Texas Cloud Seeding: Facts, Data and Misinformation.

THE BOARD OF THE TEXAS WEATHER MODIFICATION ASSOCIATION

Texas Weather Modification Association, San Angelo, Texas

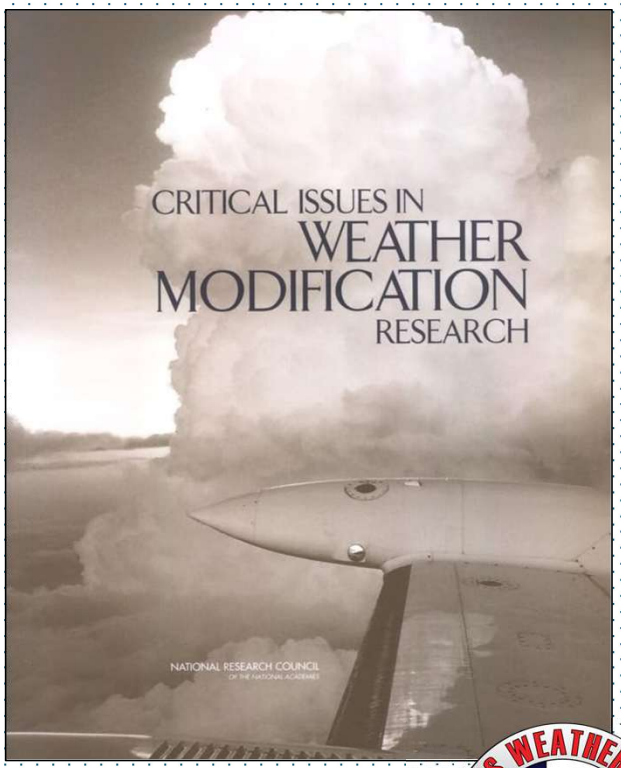
WEATHER MODIFICATION ASSOCIATION

San Angelo, TX

Introduction

“The committee emphasizes that weather modification should be viewed as a fundamental and legitimate element of the atmospheric sciences. Owing to the growing demand for fresh water, the increasing levels of damage and loss of life resulting from severe weather, the undertaking operational activities without the guidance of careful scientific foundation, and the reality of inadvertent atmospheric changes, the scientific community now has the opportunity, challenge, and responsibility to assess the potential efficacy and value of intentional weather modification technologies.”

Committee on the Status and Future Directions of the U.S. Weather Modification Operations, National Academy of Sciences, 2003 (Critical Issues in Weather Modification)



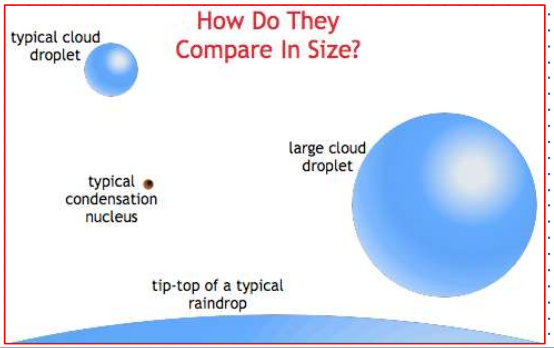
What is cloud seeding?

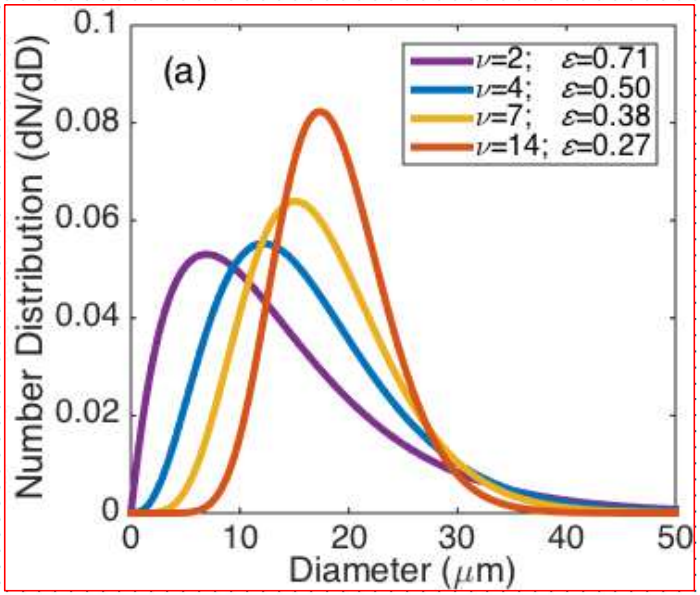
- The act of introducing favorable nuclei into a cloud to promote cloud droplet growth and ice nucleation.
- Focuses on localized events.
- Rain ***Enhancement***
  - Cloud seeding does not create rain or clouds.

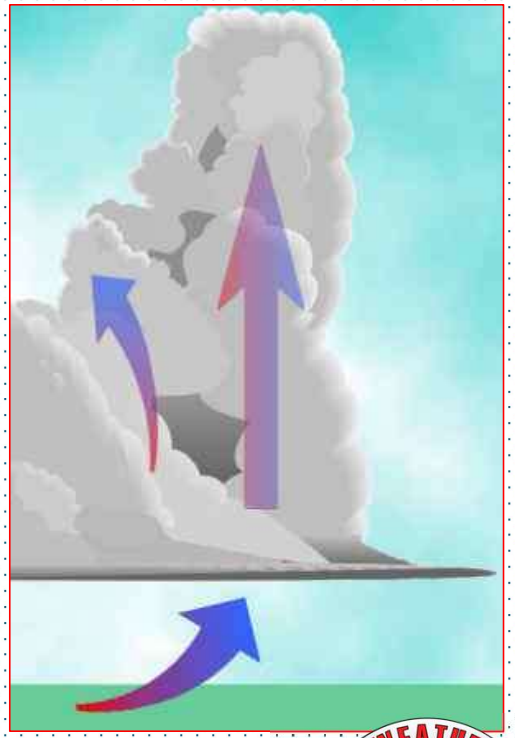
Why should we cloud seed in Texas?

- Water Demand and population increases.
- Ongoing Drought
- Clouds in Texas are vulnerable to particulates (dust, sulfates, caliche) especially those in West Texas
- ENSO conditions impact Texas more so than any other state in terms of changing weather patterns
  - **La Nina (dry!)**
  - **El Nina (wet!)**

Why does cloud seeding work in Texas?







Dust Particles are very small and in high concentrations. This narrows the droplet size distribution balancing the cloud making it less efficient while resulting in super cooled liquid water in the cloud. Both reasons lead to a need for both glaciogenic cloud seeding and hygroscopic cloud seeding.

Texas Cloud Seeding History

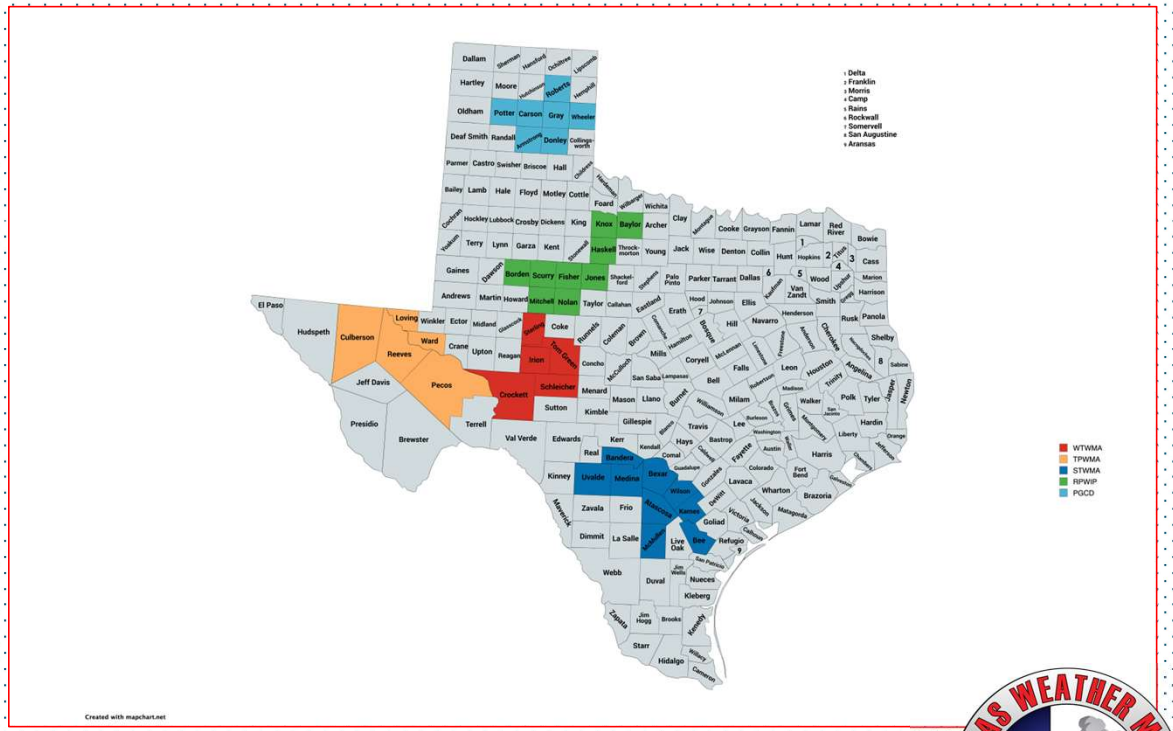
- Cloud Seeding Act of 1967
  - Now housed at TDLR (Licensing and Permitting)
- Conceptual Model built from research projects
  - 1986 HIPLEX (USBR funded)
  - 1996 TEXARC (TWDB funded)
- Operational Programs helped define the programs
  - 1974 CRWMD (what not to do)
  - 1995 WTWMA (lessons learned)
  - 2001 Evaluations
    - This is when the modern age of cloud seeding in Texas took off

Licensing and Permitting

- Permits require an operations plan and a notice of intention to be run for three consecutive weeks in general circulation newspapers.
  - Issued in 4-year increments
  - Must include suspension criteria
- Licenses require qualified meteorologist (6 months on-site experience along with a B.S. in Meteorology or related field).
  - Issued annually
- Reports must be posted to a webpage for public viewing or distributed to the TDLR.
- Pre-season and Post-season reports are required to be filed with the National Oceanic and Atmospheric Administration.
- The TWMA programs are fully transparent.

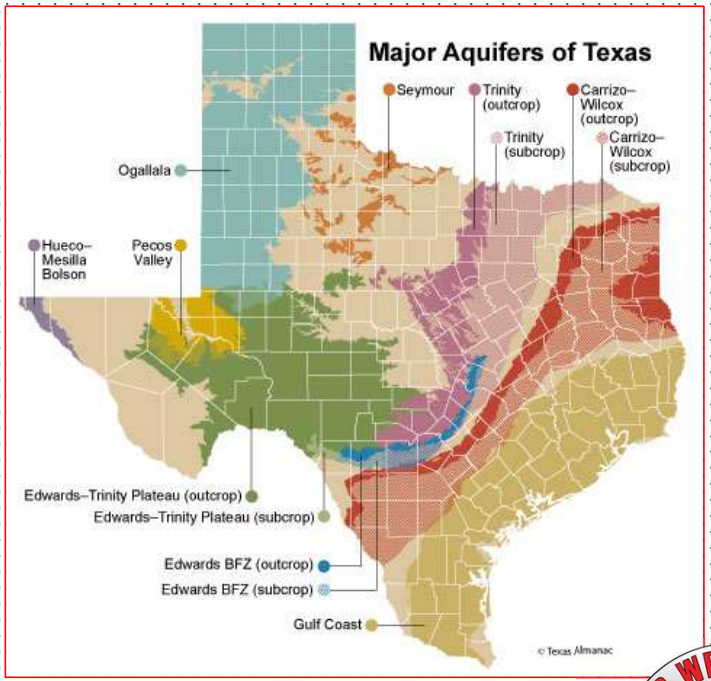
Target Areas

- Panhandle Groundwater Conservation District
- Rolling Plains Water Improvement Program
- Trans-Pecos Weather Modification Association
- West Texas Weather Modification Association
- South Texas Weather Modification Association (EAA)



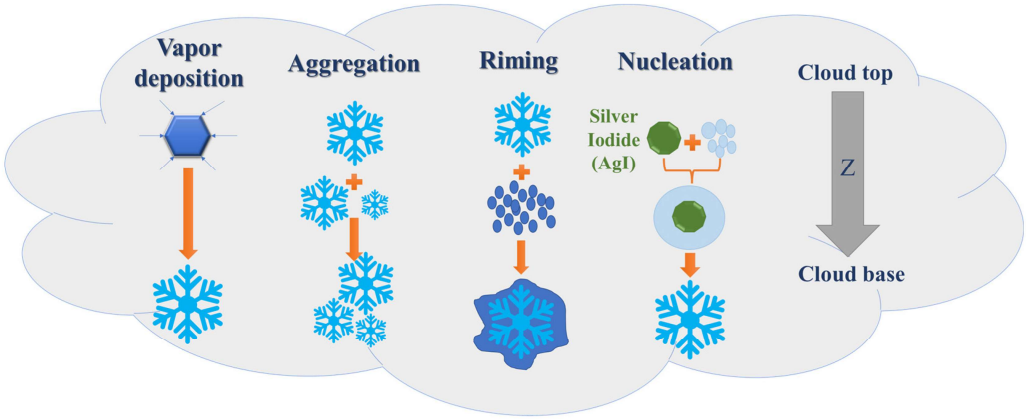
Program Goals

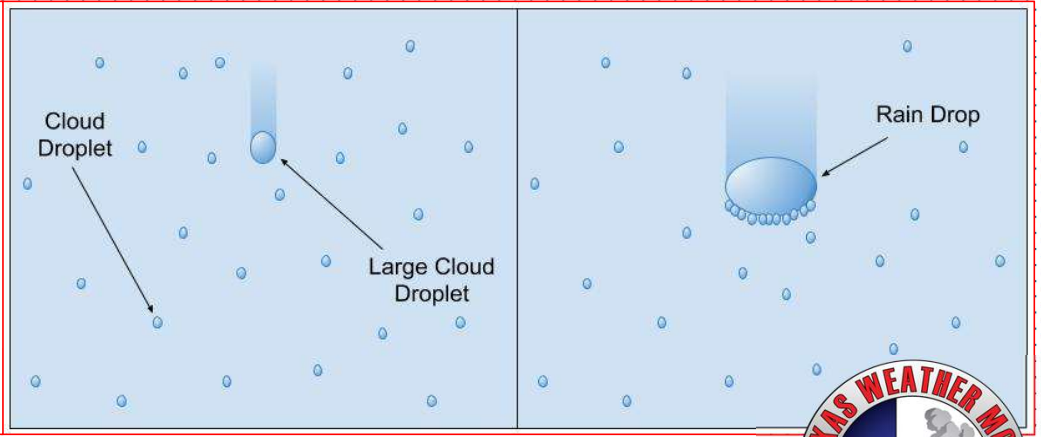
- Help increase water supply for:
  - Drinking water
  - Irrigation
  - Area Lakes, Rivers and Reservoirs
  - Aquifer Recharge
- While reducing:
  - Need to irrigate
  - Groundwater Consumption



Methodology

- Glaciogenic Seeding
  - Ice Nucleation
  - Water Droplets too small to freeze, too small to collide & coalesce
- Hygroscopic Seeding
  - Maximizes the warm rain process
  - Larger droplets, better collision & coalescence



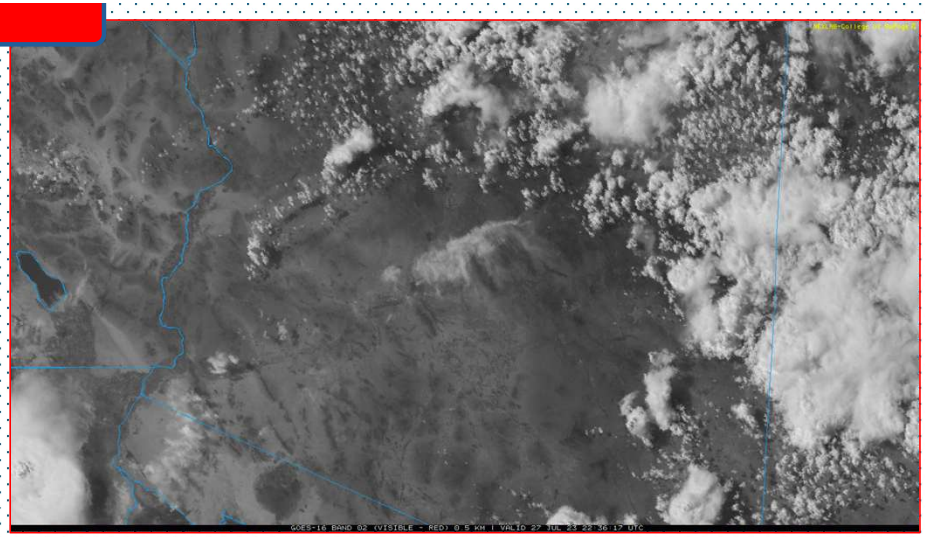


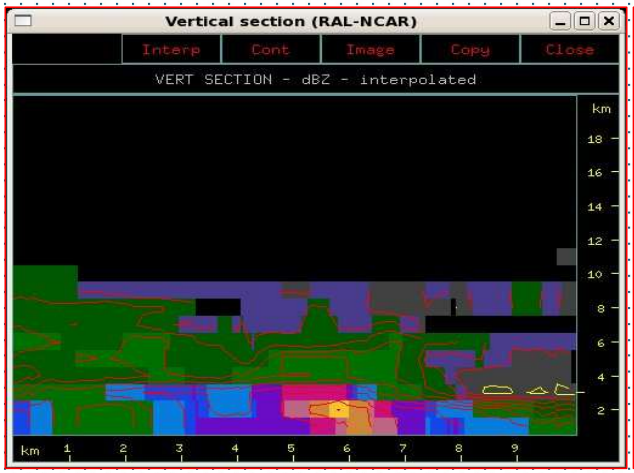
Environmental Considerations

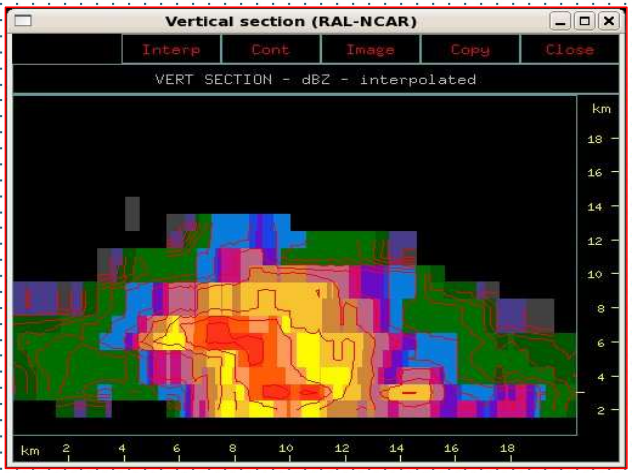
- Silver + Iodide have a strong electronegativity
  - Results in a stable and strong covalent bond
  - Allows AgI to be insoluble in water
    - Allows AgI to be both a great ice nucleating agent and environmentally safe
- Free Silver Ion…
  - The maximum concentration of silver in water via silver iodide is 0.984 µg/L.
    - This is 6x below natural background levels of silver
    - EPA drinking level standard is below 100 µg/L
    - Aquatic life is 2-7 µg/L

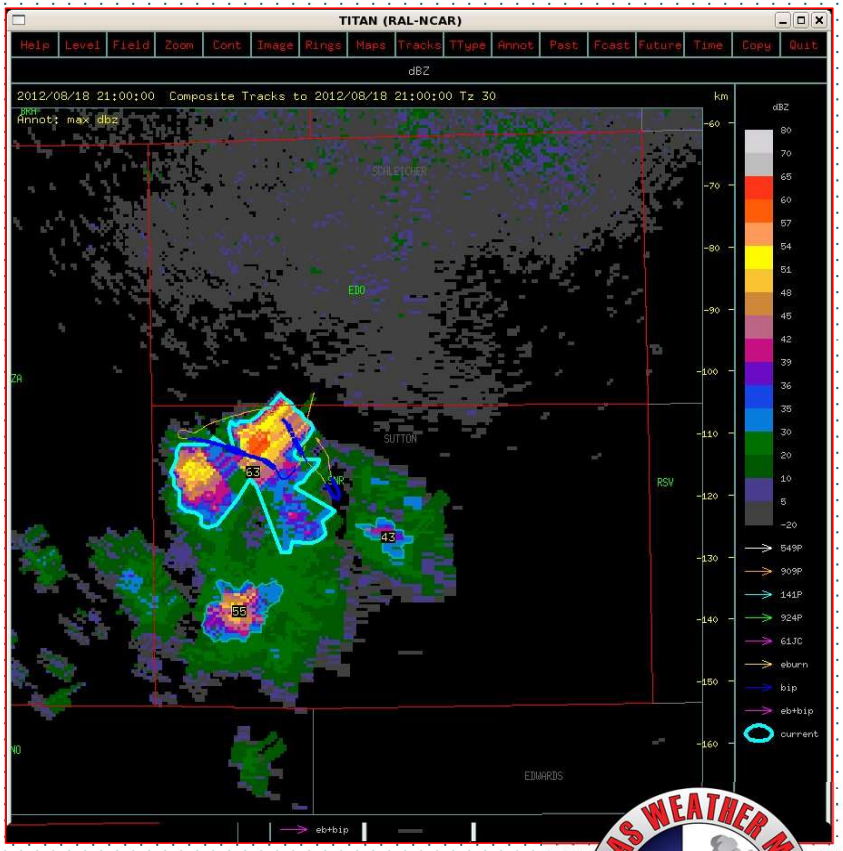
- Environmental studies in California and Idaho have shown no impacts from AgI in the environment.
- Long term programs in Utah have no silver beyond background levels in their lakes or lakebed sediment.
- San Angelo's program has been ongoing since 1995 with no impacts per water reports from the City of San Angelo.

Operations



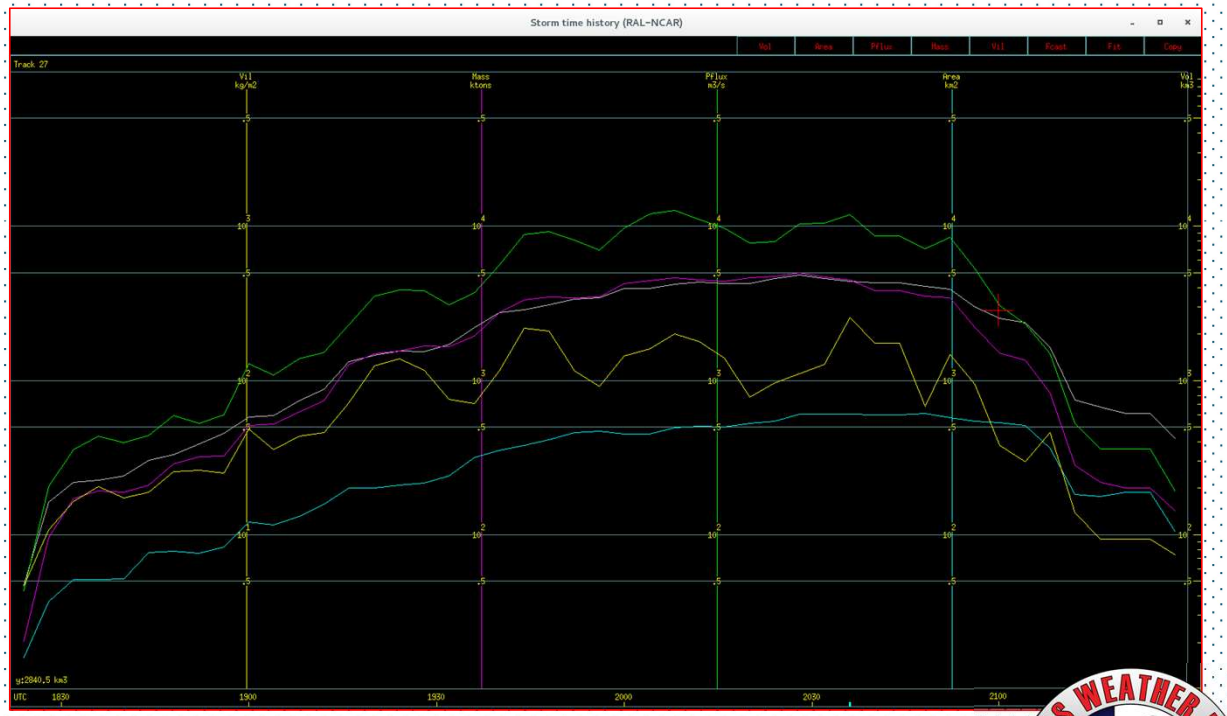

Vertical section (RAL-NCAR)
Interp
Cont
Image
Copy
Close
VERT SECTION - dBZ - interpolated
km


Vertical section (RAL-NCAR)
Interp
Cont
Image
Copy
Close
VERT SECTION - dBZ - interpolated
km


TITAN (RAL-NCAR)
Help
Level
Field
Zoom
Cont
Image
Rings
Maps
Tracks
TType
Annot
Past
Fcast
Future
Time
Copy
Quit
dBZ
2012/08/18 21:00:00 Composite Tracks to 2012/08/18 21:00:00 Tz 30
Annot: max dbz
km
dBZ
SONLETCHER
EDO
SUTTON
RSV
EDWARDS

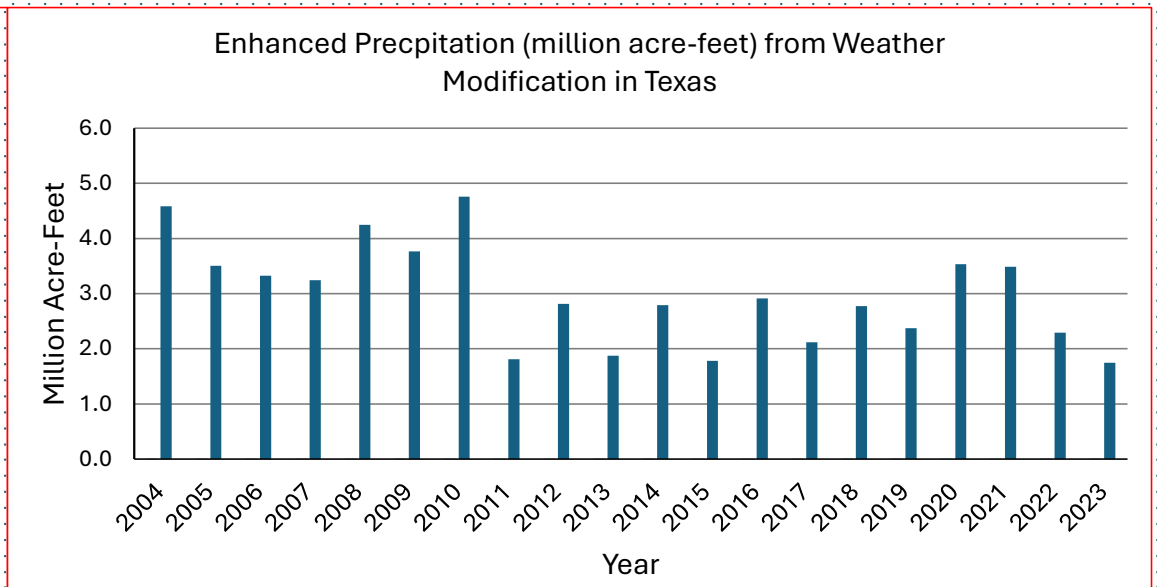
TITAN Evaluation

- Conducted by Dr. Arquimedes Ruiz-Columbie
  - Active Influence/Scientific Management
  - Texas Tech University
- Creates a data base of seeded clouds vs. unseeded
- Evaluation ongoing since 2002

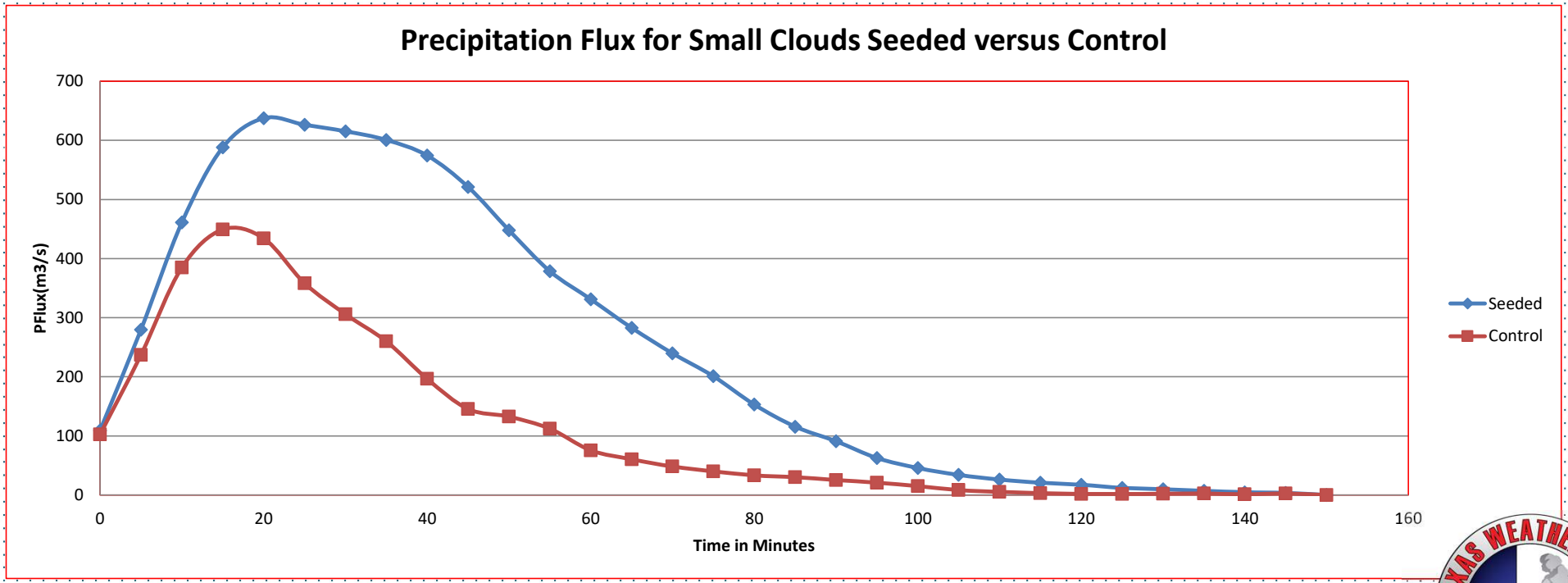


Analysis for the TWMA Programs

- Since 2004 (20-year data set)
  - 5,303 seeded clouds
  - Average Seasonal Rainfall of 14.11”
  - Increased Precipitation
    - 1.29”, or 10.21%
  - Water Production
    - 3-million a-f/year

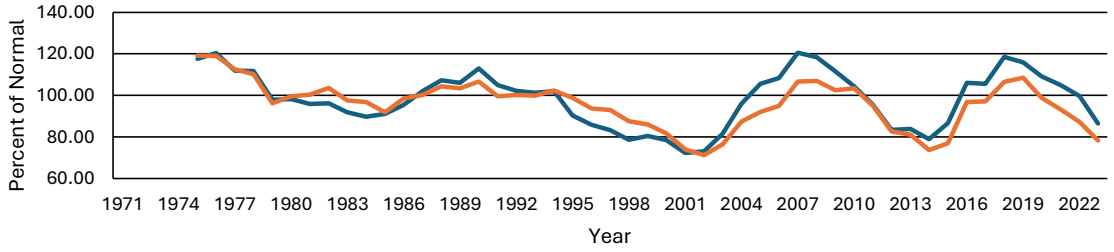


Analysis on Small Clouds

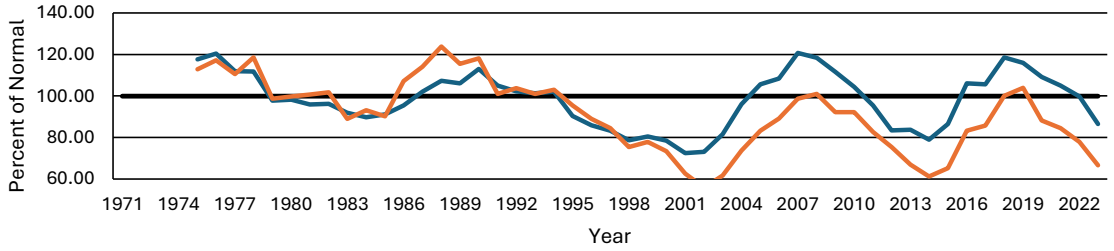


Rain Gauge (WTWMA only)

5-Year Moving Average of Percent of Normal Rainfall Inside (blue) vs. Outside (Orange) of the WTWMA Target Area



5-Year Moving Average of Percent of Normal Rainfall Inside (blue) vs. West (Orange) of the WTWMA Target Area



2004-2023 Data:

WTWMA % of normal: 104.49%

Outside TA % of normal: 97.15%

Δ of 7%

West of TA % of normal: 87.63%

Δ of 16%

North of TA % of normal: 93.72%

Δ of 10.5%

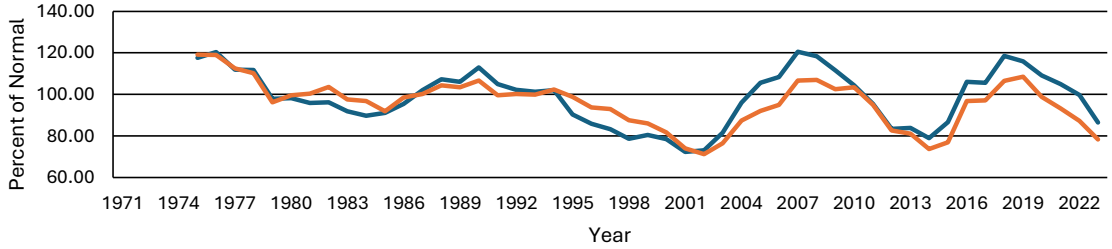
East of TA % of normal: 96.20%

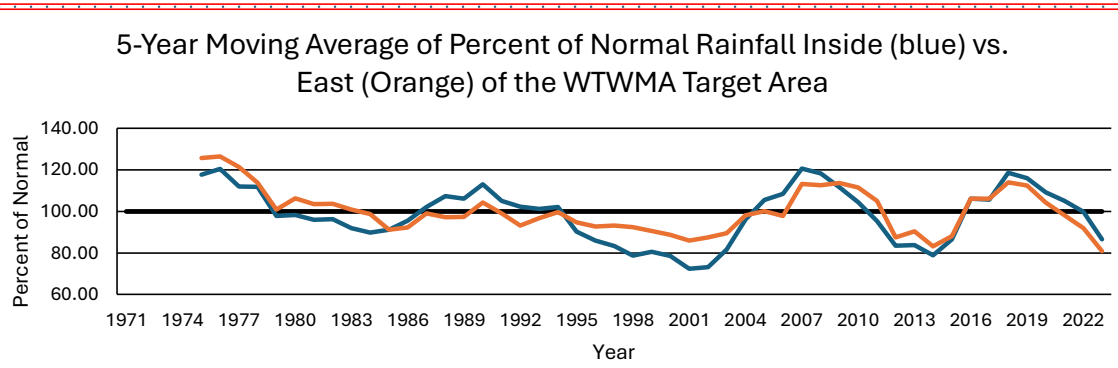
Δ of 8%

WTWMA TITAN Evaluation since 2004:

15.1%

What about “Robbing Peter to pay Paul?”





2004-2023 Data:

WTWMA % of normal: 104.49%

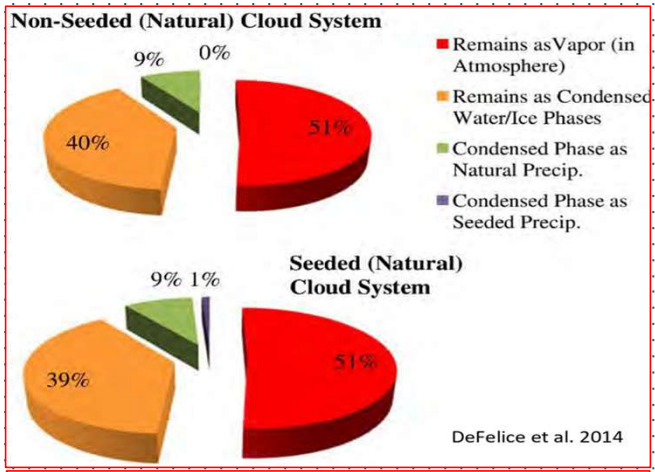
Outside TA % of normal: 97.15%
Δ of 7%
West of TA % of normal: 87.63%
Δ of 16%
North of TA % of normal: 93.72%
Δ of 10.5% (RP Contamination)
East of TA % of normal: 96.20%
Δ of 8%

WTWMA TITAN Evaluation since 2004:

15.1%

Why do we see this effect?

- Latent Heat of Fusion via Phase Change (Rogers & Yau 1989)
  - Liquid (supercooled water) > Ice through ice nucleation
  - Vapor (water vapor) > Liquid through deposition
  - The release of this heat allows clouds to grow more robust allowing them to last longer and tap into more moisture available in the atmosphere.
- Studies at UT (Maidment 2024) have recorded that 300” of “potential precipitation” move across the state on any given year.
  - Statewide average precipitation = 27”
  - Cloud seeding only taps into less than 10% of the statewide precipitation, or 1% of the total moisture moving through the state on any given year.



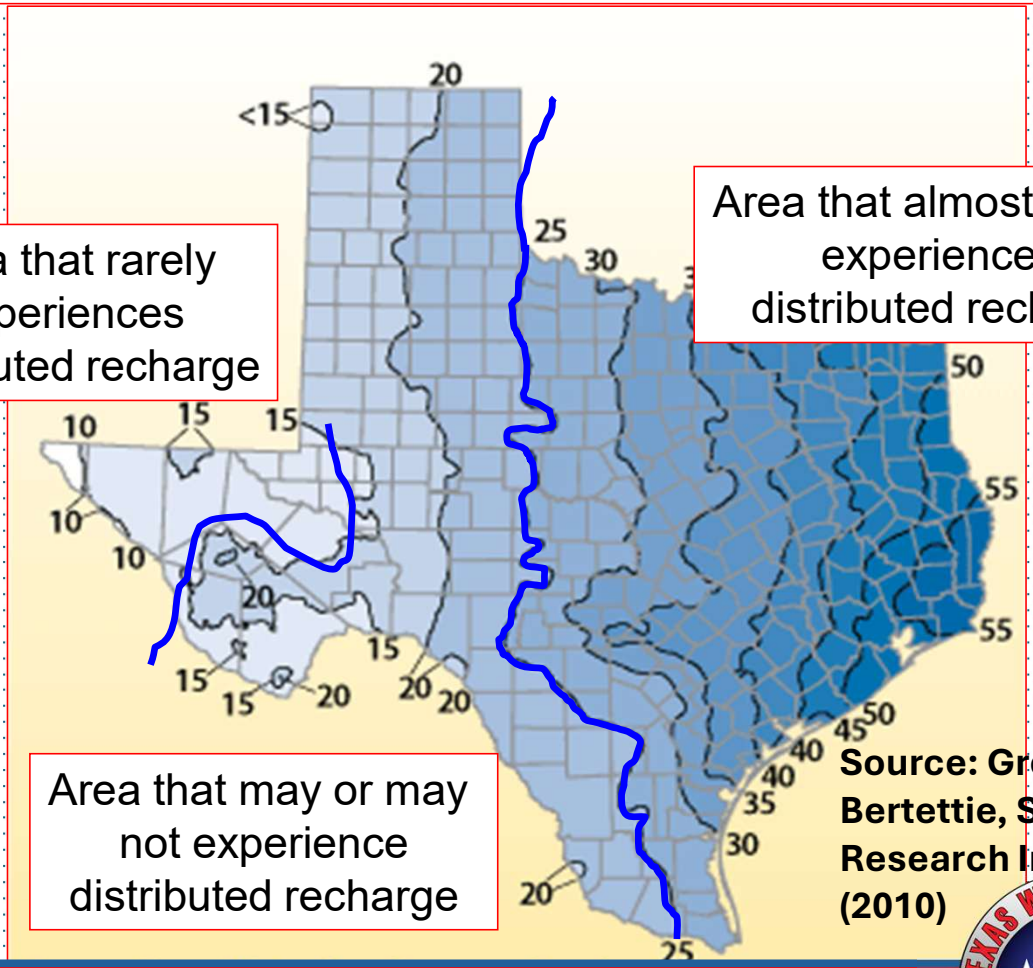
- A typical storm is only 9-19% efficient (ASCE 2016).
- A 10% increase in precipitation means only grabbing 0.9 – 1.9% more moisture out of the cloud.

Aquifer Recharge Enhancement

- Studies done by Green and Bertettie of the SwRI indicate 16.5” of precipitation annually is needed for aquifer recharger across the Edwards-Trinity Aquifer.

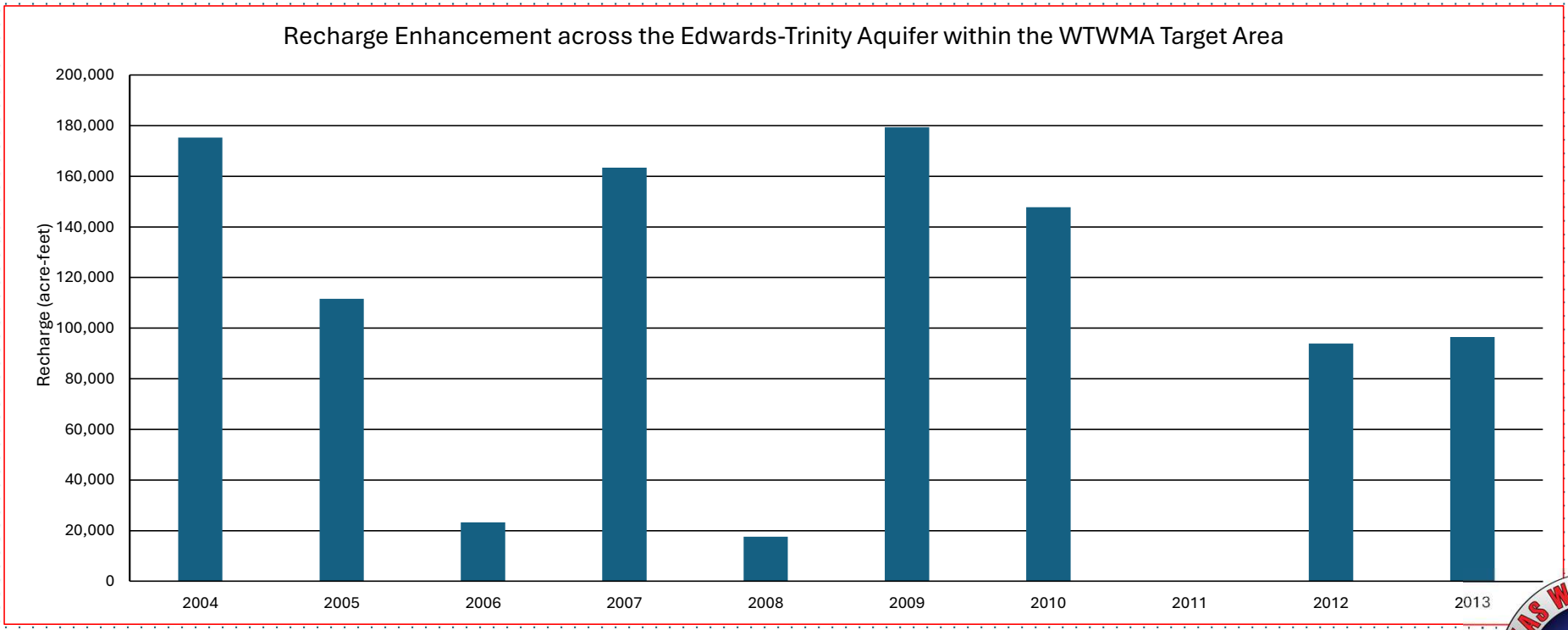
- Cloud Seeding could help push annual precipitation beyond that threshold.

Texas Can be Sub-Divided by Area into Three Categories of Recharge



Source: Green, Bertettie, Southwest Research Institute (2010)

Jennings/Green Annual Recharge across the WTWMA Target Area due to Rain Enhancement



Benefit Cost Analysis (Johnson 2014)

- Benefits Limited in this study to:
  - Increased Ag Production
    - Increase Dryland Crop Revenue
    - Cost Savings to Irrigated Acreage
    - Increasing Grazing Land Revenues
- Using the expenses of the program over the last 5 years and comparing that of the benefits described, the ratio is:
  - Direct Economic Impact: 1:16
  - Statewide Impact: 1:34

PROGRAM	Direct EI	Statewide EI	Benefit Cost Ratio (D)	Benefit Cost Ratio (S)
WTWMA	$6,016,866	$12,757,566	1:16	1:34
STWMA**	$5,691,327	$10,850,560	1:21	1:39
PGCD	$4,877,938	$9,407,140	1:22	1:43
All Combined	**$16,586,131**	**$33,015,266**	**1:19**	**1:38**

- Recharge Enhancement, Enhanced Spring/River Flow
- Decreased surface and groundwater consumption, Improved Opportunities for Economic Stability and Future Growth
- Enhanced Landscape Appearance, Increased Reservoir Levels
- Replenishment of Aquifers, Improved Habitat Conditions for Wildlife
- Increased Lake and River Levels, Fire Suppression

Future

- TWMA has been working with the **USDA** since 2017 on a new technology.
  - Technology has been approved a patent with continued research expected in the near term.
  - Technology isn't limited to just cloud seeding (pollution mitigation)
  - Early indications it is 2x more effective at tradition technologies.

Conclusions

- Weather Modification in the form of ***cloud seeding*** has been ongoing for decades and is widely considered a tool for water resource management in the west.
- This should be considered a ***long-term water management strategy.***
- **States** like Utah ($5 million ongoing, $12 million 1-time), Idaho ($7 million ongoing), Wyoming ($1 million ongoing) along with Nevada, Colorado, California, New Mexico and North Dakota are actively operating.
  - The Lower Colorado River Basin states send additional funds to Wyoming, Colorado, and Utah for increased efforts in the Colorado River Basin.
- Texas cloud seeding programs are fully funded at the local level. In 2024, the total investment was $1.296 million
  - From 1997-2003, the state invested $13 million into the program via the general revenue fund. This allowed the programs to be what they are today
- Research in Weather Modification is beginning to peak with a modern age ahead of us.
  - NCAR SNOWIE study / GAO Report / USBR Grant

Disclaimer

- Cloud seeding is fundamentally different from the unproven theory of chemtrails
  - We certainly do not have the budget or capabilities to fly at altitudes high enough for this type of work
- The Weather Modification Association is not aware of any instance of high aerosol spraying and if so, would not support that work of any kind.
- Marine cloud brightening using ships to distribute nuclei has been researched in the lab but was quickly shut down after public backlash.
  - Check with the University of Washington on their proposals with this work.
- Cloud seeding has undergone a lot of scrutiny in the past 12-months, none of it warranted.
  - The operators and researchers have 2 goals in mind. 1.) Produce water 2.) Produce water safely.
- Cloud Seeding in Texas only takes place in the aforementioned shown target areas during the months from March through October, but primarily April through September and only at the base of convective clouds, not in clear blue skies (again, the budget is too tight for non-operational flying).

TEXAS WEATHER MODIFICATION ASSOCIATION

Thank You!