Volume 3, Issue 1 February 1, 2009

The Texas Weather Modification COURIER

Texas Projects Participate in the WMA

Front Row, kneeling (L to R): KT Sebastian, Duncan Axisa, Dr. Danny Rosenfeld, Todd Flanagan, Matthew DeFelice, Fernando Ibarra. Standing (L to R): Don Duckering, Lata Sebastian, Steve Harris, Tommy Shearrer, Tom Papachristou, Archie Ruiz, Carol Griffith, Don Griffith, Gary Walker, Tom DeFelice, Michelle DeFelice, Mark Solak, Farren Hiscutt, Melanie Hiscutt, Kim Davalos, Dave Davalos.

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Texas Projects Upgrade Computers

By Roberts Rhodes

Weather modification operations in Texas had a period of technical difficulties during 2008. The National Weather Service (NWS) underwent a data feed upgrade called Build-10, which was an upgrade to code and bandwidth capable of transmitting super-resolution data. Super-resolution data is comparable to High Definition (HD) television versus analog signal. The NWS instituted the change at Midland in May, which made radar data unavailable to parts of the West Texas target area. Radar data at each office began to switch over through the next several months. Significant increases in information were being thrown through an existing pipeline incapable of the speed required to accurately display the radar data on existing TITAN (Thunderstorm Identification, Tracking Analysis and Nowcasting program) systems. TITAN is the software used to track, analyze and evaluate seeded clouds across the state of Texas during weather modification activities.

Weather Decision Technologies Inc. (WDT) worked furiously to alter code from the new data stream reverting super-resolution data back to a data

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Texas Project Updates A Review of 2008

West Texas Weather Modification

By Robert Rhodes

2008 West Texas seeding operations started on March 17th and ended on September 24th with 38 operational days. Three days were classified as experimental due to the limited moisture or suppressed vertical structure which hindered sufficient inflow. 77 clouds were seeded with 1,431 flares during 57 flights. 8 reconnaissance flights were flown while making an attempt to find seedable clouds on marginal days and pilots flew 150 flight hours.

TITAN software created some negative affects on operations this season. The National Weather Service Offices installed a new software package called Build-10 with super-resolution capabilities. The software update required manipulation to the LDM data stream from which TITAN receives and processes radar data. One day (June 13) was completely lost while the new code was written. Weather Decision Technologies (WDT) worked hard to provide the new data stream through the month of June. New issues continued to crop up through the summer associated with the change. Several instances of lost radar hindered operations at various times.

2008 was a rather dry year. The annual rainfall, 19.00 inches, at San Angelo was below normal by 1.91 inches. Record rainfall at the San Angelo Regional airport on September 8th and several days in August where Mathis Field received plentiful rains does not show accurately the amount of rainfall seen by the majority of the target area. August was the most active this season with 15 operational days. Precipitation and percent of normal maps show that much of Texas was well below normal except for March which had mainly one rain event. Another event occurring in September west of the Pecos River and over western Crockett County was also noteworthy.

WTWMA (2002-2008)					
	Seeded	Operational	Used	Increase	Annual
	Clouds	Days	Flares	Million ac-f	Rainfall
2002	285	47	3024	0.78	14.41
2003	265	50	3184	0.76	19.76
2004	109	46	1140	1.35	30.48
2005	133	39	1524	1.26	20.40
2006	157	53	1810	1.70	17.65
2007	95	46	1166	1.19	32.05
2008	78	38	1420	1.18	19.00

Table 1: Comparison of seasonal operations of 2002-2008.

Month	Days	Flares	Rainfall (Avg.) In Inches
March	1	27	2.43
April	2	90	0.64
May	4	95	0.65
June	7	267	2.24
July	7	253	0.43
August	15	707	3.37
September	2	17	2.47
Total	38	1456	12.23

Table 2: Average rainfall in WTWMA during 2008 season.

Southwest Texas Rain Enhancement Association

By Stephanie Beall

The 2008 operational season for the Southwest Texas Rain Enhancement Association was one that could be termed as a "flip-flop" season. 2008 marked the tenth operational season for the SWTREA. The season was below normal flight-wise but much more active than 2007. Most of the spring months were very slow and not until later in the summer, during July and August, did operations peak. Usually, operations peak in May and in September with the two precipitation maxima that occur over south Texas. May was about normal precipitation-wise but not operationally. As well, September turned out to be very slow compared to normal. The wettest month of the operational season was August, with a total of sixteen seeding flights on eleven seeding days. September saw a drop in flight activity, as did October when activity usually drops off. The spring months over the southwest Texas area were active in terms of severe weather, with a total of six hail suppression flights taking place in May and April.

The project's first flight usually takes place in March but this year did not take place until the beginning of April due to lack of convection across the area. A recurring problem during the 2008 operational season involved the quality of clouds that were observed. On a number of occasions, convection present in the target area was characterized by low tops, warm rain processes, and weak echo returns. This was the case mostly during the summer months and greatly impacted operations as seen in Table 3.

There was a stark contrast in rainfall over the tar-

get area from north to south. While the northern parts of the target area received very little rainfall during the summer months, southern parts of the target area saw heavy rainfall. August was an especially wet month for the two southern counties, LaSalle and Webb, as a series of upper level lows were situated over southwest Texas and eastern Mexico. These same counties also received ample rainfall from Hurricane Dolly, which moved across the lower Rio Grande Valley in July.

Operationally, there was an addition of a new pilot that served both the SWTREA target area and the STWMA target area. The STWMA is the eastern border of the SWTREA project, so this only increased operational efficiency in south Texas. As well, the project experienced data issues during the summer months due to the Build-10 upgrade that the NWS made operational in all radars around the state.

Month	Flights Hours	Flares Used	AgI used	Number of flights	Recon flights	Rain Enhancement	Hail Suppression
April	7.05	137	5360	5	0	1	4
May	5.96	144	5760	5	1	3	2
June	14.25	115	4600	6	2	6	0
July	10.9	119	4760	7	2	7	0
August	30.7	229	9160	16	2	16	0
September	8.35	127	5080	5	0	5	0
October	1.05	14	560	1	0	1	0
Totals	78.29	885	35400	47	7	41	6

Table 3: Shows the flight hours, flares used, AgI used, number of flights, recon flights, rain enhancement, and hail suppression information for each month during the SWTREA seeding season.

Panhandle Groundwater Conservation District Precipitation Enhancement Program

By Jennifer Wright

The conclusion of the PGCD's 2008 Precipitation Enhancement Program marked the ninth year of cloud seeding in the Texas Panhandle. This season began with the first mission on April 23rd and concluded on September 5th with the last mission. Typically, the season runs from April 15th until September 30th; however, if suitable opportunities are present before the 15th the season will commence.

The 2008 seeding season contained 23 days with seeding events, which consisted of 26 seeding missions and six reconnaissance missions. This season had the least amount of seeding days since 2000 which had only 22 days of seeding. This year we seeded 15 less days and 33 fewer clouds than in 2007, which can be attributed to very few seeding opportunities through the summer. Each month contributed its own factor for fewer seeding conditions.

During April, the Texas Panhandle experienced many cold fronts, warm fronts, trough passages and dry lines; however, the missing ingredient for convection was moisture. May was characterized by stratus clouds with little to no convection, and concluded with a few dry line events that the National Weather Service (NWS) issued severe thunderstorm warnings on. In the beginning of June much of the precipitation favored the eastern Texas Panhandle; however, at the end of June the pattern changed. During most days precipitation formed off the mountains with a trough and upper-level shortwave being the focus for initiation. This activity moved southeast across the western counties in the Texas Panhandle. All of the seeding missions were cut short due to NWS severe thunderstorm warnings. July was dominated by high pressure, but the weather that did occur was due to normal summer daytime heating with the combination of some mid-level dynamics to create scattered afternoon thunderstorms. All of the weather systems that moved through the area during August were dominated by slow-moving, heavy rainfall thunderstorms. Therefore, some seeding missions were ended due to flash flood warnings issued by the NWS. All of the rain in September occurred on or before the 12th due to three cold fronts and a stationary front, and the rest of the month was characterized by high pressure.

In combination with the monthly changes in weather patterns, we also saw more continental clouds this year that consisted of smaller than normal volumes

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of super-cooled water, which also affected our seeding results.

Month	# Seeding Flights	# Recon Flights	Hours Flown (H:M)	Flares Used
April	1	1	3:44	8
May	3	2	8:30	21
June	5	1	13:10	54
July	6	0	16:55	53
August	10	2	23:55	95
September	1	0	1:45	7
Totals	26	6	67:59	238

Table 4: Shows the number of seeding flights, number of reconnaissance missions, hours flown and flares used for each month during the PGCD seeding season.

South Texas Weather Modification Association

By Todd Flanagan

2008 marked STWMA's twelfth year of cloud seeding operations in south-central Texas and the seventh year of operations for the Edwards Aquifer Authority's (EAA) tri-county area. While the year as a whole was dry, there were a few months where above normal rainfall fell within the target area, notably July and August, the heart of the seeding season. March was also wet for some parts of central Atascosa County, but this was attributed to a supercell thunderstorm that dropped nearly four inches of rain. The remaining months were quite dry across the STWMA target area, with far northern parts of the area classified as being in exceptional drought by year's end. Overall, 104 clouds were seeded over a total of 40 days in 2008, almost twice as many days as in 2007.

The season's first seeding flight took place on March 18th, the only day of seeding during the month. A storm system with impressive dynamics moved across the state, generating a line of convection over the eastern counties. This was the first flight for our new pilot, Matt Pope, who trained throughout the year with Craig Funke. This was the only day of seeding in March. Given the past history, one can expect a day with seedable clouds in March about every third year.

April gave the STWMA no seeding missions as much of the area received only 25-50% of their normal rainfall. May was much drier than normal, with eastern areas only receiving 10-25% of their normal rainfall. This was not good, as May is typically one of, if not the wettest month of the year. Only two days saw cloud seeding take place, both of which occurred during the latter half of the month. In both cases the seeded convection appeared to do quite well, continuing past sunset while other untreated convection dissipated.

The dry pattern continued into June, with all of the target area receiving less than 50% of the average monthly rainfall and many areas receiving less than 5%! Oddly enough, this was one of the busiest months of the year, with nine days of cloud seeding taking place. The vast majority of clouds in June, however, were small and short-lived. One exception was on June 20th, when a seeded cloud in the eastern target area tracked southwestward into the southern target area with an average rainfall of 1-1.5 inches along the track.

July brought welcome rains to the area, with all but far western Bandera County receiving above normal rains, a good chunk of which fell on the 23rd-24th when a weakening Hurricane Dolly impacted the area. Seven days saw cloud seeding take place in July, all but one occurring during the first half of the month.

The wet pattern continued into August, with much of the area seeing well above normal rainfall, although there were a few locations that missed out and received below-normal rains. The month was quite active, with 16 days of cloud seeding recorded.

Four days in September saw cloud seeding take place, near the start of the month and also towards the end. September, unfortunately, saw a return to very dry conditions despite the presence of tropical moisture. Hurricane Ike impacted the area as it made landfall at Galveston on the 13th, but instead of bringing us rains, the circulation around Ike brought scorching heat, with many locations in the target area topping out between 100-105°F. Our final day of seeding took place on October 14th, the only day of the month that operations took place.

In 2007 at the request of the EAA, the STWMA began a multi-year experiment within the EAA target area counties of Bandera, Bexar and Medina where randomized seeding would take place. For more information on the development and operation of this experiment, refer to Volume 2, Issue 1 of the TWMA newsletter. 2008 provided even less randomization opportunities than 2007, with one randomized case overall, and that was in the SWTREA target area. The primary problem stemmed from developing clouds not being isolated enough for the protocol to be successfully enacted. The upcoming season in 2009 will hopefully bring many more opportunities for the experiment to continue. The purchase of a twin-engine Aztec to be used for top and nighttime seeding may allow for such opportunities to be realized.

Trans-Pecos Weather Modification Association

By Todd Flanagan

The TPWMA's cloud seeding program, under guidance from SOAR, continued in 2008 with their sixth year of operations. The past year was comparable to 2007, with 17 seeding days recorded versus 21 in 2007. The program's first day of seeding occurred in June, where a total of four seeding days were recorded along with an additional four days of reconnaissance flights. The regular occurrence of orographic convection to the lee of the Davis Mountains resulted in a zone of above normal rains over the far eastern target area.

This pattern continued into July, with more widespread above normal rains along and to the east of the Davis Mountains. July was the busiest month of the season for Trans-Pecos, with seven seeding days and four reconnaissance days. The presence of tropical moisture helped with the orographic convection, with some enhancement late in the month by the remains of Hurricane Dolly.

August, with four days of seeding and three days of reconnaissance, was drier than normal for all but the far eastern portions of Jeff Davis County. September saw a return to above normal rainfall to the lee of the Davis Mountains, primarily resulting from the mid-month intrusion of deep tropical moisture from the Pacific. Despite this, only one day of seeding took place along with three reconnaissance days. October saw the final seeding mission of the year. Overall, 106 burn-in-place flares were used for seeding, amounting to 4240g of AgI.

Seeding Operations and Atmospheric Research

By Todd Flanagan

Cloud seeding operations in the SOAR project area were not as busy as in 2007. Overall for the year, 20 days saw clouds being seeded within the tri-county area. In May, the eastern parts of the target area saw above normal rainfall while the western areas were drier than normal. Cloud seeding occurred on three days during the month with two additional days of reconnaissance flights. Wetter than normal weather was experienced in June; this happened to be the busiest month of the season. Eleven days of cloud seeding were recorded with an additional four days where reconnaissance flights took place. Drier weather resulting from high pressure parked over the area in July yielded only two days where seedable clouds were treated, and a further two days of reconnaissance flights. August, like May, saw variable rainfall across the target area with the central third seeing above normal rains while the northern and southern areas were drier.

Two days during the month offered clouds that were treated, with one reconnaissance day. September ended up being the last month of operations for the SOAR project, with two days of seeding taking place. It was also a wet month for all but the far northwestern corner of the target area, mainly attributed to a very wet period at mid-month when a flow of tropical moisture across western Texas resulted in a train of very heavy rains. For the entire season, 58 ejectable and 53 burn-in-place flares were used, totaling 3280g of AgI.

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By Stephanie Beall

Throughout the years, meteorologists who operate projects in Texas have become increasingly active in the Weather Modification Association (WMA). For those who are not familiar with it, the WMA is a national and worldwide association that promotes research, development and the understanding of weather modification for beneficial uses.

The WMA holds an annual meeting in different parts of the U.S. for a three to four day period. At these meetings, technical papers are presented as well as workshops that allow operators and researchers alike to fine tune their skills. Some years a semi-annual meeting is held, and during September of 2008 it was held in Mendoza, Argentina. Tommy Shearrer, president of South Texas Weather Modification Association (STWMA), and Todd Flanagan, meteorologist of STWMA and vice-president of the WMA, were in attendance of the four day meeting that covered mostly hail suppression activities and research around the world. The 2009 annual meeting will be held April 22-24 in Anaheim, California, where a continued exchange of ideas will take place for members in the weather modification community.

Currently, three of the five weather modification project meteorologists within Texas are certified weather modification operators by the WMA. The certification process involves the examination of credentials by a certification committee, and the applicant must have the necessary field experience. Along with being certified, Flanagan currently holds the president-elect seat on the executive board of the WMA which consists of a president, president-elect, secretary, executive secretary/treasury, past president, JWM editor and the trustees. Beginning April 2009, Flanagan will assume the presidential position. Also, Stephanie Beall, meteorologist of Southwest Texas Rain Enhancement Association, is the current webmaster of the WMA

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webpage which can be viewed at www.weathermodification.org. The continued involvement of Texas in the WMA is not only a helpful tool in keeping informed of the ever changing world of weather modification, but also a way to form relationships with weather modification operators and researchers around the world.

2008 State Evaluation By Active Influence and Scientific Management

By Archie Ruiz

Since 2000, Active Influence and Scientific Management (AISM) has been performing a yearly analysis of all seeded clouds in the state of Texas. Individual analyses of each project are also conducted. The analysis involves looking at a seeded cloud as identified by the TITAN (Thunderstorm Identification, Tracking, Analysis and Nowcasting) software which uses WSR-88D data from radars covering the various target areas in the state. WSR-88D data has been ingested into TITAN since 2004. The evolution of the identified seeded cloud is then compared to the evolution of a control cloud that best matches the seeded cloud in it's early life. Several factors are compared between seeded and control clouds such as lifetime, area, volume and precipitation mass. Each cloud is put into one of the three categories and is either classified as a small cloud, large cloud, or a type B cloud depending on its lifetime and size. Small clouds are those defined as clouds with radar-derived precipitation mass values less than 10,000 kilotons. Large clouds are those with precipitation masses greater than 10,000 kton. Type B clouds are those clouds, large or small, that were not seeded until they were at least an hour old as seen on radar. In this section we will look at the results of all seeded small clouds. Note that this analysis does not include data from both the SOAR and TPWMA projects.

Table 5 shows the results of the AISM analysis of all seeded small clouds in the state of Texas. 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 618 flares were used in this sub-sample with an excellent timing (88%) for an effective dose near 80 ice-nuclei per liter, which might have reached slightly higher levels in some individual cells. An increase of 121% in precipitation mass together with an increase of 51% 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 (48%), area (44%), volume (51%), volume above 6 km (64%) and precipitation flux (53%) are notable. There are slight increases in maximum reflectivity (1%) and in top height (2%). The seeded sub-sample seemed 45% more efficient than the control sub-sample. Results are evaluated as excellent for this sub-sample.

An increase of 121% in precipitation mass for a control value of 1124.2 kton in 119 cases means: $\mathbf{\Delta_1}$ **= 119 x 1.21 x 1124.2 kton = 161,874 kton = 131,279 ac-ft**

Large clouds that were seeded in Texas produced an additional **1,760,470 ac-ft** of water, and Type B clouds that were seeded in Texas produced an additional **463,850 ac-ft** of water as determined by the AISM analysis. The apparent total water produced by all seeded clouds in Texas was **2,355,599 ac-ft** in 2008 (Ruiz-Columbié 2008).

For many people, the increases in precipitation mass of over one million acre-feet is rather incomprehensible. Annually, a single person consumes 265 gallons (.008 acre-feet) of water. Household water uses on

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	65 min	40 min	1.63	63 **(48)**
Area	88.0 km^2	57.8 km^2	1.52	52 **(44)**
Volume	253.2 km^3	157.0 km^3	1.61	61 **(51)**
Top Height	7.9 km	7.6 km	1.05	5 **(2)**
Max dBZ	50.7	49.3	1.03	3 **(1)**
Top Ht of max dBZ	4.3 km	4.3 km	1.00	0 **(0)**
Volume above 6 km	25.1 km^3	12.7 km^3	1.98	98 **(64)**
Precip Flux	695.6m^3/s	415.8 m^3/s	1.67	67 **(53)**
Precip Mass	3150.6 kton	1124.2 kton	2.80	180 **(121)**
Cloud Mass	223.5 kton	131.7 kton	1.70	70 **(51)**
η	14.6	9.0	1.62	62 **(45)**

Table 5: Seeded samples versus control samples. (119 couples, average)

average is 50-100 tons which is equivalent to .445 and .885 acre-feet respectively. Additionally, water used to irrigate crops for making clothing and the food we eat is estimated at 1500-2000 tons or 13.27-17.70 acre-feet (Pearce 2007). Collectively, a single person uses on average 18.6 acre-feet each year. In the State of Texas, the cost of water ranges greatly from $300-$1,200 but for the purposes of this explanation we will use an average value of $750 per acre-foot. Using these values, the cost of water per person is $13,950 per year. The average state-wide budget for weather modification operations is $1.6million. AISM estimated the total increases in precipitation at 2,355,599 ac-ft in 2008 yielding a cost of one acre-foot of water at $1.47.

Weather Events in Texas During 2008

By Todd Flanagan

For most parts of Texas, 2008 will be remembered for two things, drought and hurricanes. With the exception of the lower Rio Grande Valley, a few spots in east Texas, parts of the panhandle, and locations near the Pecos River Valley, the state received 75 percent or less of the average annual rainfall. Some locations in south-central and southeastern Texas received only 25-50 percent of the average annual precipitation. In addition, three tropical cyclones (two hurricanes, one tropical storm) affected the state between July and September. The following is a month-by-month review of notable events observed during the year.

January turned out much drier than normal for the vast majority of the state. Only locations near the coast and the Big Bend area received above normal precipitation. It was so dry and windy that hundreds of wildfires were reported statewide, burning thousands of acres of land. This was a problem that would continue through March.

The dry weather was maintained into February, with the southwestern half of the state seeing less than five percent of the normal rainfall. A mid-winter heat wave occurred in southern Texas on February 25th, where temperatures climbed into the 90s, with Del Rio reaching 99°F. This is not entirely unheard of in south Texas; back on February 21, 1996, a heat wave gripped much of central and southern Texas, with San Antonio setting an all-time February high of 100°F.

March continued to be dry for areas along the Rio Grande as well as the Panhandle, but for areas roughly along and 50 miles either side of a Fort Stockton to Texarkana line, precipitation was above normal. The first severe weather events of the year began in early March in this aforementioned zone of above normal precipitation. On the 18th, a powerful storm system affected the state, with severe weather being reported in central and southern Texas. The potency of this storm was seen in the morning RAOB sounding from Corpus Christi, where winds just above the surface were at hurricane force.

With April came more severe weather, including tornadoes in the San Angelo area on the 10th along with straight-line winds up to 75 mph. The amount of severe weather observed was below normal during April, which echoed the dry conditions remaining in place for many areas. However, portions of north-central and northwest Texas saw above normal rainfall.

May was much quieter than one would expect to see in Texas, as May and June are typically the most active months in terms of severe weather. All of the weather modification target areas, except portions of SWTREA and PGCD's target areas saw below normal rainfall. It was particularly dry over southeastern Texas, where the drought index was extreme. The hot weather began making regular appearances during May, with many locations experiencing highs around 100°F.

June, typically a wet month for most parts of the state, was much drier than normal over central and southern Texas, with many locations seeing less than an inch of rain. However, parts of the PGCD, SOAR and WTWMA target areas did receive above normal rainfall. One event of note, a very intense thunderstorm affected Amarillo on the 19th, with 81 mph winds measured. This is the second highest wind speed ever measured in Amarillo. June also ended up being quite warm for parts of west Texas, with San Angelo experiencing the 6th warmest June on record.

July brought the first month of above normal precipitation to much of southern Texas. Locations in SWTREA and particularly STWMA's target area saw upwards of 300% of the normal monthly rains. A majority of this can be attributed to Hurricane Dolly, which made landfall in south Texas on the 23rd with sustained winds of 100 mph. Rain bands affected SWTREA and STWMA target areas on the 24th, where 1-4 inches of rain were reported. Two tornadoes occurred in the STWMA target area on the 24th: one near Poth in Wilson County and one just south of downtown San Antonio. The remains of Dolly went into Mexico before curving northward into New Mexico and then back across the Panhandle, with locations near and to the east of this path seeing rainfall as a result of the associated tropical moisture.

August brought widespread beneficial rains to much of the state, save for isolated locations which saw below normal rains. On the 5th, Tropical Storm Edouard made landfall in southeastern Texas as a 65 mph cyclone. The storm gradually dissipated over the course of the next two days as it tracked into central and northwestern Texas. Heavy rains associated with

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the remains of Edouard affected locations east of Brownwood on the 6th. With a general weakness in the ridge that typically stretches across the southern United States in summer, the potential for scattered diurnal convection was realized on many days during the month. One problem that seemed to plague the weather modification projects was the abundance of tropical moisture resulting in cloud structures that were less than desirable for glaciogenic seeding. However, the rains that fell were welcomed by most.

After a couple months of above normal rainfall, the dry pattern returned to the Panhandle as well as portions of west-central and southern Texas in September. The biggest weather story of the year occurred in September, when Hurricane Ike made landfall at Galveston on the 13th as a borderline Category 2/3 storm with maximum sustained winds of 110 mph. What was impressive about Ike was its wind field, which was larger than that of Hurricane Katrina. The rains from Ike were confined to the eastern third of Texas. The circulation around Ike produced a not-entirely-unusual effect: the combination of subsidence and down sloping winds from higher terrain in Mexico produced very high temperatures over southern Texas, with portions of the STWMA and SWTREA target areas seeing temperatures between 100 and 105°F. No other major weather events occurred during the month.

October provided above normal rains to the Panhandle and portions of the South Plains, but the remainder of the state saw below normal rains as the dry spell continued. Cold weather began impinging on the state, with an early freeze occurring at San Angelo on the 23rd. The dry weather continued through November and December with the main storm track remaining well to the north of Texas, a trend that most are hoping will change, particularly for locations between Austin, San Antonio and Houston, an area now classified as being in exceptional drought.

Cumulus Cloud Seeding for Rainfall Enhancement in Texas

By William G. Finnegan, Desert Research Institute, Reno, Nevada; and Lee Ates, Concho Cartridge Co. Inc., San Angelo, Texas

Prior to the mid-1990s, cumulus cloud seeding operations in Texas for rainfall enhancement, were generally conducted by commercial "Weather Modification" operators. When it became apparent that the desired results were not being gained, conclusions were drawn by Mr. Dale L. Bates of San Angelo and George W. Bomar, Austin, that the seeding techniques and seeding materials, used in these programs, were not suited for use in Texas. It was then decided that pyrotechnic silver iodide aerosol generators should be manufactured in Texas for use in Texas programs. Concho Cartridge Co. Inc., was selected as the manufacturer and WGF agreed to advise on nucleation and nuclei chemistry; to devise new pyrotechnic formulations and to train the personnel of Concho Cartridge Co. in the manufacture of pyrotechnics. Seeding techniques were to be the concern of the West Texas Weather Modification Association, (WTWMA).

The program eventually yielded the RS-3 pyrotechnic, which generates a mixture of AgI (silver iodide), AgCl (silver chloride) and KCl (potassium chloride). It has proved to be an effective generator of ice nucleus aerosols. It is functionally reliable, with fewer than about 2-3 failures per 1000 fired, when properly stored, handled and the seeding aircraft are properly equipped.

These pyrotechnics have been tested for ice nucleus activity in the cloud chamber at Colorado State University, although the value of these tests may not be as great as normally considered. The seeding technique used in Texas is to use the pyrotechnics in updrafts at warm cloud base, which subjects the nuclei to warm cloud for 10-15 minutes, until they reach -4 or -5 C. Cloud chamber tests are conducted by injecting samples of ice nucleus aerosols into the chamber which contains a super-cooled cloud. Since utility in field operations is the primary result to be gained, field tests are more apt to give useful information than cloud chamber tests. Radar observations have shown that nuclei from the RS-3 pyrotechnics, burned at warm cloud base, promote horizontal cloud growth while vertical growth is suppressed. Rainfall from seeded clouds invariably lasts longer than that from unseeded clouds. Preliminary experiments have shown that hail from these clouds is modified in size and amount.

While the RS-3 pyrotechnic has been shown to have excellent utility when used in the manner described, recent developments have made it apparent that a new ice nucleus and a formulation for pyrotechnics to generate them, has to be devised for cumulus cloud seeding. The price of silver has risen markedly in the past 5 years (the price today was $ 19.00 per troy oz., a few months ago it was $ 20.00). Low silver iodide content pyrotechnics, such as the Russian "Silverspare", which contains1% silver iodide, have not been shown, scientifically, to be effective for rainfall enhancement or hail suppression and can, therefore, not serve as replacements for the RS-3 pyrotechnic.

With the need for new nuclei now apparent, we have started a search for chemicals with ice nucleation characteristics and which are capable of being generated by pyrotechnic combustion. A 5 cubic foot cloud chamber has been built and installed at Concho

Cartridge Co. for determining the ice nucleus activity of new compositions in a qualitative sense and the threshold temperatures of activities in particular. We have several candidate chemicals, which show ice nuclei activity at lower temperatures and further work is in progress to improve the temperature thresholds.

We propose to conduct the evaluation of the utility of these new nuclei generating pyrotechnics by aircraft seeding of cumulus clouds in the normal manner. Radar observation will give us information on vertical and horizontal growth and rainfall duration of seeded clouds. Comparison of experimentally seeded clouds with those seeded with RS-3 pyrotechnics will show utility. Comparison with unseeded clouds can be done if a quantitative determination of rainfall increase needs to be accomplished. It should be noted that in-cloud testing of experimental pyrotechnics may not necessarily always result in complete success. The tests are conducted, sometimes, to gain information on what to do in further studies. Mr. Ates will monitor the radar in real time, during experimental field tests. We prefer to do our own evaluations of field tests.

Photo take by Matt Pope. Flare burning while seeding in the South Texas Weather Modification Association target area, Frio County, on May 21, 2008.

Photo take by Todd Flanagan. A seeded storm in the South Texas Weather Modification Association target area, Karnes County, June 20, 2008.

Texas Weather Modification Project's Contact Information

Panhandle Groundwater Conservation District
Jennifer Wright
P.O. Box 637
White Deer, Texas 79097
jwright@pgcd.us

West Texas Weather Modification
Robert Rhodes
8696 Hangar Road
San Angelo, Texas 76904
meteorologist@wtwma.com

Southwest Texas Rain Enhancement Association
Stephanie Beall
110 Wyoming Blvd
Pleasanton, Texas 78064
wxbliss21@yahoo.com

Active Influence and Scientific Management
Archie Ruiz
8696 Hangar Road
San Angelo, Texas 76904
twma@texasweathermodification.com

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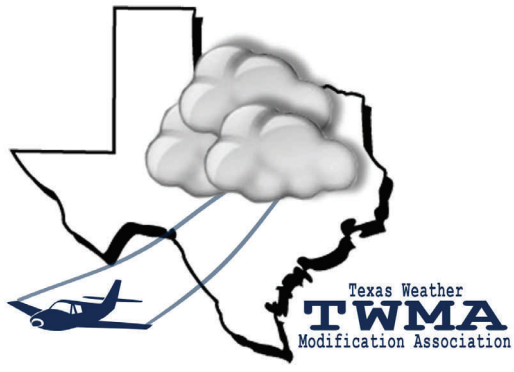
feed that the current and aged TITAN systems could read. Most of the bugs were worked out during the summer, allowing meteorologists to continue using the system; but it was obvious that each office would need to make an investment into more powerful computers for the next year.

WDT and Texas weather modification personnel worked together at the end of 2008 to build new computer systems able to retrieve and display the new super-resolution data. All weather modification operations are expected to be under full view of the newest TITAN program and super-resolution data when convective weather begins in March and April of 2009.

SOAR
11555 County Road 305, P.O. Box 130
Plains, Texas 79355

South Texas Weather Modification Association
Todd Flanagan
110 Wyoming Blvd
Pleasanton, Texas 78064
toddrf72@yahoo.com



Texas Weather Modification Association Program Officers

President: Tommy Shearrer, Pleasanton

Vice President: C.E. Williams, White Deer

Secretary: Ed Walker, Carrizo Springs

Treasurer: Craig Funke, San Angelo

West Texas Weather Modification
Robert Rhodes
8696 Hangar Road
San Angelo, Texas 76904

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