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The Texas Weather Modification COURIER

Introduction to the Texas Weather Modification Association Newsletter

By: Robert Rhodes

Welcome readers, to the New Texas Weather Modification Newsletter. This document will have several articles from the different projects throughout Texas to apprise you of what is occurring in the world of rain enhancement and in some cases, hail suppression. It has come to our attention over recent months that the public does not know if we are still around.

For those who are unaware of what we do, here is a short description of weather modification. Drought is the underlying issue for the development of a cloud seeding program. Cloud seeding and

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A seeded cell builds in the sky outside the South Texas Weather Modification Association and the Southwest Texas Rain Enhancement office. *Photo taken by Todd*

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WMA Annual Meeting San Francisco, California

By: Todd Flanagan

The annual meeting of the Weather Modification Association (WMA) was held in San Francisco, California at the Sheraton Fisherman's Wharf April 18-20, 2007.

The first round of presentations took place on Wednesday morning. They consisted of summaries of ongoing projects from around the world, research dealing with inadvertent weather modification (i.e., anthropogenic aerosols or pollution), and the need for a change in the thought structure in weather modification. One hot topic was the use of hail cannons and how the WMA stands on their use.

On Wednesday afternoon, WMA members were treated to a three hour cable car tour that visited many sites in San Francisco. From Fisherman's Wharf to the Golden Gate Bridge to Twin Peaks and Chinatown, the views were nothing

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Texas Project Updates
A Review of 2006 and a Look Forward to 2007

West Texas Weather Modification

By: Robert Rhodes

West Texas Weather Modification in San Angelo Texas began the season with operations March 26, 2007. The general weather pattern early this spring has limited the suitable conditions for seeding. Even though we have had limited seeding chances, the target area has received generous amounts of rain from nature. Mathis Field recorded 3.86 inches of rain giving a departure from normal at 2.87 above and 3.28 inches above normal for 2007. Several portions of the target area received more than this amount while others slightly less. April rainfall slowed producing below average precipitation by .64 inches at Mathis Field as of April 26, 2007. The general consensus is that this has been a great start for the year.

2006 was an excellent year for efficacy of seeding over West Texas. 157 clouds were seeded during 53 days. Despite drought over the majority of the Plains, overall effect of seeding is calculated to be 23% better than had nature been left alone. West Texas maintains operational seeding over 8 counties: Crockett, Glasscock, Irion, Reagan, Schleicher, Sterling, Sutton, and north/west Tom Green. Percent of increase by county ranged from 16.3% – 35.5% where Glasscock County was least and Irion County received the greatest average increase.

West Texas began a new chapter this past summer with a new Meteorologist. Robert Rhodes began training in June of 2006, and was certified as the Project Meteorologist in September. His contact e-mail is meteorologist@wtwma.com. We also hired a full time pilot in March 2007. A full time pilot ensures timely launch for fast-moving and limited lifetime clouds. Operations reports and images describing each seeding event are posted on the website within a few days of the operation. www.wtwma.com.

Southwest Texas Rain Enhancement Association

By: Stephanie Beall

First, a review of 2006 from the Southwest Texas Rain Enhancement. 2006 was a dry year to say the least. Below are some comparisons around the target area of what normal precipitation is and what actually occurred last year.

Uvalde (2006): 14 inches
Uvalde (normal): 23 inches

Cotulla (2006): 16 inches
Cotulla (normal): 21 inches

Laredo (2006): 15 inches
Laredo (normal): 19 inches

As seen above, rainfall was below average for 2006. For most of the year, drought conditions were widespread over most of South and Southwest Texas. From the values above, the worst of the drought was in the northern areas of the target area and eased a bit when going further south. Unusually warm and abnormally dry was the story for other areas in North, North Central and West Texas.

The only part of Texas that was able to avoid the pressing drought was Southeast Texas, where rainfall totals for 2006 were above normal. Drought conditions did improve over most of the northern portions of the state in the fall but continued for the southern areas. However, starting in mid November rains did return to South and Southwest Texas. This was mainly due to a strengthening El Nino in the South Pacific, which for Southern Texas, usually translates into a mild and wet pattern for the winter months.

2007 brings the prospect of a new seeding season and renewed rain chances. Most of January was wet, February was dry, and March was wet. Also, a few staff changes have occurred in the project. An addition of two new pilots will help the project to be even more successful than it has already been. The target area now will have a pilot in Uvalde, a pilot in Carrizo Springs, and a pilot in Zapata. The even spreading of the pilots throughout the target area will ensure a total coverage of convection that moves in or occurs in the target area. As of April 25, 2007, the project has had a total of three missions and one reconnaissance flight. It is also useful to note that all missions thus far have been hail suppression due to the active severe weather season this spring.

Panhandle Groundwater Conservation District Precipitation

By: Jennifer Wright

The Panhandle Groundwater Conservation District's (PGCD) Precipitation Enhancement Program (PEP) strived to meet new goals and continue to increase rainfall across the Texas Panhandle in 2006. The PEP started the season with a new addition to the staff; Jennifer Wright, project meteorologist. Wright joined pilots Herb Speckman and Chad Gerard. The PEP normally

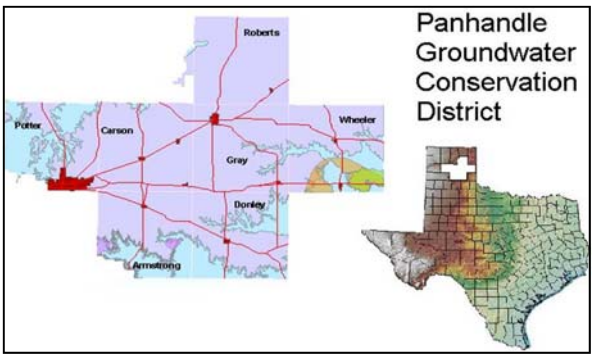
starts its season during the month of April; however, the first flight occurred May 2, 2006.

The season had a combined total of 46 flights which is the most flights ever to occur during a season at PGCD. May consisted of 11 flights, while June had nine flights, July had 11 flights, and August had 15 flights. No flights occurred during April or September. The district was on stand down from August 25 – September 5, 2006, due to flood warnings and advisories throughout the Target Area.

Not only did 2006 have the most flights throughout the history of PGCD, but it also had the most rainfall increase during the seven year project history. The rainfall increase was 3.85 ac-in which was calculated by Active Influence & Scientific Management. The increase percent of average rainfall per acre can be contributed to an abundance of seedable clouds with above normal rainfall during some months. With this rainfall increase once again the District lowered its program cost which resulted in a greater return on investment of tax dollars. The District cost of the program per acre/inch was $0.012.

The season started off fairly dry and ended very wet. April, May, June and September were all below the monthly average; where as July and August were above the monthly average. Out of the last seven seasons of data 2006 was the second wettest season at a monthly average of 2.445 inches behind 2004 which was 2.631 inches, and August was the wettest month with 6.67 inches. In conclusion, 2006 proved to be a wet season; however, the rainfall occurred mostly in July and August rather than being spread throughout the entire season.

The 2007 PEP season started with renewed cloud seeding chances and an abundance of opportunities thus far. The season started March 28, 2007, and has had a total of eight missions. A few events have been characterized by severe weather dominated by a dry line pattern; which has cut a few missions short due to severe thunderstorm and tornado warnings.



This diagram shows where the district is located within Texas. The district includes Potter, Armstrong, Carson, Gray, Donley, Wheeler and Roberts counties.

South Texas Weather Modification Association

The office for the South Texas Weather Modification Association and Southwest Texas Rain Enhancement Association is located in Pleasanton, Texas. *Photo taken by Todd Flanagan.*

By: Todd Flanagan

2006 marked the tenth year of operations for the South Texas Weather Modification Association (STWMA). It was a record-breaker as far as number of seeding days, with 57 total days on which cloud seeding operations took place. This is somewhat misleading, however, as the year was much drier than normal. Although there were more days on which seeding took place, much of the activity was isolated in nature with fewer days seeing widespread convective events. Eastern counties fared the best with rainfall totals for the year closer to normal than western areas, where less than 50% of the average annual rainfall fell.

The first flight of the year took place in late March, but problems with the flare firing mechanism and the unfavorable weather resulted in a poor mission. The next mission did not take place until late April, when a cold front and shortwave helped initiate convection over the southwestern half of the target area. Severe weather warnings ended the mission. As spring progressed and summer approached the number of opportunities increased. May was still a disappointing month, with only two seeding days and one reconnaissance flight.

June saw a change in the weather pattern with more diurnal convection taking place. Tropical moisture had moved into the area and resided over south Texas for the vast majority of the month, even during the middle two weeks when high pressure suppressed convection. Overall, nine days saw seeding activity take place, with a tenth day offering a reconnaissance flight. One

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item of note during June, the STWMA acquired Gonzales County into the main target area. Their first day into the program was on the 15th, and that was the first seeding flight in that county.

July was rather busy, with 17 days of seeding operations. This was comparable to July 2005, when seeding operations took place on 20 of the 31 days. August gave us 12 more days of seeding opportunities, but most of the convective activity was small and isolated in nature. September was wetter than normal, and seeding operations were conducted on seven days. October ended up being the final month of operations for the year, with six more days of seeding operations taking place. After Halloween, no more favorable convective opportunities presented themselves during the daylight hours for seeding.

So far in 2007 we have had a wetter than normal period. January saw over 4 inches of rain in many locations in the target area as several disturbances moved across the area, none of which presented any seeding opportunities. February was much drier with most locations in the target area seeing less than 0.25 inches of rainfall. March ended up being the wettest month on record for several locations, with amounts ranging from less than an inch over the extreme southern zones to over ten inches across the central and northern areas. Severe weather events began during March and continued into April. If this pattern can hold, we will end up having a very active seeding season. As of April 27th, the STWMA has yet to have its first seeding mission of the year. The Climate Prediction Center's forecast for the upcoming summer indicated equal chances for a wet or dry summer.

Very Wet March 2007 in West Texas

By Archie Ruiz

March 2007 was a wet month in many places of Texas, especially in the West. For instance, Amarillo received 4.00 inches of precipitation resulting in the third wettest March in history, Lubbock received 5.94 inches (the wettest March), and San Angelo measured 3.86 inches (third wettest March). Further south, San Antonio reported its wettest value since 1871 with 7.24 inches. Other places such as Del Rio and Laredo were not so favored by the weather. The most recent map from the US Drought Monitor (April 24th, 2007; figure 1) shows that there is still an appreciable area over South Central Texas which is abnormally dry. Severe weather impacted Maverick County during the last week of April.

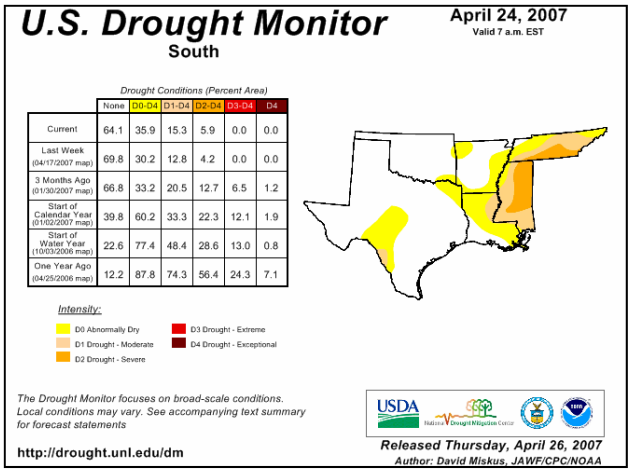

Figure 1: Drought Monitor April 24, 2007

Climatological analyses of monthly precipitation values over West Texas indicate that a wet March (March 2007 is very wet) usually precedes a normal or wetter than normal year with a probability of about 70%. This feature can be understood if one realizes that March is always among the driest months of the year. The graphic below (figure 2) illustrates it for San Angelo but similar results have been obtained across the region. On these premises, Cloud Seeding Programs in West Texas this year are expecting a busy season, although so far April has been a disappointing month.

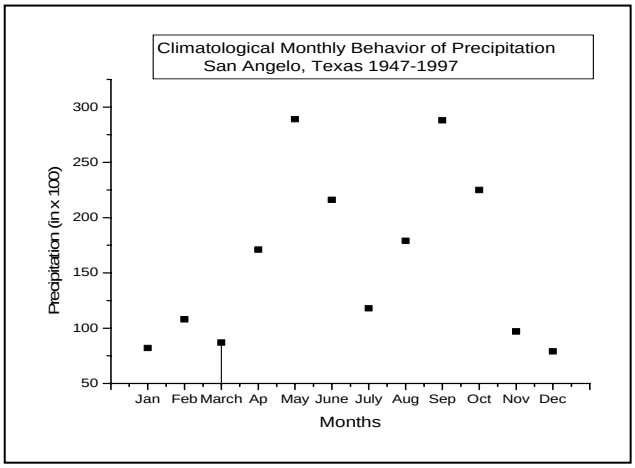

Figure 2: Climate Monthly Behavior of Precipitation

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weather modification are interchangeable, but there are a wide variety of weather modifiction methods and cloud seeding is the most common. A meteorologist directs a pilot using sophisticated radar tracking software toward a suitable cumulus cloud. The cumulus cloud is the larger, vertically stretched, cauliflower-shaped cloud common in the summer sky. Within this cloud is an inflow where the cloud breathes and at this location in the cloud

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A Summary of the 2006 Texas Weather Modification Evaluation Report

By: Archie Ruiz

Cloud seeding operations 2006 began over Texas in March. A total of **551 clouds** were seeded and identified in **218 target area operational days**. Table 1 below summarizes the general figures:

Table 1 Generalities

First operational day: **March 8th, 2006 (WTWMA -San Angelo)**
Last operational day: **October 12th, 2006 (STWMA -Pleasanton)**

Net Number of operational days: 199
(Most active months May to August: ~ 80 % of the operation days, Least active month: March: ~ 1 % of the operation days)

Number of seeded clouds: 554
(298 small seeded clouds, 116 large seeded clouds, 131 type B seeded clouds, and 9 npf))

Missed Opportunities: 2 (0.4 % of the seedable conditions)

The following table 2 shows the calculated increases in precipitation mass (Δ) using radar data through the TITAN software.

Table 2 Estimates Increase

	#	Flares	Timing	Dose	Δ (%)	Δ (million ac-f)	Δ (in)
Small Clouds	298	1344	84%	90	120	~ 0.25	0.63
Large Clouds	116	1784	96%	90	19	~ 0.95	0.31
Type B Clouds	131	2100	74%	115	15	~ 2.11	0.36
Total	545	5228				~ 3.31	
Average			84%	96	73		0.5

Table 3 shows a summary of the results per project:

Table 3 Results per Project

	# Seeded Clouds	# Operational Days	# Missed Opportunities	Timing	Dose	Δ (%)
NPGCD	73	31	0	88%	60	61
PGCD	87	42	0	83%	95	57
WTWMA	157	53	2	78%	100	82
STWMA	139	44	0	87%	110	90
SWTREA	98	34	0	86%	100	96

Final Comments
Results were evaluated as **excellent**. The main problem detected was the loss of radar data (12 operational days did not get proper files; in year 2005, 31 operational days were lost);

The micro-regionalization analysis showed increases per county; the average increase in precipitation, referred to an average seasonal value, was about **15.8 %**;

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

Review of Texas Climate for 2006

By Stephanie Beall

This article will review the 2006 climate across Texas. 2006 will go down as a very dry and drought stricken year for most of Texas. Even though some parts of Texas were very, very wet last year, other parts where quite the opposite. Included with this article are drought monitor reports from four months during 2006. The monitor reports are usually released about every week and typically only show changes of long term weather patterns not so much focusing on individual storm systems. The reports given here are from March, June, August and November. These months were chosen because typically, cloud seeding does not start until March for any project and typically winds down by mid November. Figures 1 through 4 show these drought reports.

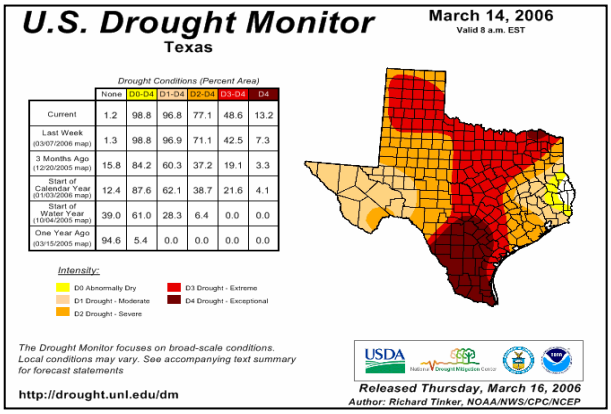

Figure 1: Drought Monitor March 14, 2006

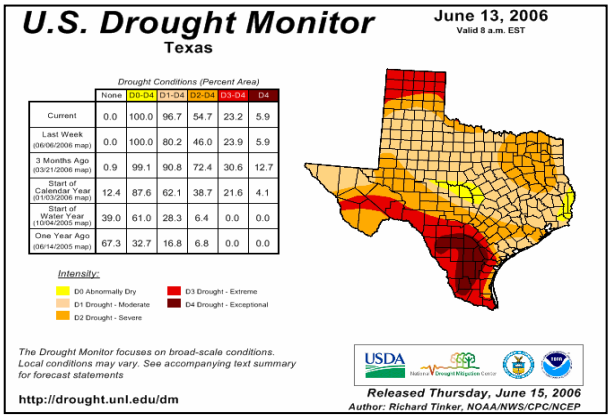

Figure 2: Drought Monitor June 13, 2006

Now a brief month by month run down of 2006 for Texas. Southeast Texas was the wettest part of Texas overall for 2006, with almost 90 inches of rain in some locations near the Texas/Louisiana border. For most of the western half of Texas, 2006 was very, very dry. The year started out dry, where usually spring and winter rains help areas start off wet. The rain did not come into most areas until mid to late summer. The Panhandle probably fared the best, with a pretty wet summer and fall. West Texas suffered through a dry winter and summer but rains returned by August and continued into the winter. As winter came to the area and an El Nino developed in the Pacific, rains came to drought stricken parts of Southwest and South Central Texas where most of the year besides the late fall was dry.

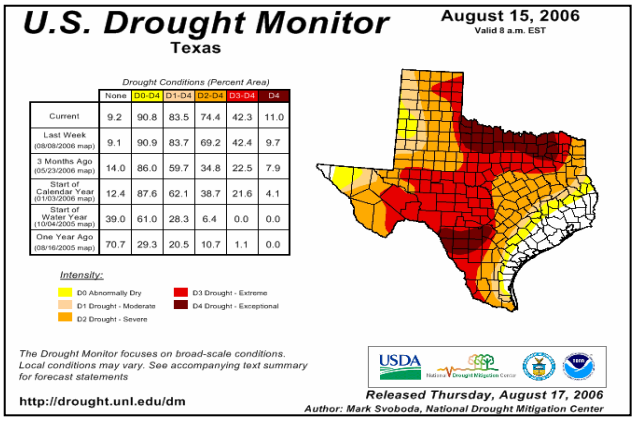

Figure 3: Drought Monitor August 15, 2006

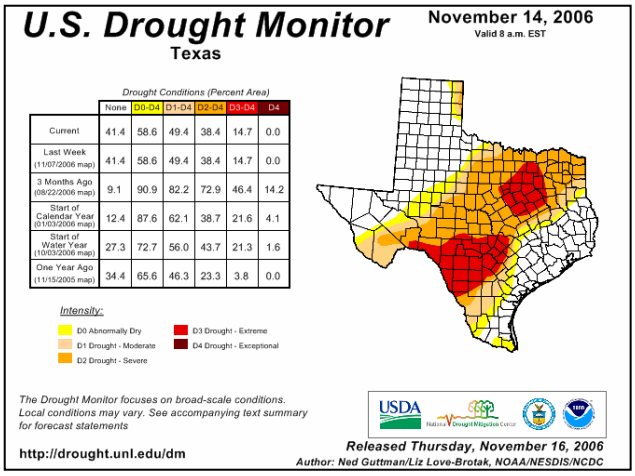

Figure 4: Drought monitor November 14, 2006

A weak to moderate El Nino event occurred during the latter part of December and into January 2007. El Nino is a major warming of equatorial waters in the Pacific Ocean, most commonly confined to the Eastern South American coast. El Nino events usually occur ever three to seven years, and are characterized by shifts in the "normal" weather patterns (www.crh.noaa.gov/lmk/glossary.htm). Typically, this phenomena occurs during the winter and usually weakens with a seasonal transition into spring. Figure 5 is an impact map of North American during a typical El Nino episode. This feature usually amplifies the subtropical or southern jet stream, altering storm tracks from the west coast into the southwestern U.S, including Texas.

This means wetter and cooler conditions for most of Texas during El Nino events.

The 2006/2007 El Nino brought beneficial rains to most of Texas and created a cooler winter than normal. This also brought the added bonus of wintry precipitation to the state that is usually confined to states further north. This event was at it most active in January and was characterized as a moderate episode. It dissipated in early February much earlier than expected. A return to neutral conditions returned in the spring and a La Nina is forecasted to evolve during the late spring and early summer period. La Nina is a cooling of the waters off the South American coast, and usually means drier, warmer conditions for the Southern U.S. Figure 5 shows both the El Nino and La Nina patterns on North America.

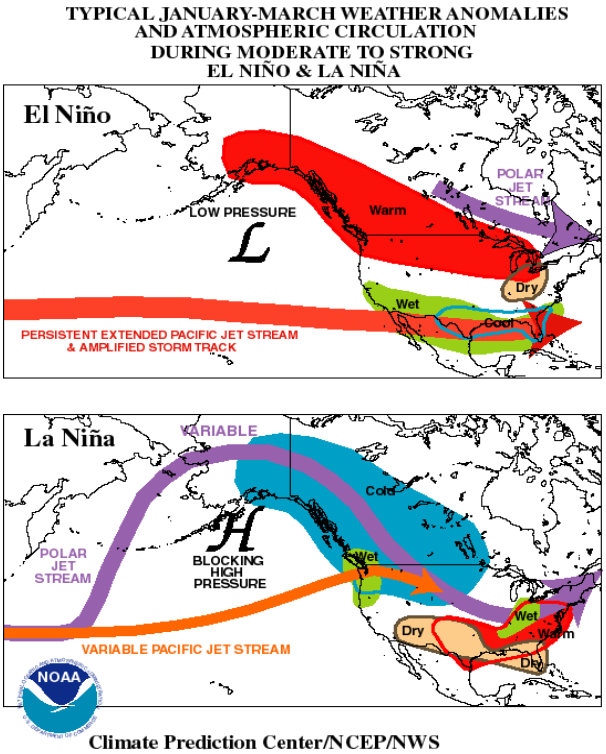

Figure 5: El Nino and La Nina Patterns

Is Weather Modification the "black sheep relative" of the Atmospheric Science Family?

By Archie Ruiz

The question is as provocative as the most rigorous questions are. Weather Modification activities have always followed the needs for fresh water or the mitigation of severe weather and; therefore, they have been evaluated mainly by their practical success rather than by the acquired knowledge. This fact puts the discipline in an awkward position in relation with its relatives. When experts in Weather Modification talk about the natural processes in the clouds the community considers that they are talking about "Cloud Physics". Only if the subject is on precipitation increases, hail suppression, fog dissipation, or mitigation of hurricanes do the listeners believe the speakers are touching weather modification matters. It is not fair since through weather modification techniques we have been able to understand scales and processes that were hidden from us for several decades, whereas nowadays it is a recognized fact that we were for centuries "unadvertently" impacting the environment. This owes to Weather Modification a lot of credits. Weather Modification is a mongrel discipline (an illegitimate one?), and its natural vocation to experiment with weather phenomena allowed researchers to accelerate the rate of growth of scientific knowledge. The tendency to experiment behind the mere observation is a trait inherited from Physics and Chemistry and not from Meteorology. Although the convergence of these three interrelated sciences permitted the creation of Experimental Meteorology the original name for Weather Modification.

In its 2003 report "Critical Issues in Weather Modification Research", the Board on Atmospheric Sciences and Climate (BASC) recognized Weather Modification as the poorest relative of the aforementioned family:

… Weather Modification does not appear as a line item in the budget of any federal agency– although closely topics such as cloud physics, water management and climate change are being pursued– and no work is being done on the complex social and economic implications of attempts to modify the weather… (BASC 2003, page 13)

The situation was very different 30 years ago, as it is also reflected by the report:

...research in weather modification was actively pursued...in the later 1940s and peak in the late 1970s when funding in the United States alone was around $20 million per year… (BASC 2003 page 24)

What happened?

It is impossible to recreate here all the historical details, but it is enough to present another quote from the same report:

… under the umbrella of cloud seeding, scientists mounted field and laboratory efforts that led to a breathtaking increased understanding of the microphysics and dynamics of clouds. In an effort to put cloud seeding on a more rigorous foundation, several university and gov-

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ernment groups launched major studies of clouds and their reaction to seeding… (BASC 2003, page 18)

When the money ran out the interest went away.

A few decades later, we are still trying to prove that the efforts are legitimate and beneficial (the estimated cost / benefic rates are very promissory). The importance of scientific research is recognized by the expert community, but the future research should be done **"in a weather modification – oriented fashion"** which will allow in turn the effective and quick application of the results to the operational activities. Randomized Cloud Seeding Experiments might and should be designed within operational scenarios when possible, whereas Operational Programs should be well-designed and focused in data mining. The targeted processes are very complex and the insights obtained from physical measurement and statistical evaluation ought to be accompanied by well-done operations in which the engineering spirit is predominant.

The family of the atmospheric sciences took clear advantages of the splendorous time once Weather Modification enjoyed. It is time now to retrieve some of those profits. Weather Modification is the poorest relative, probably the black sheep one, but this is also the time for the return of the prodigal son.

BASC, 2003: **Critical Issues on Weather Modification Research**
http://books.nap.edu/openbook.php?isbn=0309090539

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is where Silver Iodide is introduced into the cloud. Silver Iodide is a material with a similar structure to that of ice. Summer clouds in Texas often have a reduced amount of ice which is necessary to produce the maximum amount of rain capable of reaching the ground. Therefore, this material is introduced into a cloud to produce more rain than the cloud was capable of by nature alone.

Several projects will take part in this newsletter and readers are more than welcome to send correspondence to the meteorologists. We would like to hear your questions and comments. Given the volume of potential questions and answers, personal reply may be slow or will be subject of the following volume. We have in mind to produce a newsletter in spring, mid-summer, and fall.

Brief History of Texas Weather Modification

By: Robert Rhodes

The following historical overview is a brief summary of Texas weather modification. For more detail of the projects through 2003, readers can visit the Texas Weather Modification website at http://texasweathermodification.com.

Weather modification is not a new concept. In 1891, Robert Dyrenforth was given a $2,000 grant by the U.S. Congress to do rain making experiments near Midland, Texas. Drought over many parts of desert regions has driven weather modification projects since early on using ground based generators, dropping dry ice out of airplanes, and then flares to deliver a hygroscopic or glaciogenic material. The 1950's drought and continued drought through the 1960's encouraged a significant amount of cloud seeding which promoted the Texas legislature to enact the Texas Weather Modification Act in 1967. This act required that anyone attempting to alter the weather by any means should obtain a license and permit from the State water agency. The Texas Natural Resource Conservation Commission (TNRCC) governs the legislation, license, and permit for cloud seeding using aircraft.

The first modern day cloud seeding began in 1971 in West Texas. The Colorado River Municipal Water District (CRMWD) was formed as a rain-enhancement project. In 1995, nine counties between San Angelo and Midland formed a weather modification association. Water-conservation districts served as a convenient way to finance project operations. The West Texas Weather Modification Association invested in its own aircraft, radar facilities, and personal and since 1998 has been conducting operations. Nine other projects were developed across west and south Texas through the late 1990's. South Texas Weather Modification Association was formed in 1996 including counties south of San Antonio. The Southwest Texas Rain Enhancement Association (SWTREA) was formed in 1998 for counties along the Rio Grande west of San Antonio. The Panhandle Groundwater Conservation District (PGCD) was formed in 2000 including counties in the central Texas Panhandle.

All projects are operated by a local board of directors. In the beginning, one half of money used for operations was raised by local water districts, counties, cities, irrigation districts, water supply districts and land owner associations and the state legislature matched funds through the TNRCC or Texas Department of Agriculture. In recent years, the projects are

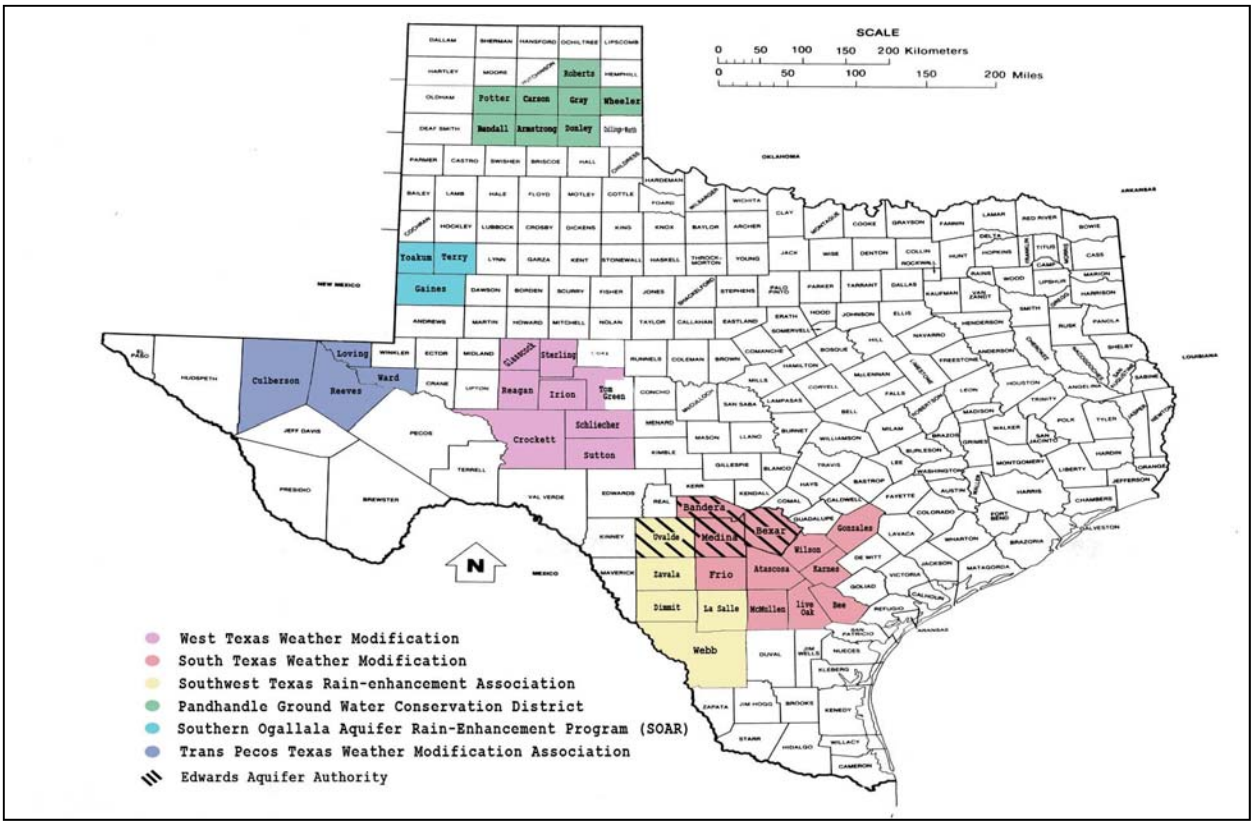

Figure 1: Current Texas Weather Modification Projects in Texas

supported by the local entities only.

Given that the atmosphere is an open system it is difficult to quantify the effect of one activity on a given region. Therefore, one of the most strenuous things for a weather modification program to have is an objective study done on the efficacy of seeding and the true results acknowledged by the public and the scientific community. Texas Weather Modification employs Arquimedes Ruiz, as Active Influence and Scientific Management (AISC) since July 2002. AISC is a vital component for the training, quality control, and evaluation of data to provide the Association with quantitative results that can help to assess performance.

As of 2007, five Texas Programs are conducting operations (figure1): Panhandle Groundwater Conservation District in White Deer, Southern Ogallala Aquifer Rain Program in Plains, West Texas Weather Modification Association in San Angelo, South Texas Weather Modification Association in Pleasanton, Southwest Texas Weather Modification in Pleasanton, and Trans Pecos Weather Modification Association in Pecos.

Thursday was a day full of presentations ranging from summer weather modification programs to winter weather modification programs and research projects relating to both. One item of particular interest was a presentation given by a Weather Modification, Inc. employee regarding the successful use of polarimetric radar to look at phase changes in a seeded cloud. There was also a presentation about modifying hurricanes, with one scientist simulating the seeding of the outer region of Hurricane Katrina. It showed that by seeding the outer bands, that region becomes more dominant and may weaken the eyewall. A third presentation dealt with the use of trace chemicals (inert gases) to mark the "seeding material plume". A cocktail hour and awards banquet followed in the evening, with a representative from Pacific Gas and Electric giving a talk on water use in California and the impacts it has on electricity.

On Friday morning the WMA Members meeting was held, and the 2007-08 Board was voted on. A workshop was held Friday afternoon dealing with the use of analysis and experiments in determining the efficacy of cloud seeding, with emphasis on winter weather modification.

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short of spectacular thanks to the many hills in and around the city.

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A seeded thunderstorm that moved over White Deer, Texas, on April 23, 2007. *Photo taken by Jennifer Wright*

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RETURN SERVICE REQUESTED