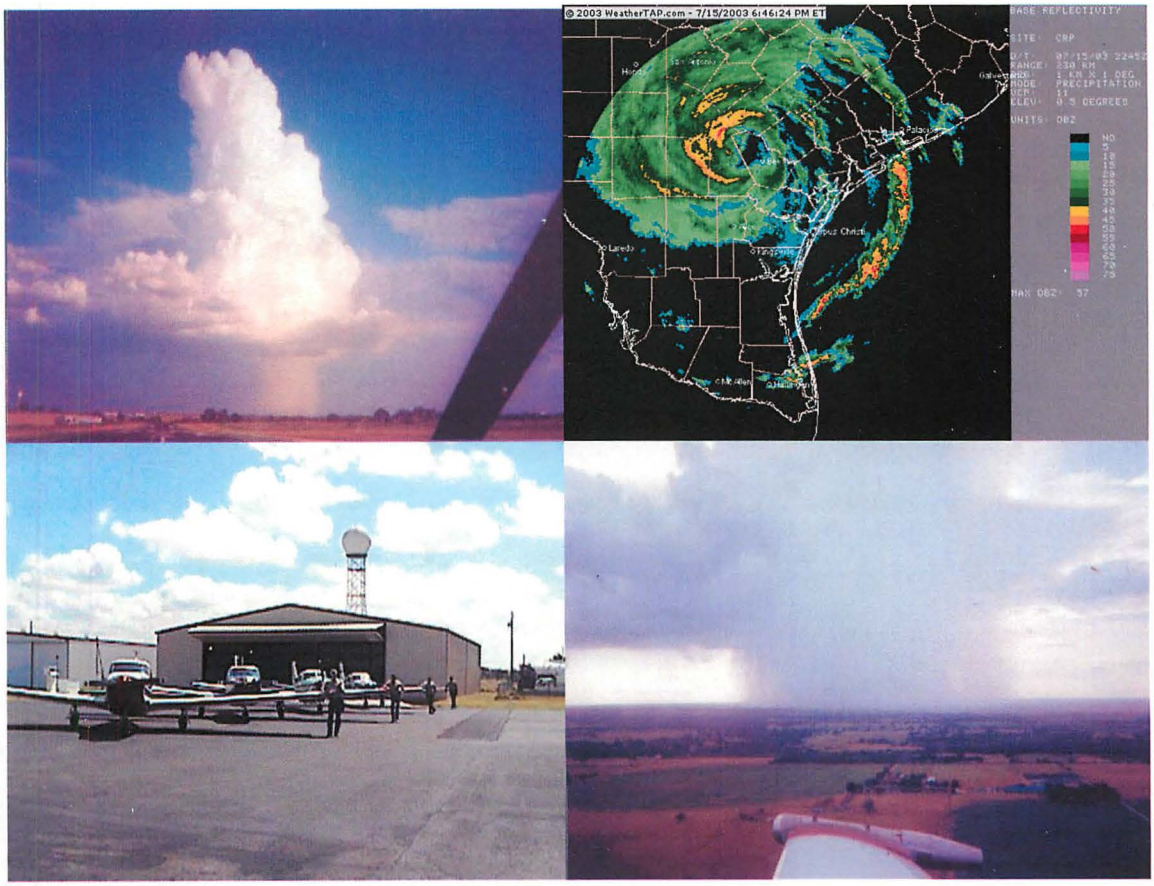
SOUTH TEXAS WEATHER MODIFICATION ASSOCIATION

EAA TARGET AREA



2003 REPORT

2003 FINAL REPORT

for the

SOUTH TEXAS WEATHER MODIFICATION ASSOCIATION

EAA TARGET AREA

by

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THE YEAR IN REVIEW

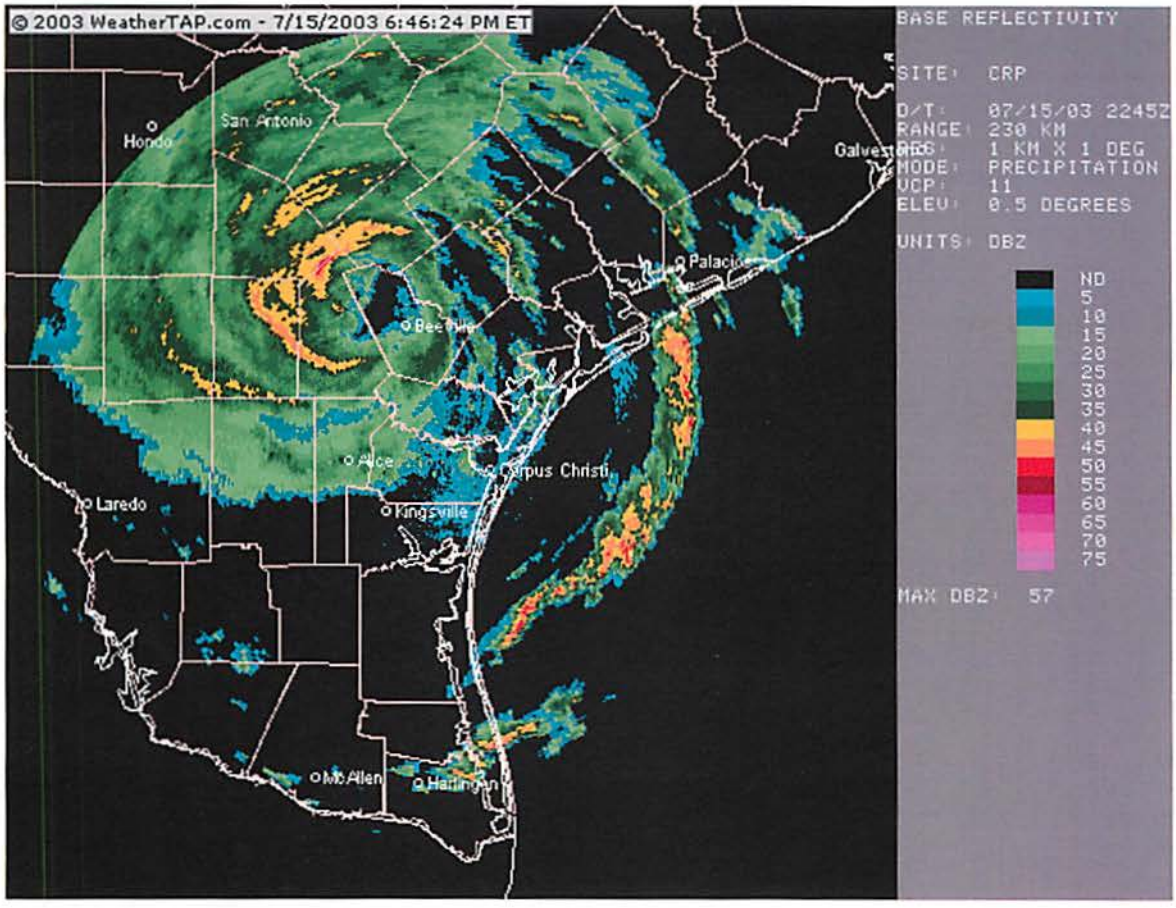
2003 marked the second year of operations for the EAA by the STWMA. One change seen was the extension of the seeding season from September 30th to October 31st. This was done in 2002 as a result of the downtime we experienced due to flooding rains. For 2003, the extension really didn't make much of a difference, as no seeding was done after September 17th.

As was the case in 2002, 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.

2003 turned out to be a much better year for seeding in the EAA target area, with 22 days of seeding, compared with only 8 in 2002. With a record-setting dry spell in May, our first seeding mission did not take place until May 27th. June saw 4 days with seeding, while July ended up being the busiest month, with 8 seeding days. Hurricane Claudette tracked across south Texas on July 15th, bringing heavy rain and high winds to much of the area. Due to a risk of flooding, operations were suspended from the 15th through the 20th to allow for any rains to soak in and flooded rivers to recede. A rare July cold front pushed down into Texas on July 23rd. The front itself stayed north of the area, but a pre-frontal trough did make it through the area, igniting showers and thunderstorms. The busy weather continued into August, with 7 days of seeding taking place. Things quieted down in September, with only two days of seeding. After the middle of the month, there were no more missions for the year.

Once the season concluded, Archie Ruiz completed the radar evaluation of the program, and again it appears that seeding produced favorable increases in rainfall. These numbers are presented and discussed on page 36 of this report.

For 2004, there will be a dramatic change in the radar data. We have acquired an agreement with WDT, a company based in Oklahoma City. They will be taking the TITAN software, which we currently use in conjunction with our C-band radar, and integrating it into the National Weather Service Doppler radars in New Braunfels, Corpus Christi, and Brackettville. Starting in 2004, our program will use WDT's software to peruse radar data from the NWS in order to conduct operations. It is an exciting change, since the meteorologist will now have access to many of the algorithms currently used by the NWS. Some of these include, but are not limited to, tornado detection, hail detection, lightning strike display, and future radar, which takes past reflectivities and extrapolates 30-60 minutes into the future to give you a "predicted radar image". Radial velocity data will also be available, which lets the meteorologist look at the winds within a storm.



Hurricane Claudette centered near Beeville at 4:45pm CDT, July 15th, 2003. Image is from the NWS 88D radar at Corpus Christi. Courtesy of Weathertap.com

2003 FLIGHT LOG FOR STWMA'S EAA TARGET AREA

Date	Plane	Flight No.	Take Off Time	Landing Time	Total Time	No. Flares Used	Amount of AgI (g)	Flare Locations
27-May	7AA	1	20:20	21:45	1.4	7	640	Medina - 6; Uvalde - 1
3-Jun	7AA	2	18:35	21:15	2.7	14	1120	Bandera - 6; Bexar - 1; Medina - 7
3-Jun	60P	3	19:35	20:45	1.2	1	80	Bexar - 1
3-Jun	47P	4	19:45	21:15	1.5	8	640	Bexar - 8
5-Jun	09P	5	15:35	17:00	1.4	2	80	Bexar - 2
19-Jun	60P	6	22:30	0:00	1.5	5	400	Medina - 5
19-Jun	47P	7	23:00	0:30	1.5	3	240	Medina - 3
26-Jun	7AA	8	0:00	0:45	0.8			Recon Flight to Medina County
28-Jun	60P	9	23:30	1:13	1.8	8	640	Bexar - 3; Medina - 5
1-Jul	7AA	10	19:25	23:45	4.3	10	800	Bexar - 7; Medina - 3
2-Jul	7AA	11	19:20	22:45	4.4	9	720	Medina - 9 (2 of these also inside Uvalde Co.)
3-Jul	7AA	12	16:45	19:00	2.3	3	240	Bexar - 3
3-Jul	7AA	13	20:05	22:25	2.3	9	720	Medina - 6; Uvalde - 3
4-Jul	60P	14	15:55	17:50	1.9	10	800	Bexar - 10
8-Jul	7AA	15	18:05	19:45	1.7	3	240	Medina - 3
23-Jul	7AA	16	20:10	21:50	1.7	7	280	Medina - 7
24-Jul	7AA	17	21:45	22:55	1.1	3	120	Medina - 3
27-Jul	47P	18	21:25	23:15	1.8	27	1080	Bandera - 12; Bexar - 7; Medina - 8
8-Aug	7AA	19	22:10	0:00	1.9	9	360	Bandera - 6; Medina - 3
9-Aug	7AA	20	21:55	23:55	2	11	440	Bandera - 8; Medina - 3
11-Aug	7AA	21	19:35	21:30	1.9	15	600	Bexar - 11; Medina - 4
12-Aug	7AA	22	21:20	22:55	1.6	7	280	Medina - 7
16-Aug	7AA	23	19:30	20:35	1.1	3	120	Bexar - 3
23-Aug	7AA	24	18:20	21:15	2.9	6	240	Bexar - 6
24-Aug	7AA	25	20:55	23:00	1.1	19	760	Bandera - 2; Medina - 14; Uvalde - 3
5-Sep	7AA	26	17:15	19:50	2.6	16	640	Bexar - 5; Medina - 11
17-Sep	7AA	27	19:25	22:45	3.3	12	480	Bandera - 6; Medina - 6
TOTALS		**27**			**53.7**	**227**	**12760**	**Bandera - 40; Bexar - 67; Medina - 113; Uvalde - 7**

GENERAL DISCUSSION:

An unusual weather pattern took hold this month, with Pleasanton only reporting 0.01" for the entire month. Most other locations were in the same boat, with a relatively rain-free month. There was one day in the latter part of May where seeding took place. Otherwise, it was a record-setting month in terms of lack of rainfall.

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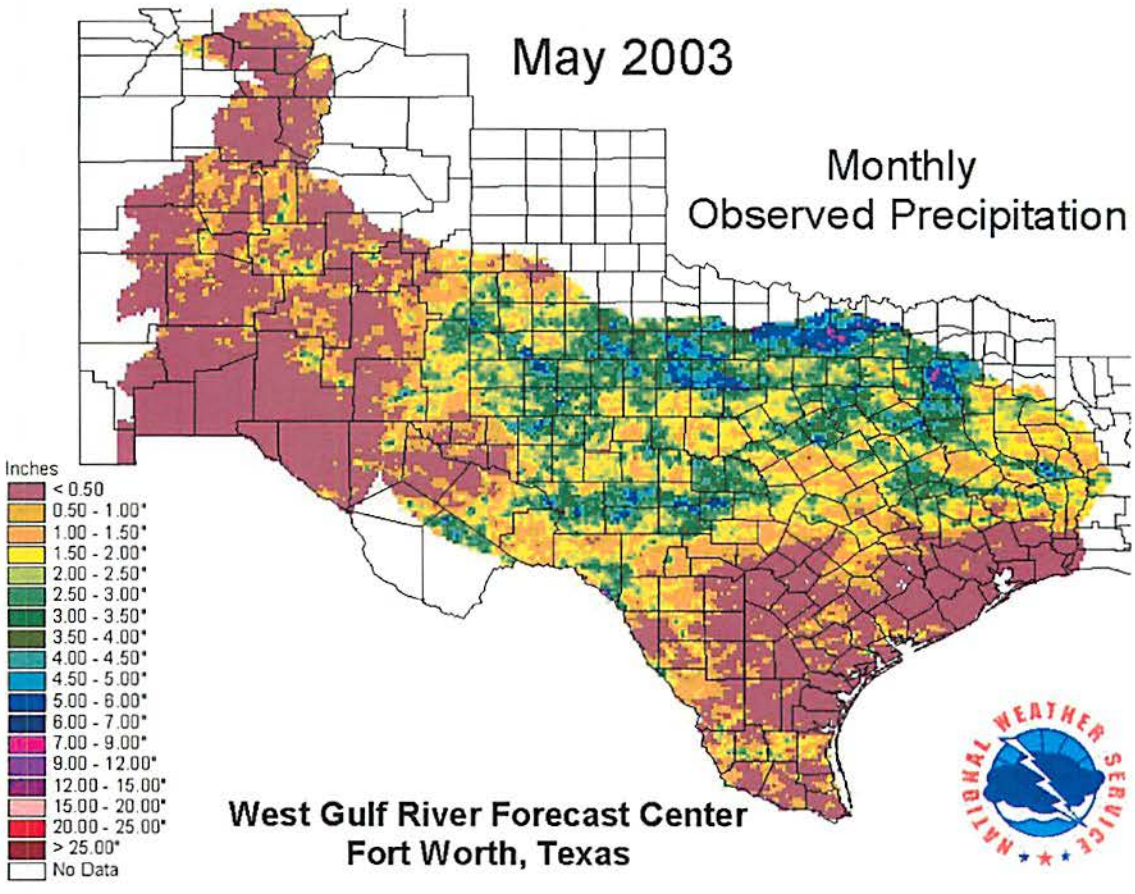

MAY 27

An upper level low located near the Rio Grande was producing intense convection around Del Rio, where over 6 inches of rain fell. Weak impulses were rotating around the bottom of the upper low, which initiated convection over Medina County. 7AA was launched to treat activity in this area.

7 flares were burned in the EAA target area (6 x 80g flares in Medina Co.; 1 x 80g flare in Uvalde Co.)

Due to computer glitches, track data for May 27 is not available.

METEOROLOGICAL PERSPECTIVE OF SEEDING IN MAY 2003

There was not much to work with in May. With a record-setting dry spell in place, most areas saw less than 0.10" of rain for the month. The exception was on May 27th, when convection crossed Medina County. Seeding appeared to extend the lifetime of the cells when compared to untreated cells seen on the radar. Overall, a good day for seeding, but the month was a big disappointment thanks to high pressure.

GENERAL DISCUSSION:

June turned out to be a "normal" month for south Texas, with just above average rainfall and near normal temperatures. Early in the month, northwest flow aloft was responsible for bringing in a series of disturbances, which triggered thunderstorm activity (clusters, Mesoscale Convective Systems) across Texas. Some of this activity managed to get into the target area, and was subsequently seeded. Then, after a dry spell lasting just past mid-month, more humid, tropical-like weather moved into the area, spawning convection again near the end of the month.

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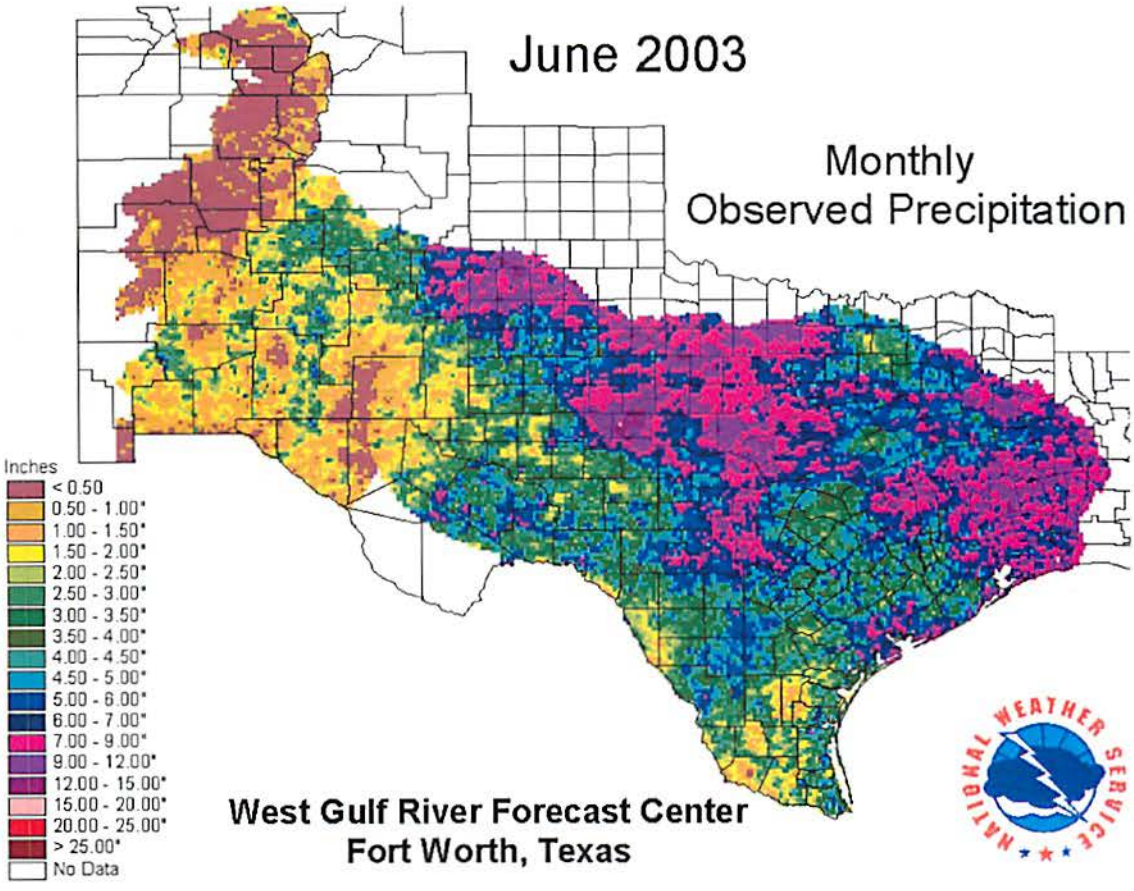


JUNE 3

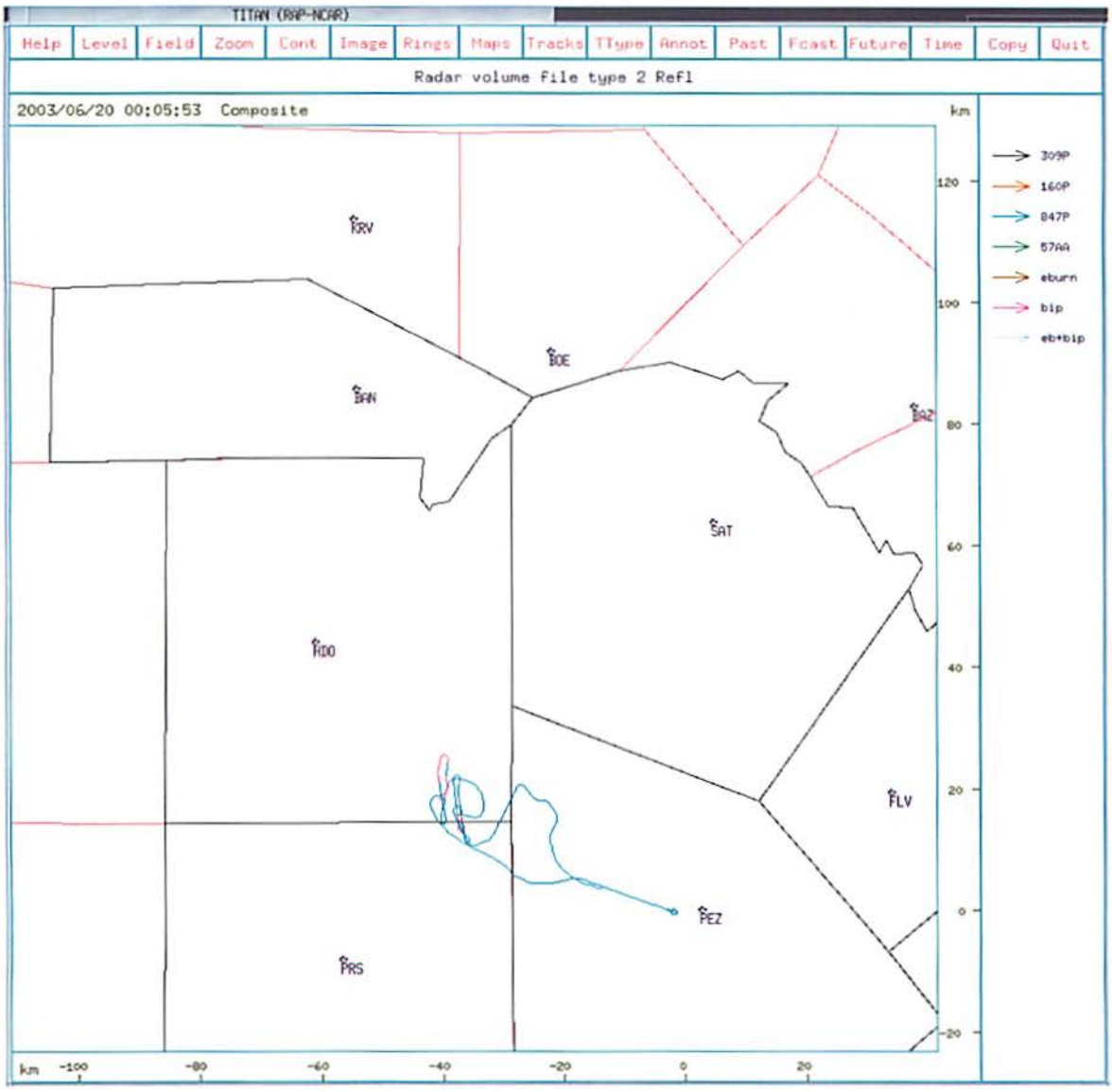
A subtle shortwave moving across the area helped fire off thunderstorms just northwest of the target area in the early afternoon hours, with NW flow aloft carrying the storms across the target area. 7AA took off from Stinson Field just after 1:30pm CDT and proceeded to the area of storms pushing into Bandera County. 60P and 47P soon followed. The storms eventually pushed south into the STWMA target area. In all, 6 flares were fired over Bandera County, with 8 flares in both Bexar County and Medina County, totaling 22 flares. Total AgI was 1760g. Due to computer glitches, track data for June 3 is not available.

JUNE 5

Another MCS pushed across the area, this time just after sunrise. 09P was launched to seed the leading edge of the complex as it pushed across the area, although inflow was not too impressive. 7AA was also launched, but had problems locating inflow. The activity decreased in size and intensity as afternoon approached. 2 flares were burned in Bexar County, totaling 160g of AgI.
Due to computer glitches, track data for June 5 is not available.

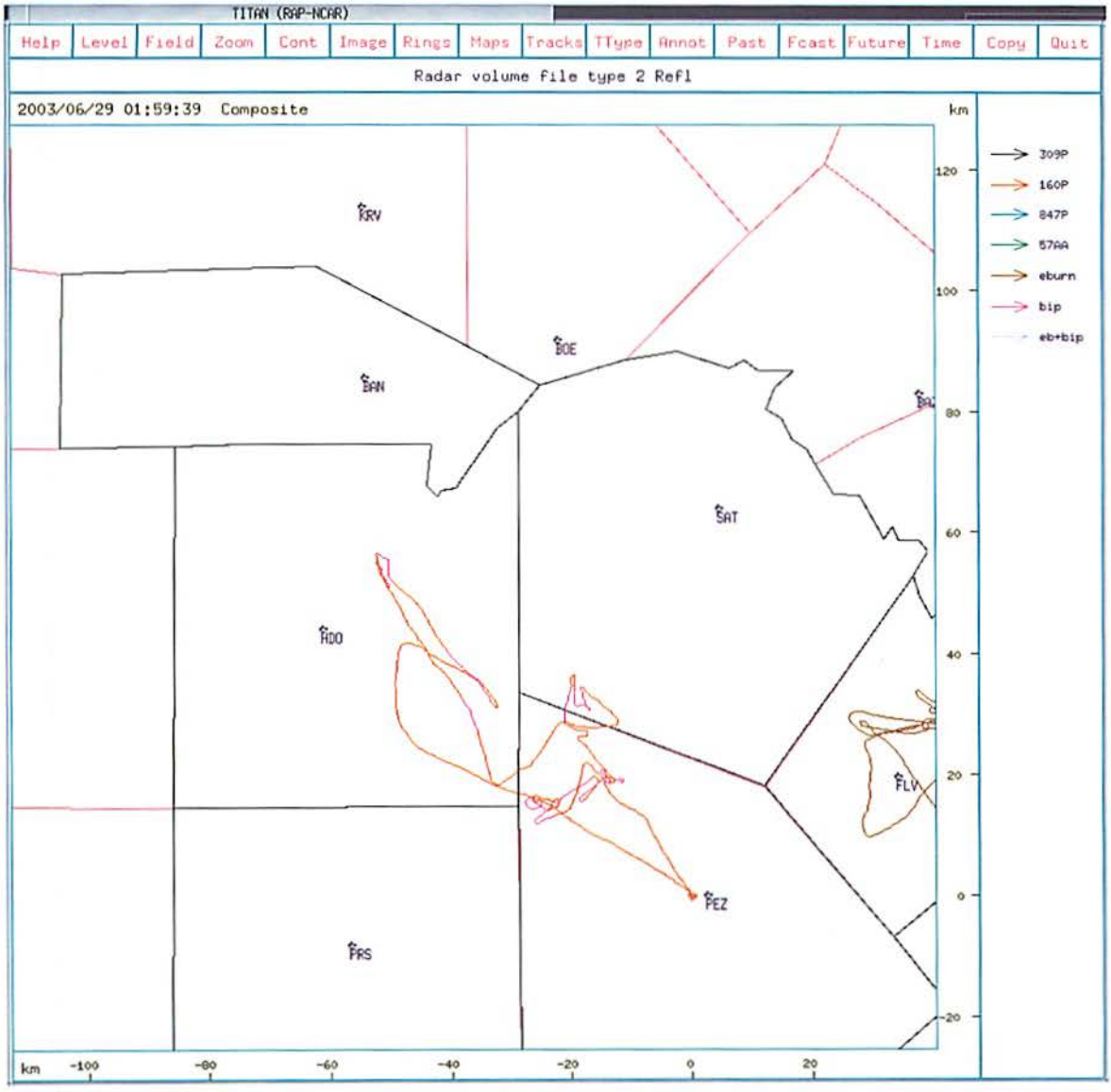
JUNE 19

A few showers developed late in the afternoon over Bexar and Medina counties. 60P and 47P were launched at 5:30pm and 6pm, respectively, to look at developing cells in Medina County. A total of 7 flares were burned over Medina County, totaling 560g of AgI.



JUNE 28

Daytime heating and a weak cap allowed for scattered showers and thunderstorms to develop across parts of the target area. Activity began to develop in Kendall County during the afternoon hours and pushed south and west into Bexar and Medina counties. 60P was launched at 6:30pm CDT and treated activity in Medina and Bexar counties. 5 flares were burned in Medina County, with 3 flares in Bexar County. Total AgI used was 640g. Activity appeared to have a favorable response, with growth in areal coverage and a lifetime that appeared to be longer than a couple of cells outside the target area that were not seeded.



METEOROLOGICAL PERSPECTIVE OF SEEDING IN JUNE 2003

June turned out to be a much better month for seeding. The weather patterns changed so that storm systems were affecting our area more compared to May. The days of sultry dewpoints arrived early in the month and combined with disturbances to produce a few convective events. Seeding on June 3rd appeared to increase the lifetime and areal coverage of clouds compared to those that were not touched. Some of the storms became severe, with warnings issued. I do not believe that seeding helped these storms become severe. As it was, the atmospheric conditions that day were already conducive to severe storm formation, and unseeded storms were primarily the ones that became severe as opposed to the treated cells. A rather disappointing mission took place on the 5th; the plane did not reach the activity right as it entered the northern target area, but rather after it had moved into the target area about 20 miles. Unfavorable sky conditions at the leading edge of the complex of storms resulted in no seeding done in the most favorable areas. For this particular day, timing was not good, and this is what resulted in a less than favorable mission. Mid-month saw one seeding event, but the visual results on radar were marginal. It appeared that June 28th was the best day of the month in terms of seeding results, as storms seeded across southern Bexar/northern Atascosa/southeastern Medina counties fared very well, with distinct extensions in lifetime and areal coverage compared to the unseeded/control clouds outside the target area. To sum up the month, it was an unfavorable start, with a great finish.

GENERAL DISCUSSION:

July continued with the trend of normal to slightly above normal rainfall across much of the area. A slow-moving upper low early in the month produced several days with convection. Tropical waves affected the area on the 8th and 27th, with locally heavy rainfall in some areas. An unusual cold front pushed down into Texas on the 23rd and 24th. While it did not make it to south Texas, the pre-frontal trough did manage to make it into the northern target area, producing showers and thunderstorms. By far, the biggest weather event of July was Hurricane Claudette, which moved across south Texas on the 15th. Light to moderate rain and gusty winds affected the target area, with some river flooding noted south of the target area. Claudette's remains affected the area for two days after landfall, bringing scattered showers and thunderstorms to the area.

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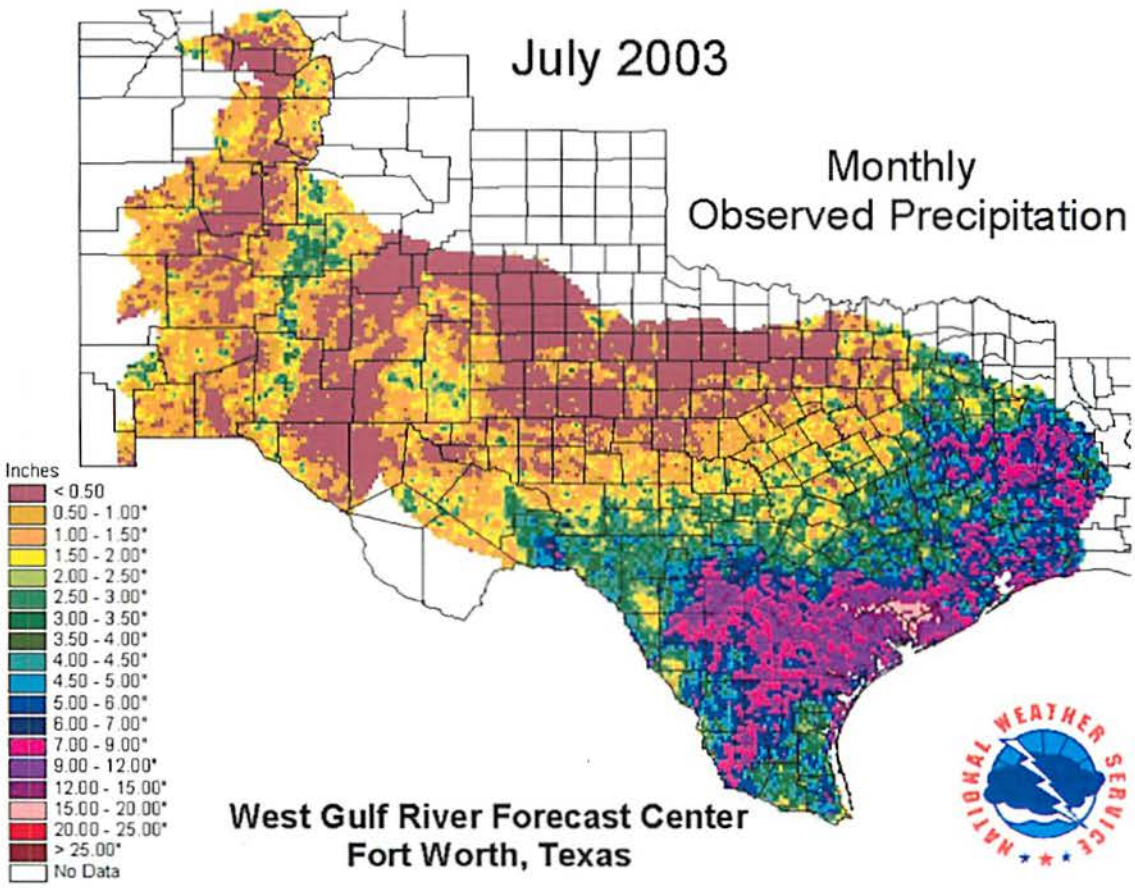
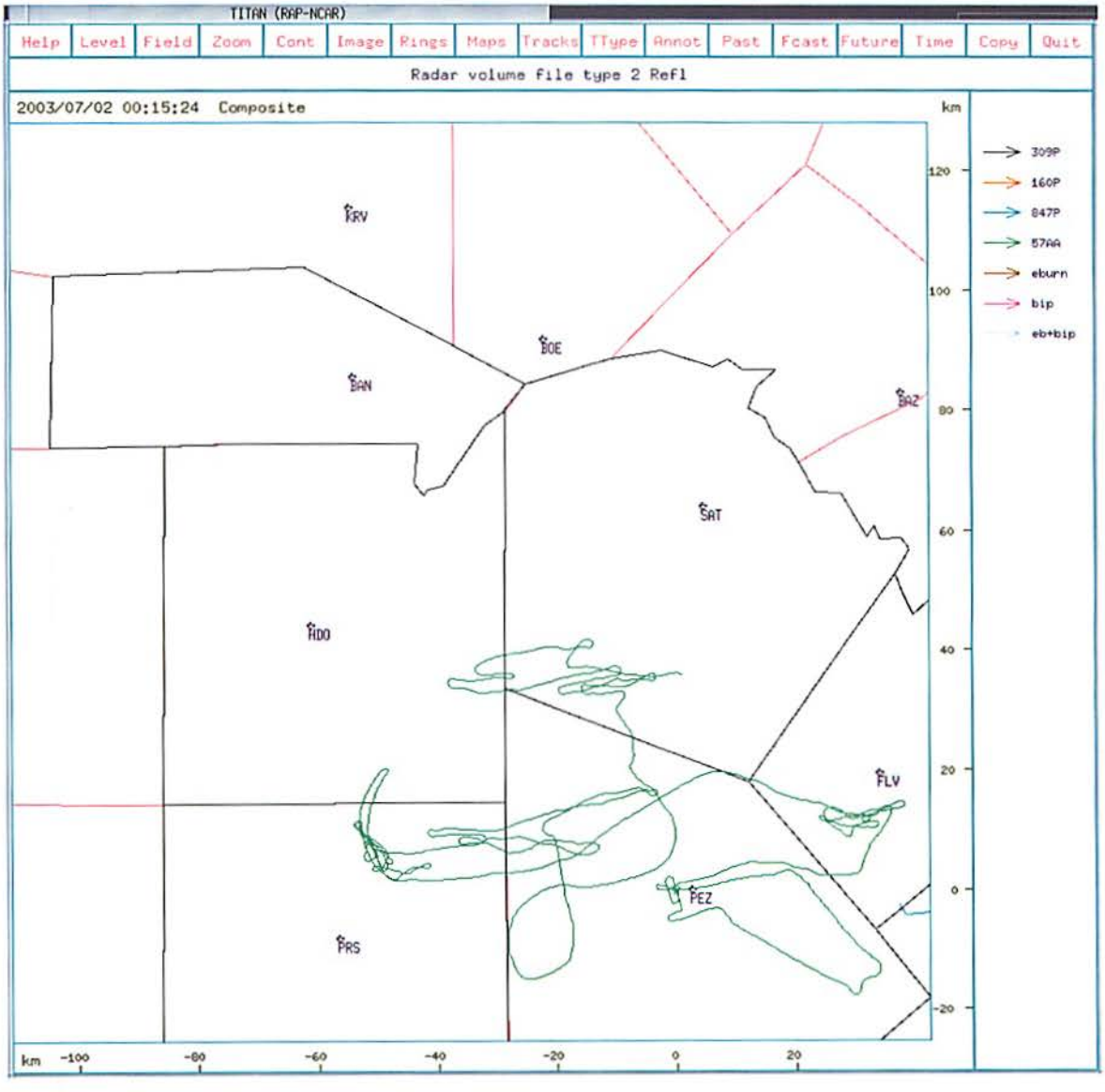


JULY 1

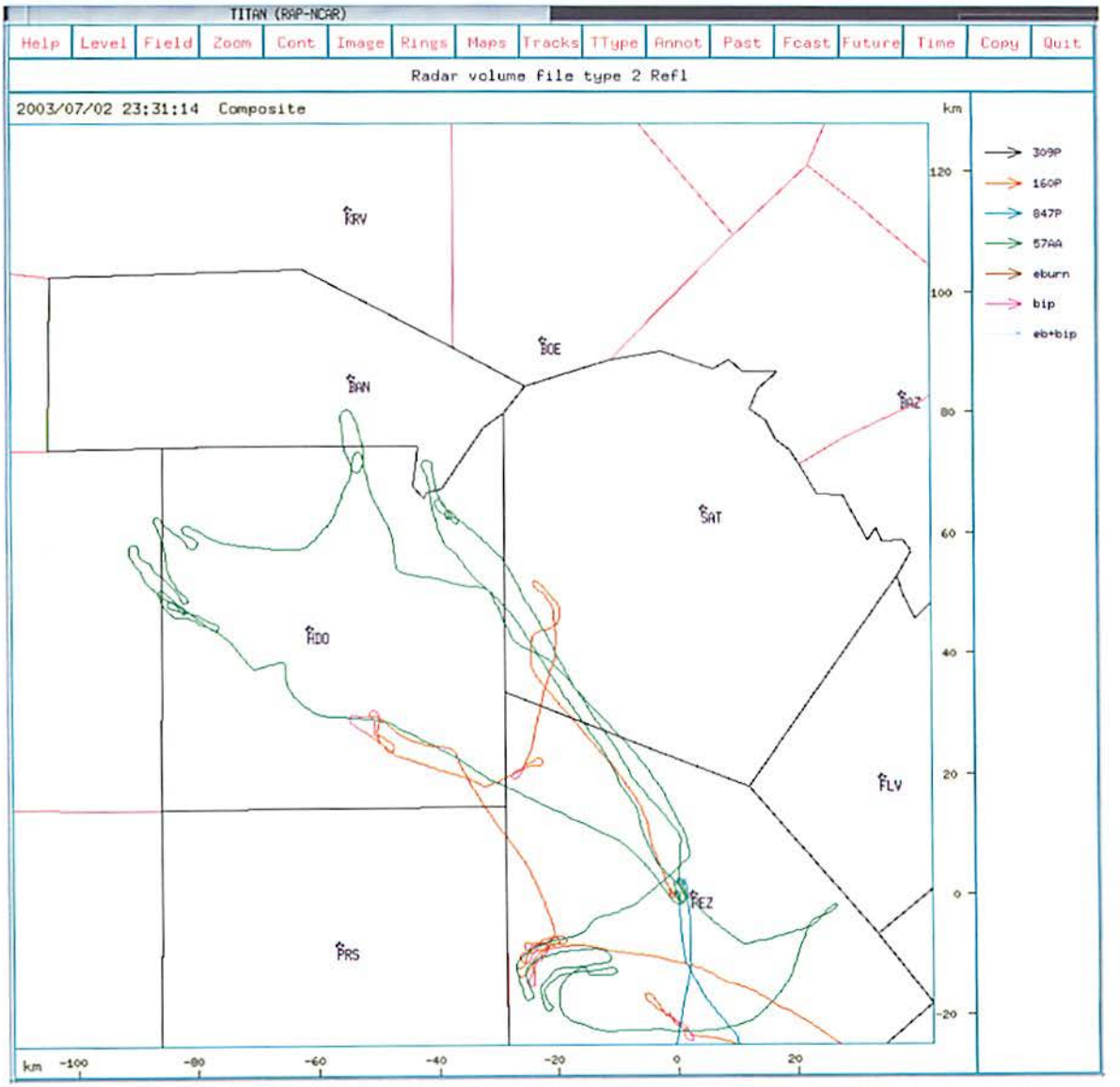
High precipitable water values (more indicative of a tropical atmosphere) and an uncapped atmosphere set the stage for popcorn-type showers and thunderstorms across Bexar and Medina counties today. With ample sunshine, convective temperatures were reached just past noon, and convection developed west of San Antonio. 7AA was launched to seed activity as it moved southward across Bexar and Medina counties. The seeded activity appeared to respond well, with cell lifetimes extended compared to other nearby activity.

10 flares were burned over the target area (Bexar - 7; Medina - 3), totaling 800g of AgI.



JULY 2

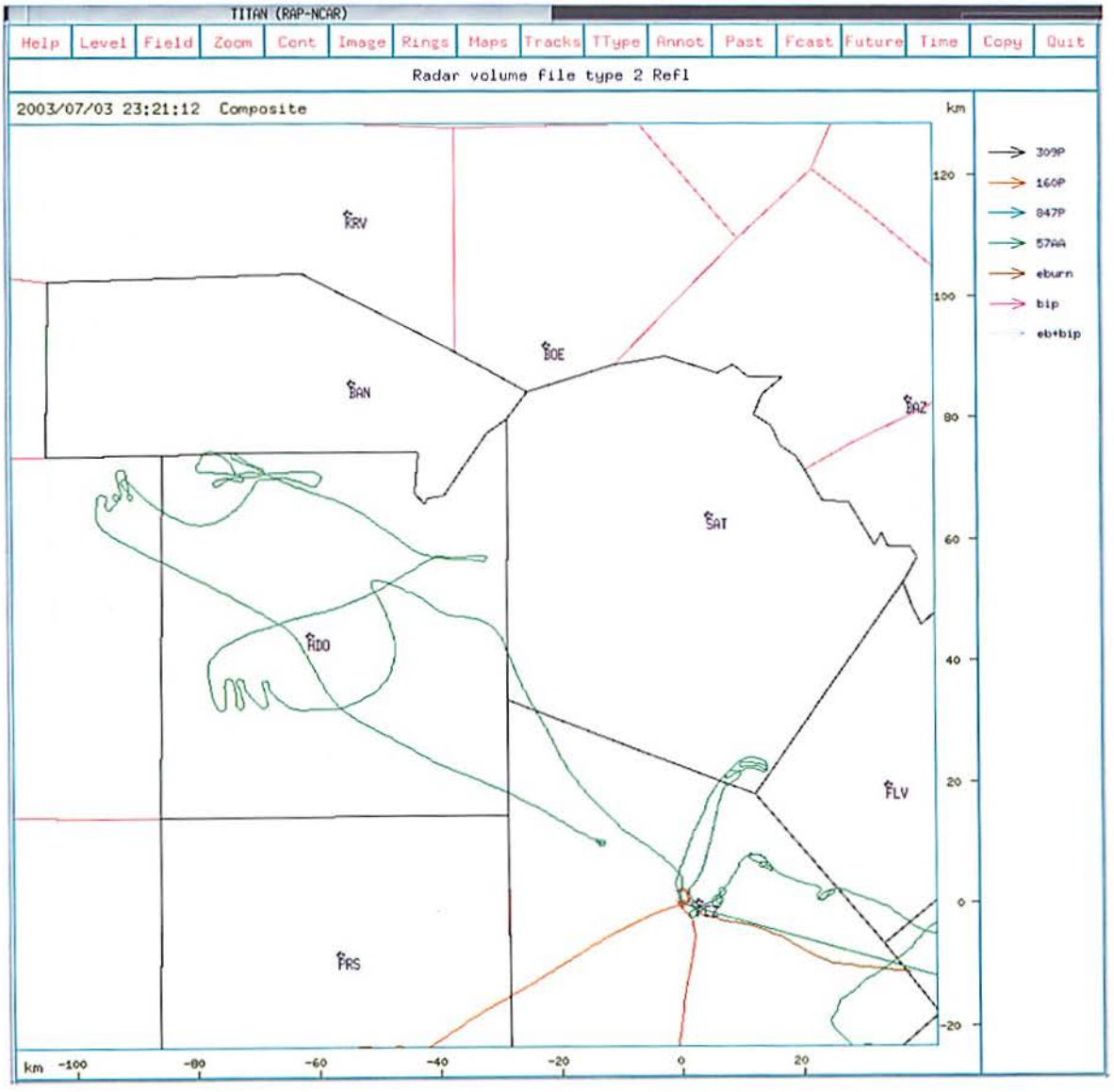
A continuation of the tropical feed of moisture, combined with energy impulses rotating around an upper low in Mexico produced scattered showers and thunderstorms across the target area once convective temperatures were reached. Activity began early in the afternoon and lasted into the evening, giving some areas a couple inches of rainfall. 9 flares were burned over Medina County, totaling 720g of AgI.



JULY 3

A large complex of showers and thunderstorms moved inland from the Gulf in the morning hours, with the leading edge of convection resembling a seabreeze boundary pushing northwest across the entire target area. Two planes (7AA and 60P) were launched to treat the leading cells as they advanced across the target area, fueled by daytime heating, abundant moisture, and convergence along the leading edge of the complex. This activity lasted into the late afternoon hours before exiting the target area after 6pm.

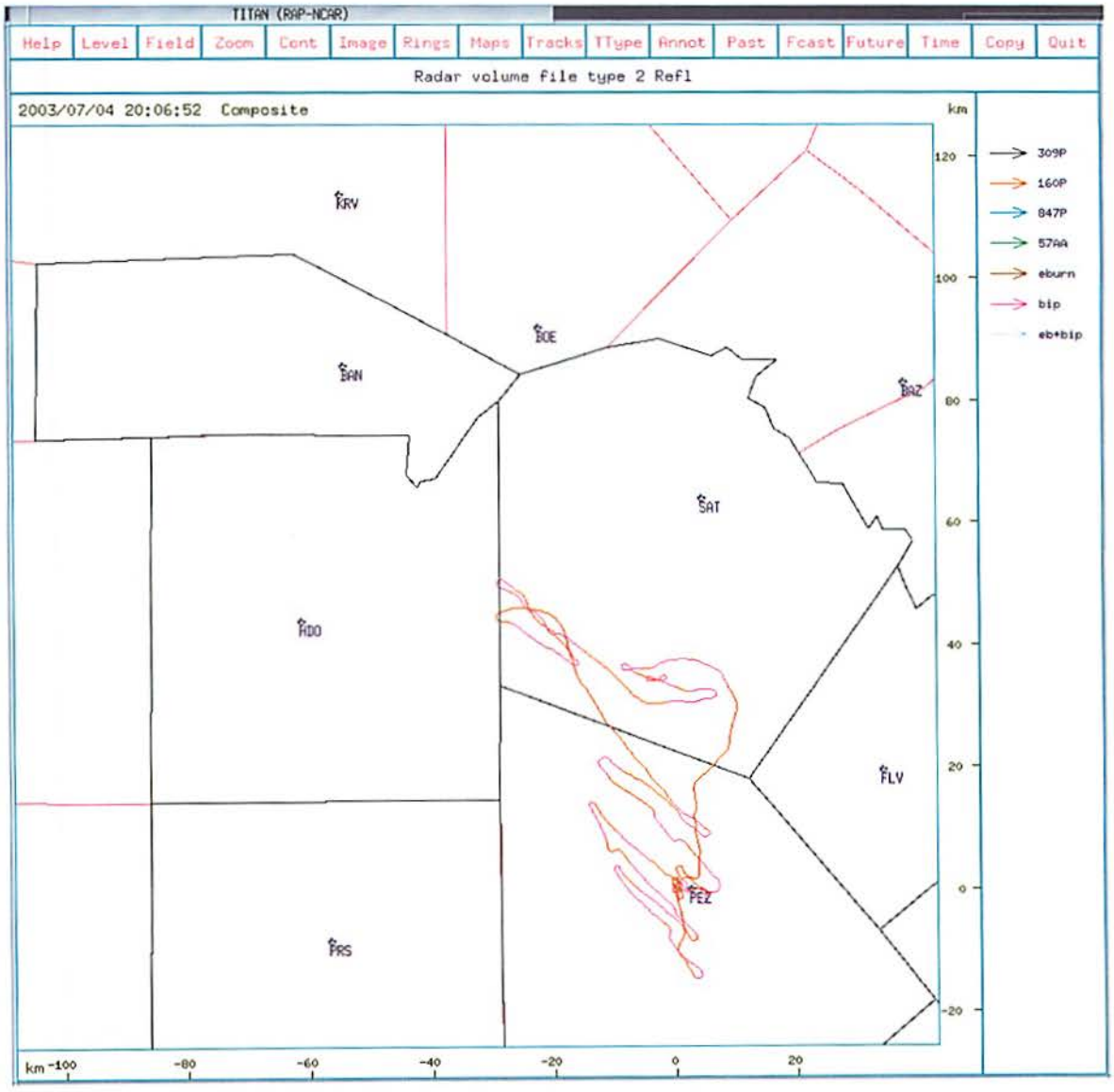
12 flares were burned over the target area (Bexar - 3; Medina - 6; Uvalde - 3), totaling 960g of AgI.



JULY 4

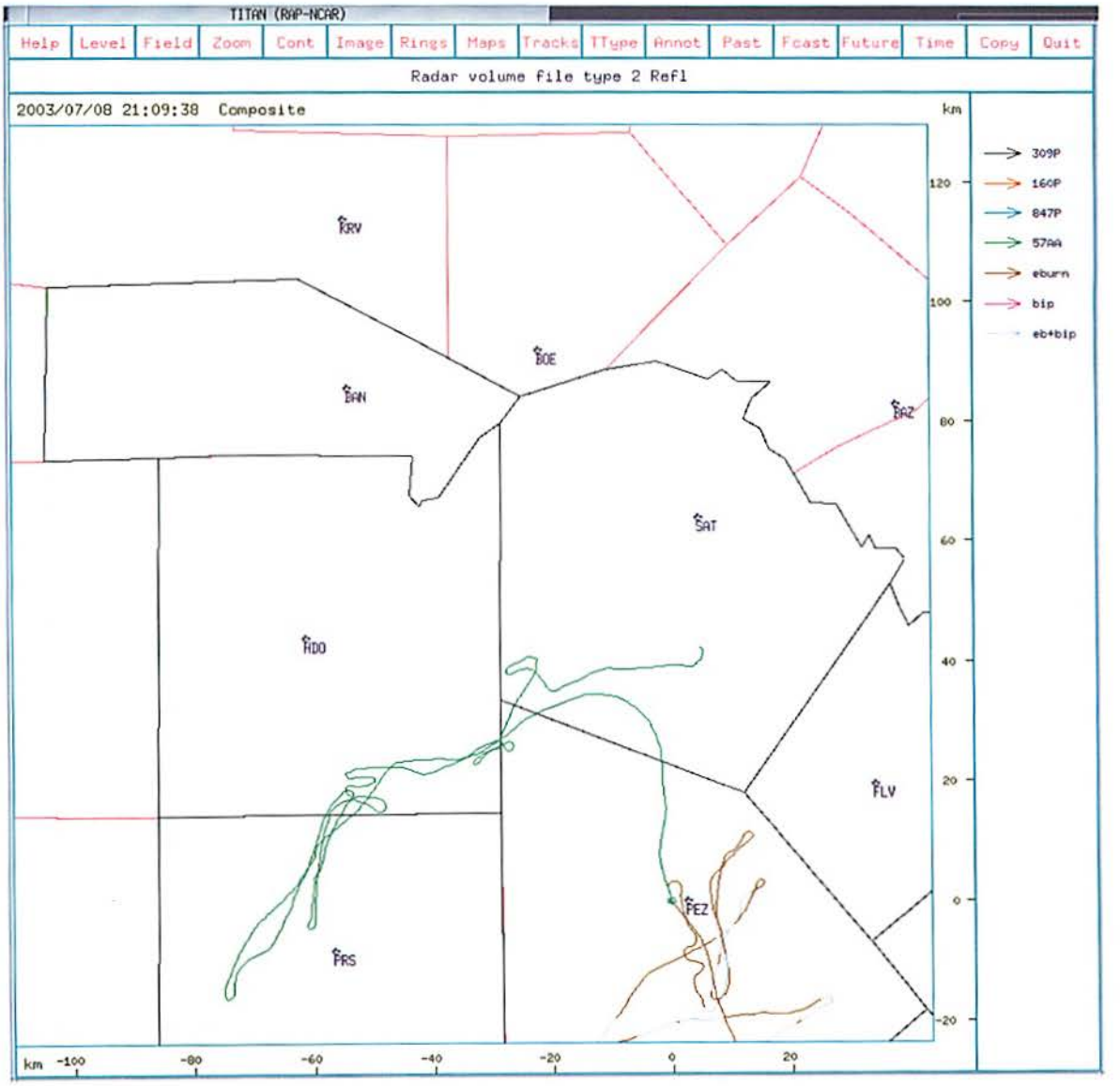
The upper low to the west continued to spin without moving much. Energy ripples rotating around the low and approaching our area from the south spawned numerous showers and thunderstorms across the target area today. Two planes were launched to treat activity as it moved northward across the target area during the late morning and early afternoon hours.

10 flares were burned over Bexar County, totaling 800g of AgI.



JULY 8

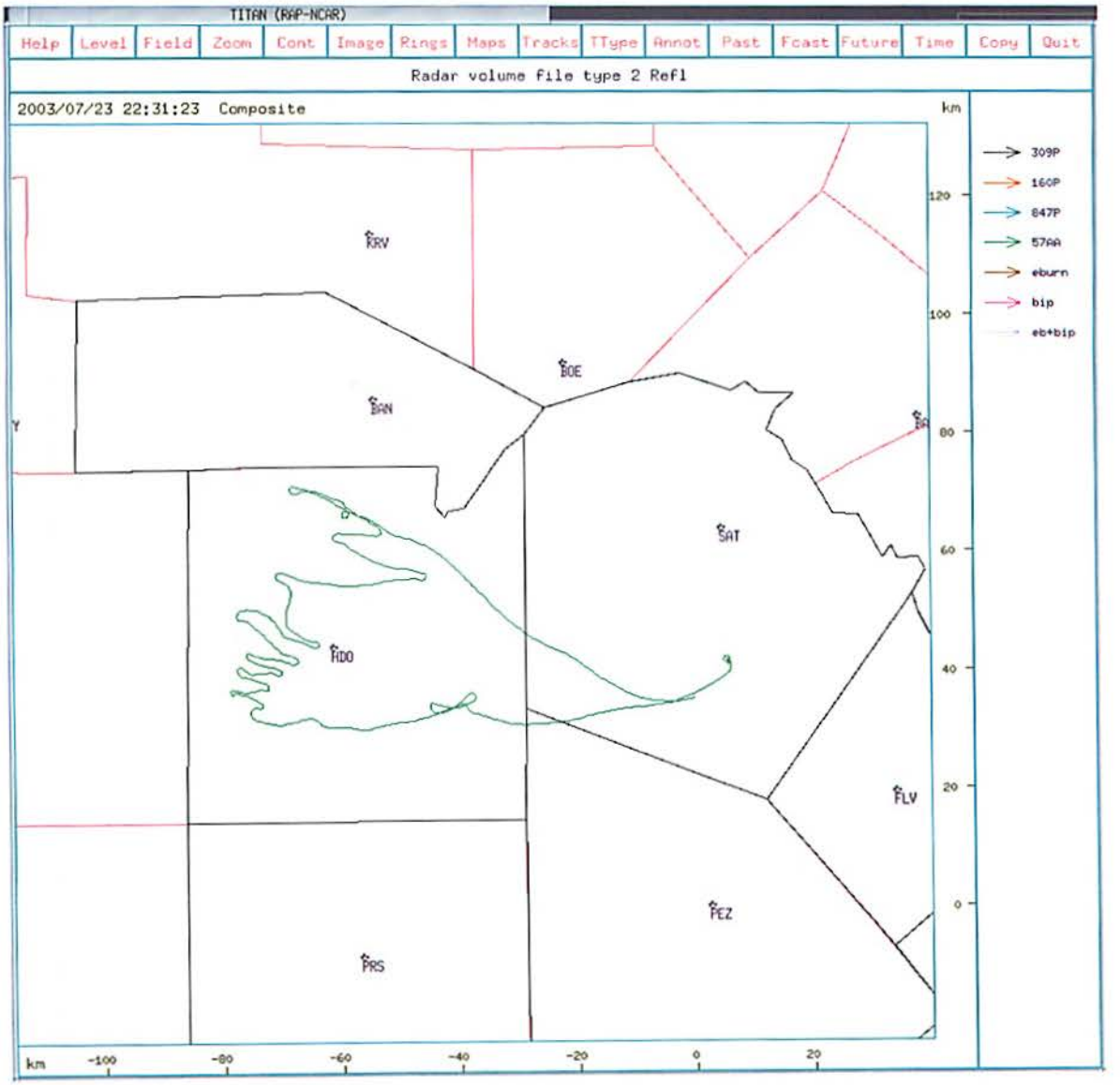
A TUTT was located near the middle Texas coast, with little overall motion noted. Abundant moisture had overspread the area. With daytime heating and upward vertical motion near the TUTT, showers and thunderstorms began to pop up near the coast and advect inland to the west and northwest. 09P and 7AA were launched to do seeding of the activity as it moved across the entire target area during the afternoon hours. One problem the pilots encountered today was the rather low bases on the convection, due to a very moist atmosphere.
3 flares were burned in Medina County, totaling 240g of AgI.



JULY 23

A rare July cold front pushed into north Texas, where it stalled. An MCS developed in east Texas and pushed southward during the day. Storms began to build to the west, along the outflow boundary and in an area of high theta-e. The storms approached the NW part of the target area, and 7AA was launched to treat the storms as they pushed southwestward into Bandera and Medina counties. The storms appeared to die rather rapidly as they moved further south…maybe encountering warmer mid-level temperatures.

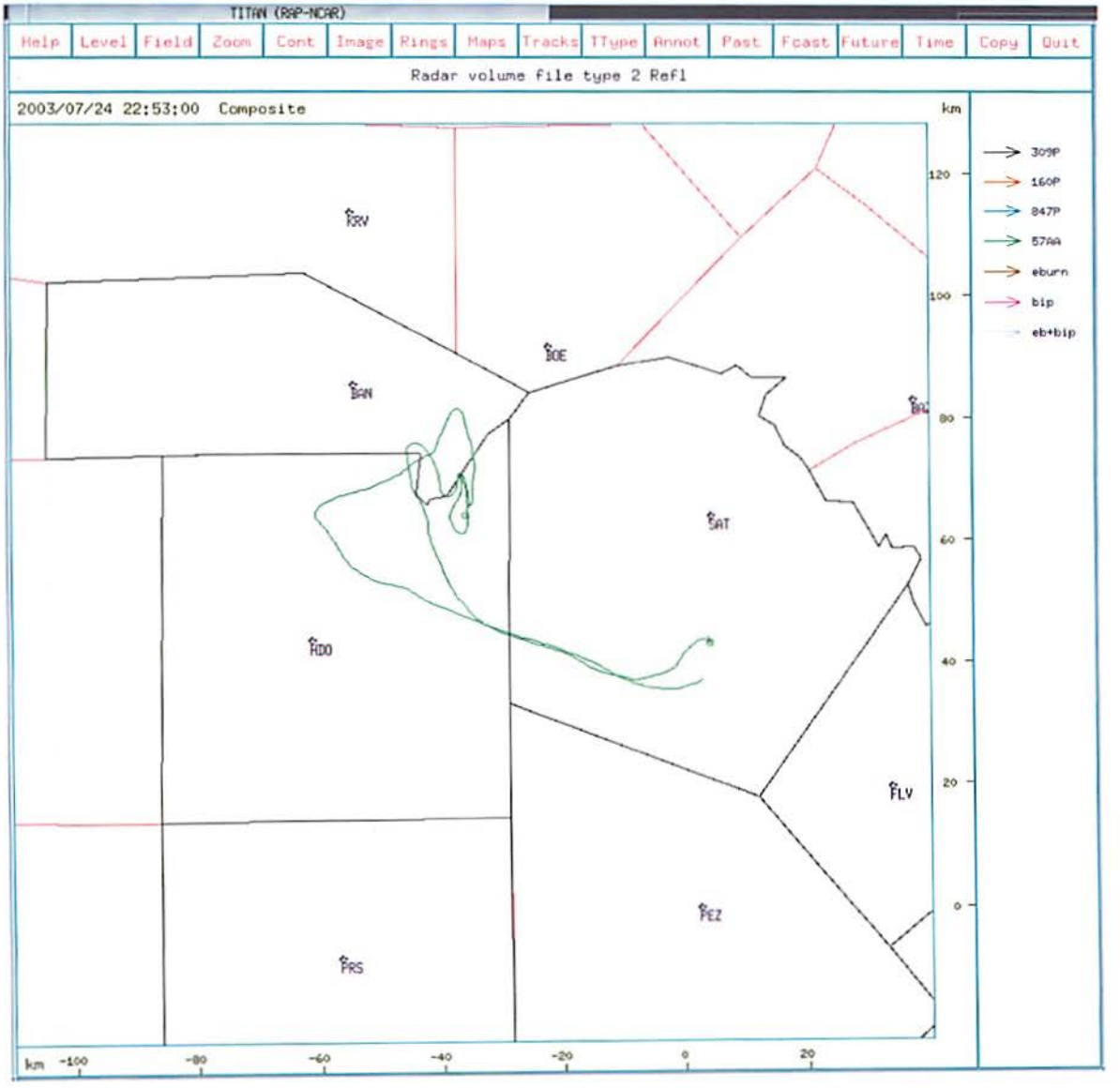
7 flares were burned in Medina County, totaling 280g of AgI.



JULY 24

The tail end of a shortwave trough moved across south-central Texas today. Lift from this feature helped to ignite a few showers and thunderstorms across Bandera and Medina counties towards the late afternoon hours. 7AA was launched to treat the isolated activity, all of which dissipated by early evening.

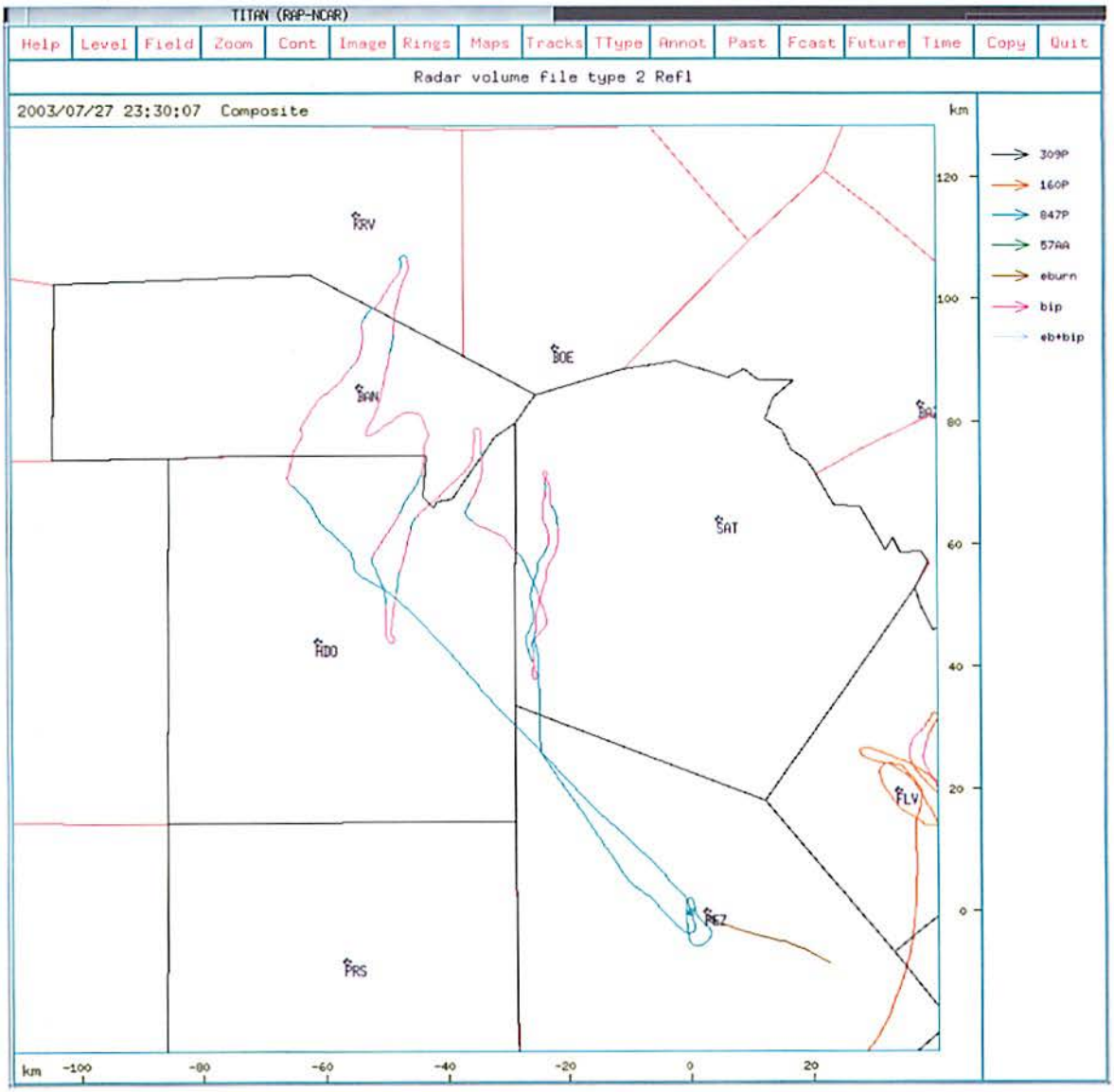
3 flares were burned in Medina County, totaling 120g of AgI.



JULY 27

A tropical wave moved across south Texas during the late morning and afternoon hours. Abundant moisture, strong surface heating and lift from the wave induced shower and thunderstorm activity that traversed the entire target area from east to west during the afternoon hours. Seeding of this activity was done by 47P.

27 flares were burned over the target area (Bandera - 12; Bexar - 7; Medina - 8) plus one in Kerr County. Total AgI used was 1120g.



METEOROLOGICAL PERSPECTIVE OF SEEDING IN JULY 2003

July, with eight days of seeding, turned out to be the busiest month of the season, despite a temporary suspension around the time of Hurricane Claudette. There were plenty of disturbances providing the necessary dynamics for convective activity, and lots of tropical moisture.

The first week of July was very busy, with convective activity nearly every day. On July 1, seeding across Bexar and Medina counties appeared to produce an increase in areal coverage and keep intensities steady. The next day, seeding was effective in extending the cell lifetimes compared to the control clouds. The response time of the planes were good, with seeding occurring before the half-lifetime of the cell was over. July 3 continued the trend of seedable clouds with positive results. On July 4, deep tropical moisture began to overspread the target area. Showers and thunderstorms developed across the target area, which were seeded. The response time on this day was not favorable, and results appeared to have a marginal effect on the clouds. July 8 was not a good day for seeding, despite the copious amounts of moisture present. Cloud bases were very low (<1000 ft AGL), and visibility was poor. Activity did not appear to respond to the flares. The next week was not quiet weatherwise, as Hurricane Claudette crossed the target area, but no seeding was done again until the 23rd, when heavy thunderstorms developed to the northwest of the target area and pushed across Bandera and Medina counties. Seeding results were questionable, as the storms appeared to weaken considerably the further south they went. This may have been due to warmer temperatures aloft, which capped the atmosphere across much of the target area. The last week of July saw two days of seeding, with good results noted in most of the seeded clouds.

Overall, July was a successful month for seeding, as the apparent positive effects outweighed the neutral or negative effects.

GENERAL DISCUSSION:
August continued to be relatively busy in terms of seeding across the area. After a dry first week, convective activity increased across the area. Two tropical storms (Erika, Grace) affected the area, although not much rain fell as a result. Severe weather affected the area on August 11. Tropical airmasses were common this month, as is usually the case. Overall, most areas received a below average amount of rainfall for August.

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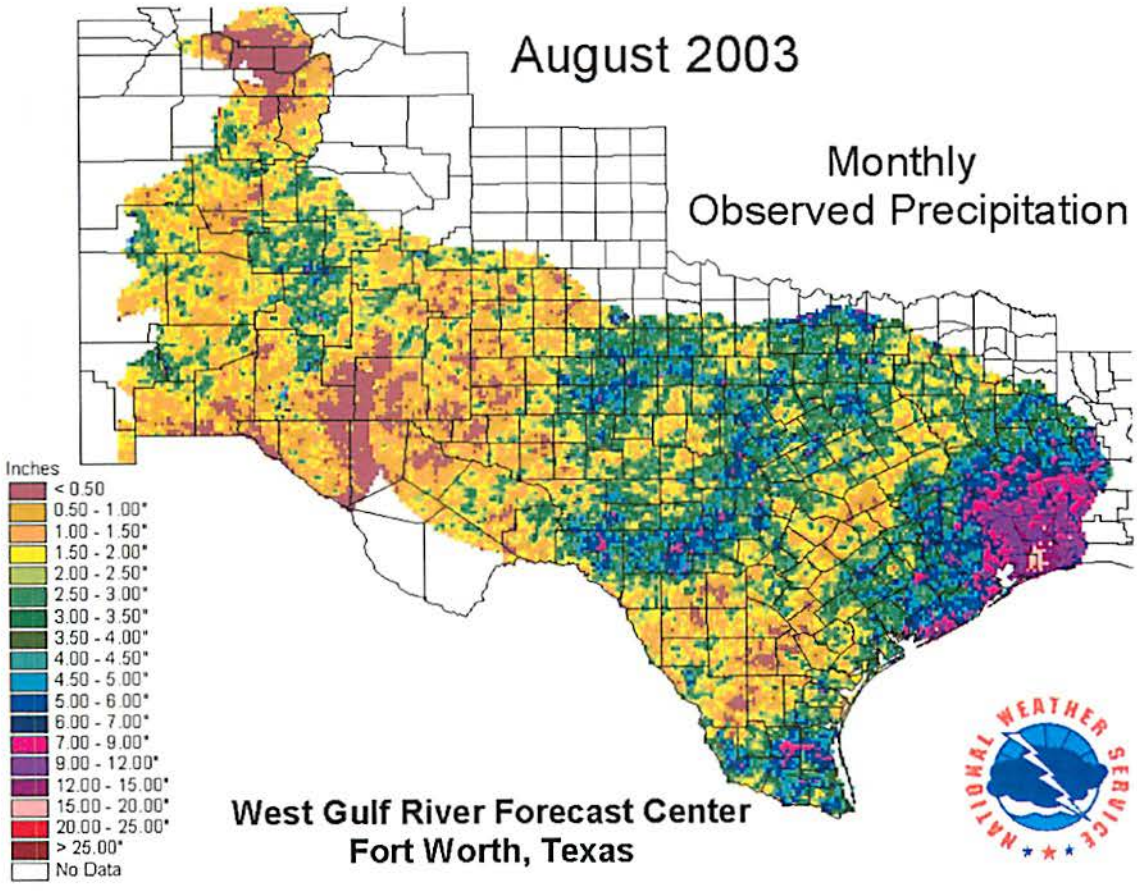
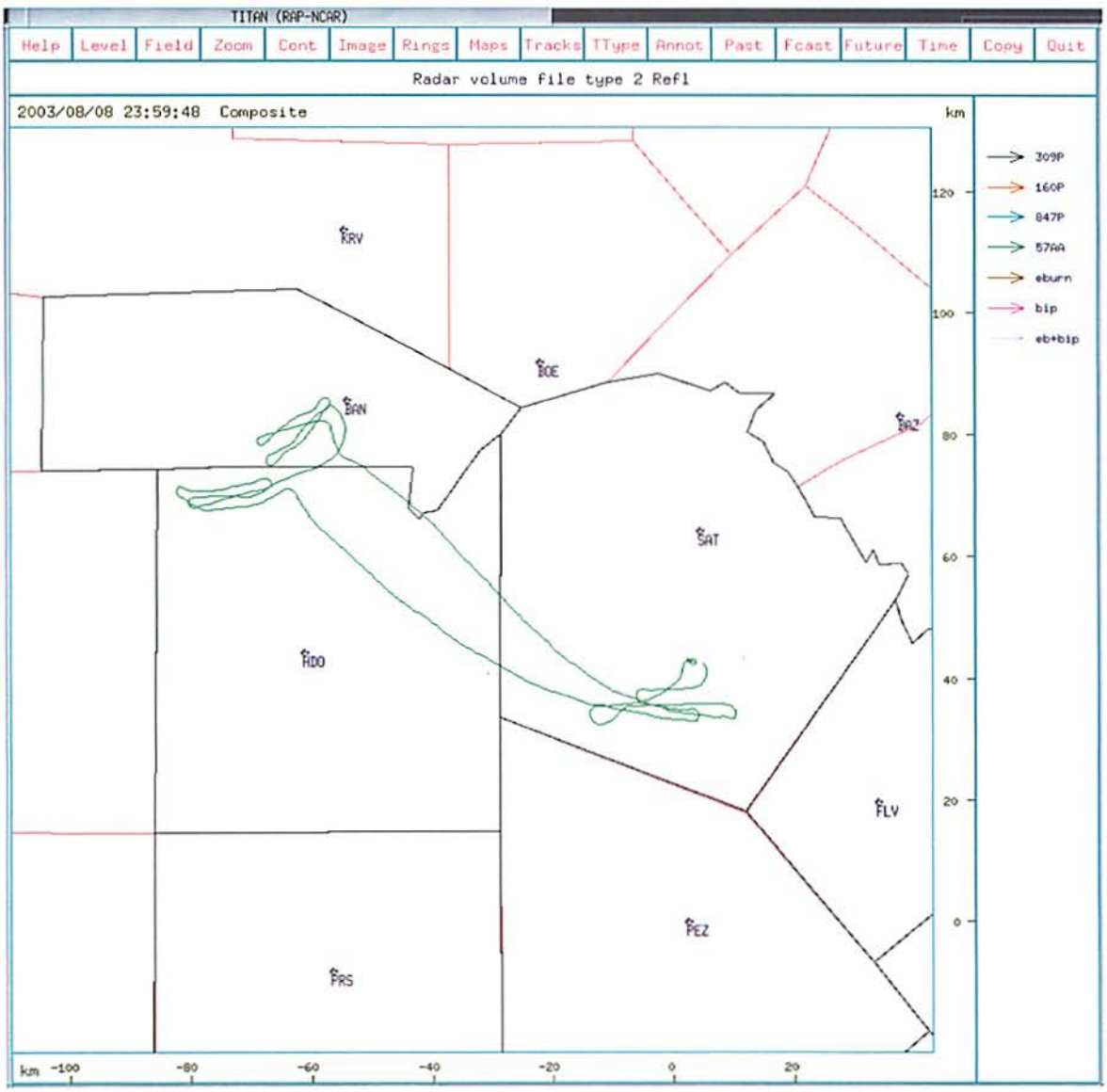


AUGUST 8

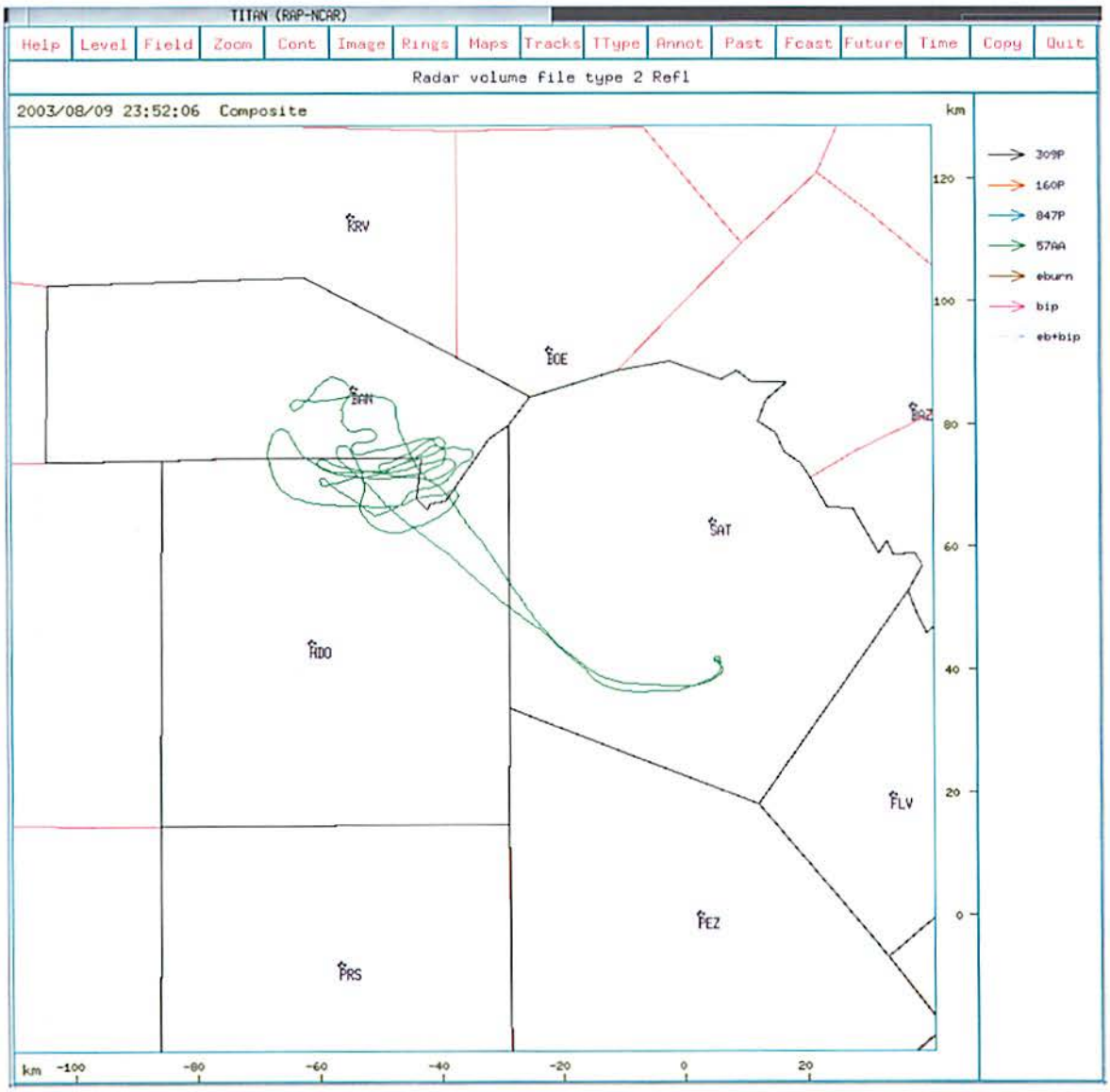
A frontal boundary lay east to west across central/SE Texas. During the afternoon, showers and thunderstorms developed along this feature and moved to the S and SW. One area of storms was over central Bexar County, and the other area was further north and west, in Bandera and Medina counties. 7AA was launched late in the afternoon to treat the activity in the NW target area. The cell over San Antonio became severe, with a warning issued. This cell was avoided, as a result.
9 flares were burned (Bandera - 6; Medina - 3), totaling 360g of AgI.



AUGUST 9

An MCS traveled southward across the state, with the decaying complex approaching the northern target area during the afternoon. While the original storms dissipated, new storms developed along the outflow boundary and pushed into the northwestern counties during the late afternoon and early evening hours. 7AA was launched to treat the activity in Bandera and Medina counties, with fair to good resulted as indicated by radar trends.

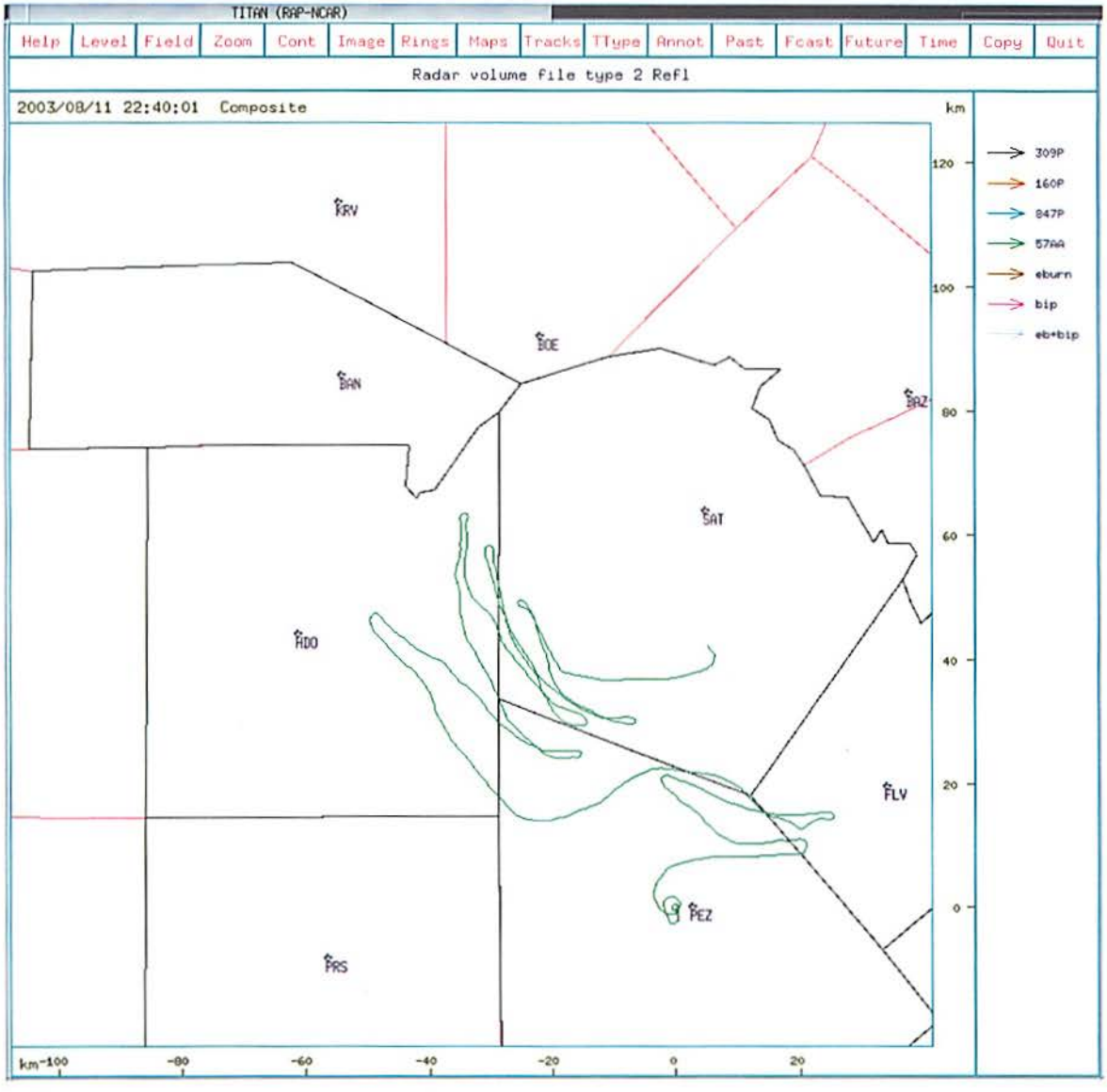
11 flares were burned (Bandera - 8; Medina - 3), totaling 440g of AgI.



AUGUST 11

A shortwave, sparking thunderstorms in north Texas, continued to move south towards the target area. Showers and thunderstorms developed north of the target area early in the afternoon, intensifying and pushing to the south and southwest during the afternoon as they encountered a more moist and unstable airmass. With the risk of severe weather, a Severe Thunderstorm Watch was issued at 1935 UTC, in effect until 0100 UTC. 7AA was launched to treat activity that moved across Bexar and Medina counties. Some of the storms became severe, with warnings issued.

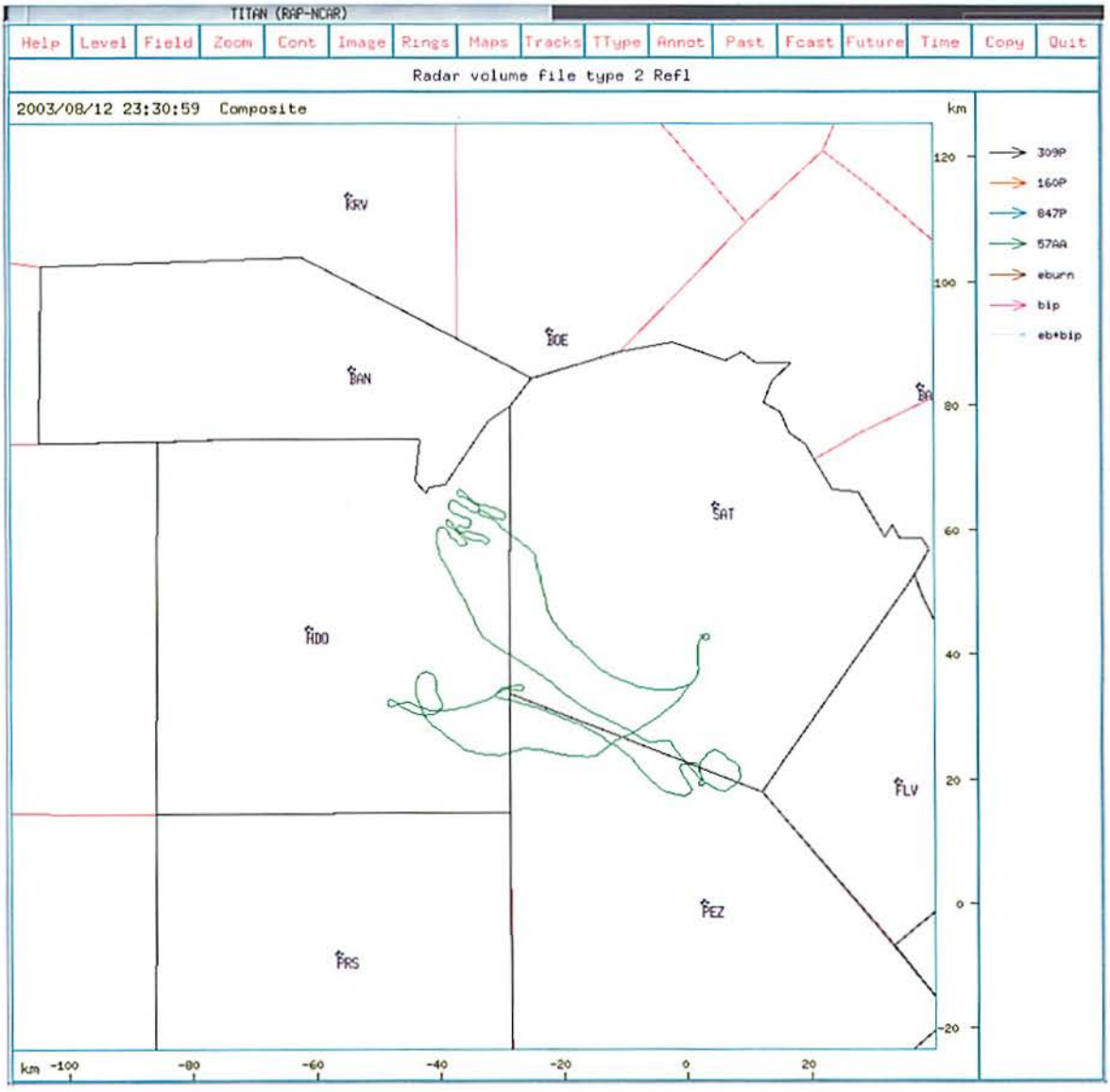
15 flares were burned (Bexar - 11; Medina - 4), totaling 600g of AgI.



AUGUST 12

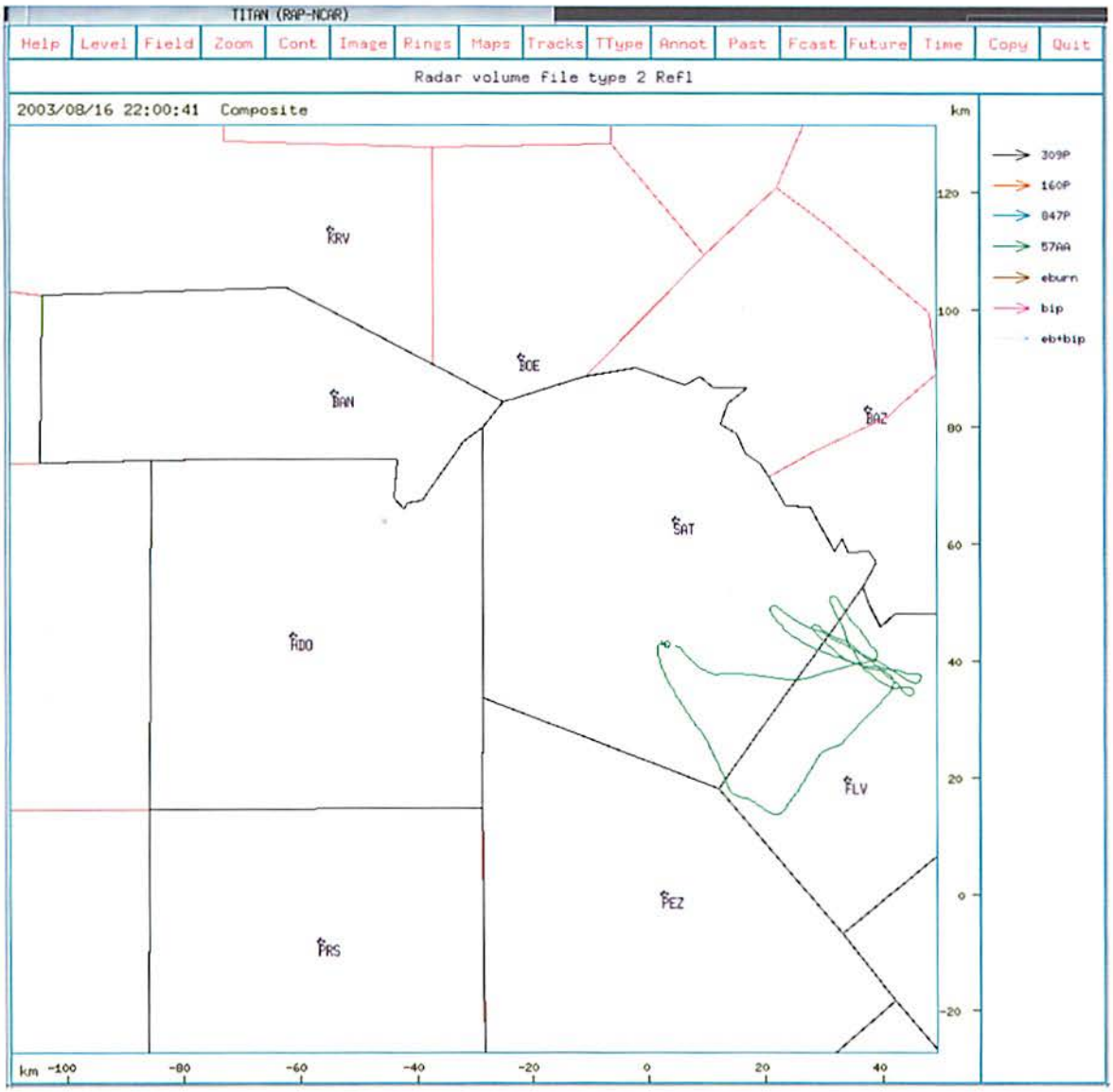
An upper level low over east Texas was slowly pushing to the west and southwest towards the target area. A ripple of energy was rotating around this low, accompanied by a mid-level jet streak. Plenty of low-level moisture was in place, with soundings revealing precipitable water values between 1.75" and 2". Showers and thunderstorms began to develop just north of the target area, and these continued to develop and push south and southwest across the northern target area. 7AA was launched to treat the activity over Medina County.

7 flares were burned, totaling 280g of AgI.



AUGUST 16

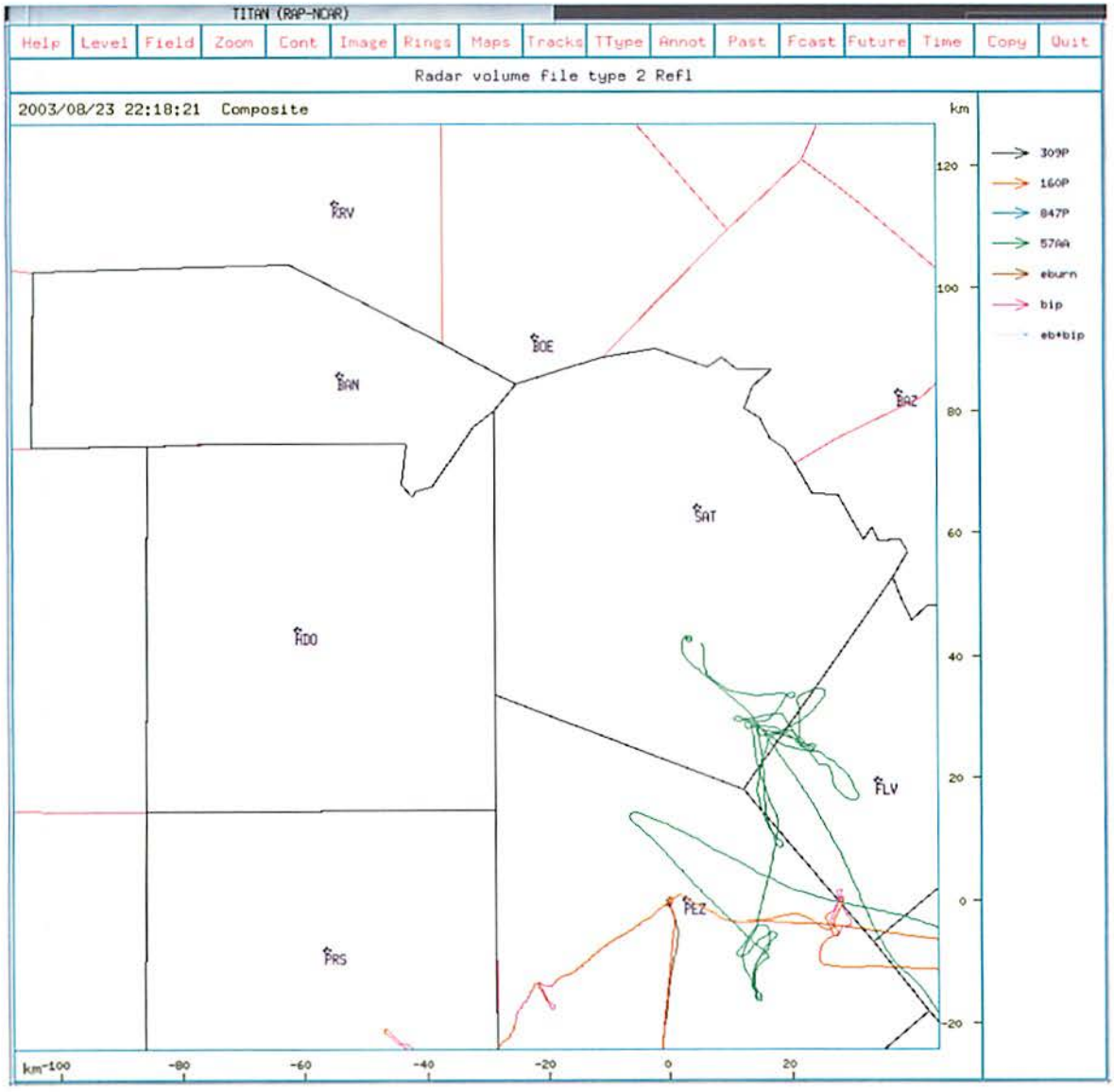
Tropical Storm Erika, a compact but potent tropical storm (perhaps a minimal hurricane at the time of landfall around 5am) was making her way into Mexico, with weak feeder bands developing around the outer edges of her influence. One of these weak broken bands of convection moved westward across the target area during the afternoon hours. 7AA was launched to look at the activity, with a few flares fired into a convective cell in Wilson and Bexar counties. It did not appear that seeding helped the activity, as it (and all other convective cells this particular day) dissipated within 30-45 minutes of existence.
3 flares were fired in Bexar County, totaling 120g of AgI.



AUGUST 23

Plenty of tropical moisture was in place across much of the eastern half of Texas. Numerous outflow boundaries lie over the area from previous convection. With little in the way of a cap on the atmosphere, convection began to pop early once the sun began to heat the air up. Popcorn-type showers and thunderstorms developed quickly across much of the target area, eventually forming several small clusters of storms. 7AA was launched to treat the activity developing across Bexar County.

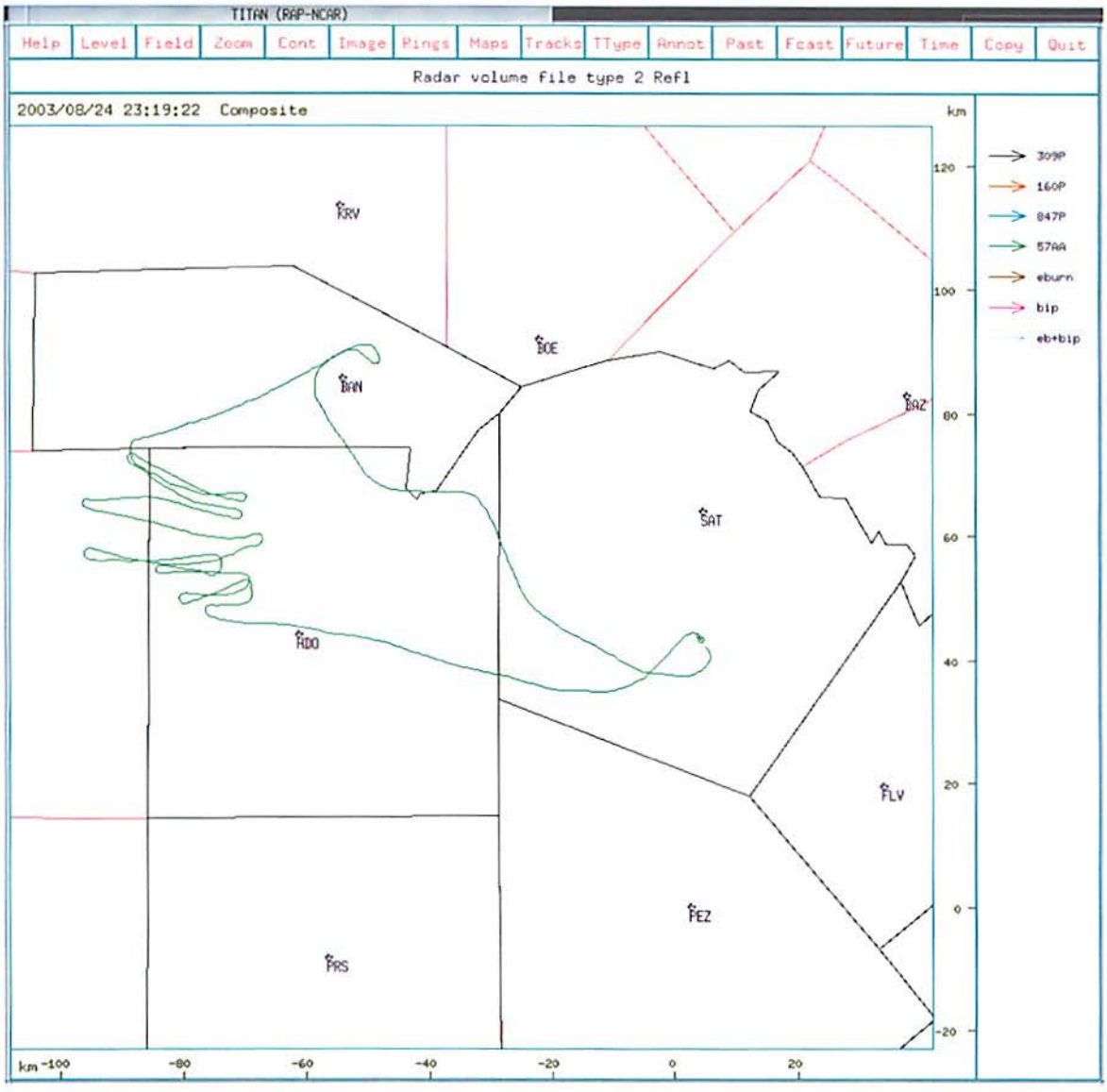
6 flares totaling 240g of AgI were burned over Bexar County.



AUGUST 24

Tropical moisture was spilling into the area from both the Gulf of Mexico and from the former Hurricane Ignatio near La Paz, Mexico. Weak ridging was evident over the area, resulting from a weak TUTT positioned west of the area, in Mexico, and from a weak low in the Gulf. However, with the abundant moisture, little in the way of convective inhibition, and several outflow boundaries, all it took was a little heating from the sun and showers and thunderstorms began to develop. The activity developed in Bandera and Medina counties, and 7AA was launched at mid-afternoon to seed the activity.

19 flares were burned (Bandera - 2; Medina - 14; Uvalde - 3), totaling 760g of AgI.



METEOROLOGICAL PERSPECTIVE OF SEEDING IN AUGUST 2003

The relatively busy weather pattern that occurred in July carried over into August, after a quiet first week. The first seeding mission of the month took place on the 8th, when a frontal boundary to our north spawned storms, which moved southwestward across Bandera and Medina counties. Areal coverage was fair, although there did not appear to be a significant increase in lifetime compared to control clouds. The next day would see a better result, with seeded activity near Medina Lake resulting in two showers merging together; the increase in size, lifetime, and a steady intensity were appreciable. Storms on the 11th were seeded, although with caution as the atmosphere was ripe for severe weather. Storms on the west side of Bexar County appeared to fare well, with an increase in the apparent intensity and size of the cloud. On August 12, popcorn-type showers were seeded in Medina and southern Bexar counties. The activity in Medina County appeared to show a steady intensity, and a lifetime longer than the control clouds. Of particular interest was a small shower seeded over southern Bexar County with one flare. This small shower tracked south across Atascosa County, with a tenth of an inch of rain at Pleasanton in a very short period of time. This small shower made it all the way to the McMullen County line before finally dissipating. Although small, this cloud showed a positive effect from seeding. The last part of August saw two days with seeding (23rd and 24th). Seeding effects on the 23rd showed a positive effect, with lifetime extension of the treated activity apparent compared to untreated clouds. Activity seeded on the 24th did not show much response.

SEPTEMBER 2003

GENERAL DISCUSSION:
September turned out to be a rather wet month for south Texas, particularly during the first two weeks. A tropical airmass resided over the area for the first half of the month. As various disturbances trekked across the area and interacted with the very moist atmosphere, heavy showers and thunderstorms developed. The latter half of September was somewhat drier, but there were still a couple of rainy days. In spite of all the rain, there were only two days this month when seeding took place in the EAA target area.
For the month of September, 28 flares (Bandera - 6; Bexar - 5; Medina - 17) were burned, totaling 1120g of AgI.

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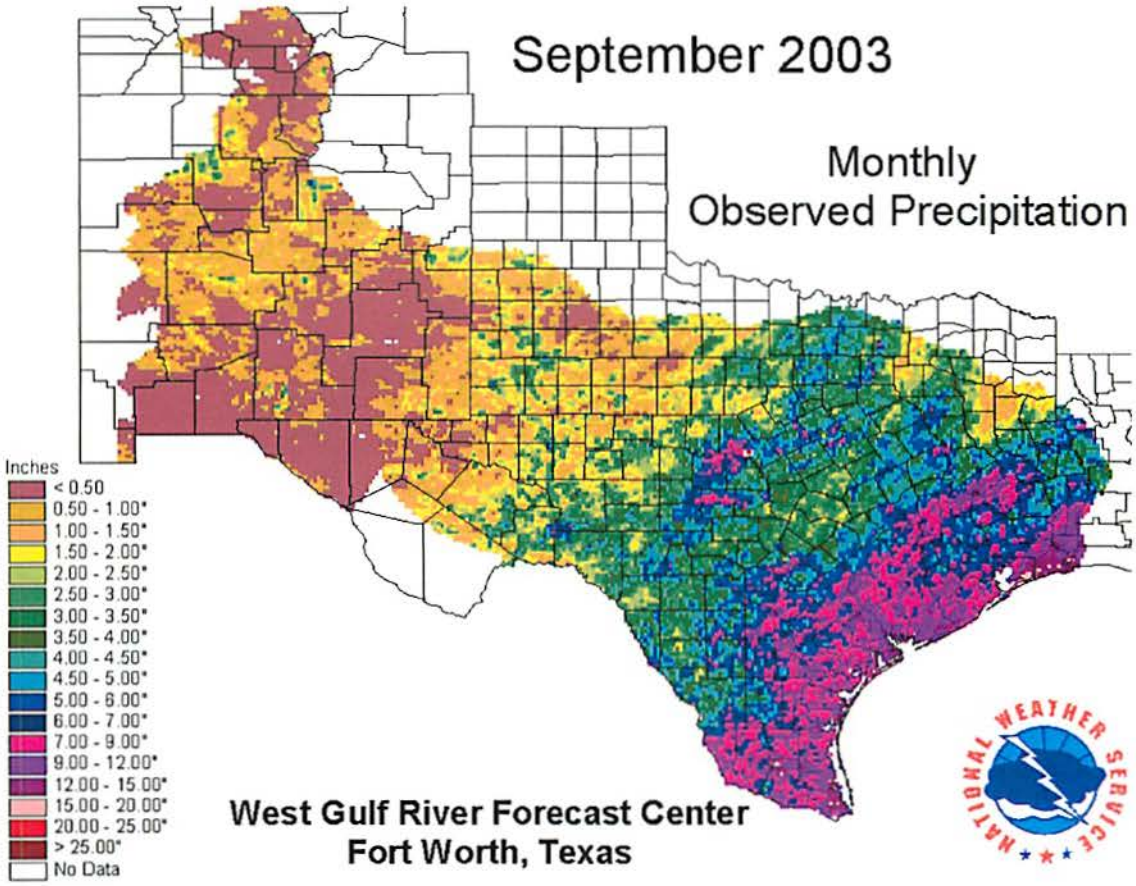
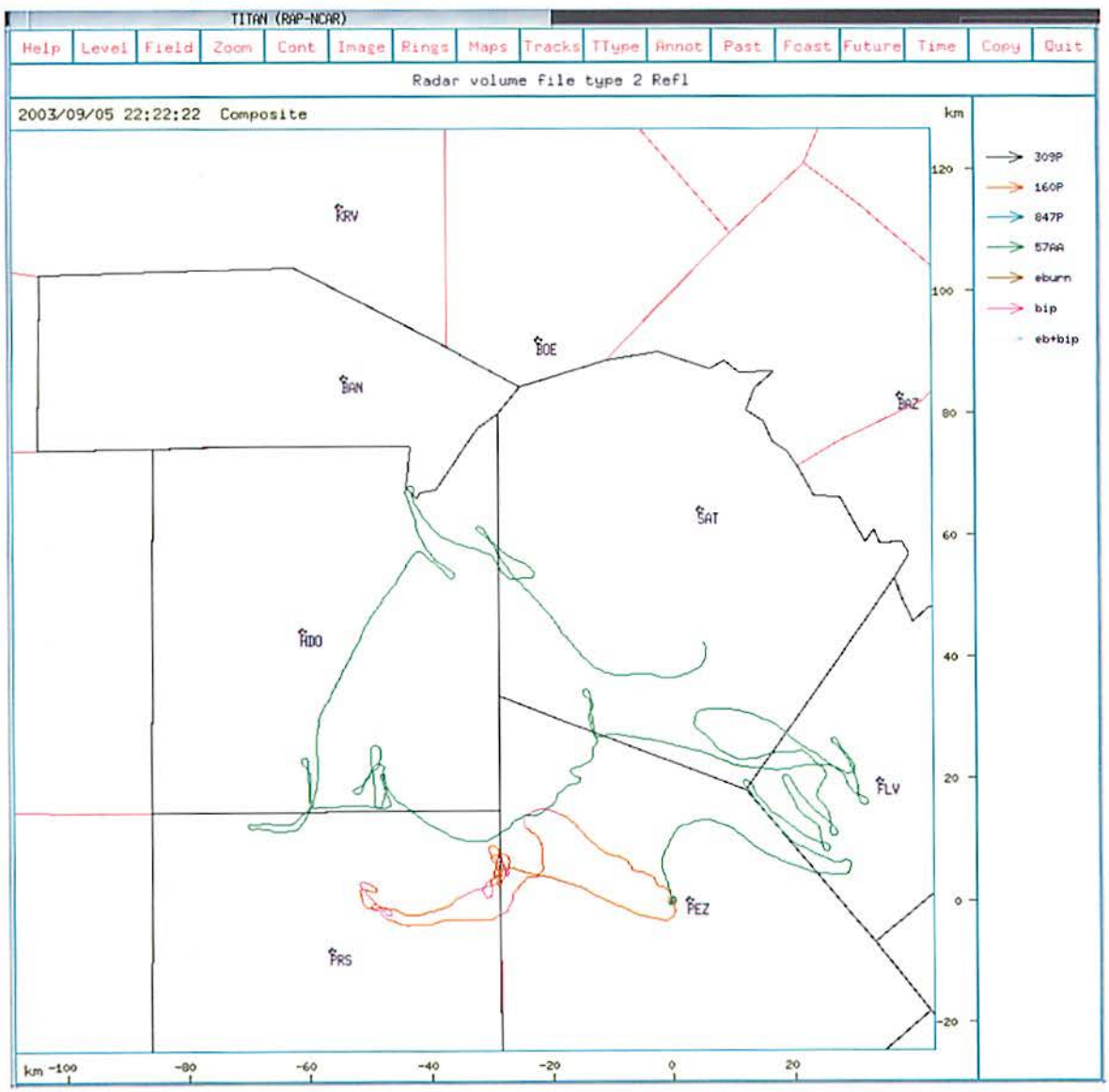


SEPTEMBER 5

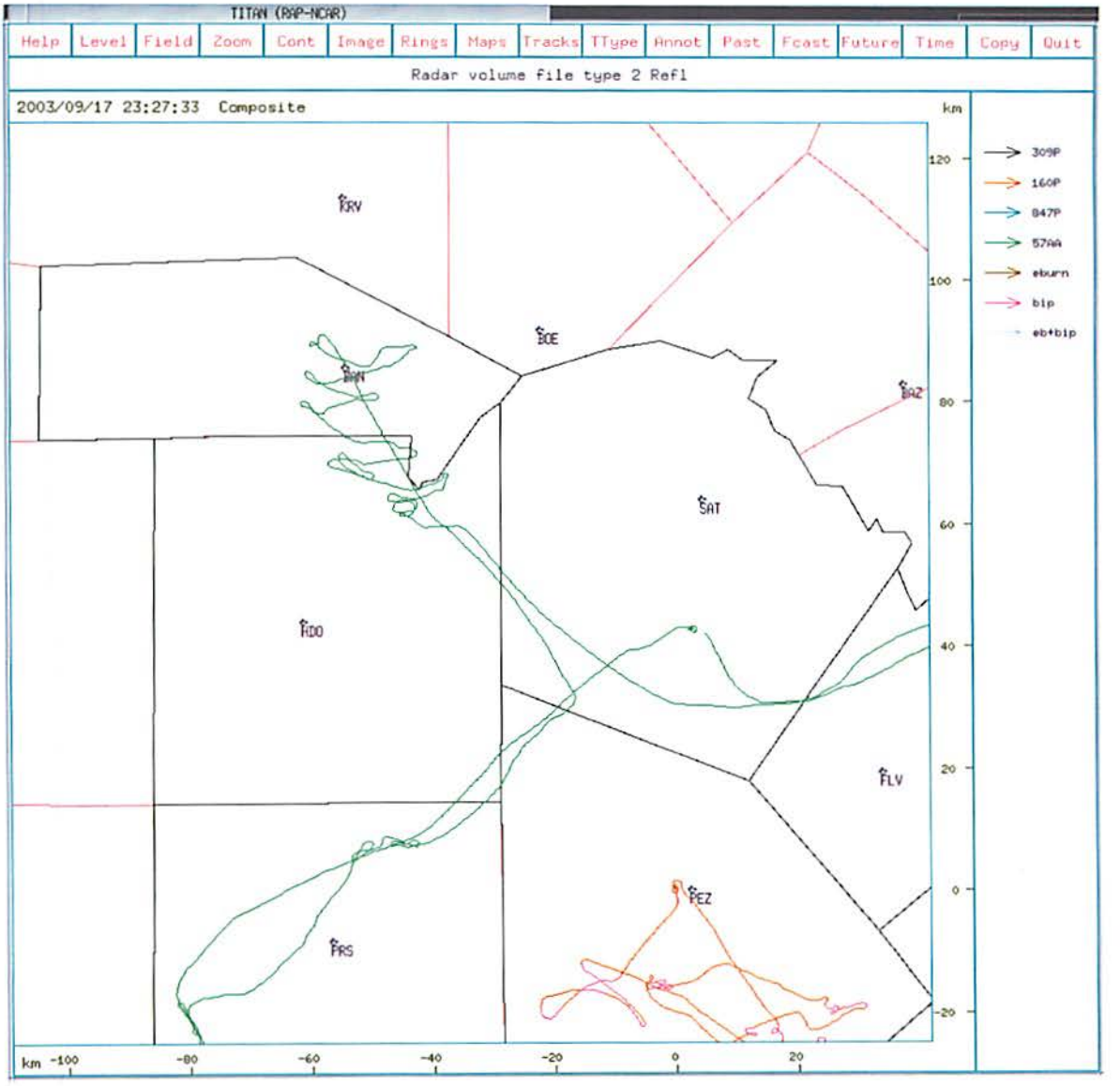
A very moist and unstable atmosphere was situated over south Texas today. With no cap in place, all it took was some daytime heating before showers and thunderstorms began to develop. The storms formed just north of the target area and pushed slowly southward over a period of a couple of hours. The storms became quite intense across San Antonio and points south, with Flash Flood warnings issued. Seeding was done with these storms, with 16 flares (Bexar - 5; Medina - 11) burned, totaling 640g of AgI.



SEPTEMBER 17

As had been the case for the past couple of weeks, a very moist and unstable airmass sat over the area, with little in the way of a cap. Showers and thunderstorms began developing early in the afternoon as daytime heating progressed. 7AA was launched to treat activity that developed over Bandera and Medina counties, with decent increases in lifetime and areal coverage compared to untreated clouds.

12 flares were burned (Bandera - 6; Medina - 6), totaling 480g of AgI.



METEOROLOGICAL PERSPECTIVE OF SEEDING IN SEPTEMBER 2003

For the month of September, there were only two days where seeding took place in the EAA target area. Both days, however, showed very good results implied from the radar data. On September 5th, we saw a "good seeding day", when several storms were seeded over the northern portion of the target area. These storms merged into one large cluster that propagated south across the entire target area, lasting well after leaving the southern border. Cell mergers were apparent, and lifetime increases were substantial compared to other convective cells not treated. Our final day of seeding for 2003 was on September 17th, and this turned out to be a great ending to the year, with apparent cell lifetime extensions and intensity increases compared to the control clouds.

GENERAL DISCUSSION:
For the most part, October was a drier than normal month in terms of precipitation. There were a few days with some significant rains, but these events were more of a stratiform-type rain, which does not respond to seeding. As such, the month went by with no cloud seeding taking place.

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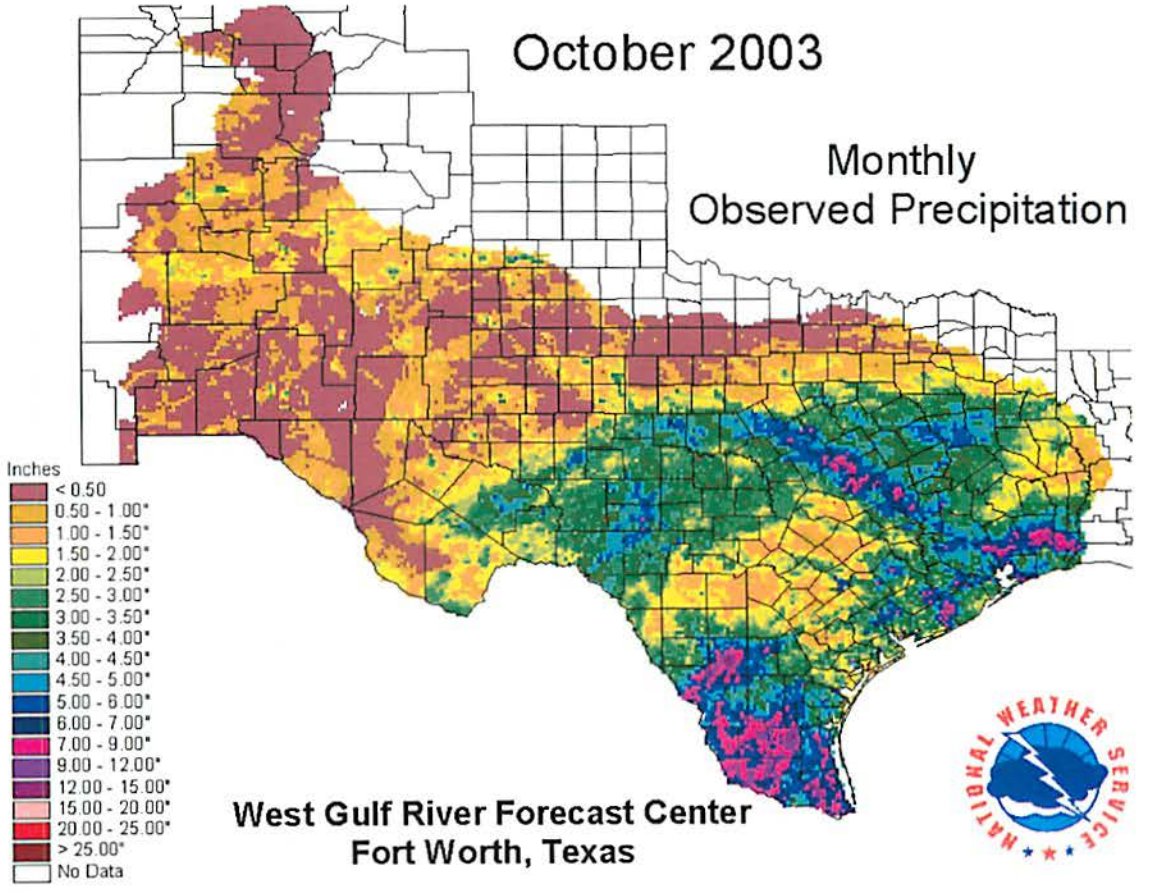

2003 RESULTS FOR BANDERA, MEDINA AND BEXAR COUNTIES (EAA)

The following is an excerpt from Archie Ruiz' 2003 radar analysis report for the STWMA:

38 clouds were seeded over these counties in 19 operational days. (19 small clouds, 6 large clouds, and 13 type B clouds)

Table A: Small seeded clouds vs. their control clouds (19 cases)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)*
Lifetime	60 min	35 min	1.71	71 **(54)**
Area	36.6 km^2	29.8 km^2	1.23	23 **(32)**
Precip Flux	179.4 m^3/s	117.1 m^3/s	1.53	53 **(60)**
Precip Mass	632.1 kton	255.9 kton	2.47	147 **(104)**

A total of **83 flares** were used in this sub-sample. Timing was very good **(70%)** for an effective dosage of about **100 ice nuclei per liter.**

An increase of 104% in precipitation mass for a control value of 255.9 kton in 19 cases means:

Δ_1 = 19 x 1.04 x 255.6 kton = 5051 kton = 4096 ac-f

Table B: Large seeded clouds vs. their virtual control clouds (6 cases)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	180 min	155 min	1.16	16
Area	193 km^2	165 km^2	1.17	17
Precip Flux	1100 m^3/s	865 m^3/s	1.27	27
Precip Mass	8260 kton	4561 kton	1.81	81

A total of **65 flares** were used in this sub-sample. Timing was excellent **(80%)** for an effective dosage of about **50 ice nuclei per liter** which may have reached higher values in some particular cells.

An increase of 81% in precipitation mass for a control value of 4561 kton in 6 cases means:

Δ_2 = 6 x 0.81 x 4561 kton = 22166 kton = 17977 ac-f

Table C: Type B seeded clouds vs. their virtual control clouds (13 cases)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	180 min	155 min	1.16	16
Area	586 km^2	480 km^2	1.22	22
Precip Flux	2943 m^3/s	2241 m^3/s	1.31	31
Precip Mass	23334 kton	17255 kton	1.35	35

A total of **140 flares** were used in this sub-sample. Timing was very good **(65%)** for an effective dosage of about **20 ice nuclei per liter,** which may have reached higher values in some particular cells.

An increase of 35% in precipitation mass for a control value of 17255 kton in 13 cases means:

Δ_3 = 13 x 0.35 x 17255 kton = 78510 kton = 63672 ac-f

The total increase, Δ_T, is:

$\Delta_T = \Delta_1 + \Delta_2 + \Delta_3$ = 4096 ac-f + 17977 ac-f + 63672 ac-f = 85745 ac-f

- **NOTE: The values in parentheses under "Increases (%)" in Table A represent the % increase of the parameter when the seeded cloud is compared to a MODELED control cloud as opposed to a real control cloud.**

COMPARISON OF 2002 AND 2003

The STWMA has been performing cloud seeding operations for the EAA since 2002. Each year, analysis of the radar data is done to determine the effects of seeding. These values pertain to what the radar has indicated, and are not direct measurements taken in the field. While there has not been enough data collected to make a long-term comparison of yearly rainfall to the average rainfall in the EAA target area, it might be of interest to look at the past two years' analyses numbers and draw some conclusions. The comparison will be broken down into three parts: small clouds, large clouds, and type B clouds.

2002 RESULTS - SMALL CLOUDS

Eight small clouds were seeded and included in this analysis. 55 flares were used with mediocre timing (46% of AgI in cloud before half-lifetime). Effective dosage, however, was 105 ice nuclei per liter of air, which is excellent.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	55 min	30 min	67
Area	57.6 km^2	47.8 km^2	15
Precip Flux	347.0 m^3/s	192.1 m^3/s	67
Precip Mass	1405.1 kton	631.7 kton	108

2003 RESULTS - SMALL CLOUDS

19 small clouds were seeded and included in this analysis. 83 flares were used with very good timing (70% of AgI in cloud before half-lifetime). Effective dosage was 100 ice nuclei per liter, which is excellent.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	60 min	35 min	54
Area	36.6 km^2	29.8 km^2	32
Precip Flux	179.4 m^3/s	117.1 m^3/s	60
Precip Mass	632.1 kton	255.9 kton	104

From looking at these two tables, one can see that the increases observed for the two years are fairly similar. What is not similar are the clouds themselves; specifically, the clouds in 2002 were larger and contained more water, on average, than the clouds from 2003. This is a good example of the variability of weather from year to year. Also, more clouds were seeded in 2003 compared to 2002. This is not to say that there weren't the same amount of clouds in 2002. In fact, there may have been more seedable clouds in 2002, but due to the extreme flooding that occurred during that summer, there was a lot of stand-down time while waiting for flood waters to recede in many areas.

2002 RESULTS - LARGE CLOUDS

10 large clouds were seeded and included in this analysis. 176 flares were used, giving an effective dosage of 25 ice nuclei per liter of air. No mention of timing was given.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	210 min	185 min	14
Area	570 km^2	518 km^2	10
Precip Flux	3274 m^3/s	2850 m^3/s	15
Precip Mass	45360 kton	36755 kton	23

2003 RESULTS - LARGE CLOUDS

Six large clouds were seeded and included in this analysis. 65 flares were used with excellent timing (80% of AgI in cloud before half-lifetime). Effective dosage was 50 ice nuclei per liter of air.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	180 min	155 min	16
Area	193 km^2	165 km^2	17
Precip Flux	1100 m^3/s	865 m^3/s	27
Precip Mass	8260 kton	4561 kton	81

As was the case with the small clouds, it is apparent from comparing numbers with the large clouds in 2002 and 2003 that the clouds in 2002 were larger. Increases for both years are similar, except for the increase in Precip Mass in 2003, which was significant (81%).

2002 RESULTS - TYPE B CLOUDS

Three type B clouds were seeded and included in this analysis. 39 flares were used, giving an effective dosage of 20 ice nuclei per liter of air. No mention of timing was given.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	285 min	265 min	8
Area	760 km^2	714 km^2	6
Precip Flux	3694 m^3/s	3375 m^3/s	9
Precip Mass	66016 kton	57667 kton	14

2003 RESULTS - TYPE B CLOUDS

13 type B clouds were seeded and included in this analysis. 140 flares were used with very good timing (65% of AgI in cloud before half-lifetime). Effective dosage was 20 ice nuclei per liter of air.

Variable	Seeded Sample	Control Sample	Increases (%)
Lifetime	180 min	155 min	16
Area	586 km^2	480 km^2	22
Precip Flux	2943 m^3/s	2241 m^3/s	31
Precip Mass	23334 kton	17255 kton	35

Again, the most obvious factor is the difference in size of clouds in 2002 compared to 2003. The increases in 2003, however, are appreciable.

Overall, the main factor that is evident from comparing the 2002 and 2003 analyses deals with the cloud attributes. The clouds in 2002 were larger, on average, and appeared to contain more water than those in 2003. When looking at the parameter increases alone, 2003 was a more successful year in terms of the apparent effectiveness of seeding. With further work in weather modification in the EAA target area and more analyses, we will get a better understanding of the effects of glaciogenic seeding in south Texas.

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.

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

2003 saw more activity weatherwise compared to the previous year, and as such, we saw more cloud seeding missions take place in the EAA 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. 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 2003 came from the following website:
http://www.srh.noaa.gov/wgrfc/precip/html/monthly_summary_2003.htm

Radar analysis numbers came from Archie Ruiz's final report of the 2003 season for the STWMA (7 pp.), as well as his 2002 final report for the EAA (9 pp.).