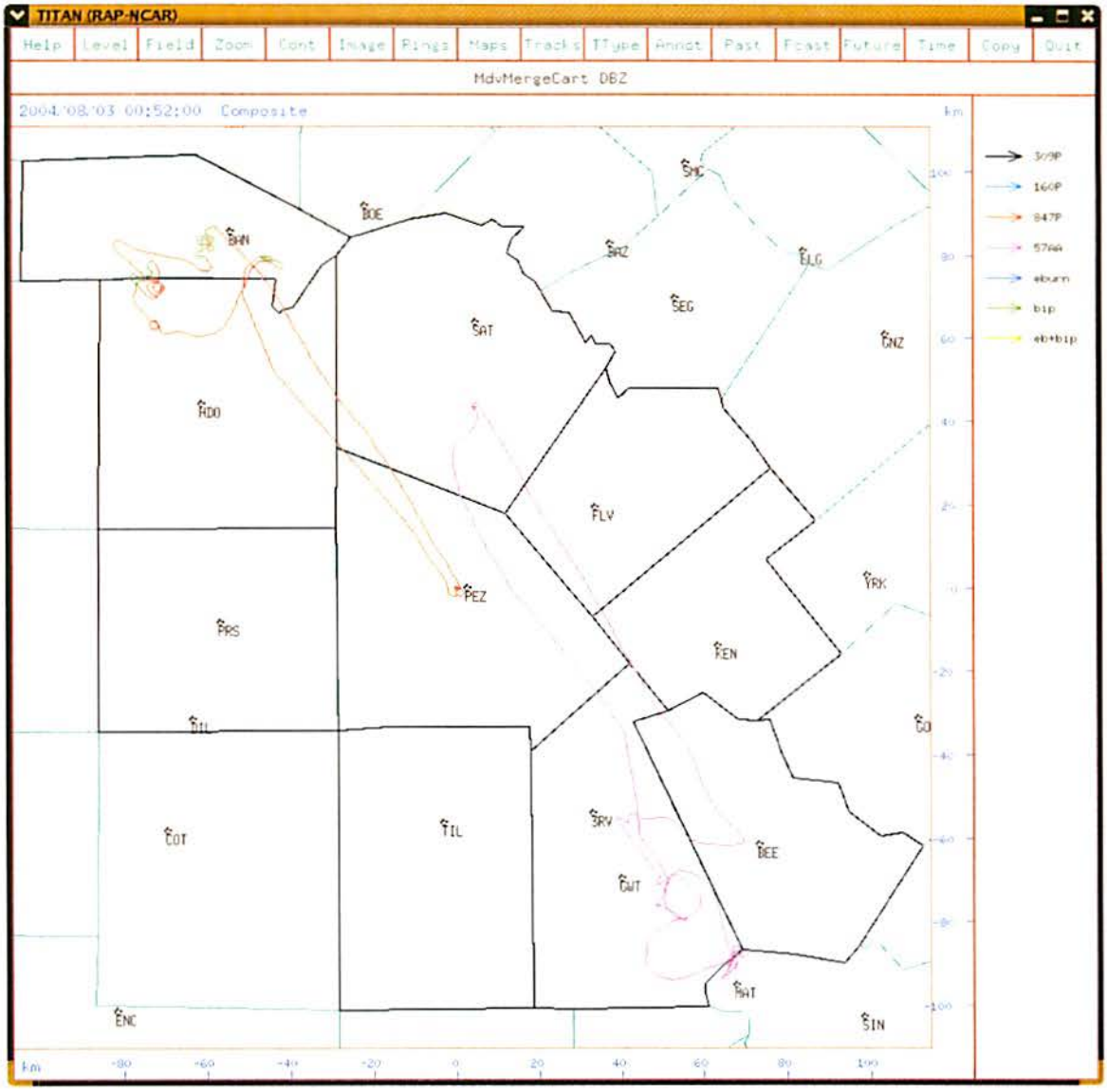
August turned out to be a rather active month for south Texas, as the unusual weather pattern experienced during the first half of the summer continued. This meant more cold frontal passages for the target area, very atypical for this time of year. In addition, several MCS' (Mesoscale Convective Systems) affected the area. Temperatures were lower than average as a result of the increased cloud cover due to almost daily rains around south Texas. Towards the latter part of the month, an unstable airmass sat over the target area, with outflow boundaries being the main trigger for developing convection.

For the month, there were seven days on which seeding took place. Seven flights were launched - one per day of seeding. A total of 55 flares (Bandera - 14; Bexar - 10; Medina - 31) were burned, totaling 2400g of AgI. 40g flares were used on all days except for August 29, where 80g flares were used.



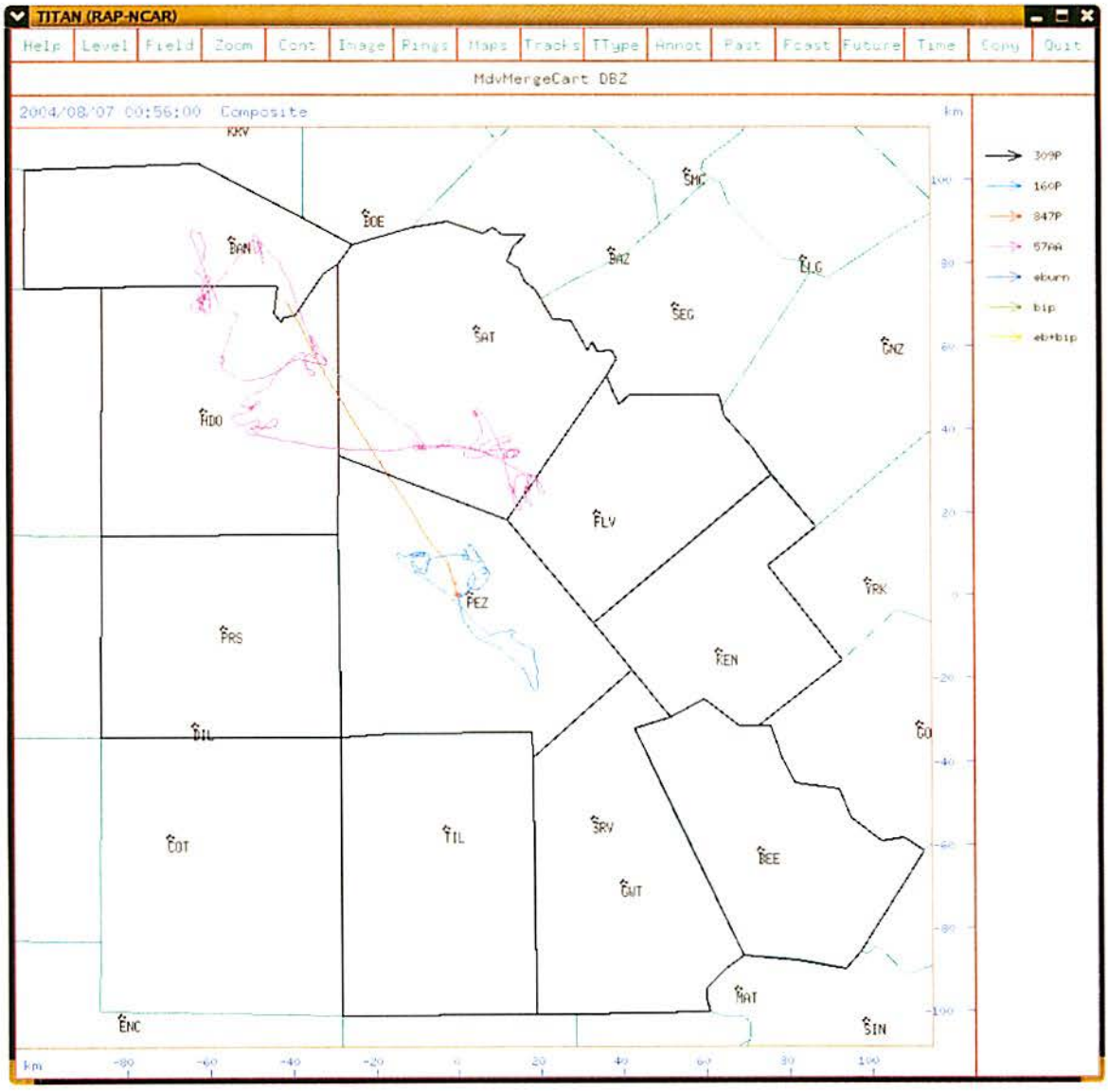
AUGUST 2

It was a typical south Texas summer day, with high pressure in control of the weather. Gulf moisture was plentiful, particularly over southern areas, with precipitable water values in excess of two inches. A flight was launched at late afternoon to investigate airmass-type showers and thunderstorms that developed over the northwestern target area. Some seeding of this activity took place into the early evening hours. Ten 40g flares were burned (Bandera - 9; Medina - 1), totaling 400g of AgI.



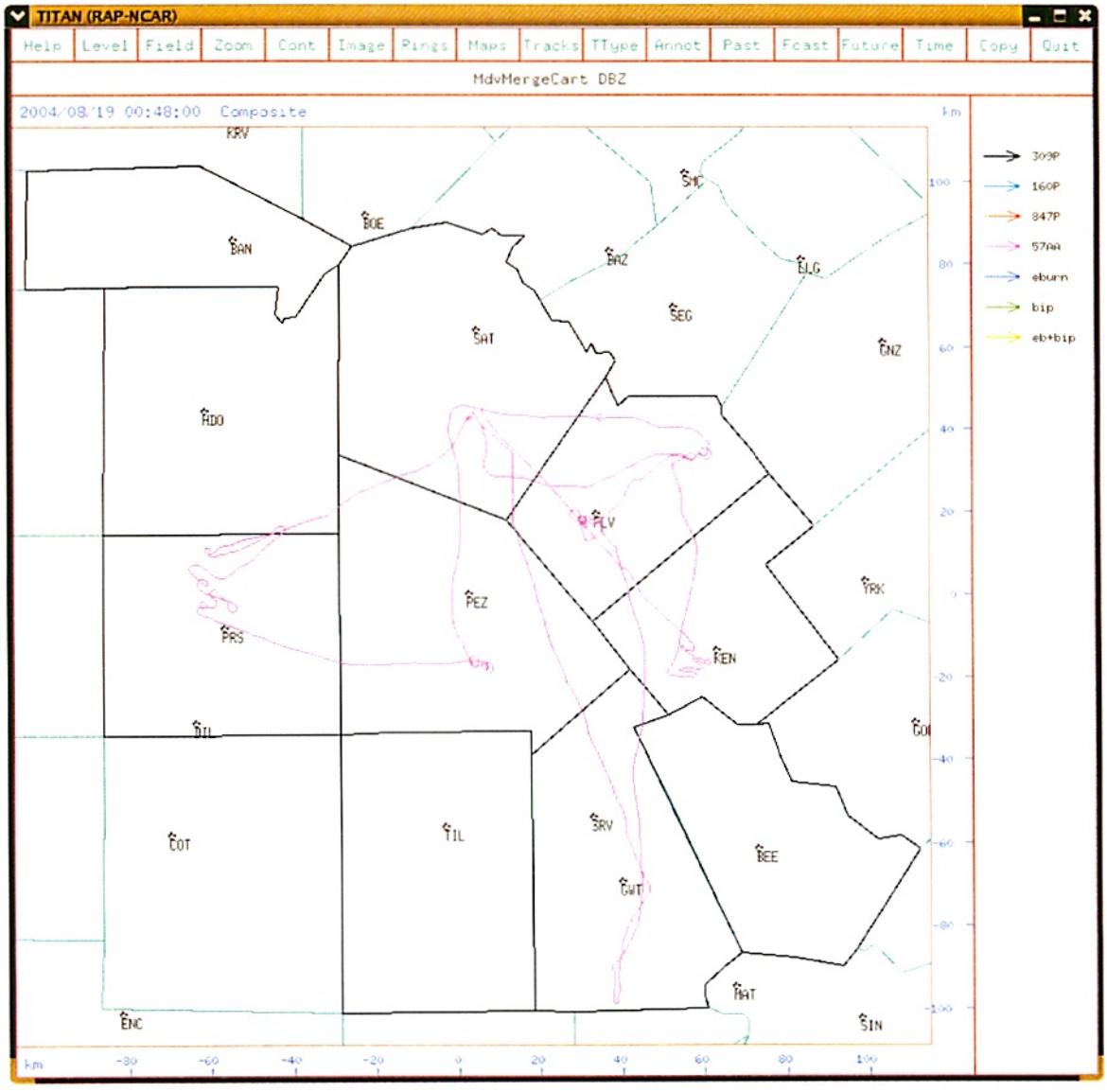
AUGUST 6

Over the course of the day, a rare August cold front pushed closer to the target area. Strong heating and ample moisture combined to produce an increasingly unstable atmosphere out ahead of the front. By mid-afternoon, showers and thunderstorms began to develop near and ahead of the front. Showers developed in the target area, and a plane was launched to seed various cells across Bexar, Medina and Bandera counties as the activity slowly propagated southwestward. As the day progressed, the storms began to slowly solidify into a linear mode. The storms prompted a few flood advisories and one SVR warning for San Antonio. Sixteen 40g flares were burned (Bandera - 2; Bexar - 3; Medina - 11), totaling 640g of AgI.



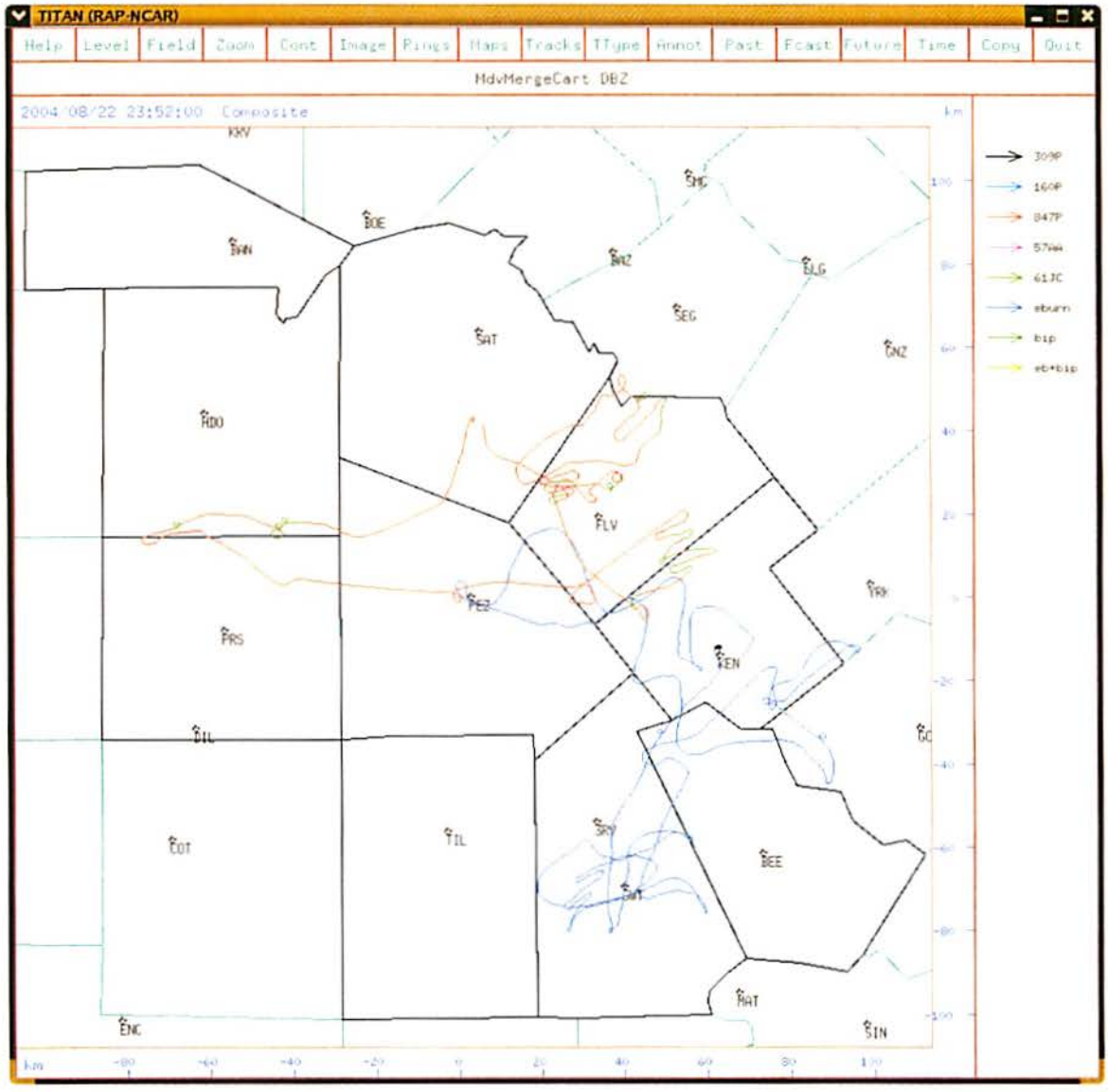
AUGUST 18

After several days of what would be typical fall-like weather, a more unstable airmass moved back into south Texas, along with the increased humidity levels. A trough was located across west Texas, and a vorticity maxima was rotating around the base of the trough, crossing the area during the afternoon hours. Showers and thunderstorms, likely aided by this feature as well as the seabreeze front, developed early in the afternoon and began to trek north towards the target area. A plane was launched to treat activity moving northward into the southern target area, with most of the flares being fired outside the target area. One flare was burned in southern Bexar County, totaling 40g of AgI.



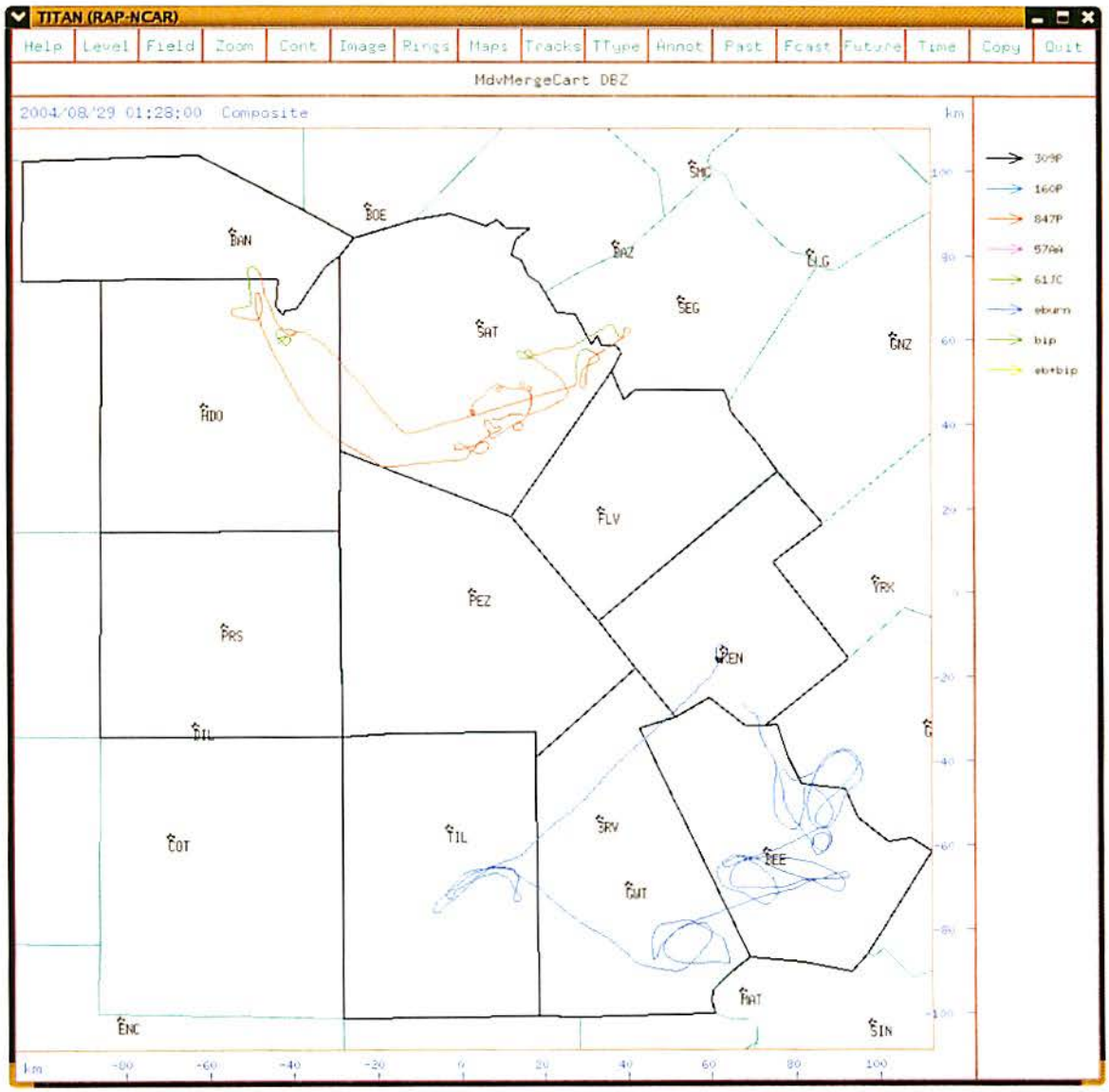
AUGUST 22

An unstable airmass remained over south and central Texas, with a few outflow boundaries around. These boundaries served as a focus for thunderstorm development mainly southwest of the target area during the early afternoon hours as it slowly lifted north. A plane was launched to treat activity south of the target area initially, but developing activity over Frio and Medina counties early in the evening received seeding treatment as well. Three 40g flares were burned in Medina County, totaling 120g of AgI.



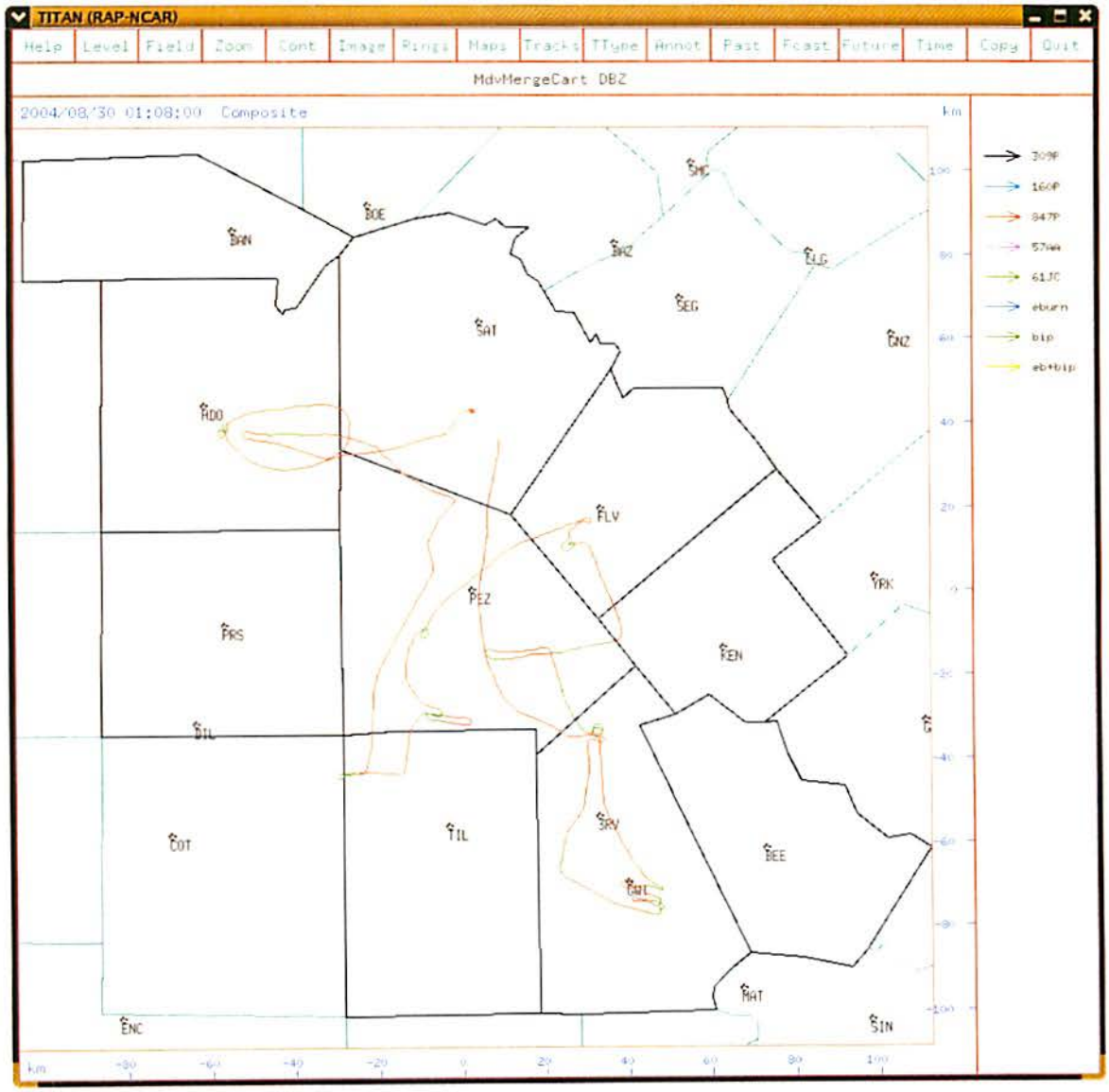
AUGUST 28

Early in the morning there were two areas of significant convection: one in central Texas, the other over the northern coastal bend. Both areas of convection formed outflow boundaries - the area to the north sent out a southward-moving boundary, and the area to the east sent out a westward-moving boundary. As both of these boundaries approached the target area, convection developed along them. A plane was launched to look at the incoming activity from the east, and shortly a second plane was launched to look at activity over the northern target area, in a region where the two outflow boundaries were colliding with each other. Seeding along both outflow boundaries took place, as well as the seabreeze front over the southern target area as it pushed westward. The planes landed as activity began to wane and sunset approached. Eleven 40g flares were burned (Bandera - 1; Bexar - 6; Medina - 4), totaling 440g of AgI.



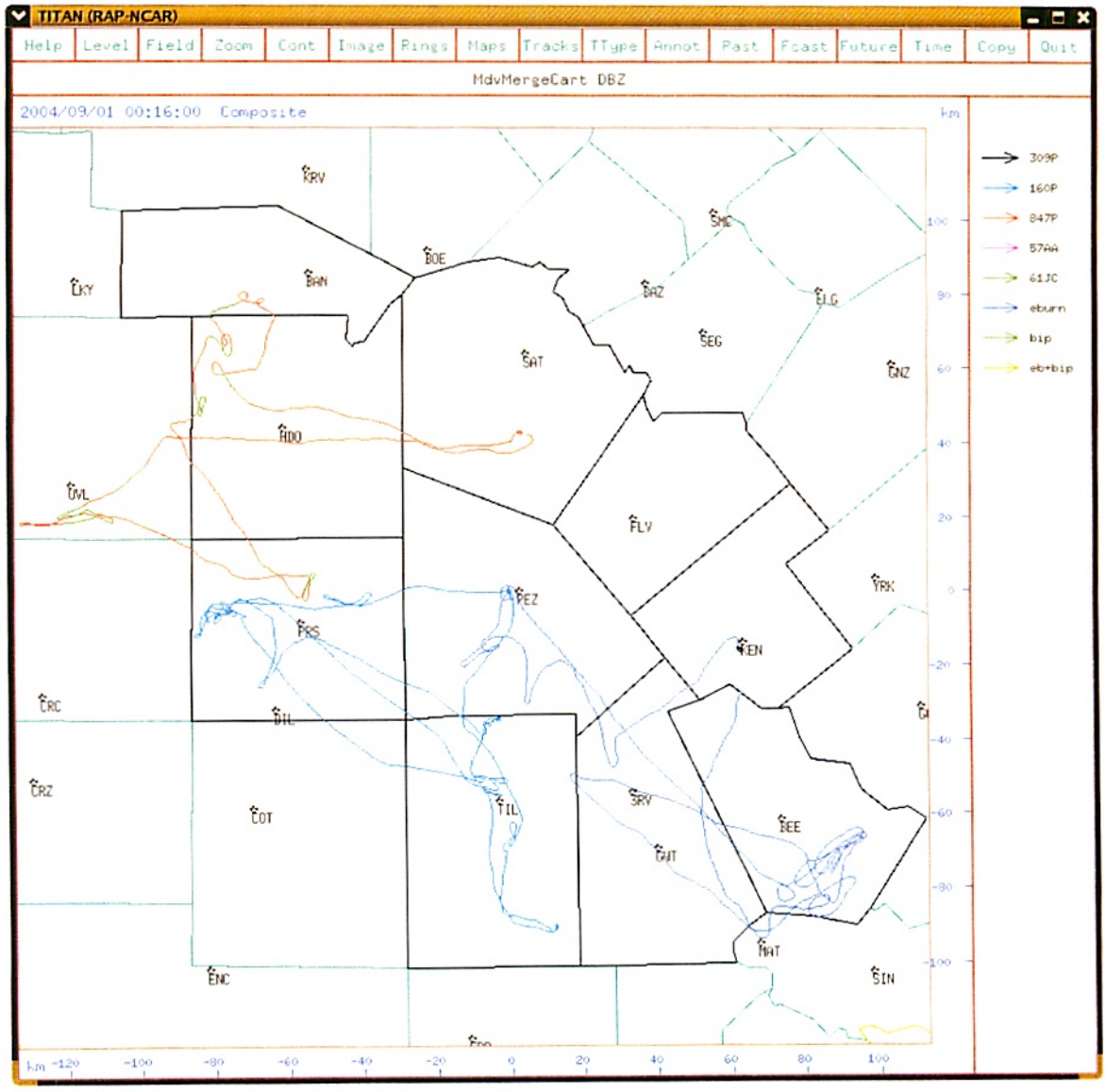
AUGUST 29

An unstable airmass remained in place over south Texas. As daytime heating began to reach its peak, showers and thunderstorms began to develop, mainly along old outflow boundaries. A plane was launched to treat activity in Medina County. The aforementioned activity pushed west and southwest, with heavy rains falling over some areas. Five 80g flares were burned over Medina County, totaling 400g of AgI.



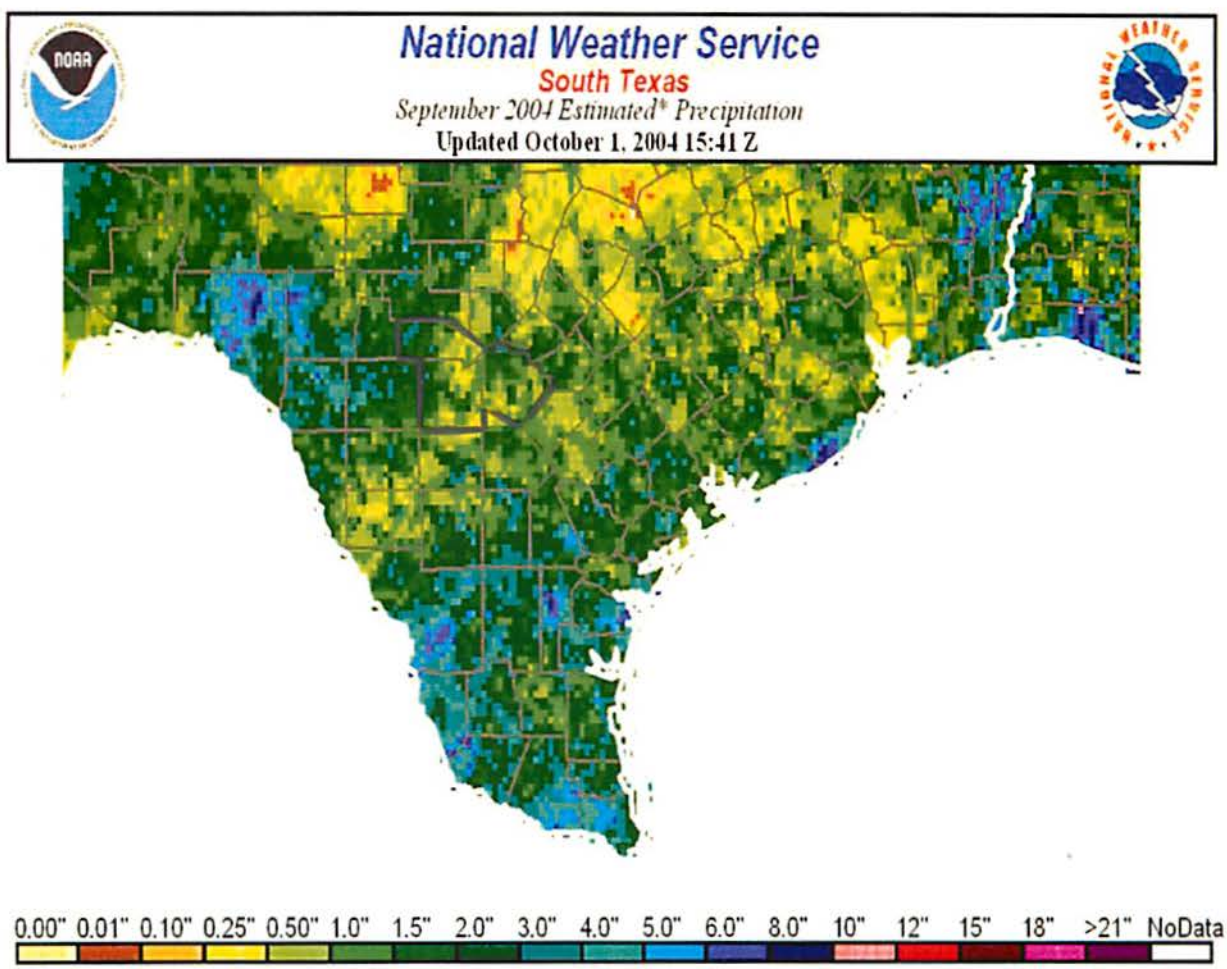
AUGUST 31

As had been the case for the past few days, numerous outflow boundaries lie across the target area, and with some heating taking place, showers and thunderstorms began to develop along these focal points. Three planes were launched to treat activity south of the target area, with one of these planes treating activity as it moved into Bandera and Medina Counties. Radar trends indicated a good response with these treated cells. Nine 40g flares were burned (Bandera - 2; Medina - 7), totaling 360g of AgI.



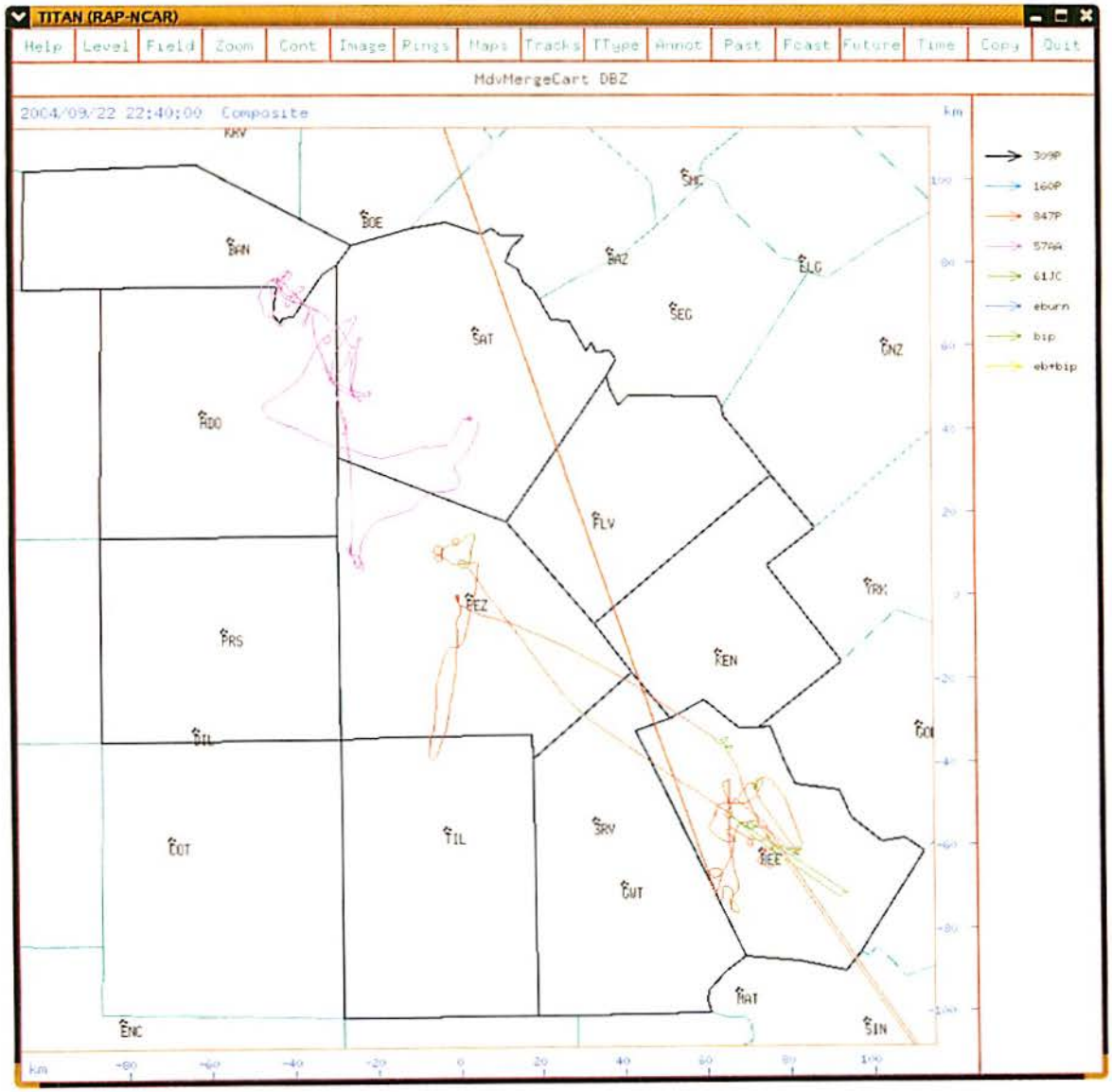
SEPTEMBER 2004

September was a rather quiet month for the target area in terms of seeding activity. Most of the activity was confined to the latter half of the month, although there was some rainfall during the first week. One flight was launched on the 4th to investigate activity over Medina County, but low ceilings and difficulty in locating inflow precluded seeding from taking place. Around mid-month, Tropical Storm Ivan pushed onshore in southwest Louisiana. Subsidence associated with the storm moved into the target area, suppressing convection. During the last 10 days of the month, a more active pattern affected the area, with seeding missions on the 22nd and 23rd as tropical moisture streamed over the area. In all, three flights were logged for the month (1 recon, 2 seeding). Fourteen 40g flares were burned (Bandera - 6; Bexar - 2; Medina - 6), totaling 560g of AgI.



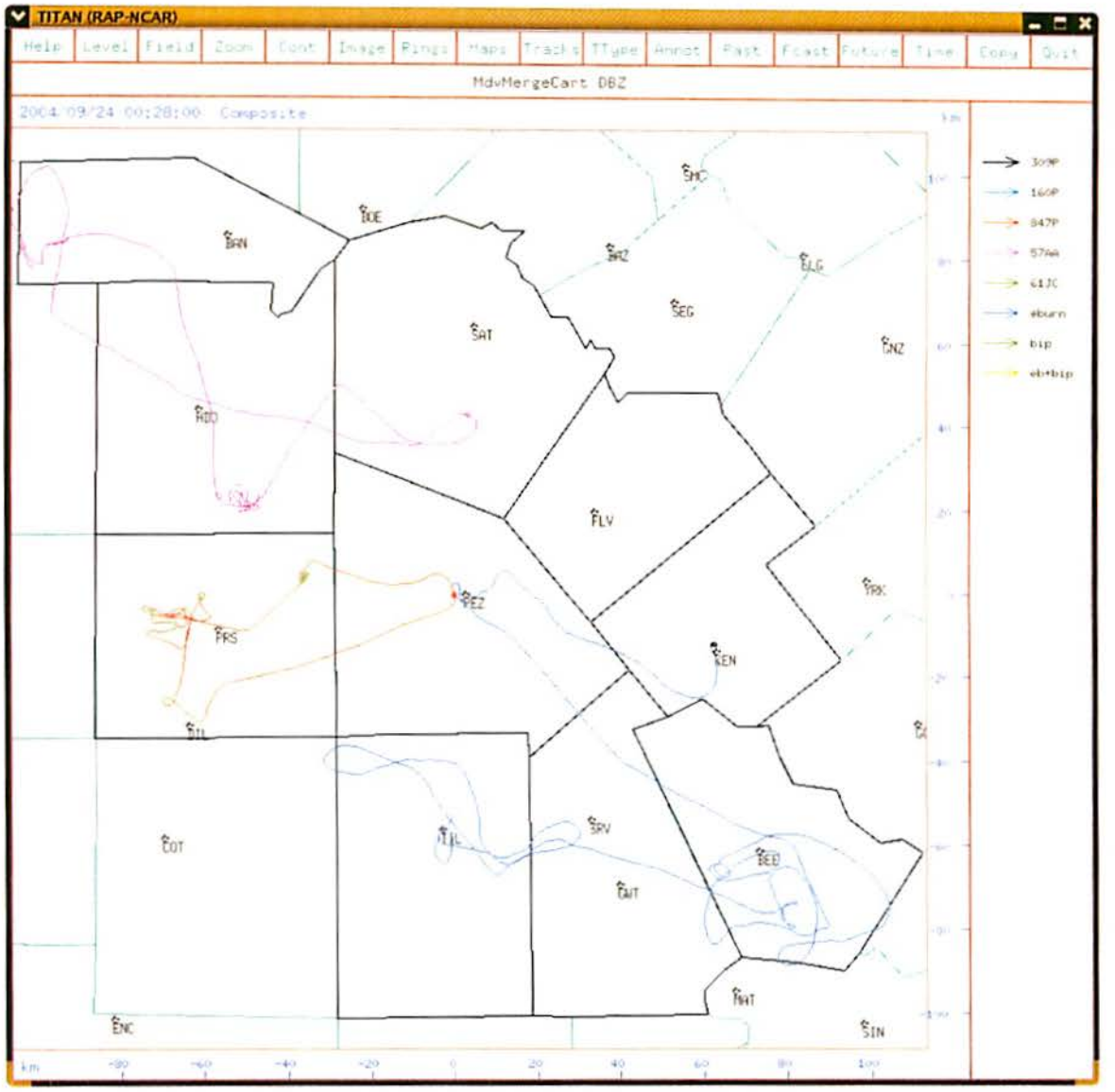
SEPTEMBER 22

A longwave trough continued to sit over the western U.S., with a ridge over the eastern part of the country. This pattern was helping to funnel Gulf moisture up through Texas into the central part of the country. With little in the way of a cap, daytime heating resulted in scattered showers and thunderstorms developing south of the target area, spreading north and west. A plane was launched to seed the convective cells as they trekked northwest. The activity lasted into the early evening hours, with a cluster of very heavy thunderstorms developing over San Antonio near sunset. Accompanied by torrential rainfall, a Flood Advisory was issued. This particular activity was not seeded, as it sat over the city, and could not be reached. Eight 40g flares were burned (Bandera - 2; Bexar - 2; Medina - 4), totaling 320g of AgI.



SEPTEMBER 23

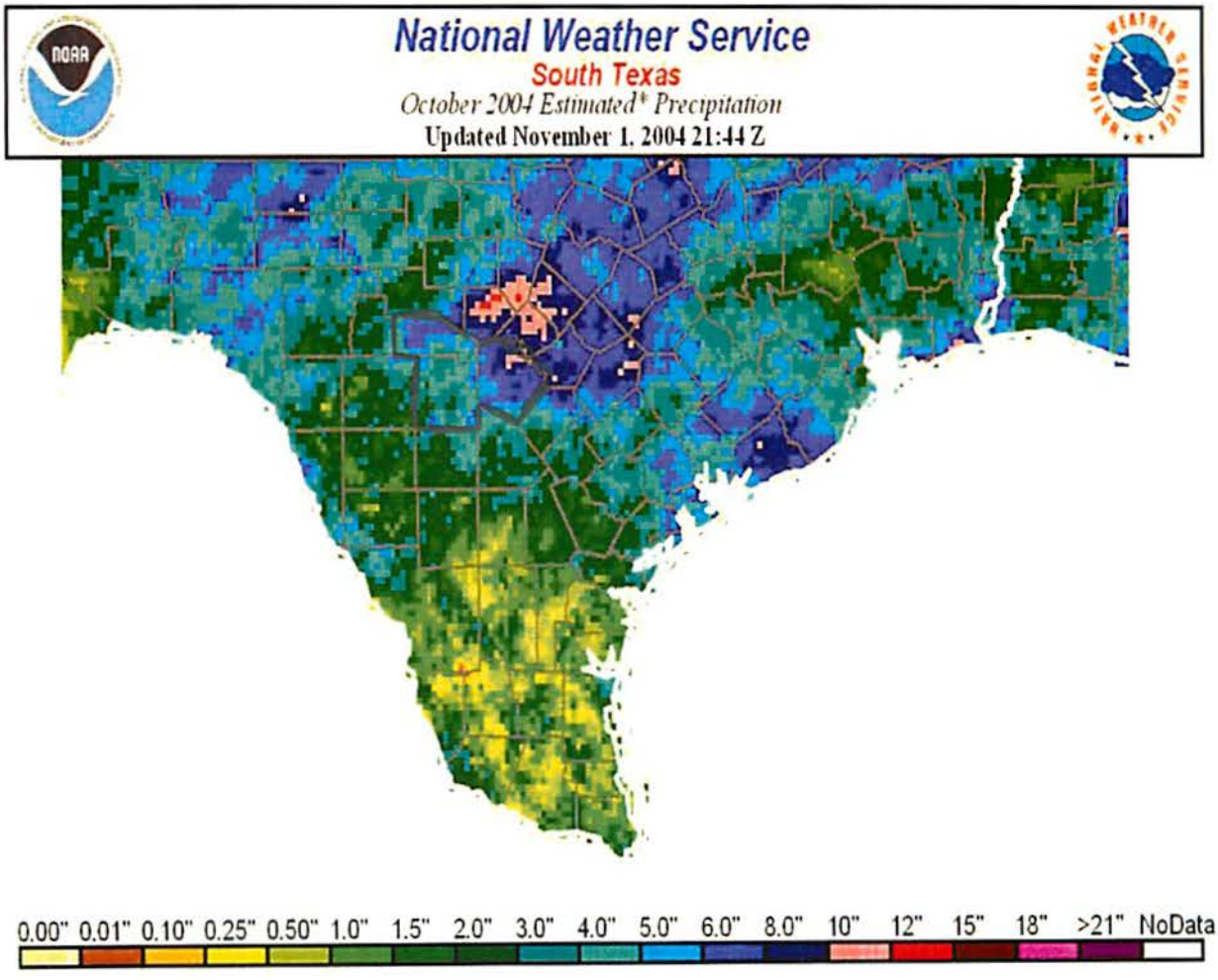
Subsidence associated with Tropical Storm Ivan, south of the LA coastline, was edging into the northeastern target area with drier and more stable air. Meanwhile, over the central and western target area, moisture from the Pacific was streaming in, combined with a good influx of low-level moisture from the Gulf. Being closer to the trough axis, showers and thunderstorms began to break out in the aforementioned area, and a flight was launched to treat this activity. A plane was launched to treat cells over Medina and Bandera counties. Overall, good results were noted on radar, with particular mention to the activity over western Bandera County. Six 40g flares were burned (Bandera - 4; Medina - 2) totaling 240g of AgI.



OCTOBER 2004

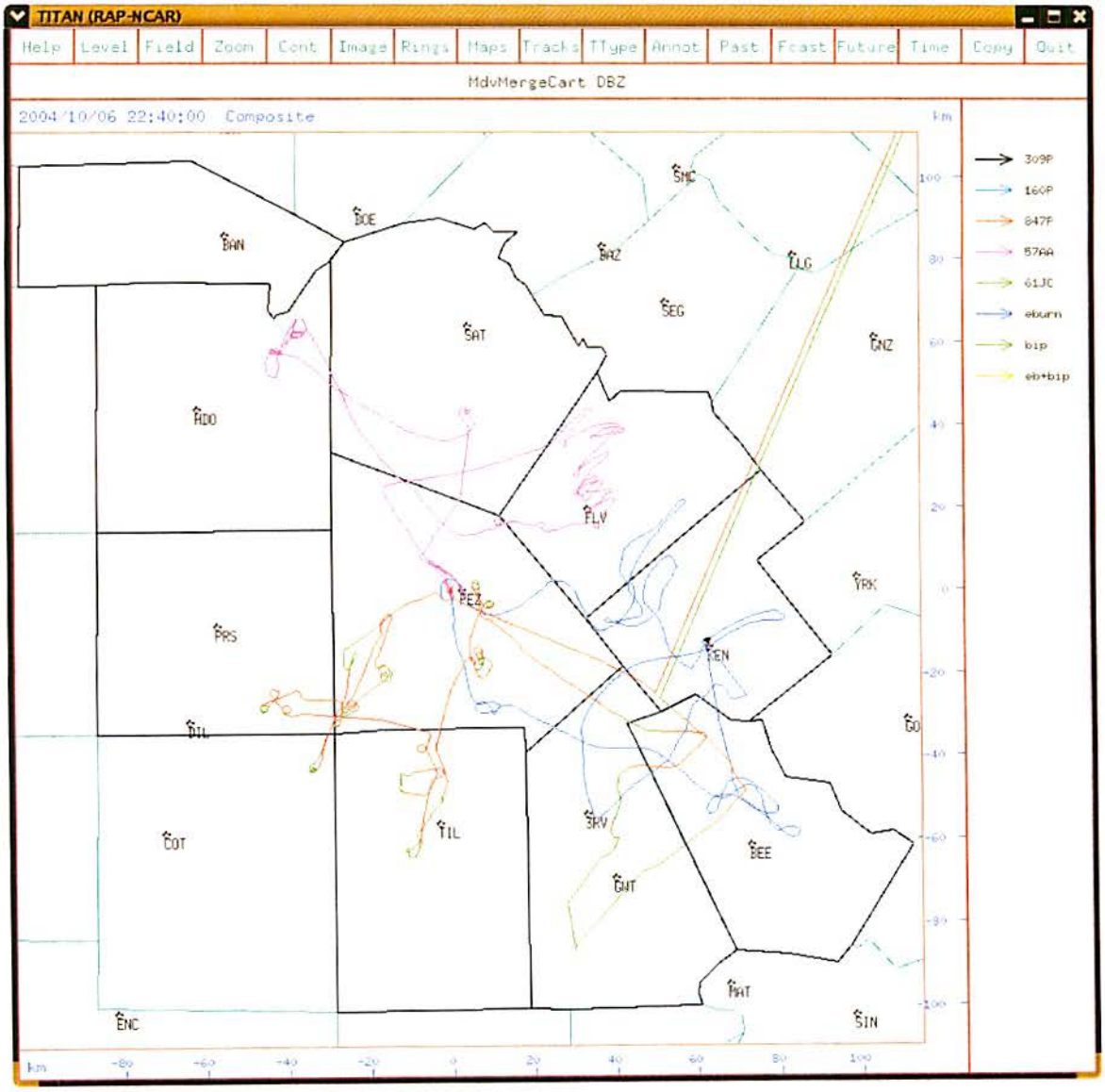
October was a bit unusual in terms of temperatures. The setup of high pressure over the Gulf and a trough of low pressure over the western part of the country during the second half of the month resulted in a prolonged period of very warm and humid weather, leading to several record high temperatures. October 2004 was one of the warmest Octobers on record. In addition, rainfall was heavy over the eastern part of the EAA target area, with over nine inches of rainfall recorded in Bexar County, with lesser amounts to the west. Unfortunately for seeding, the NWS issued several flood warnings and advisories during several of these rain events, which prevented any seeding from taking place.

For the month, there were two days on which seeding took place in the target area, on October 6 and 27. Five flares (2x80g, 3x40g) totaling 280g of AgI were burned (Bandera - 0; Bexar - 2; Medina - 3).



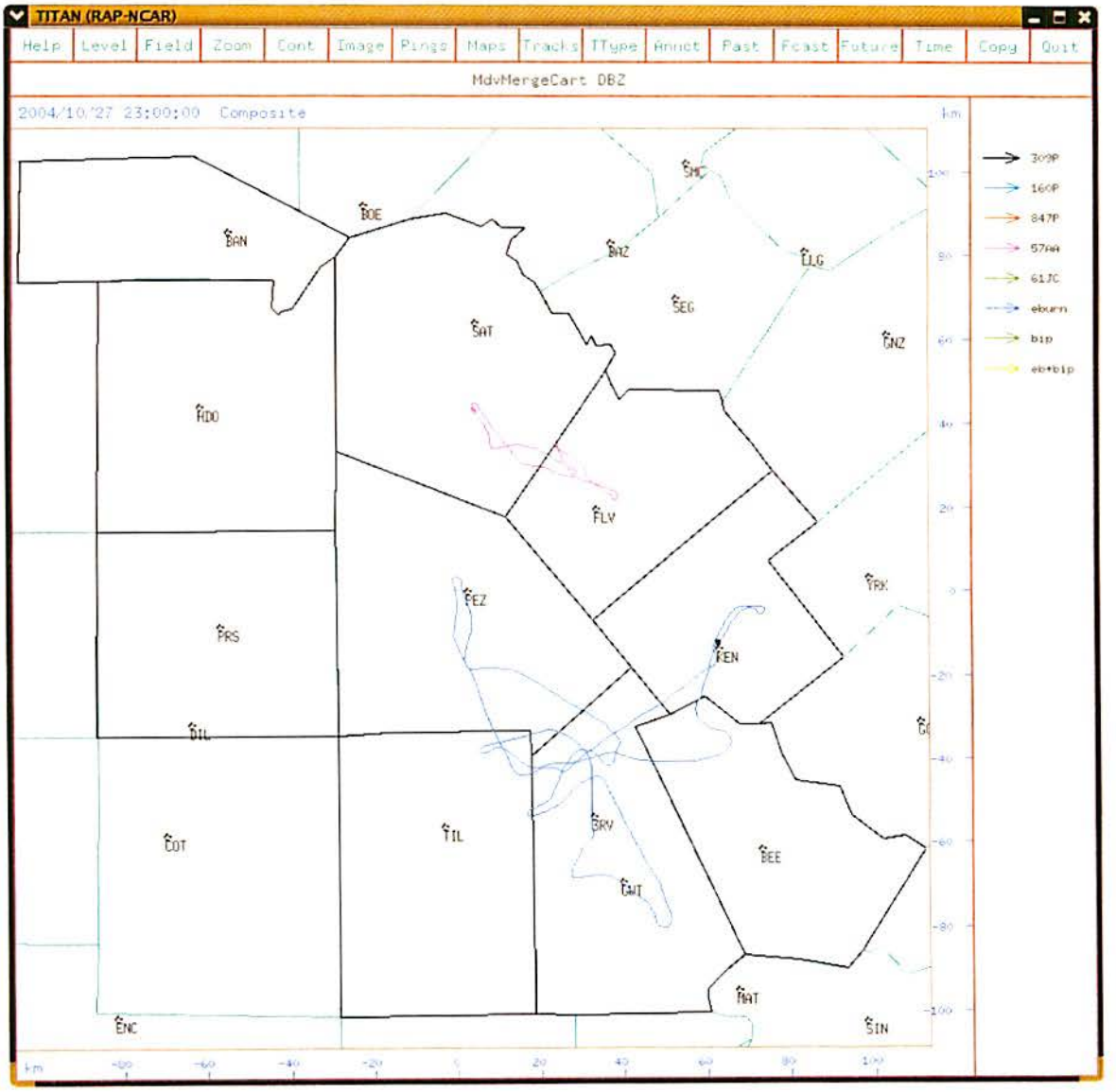
OCTOBER 6

Morning analysis indicated shower and thunderstorm activity northwest of the target area (MCS) moving ESE into a more unstable atmosphere. In addition, an area of showers and thunderstorms was ongoing near the coast, along a stalled boundary/front and in the vicinity of a developing area of low pressure. This activity was moving northwest towards the target area. As the activity to the northwest entered the target area, a plane was launched to investigate the convection, with seeding taking place. Results appeared favorable according to radar trends. Three flares (2x80g, 1x40g) were burned in Medina County, totaling 200g of AgI.



OCTOBER 27

High pressure over the Gulf continued to pump warm and humid air into south Texas. One of these surges of moisture pushed inland during the morning hours, working northwestward into the target area. This surge was helped along by an incoming shortwave from the west. With a bit of heating, showers and thunderstorms developed along the leading edge of this surge, pushing north and northwest into the target area. Two planes were launched to treat the activity as it moved across the eastern half of the target area. The activity lasted until late afternoon, when subsidence in the wake of the departing shortwave helped squelch any remaining convection. Two 40g flares totaling 80g of AgI were burned in Bexar County.



COMPARISON OF 2003 AND 2004 DATA FOR BANDERA, BEXAR AND MEDINA COUNTIES

YEAR	COUNTIES	SEEDING DAYS*	FLARES BURNED	AgI USED (g)	ENHANCED RAIN (ac-ft)
2003	Bandera	7	40	1840	
	Bexar	11	67	4000	
	Medina	18	113	6480	
	TOTALS	**36**	**220**	**12320**	**85,745**
2004	Bandera	10	38	1600	
	Bexar	10	37	1480	
	Medina	17	91	3920	
	TOTALS	**37**	**166**	**7000**	**350,716**

*Note: Seeding days refers to the number of days on which seeding took place within the county, so while on one day alone, all three counties may have had seeding, the totals would be reflected as 3 days of seeding (one for each county).

METEOROLOGICAL PERSPECTIVE OF SEEDING IN 2004

In this section, the perceived effects of seeding as determined by radar trends will be summarized.

Although May saw a few convective events within the target area, none of these were seeded due to several factors, such as darkness, poor visibility (i.e., low cloud bases), and location of the activity over the city of San Antonio or within the flight pattern for KSAT.

June fared pretty well as far as notable effects of seeding go. A lot of seeding took place on the 7th, with 60 flares being used both in and outside the target area to extend the lifetime of numerous cells as they pushed northward through the area. On June 23rd, a cell was seeded over Medina County, which lasted well after sunset, even as other storms were dissipating. The next day (24th) saw some very good responses to seeding, with initial activity near Medina Lake merging with other cells into an elongated band. Additional activity developed near Stinson Field, which was seeded and appeared to show an increase in the size of the cloud. The last couple of days of seeding in June all exhibited positive responses, with some storms producing hefty amounts of rainfall, with definite extensions noted in their longevity.

July had a mix of good days and bad. The first day of seeding on the 10th appeared to help the storms maintain their size and intensity as they traversed the entire target area. The next day, on July 11th, rapid seeding of a group of cells resulted in their eventual merger. This larger storm then moved across San Antonio, dropping over an inch of rain. The storm continued past Medina Lake before finally weakening. On the 23rd, seeding of several cells just south of the target area helped to merge them into a line of showers and thunderstorms that eventually pushed north across the tri-county area. Mergers also resulted from seeding of several cells on the 27th over the eastern counties of the target area. Seeding around the end of the month was rather disappointing, as a very warm layer of air prevented cells from growing to sufficient depths, and this activity died rather quickly.

August turned out to be the busiest month of the year, with seven seeding days recorded in the target area. Like July, there were some really good days and some not-so-good days. Favorable changes in seeded activity showed up on August 2nd and 6th, with intensities being maintained in the different cells. On August 18th, a cell was seeded primarily south and east of Bexar County, but this cell eventually moved northward into the county, lasting for a long time and showing signs of an increase in areal coverage. The remaining days of seeding in August showed some promise, with favorable increases in areal coverage and lifetime apparent.

Seeding during the month of September did not seem to produce much in the way of significant changes in the clouds. On the 23rd, a storm seeded over Bandera County fared pretty well in terms of increasing the lifetime of rainfall coming from the storm, but seeding the previous day near the same area did not show much promise, despite a very intense thunderstorm moving over San Antonio at sunset.

October had a couple more days of seedable weather. Probably the busiest day of the entire year for STWMA was October 6, with 74 flares being fired into multiple cells, and good results noted in the form of mergers and an increase in lifetime. Only a small fraction of these flares were fired within the target area, but seeded storms did move in from the south. This positive response was repeated on the 27th, when a long-lived seeded cell track up the entire eastern border of the target area.

Overall, 2004 can be summarized as a good year for seeding. Although there were days where it seemed that seeding was not working, the days on which seeding did produce favorable results outnumbered the bad days. On many of the unfavorable days, dry air aloft tended to be the Waterloo for the clouds. The really stellar days, on the other hand, seemed to be helped along by the collision of boundaries.

2004 RADAR ANALYSIS FOR THE EDWARDS AQUIFER AUTHORITY

The following is an excerpt from Archie Ruiz' 2004 radar analysis report for the EAA, which includes Bandera, Bexar, Medina and Uvalde counties:

A total of **36 clouds** were seeded and identified by TITAN in **16 operational days**. (NOTE: four other days on which seeding took place were not evaluated due to improper files in the archive or bad data).

Table 1. Small Seeded Sample versus Control Sample (15 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	105 min	65 min	1.62	62 **(47)**
Area	53.6 km^2	37.0 km^2	1.45	45 **(26)**
Volume	155.2 km^3	110.7 km^3	1.40	40 **(31)**
Top Height	7.5 km	7.6 km	0.99	-1 **(0)**
Max dBZ	48.9	48.6	1.01	1 **(0)**
Max dBZ height	4.2 km	4.6 km	0.91	-9 **(-11)**
Vol > 6km	26.9 km^3	23.6 km^3	1.14	14 **(15)**
Precip Flux	363.9 m^3/s	270.5 m^3/s	1.35	35 **(15)**
Precip Mass	1869.5 kton	963.6 kton	1.94	94 **(87)**
Cloud Mass	118.1 kton	86.5 kton	1.37	37 **(14)**
η	15.8	11.1 **(9.6)**	1.42	42 **(65)**

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 34 flares were used in this sub-sample with a very good timing **(84%)** for an effective dose about **100 ice-nuclei per liter**. A very good increase of 87% in precipitation mass together with an increase of 14 % 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 (47%), area (26%) volume (31%), and volume above 6 km (15%) are notable. There were no increases in maximum reflectivity (0%), and in top height (0%). The seeded sub-sample seemed 65% more efficient than the control sub-sample. Results are evaluated as **excellent**.

An increase of 87% in precipitation mass for a control value of 963.6 kton in 15 cases means:

Δ_1 = 15 x 0.87 x 963.6 kton = 12,575 kton = 10,198 ac-ft

The sub-sample of 13 **large seeded clouds** received a synergetic analysis. On average, the seeding operations on these large clouds affected 75% of their whole volume; with an excellent timing (90% of the material went to the clouds in their first half-lifetime). A total of 78 flares were used in this sub-sample for an effective dose about **100 ice-nuclei per liter**.

Also on average, large clouds were 35 minutes old when the operations took place; the operation lasted about 30 minutes, and the large seeded clouds lived 290 minutes.

Table 2 shows the corresponding results:

Table 2. Large Seeded Sample versus Virtual Control Sample (13 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	290 min	210 min	1.38	38
Area	668 km^2	547 km^2	1.22	22
Precip Mass	84,807 kton	60,036 kton	1.41	41

Timing for this sub-sample was excellent (90%) and the increases are appreciable.

An increase of 41% in precipitation mass for a control value of 60,036 kton in 13 cases may mean:

Δ_2 = 13 x 0.41 x 60,036 kton = 319,992 kton = 259,513 ac-ft

The sub-sample of 7 type B seeded clouds received a synergetic analysis. On average, the seeding operations on these type B clouds affected 45% of their whole volume; with a good timing (55% of the material went to the clouds in their first half-lifetime). A total of 61 flares were used in this sub-sample for an effective dose about **70 ice-nuclei per liter**.

Also on average, type B clouds were 190 minutes old when the operations took place; the operation lasted about 25 minutes, and the type B seeded clouds lived 300 minutes.

Table 3. Type B Seeded Sample versus Virtual Control Sample (40 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	300 min	265 min	1.13	13
Area	774 km^2	668 km^2	1.16	16
Precip Mass	109,395 kton	95,126 kton	1.15	15

Timing for this sub-sample was good (55%).

An increase of 15% in precipitation mass for a control value of 95,126 kton in 7 cases may mean:

Δ_3 = 7 x 0.15 x 95,126 kton = 99,882 kton = 81,005 ac-ft

The total increase: $\Delta = \Delta_1 + \Delta_2 + \Delta_3$ = 350,716 ac-ft

APPENDIX

Mesoscale Convective System (MCS) is a large complex of showers and thunderstorms at least 100 km (~60 miles) across, and may be as large as 500 km (~310 miles) across.

Shortwave, or shortwave trough, refers to a small-scale area of lower pressure, sometimes accompanied by showers and thunderstorms.

Cell refers to an updraft-downdraft couplet in a cloud. Clouds with several updraft-downdraft couplets are called **multicell** clouds. A storm with a single updraft-downdraft couplet (often rotating) that lasts for several hours is called a **supercell.**

Pre-frontal trough refers to an elongated area of low pressure found ahead of an advancing cold front. In south Texas, the passage of a pre-frontal trough usually signals the end of precipitation, as winds tend to turn more to the west or northwest, cutting off moisture supply.

Precipitable Water is the total amount of water vapor in a column of air above a given location. This value is expressed in inches. High precipitable water values (>1.5 inches) are indicative of the potential for heavy rain. Tropical airmasses usually have a precipitable water value in excess of two inches.

Convective temperature is the temperature required at or near the ground in order for convection (surface-based) to occur.

TUTT, or Tropical Upper Tropospheric Trough, refers to a upper level cold core area of low pressure found in the tropical and sub-tropical regions of the Earth. These disturbances are sometimes associated with shower and thunderstorm activity, and are associated with tropical waves.

Theta-e, or equivalent potential temperature, is the temperature a parcel or bubble of air would reach if it was lifted until all of the moisture condensed out, then brought back down to 1000 mb (at/near surface). A forecaster looks at theta-e to see how moisture is distributed over a region. High theta-e values are associated with moist airmasses, which storms may develop in and feed on.

Jet streak refers to the maximum wind speed within a river of faster-moving air (jet stream). Forecasters may look for jet streak locations at 850mb, 700mb, 500mb, and 250 mb in order to assess the possibility of strong/severe thunderstorms.

Cap refers to a warm layer of air aloft which acts as a lid, suppressing convection. The strength of the cap varies with time and location.

Convective Inhibition is the amount of energy required to overcome the cap, or the amount of energy required by a parcel of air to initiate deep convection (i.e., thunderstorms).

Lifetime refers to the length of time a cloud was detected on radar, with a reflectivity maximum of at least 32 dBZ.

Area refers to the two-dimensional space (length x width) covered by a cloud.

Precip Flux refers to the radar-derived volume of water falling through the bottom of the cloud per second.

Precip Mass refers to the total mass of water and ice for all droplets/crystals larger than 100 μm (10^{-4} m) in a cloud.

Small seeded clouds are those clouds with a radar-derived Precip Mass less than 10,000 kilotons.

Large seeded clouds are those clouds with a radar-derived Precip Mass greater than 10,000 kilotons.

Type B clouds are those clouds, small or large, that were not seeded until they were at least one hour old, as determined by their presence on radar.

Control clouds are those clouds within 100 km of the radar that were NOT seeded. Control clouds are used to determine the effectiveness of seeding, as it represents "what would have happened" if seeding had not taken place.

Effective dosage refers to the amount of seeding material that was placed in the cloud. It is expressed as a concentration of ice nuclei per liter of air.

ACKNOWLEDGEMENTS

2004 appeared to be yet another successful year of cloud seeding within the Edwards Aquifer Authority target area. Radar analysis showed that seeding effects this year were positive once again. The success of the project comes about through the hard work of many people, and it is here where gratitude must be expressed.

Our two "heads of state", if you will, Tommy Shearrer and Mike Mahoney, continue to do many hours of work to ensure that the project gets past any red tape and runs as smoothly and efficiently as possible. Many thanks go their way, as the project would likely be lost without them. Thanks also go to the board members who regularly meet to discuss purchases, improvements, seeding methods, and any other factors that affect the way the program is run. Their input in the past has helped run a successful program, and we hope they will continue their good work. We certainly couldn't have the great planes and the successful flights without the hard work of Tim Pickens, our chief pilot, and the four other pilots: Jim Transue, Larry Dement, Ron Merks and Mickey Chadwell. They deserve many thanks. We must also thank the mechanics who completed annuals on our planes, Dave Lavelle and Dave Hamilton. Thanks must also go out to Candi Gonzales, who handles much of the laborious paperwork for the project, and to Larry Akers, who keeps our radar in tip-top shape. Speaking of radars, we must thank Chip Barrere and the crew at WDT, Inc. for providing us with the NEXRAD feed. An expression of gratitude is extended to Archie Ruiz, who performs the ever-challenging radar analysis. With his work, we may yet find a way to prove once and for all the true success of cloud seeding. The cloud seeding projects may not be here had it not been for George Bomar, who work with the projects and the Department of Licensing and Regulations - thank you both. A very important person in our project is James Hayden, who has kept the computers working wonderfully, and has given much help in the continued running of our web site; many thanks to him. Thanks also to Rick Illgner, Robert Burns and the EAA for working with us this year and in the years to come. Finally, thanks go out to the public, most of who continue to believe in our project and our mission. Without your approval, our project would cease to exist. Thank you all!

Rainfall maps for 2004 came from the following website:
http://www.srh.noaa.gov/rfcshare/precip_analysis.php

Radar analysis numbers came from Archie Ruiz's final report of the 2004 season for the EAA (5 pp).