

A Proposal to Warm Cloud Seeding in West Texas using Hygroscopic Flares

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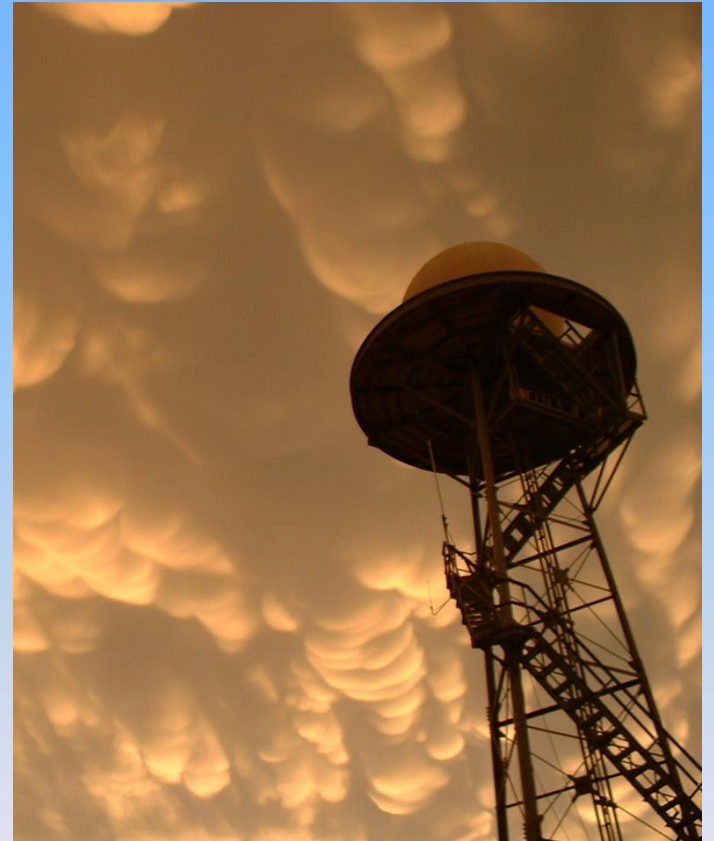
ARQUIMEDES RUIZ

Texas Tech University, Lubbock, TX

Weather Modification Association Annual Meeting – April 25-27, 2012 - Las Vegas, NV

What to expect?

- Purpose
- Hygroscopic Seeding in West Texas
- Past Experiments
- Proposal
- Target Days
- Conclusions



Influence for Proposal

- Investigate the effectiveness of existing flare assets (Hygroscopic and Glaciogenic Flares) to enhance or precipitate rainfall in the WTWMA target area in winter type stratus clouds
- Will also aid in:
 - West Texas farming and agriculture
 - Water Crisis/Drought

Farming and Agriculture

- West Texas Crops:

- Cotton
- Peanuts
- Winter Wheat



- West Texas Livestock:

- Cattle
- Sheep
- Goat



Drought of 2011

- The drought of 2011 cost West Texas Ranchers and Farmers...
 - \$6.2 **B**illion
- Increasing precipitation by 20% in winter 2010/11 would:
 - Allow for an addition 0.98” during the winter months (October through March)



Water Crisis

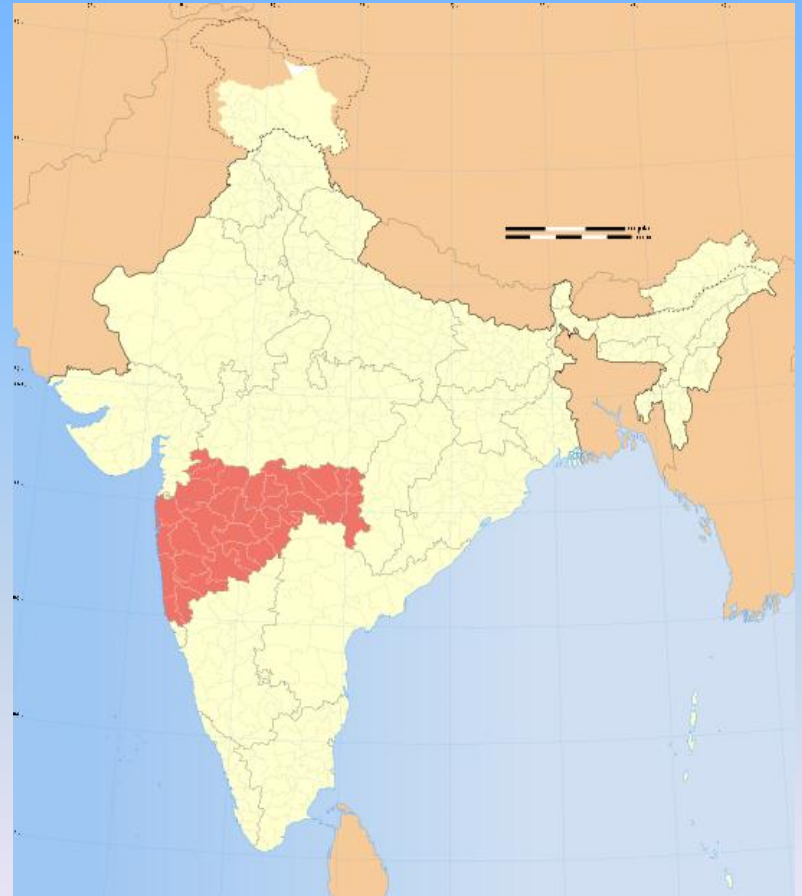
- 18,010,599 acre-feet of water is in demand in the state of Texas
- Projected to increase to 19,038,954 acre-feet by 2020
- By 2040, the demand will be over 20,000,000 acre-feet
- Texas Water Development Board
 - ***“In serious drought conditions, Texas does not and will not have enough water to meet the needs of its people, its businesses, and its agricultural enterprises.”***

Hygroscopic Seeding in West Texas

- Hygroscopic Seeding in West Texas since 2009
 - 2009 (5 cases)
 - Increases in Lifetime (10%), area (37%) and Precipitation Flux (63%)
 - 2010 (4 cases)
 - Increases in Lifetime (70%), area (82%) and Precipitation Flux (56%)
 - 2011 (4 cases)
 - Increases in Lifetime (44%), area (60%) and Precipitation Flux (79%)
 - 2012
 - Will be much more aggressive with dual-seeding/hygroscopic seeding

11-Year Warm Cloud Modification Experiment in Maharashtra State, India

- Indian Institute of Tropical Meteorology
- Conducted 11-Year Experiment
- Positive Results
- Parameters



11-Year Experiment

- Seeded clouds using a DC-3 Aircraft equipped with a funnel that could release salt seeding material at 0 to 30 kg per minute.
- The cruising speed of the aircraft was roughly 180 km/hr (~112 m/hr)
 - Not much different then Piper Comanche's used by WTWMA

11-Year Experiment

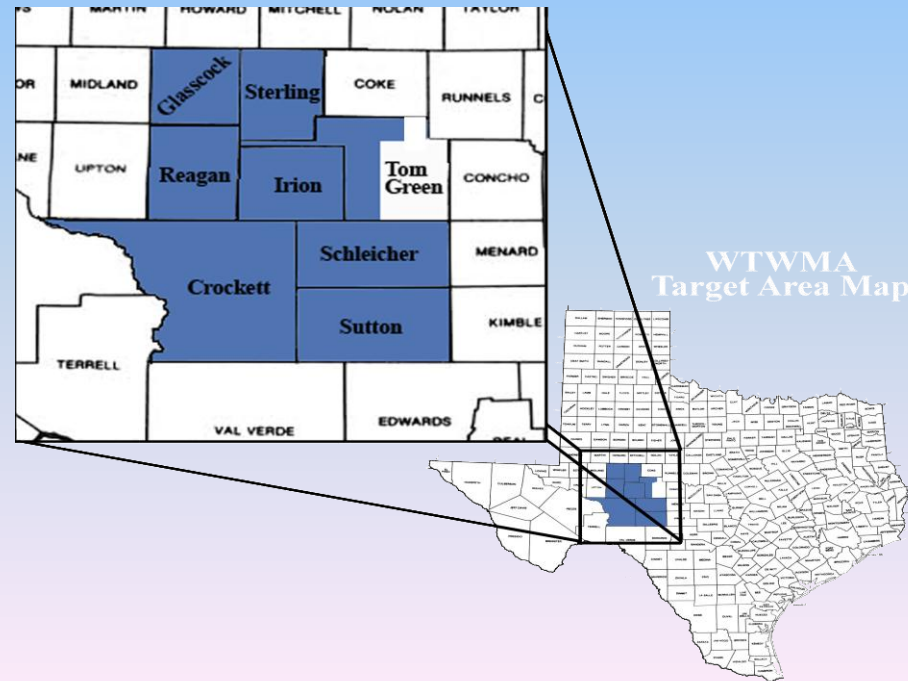
- Seeding Material Consisted finely pulverised mixture of sodium chloride and soapstone
 - 10/1 ratio
- Median Particle Mass of 10^{-9} grams
 - 75% of particles had diameters less than 10 μm
- Material released at 200 to 300 meters above the cloud base at 1 liter per cloud air
- Focused on areas with divergence at the base of the cloud

11-Year Experiment

- Found clouds with:
 - Vertical Thickness $> 1 \text{ km}$
 - Liquid Water Content $> 0.5 \text{ gm m}^{-3}$
 - Produced increases in rainfall by 24%
- Clouds with:
 - Vertical Thickness $< 1 \text{ km}$
 - Liquid Water Content $< 0.5 \text{ gm m}^{-3}$
 - Dissipated

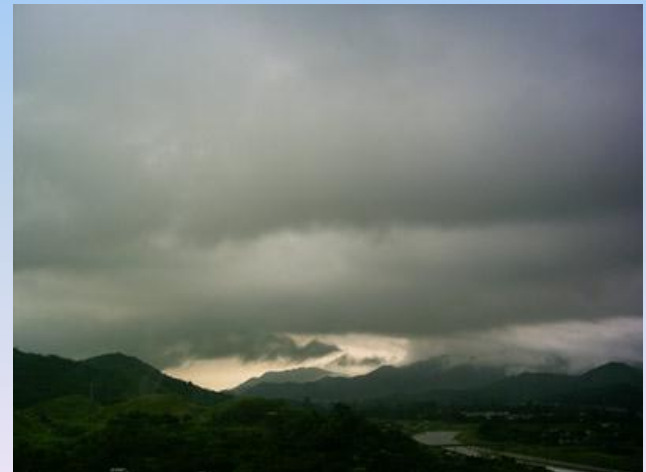
Scope

- Will target the current WTWMA target area
- 7 1/2 Counties (6.4 million acres)
- Will fly out of San Angelo Regional Airport (KSJT) under IFR flight conditions.



Time Frame

- October – March
 - Collision-coalescence dominates
 - Lack of Cumulonimbus
 - Year round?



Flight Conditions

- Conditions at KSJT must be:
 - 1,000 foot ceilings
 - 2 miles visibility
 - During operations and forecasted to remain for 1 hour after
- While similar conditions exist at:
 - Midland (KMAF)
 - Del Rio (KDRT)
 - Abilene (KABI)
 - Must be met for the duration of operations and 1 hour after

Meteorological Conditions

To be analyzed AND forecasted for 1 hour past projected flight operations

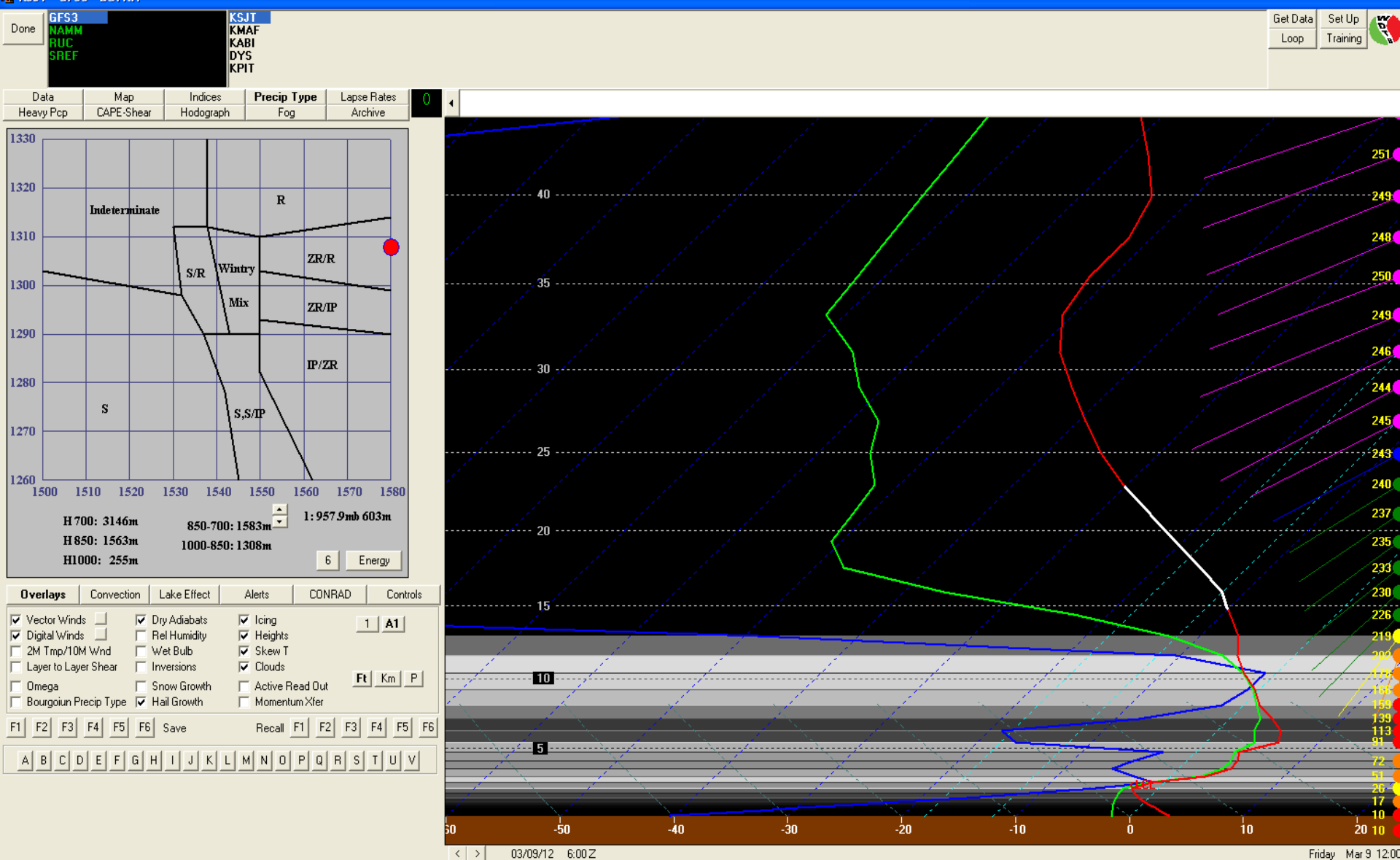
Parameters	Value
Cloud Base	> 1,500 meters
Cloud Depth	> 1,000 meters
Liquid Water Content	> 0.5 gm m ⁻³
Cloud Base + 300 meters Temperature	> 0°C

Operations

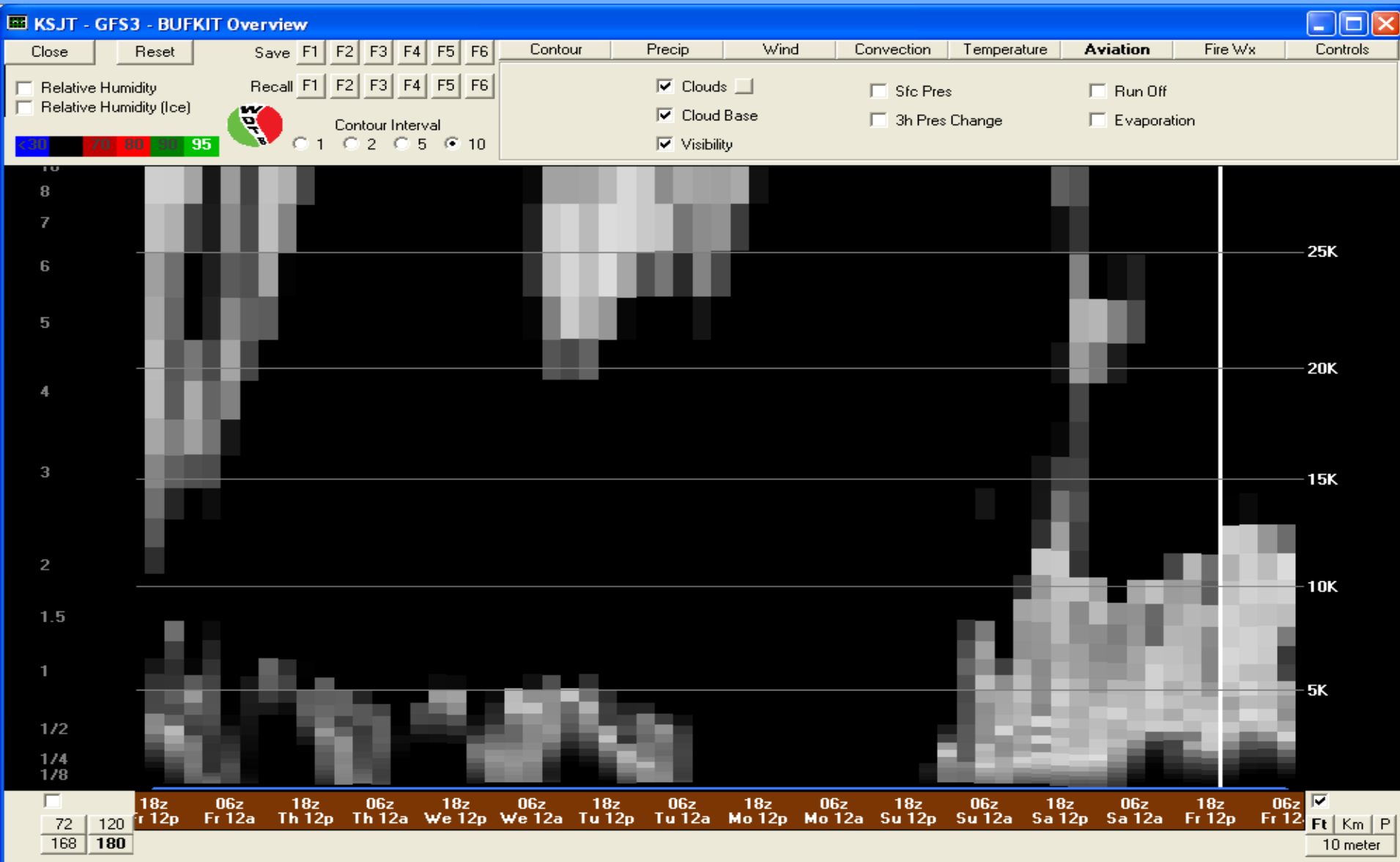
- Forecast will be conducted using BufKit
 - Able to forecast
 - Cloud Base
 - Cloud Depth
 - Precipitable Water
 - Vertical Temperatures
- Operations will be conducted using TITAN
 - Able to track
 - Cloud Base
 - Cloud Depth
 - Liquid Water Content

BufKit

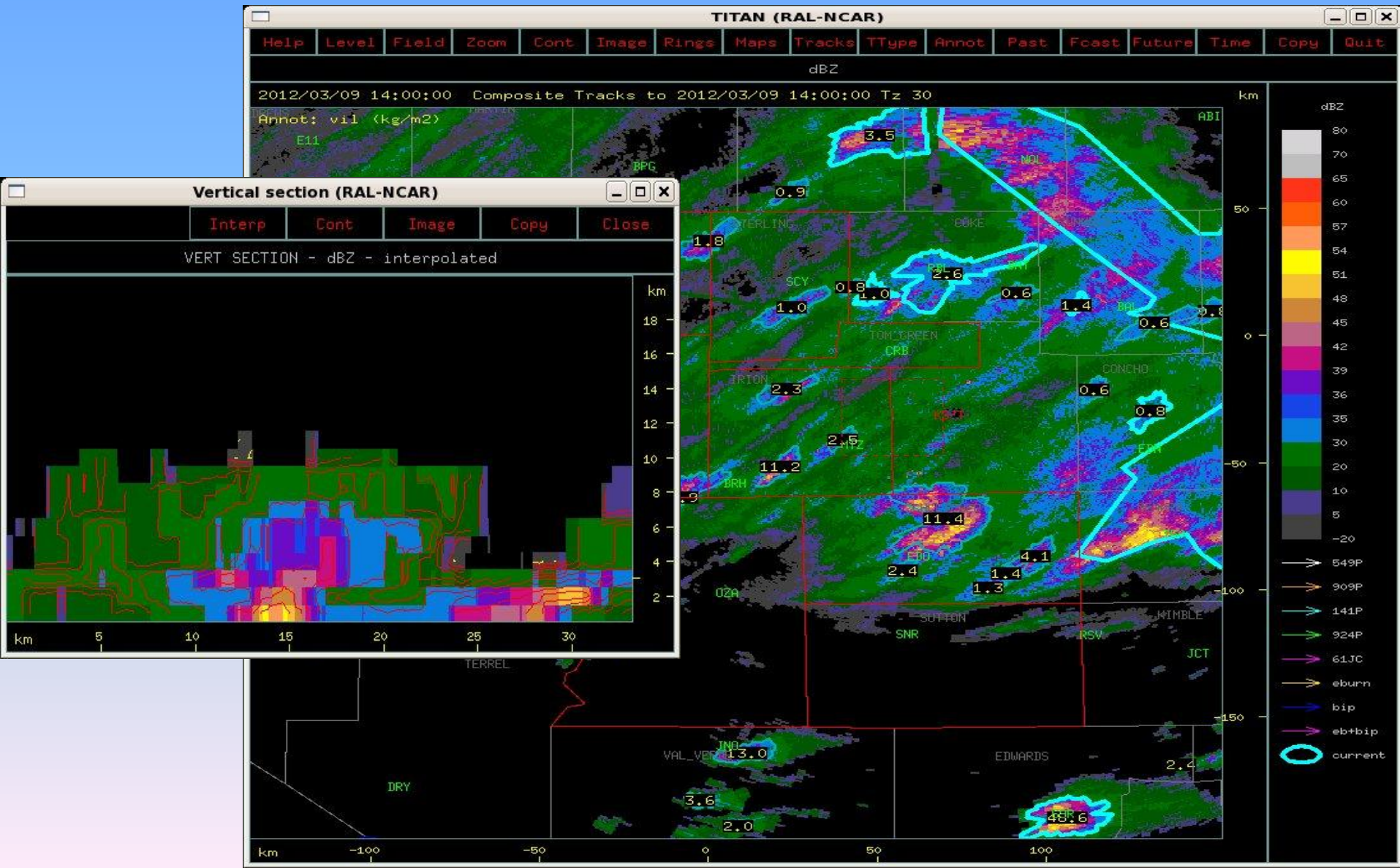
KSJT - GFS3 - BUFKIT



BufKit



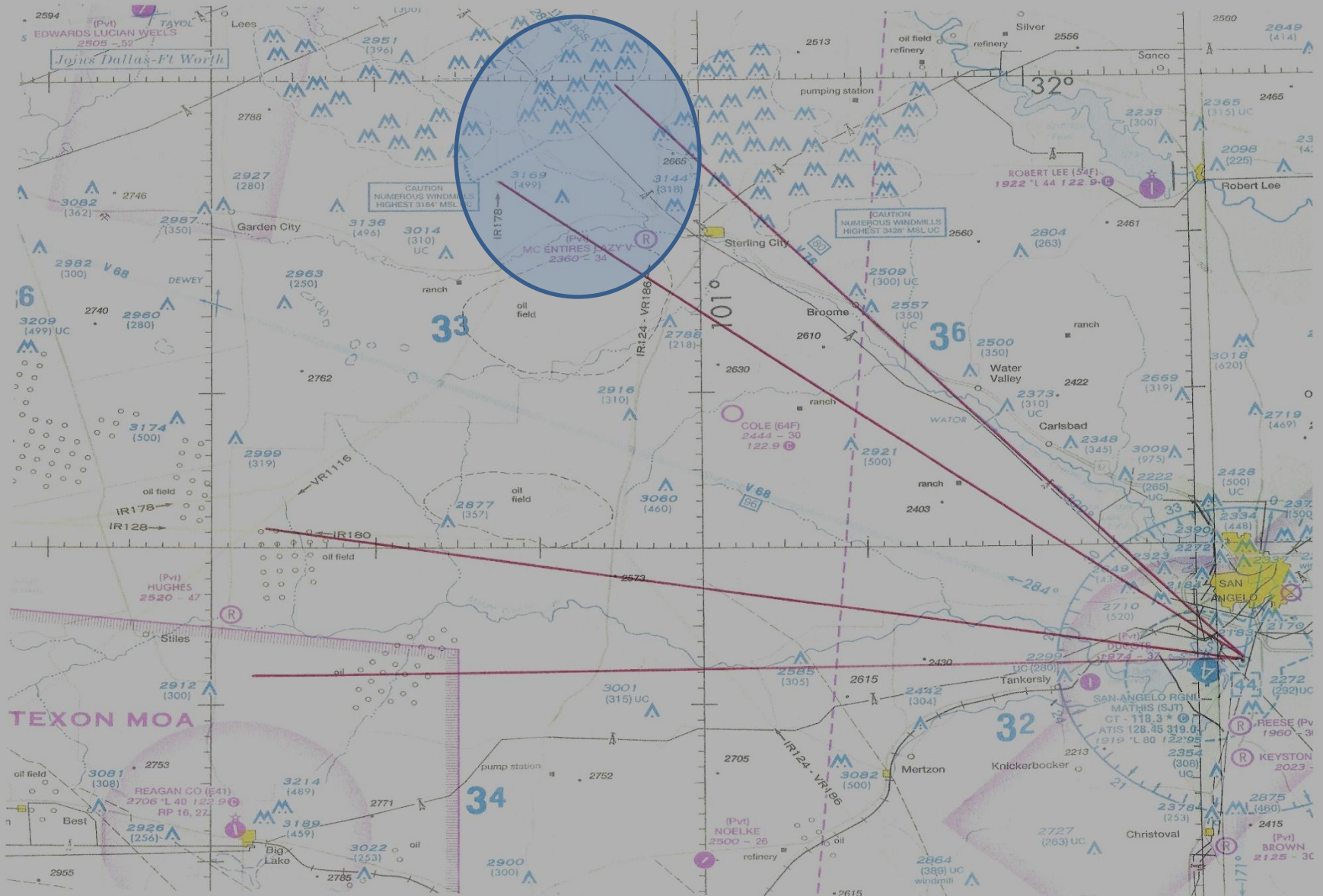
TITAN



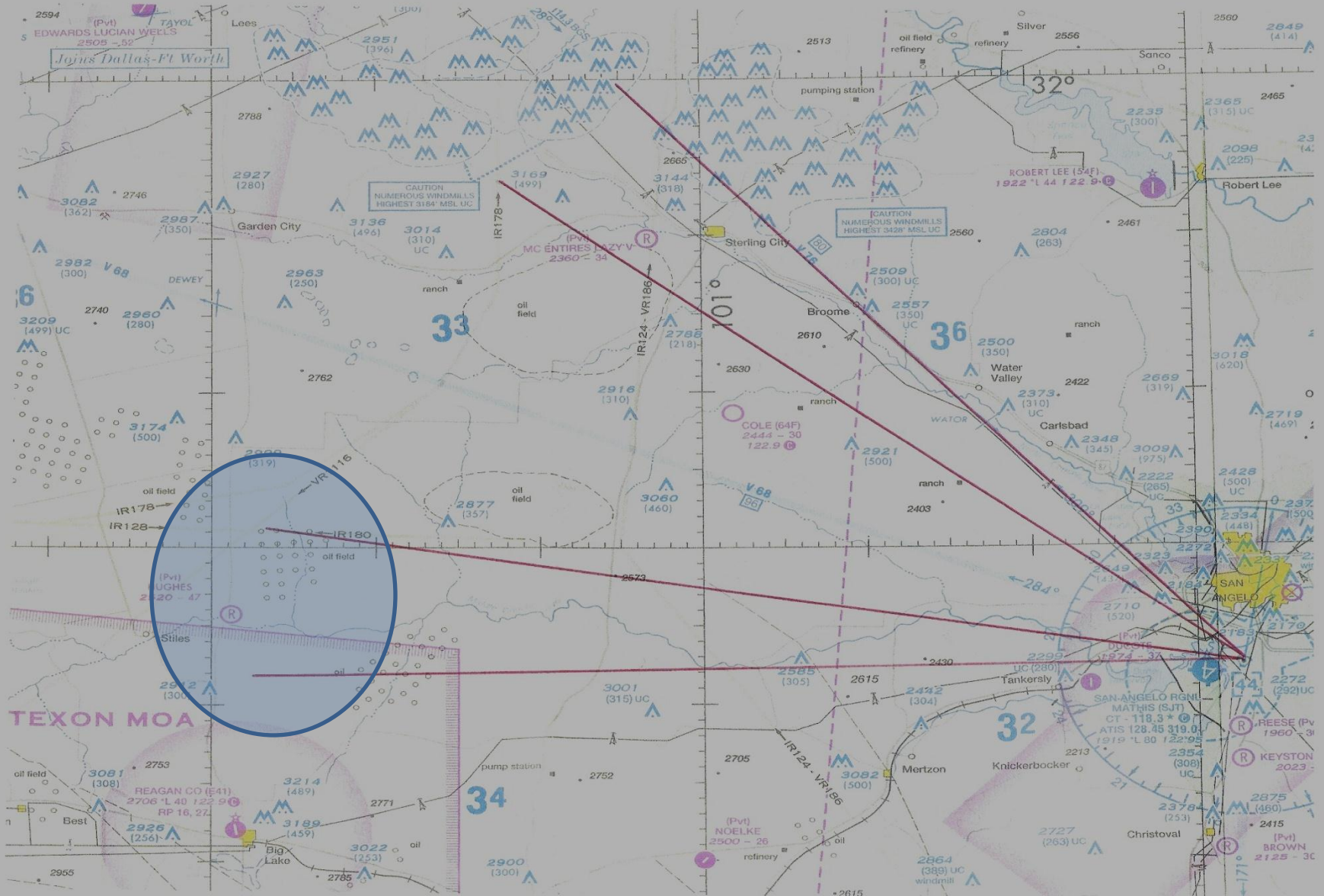
Projected Flight Path

- Will consist of 4 Flight Profiles
- Target area Rivers, Lakes and Reservoirs
- Distances from KSJT allow for rapid recovery
- Repeatable flight paths

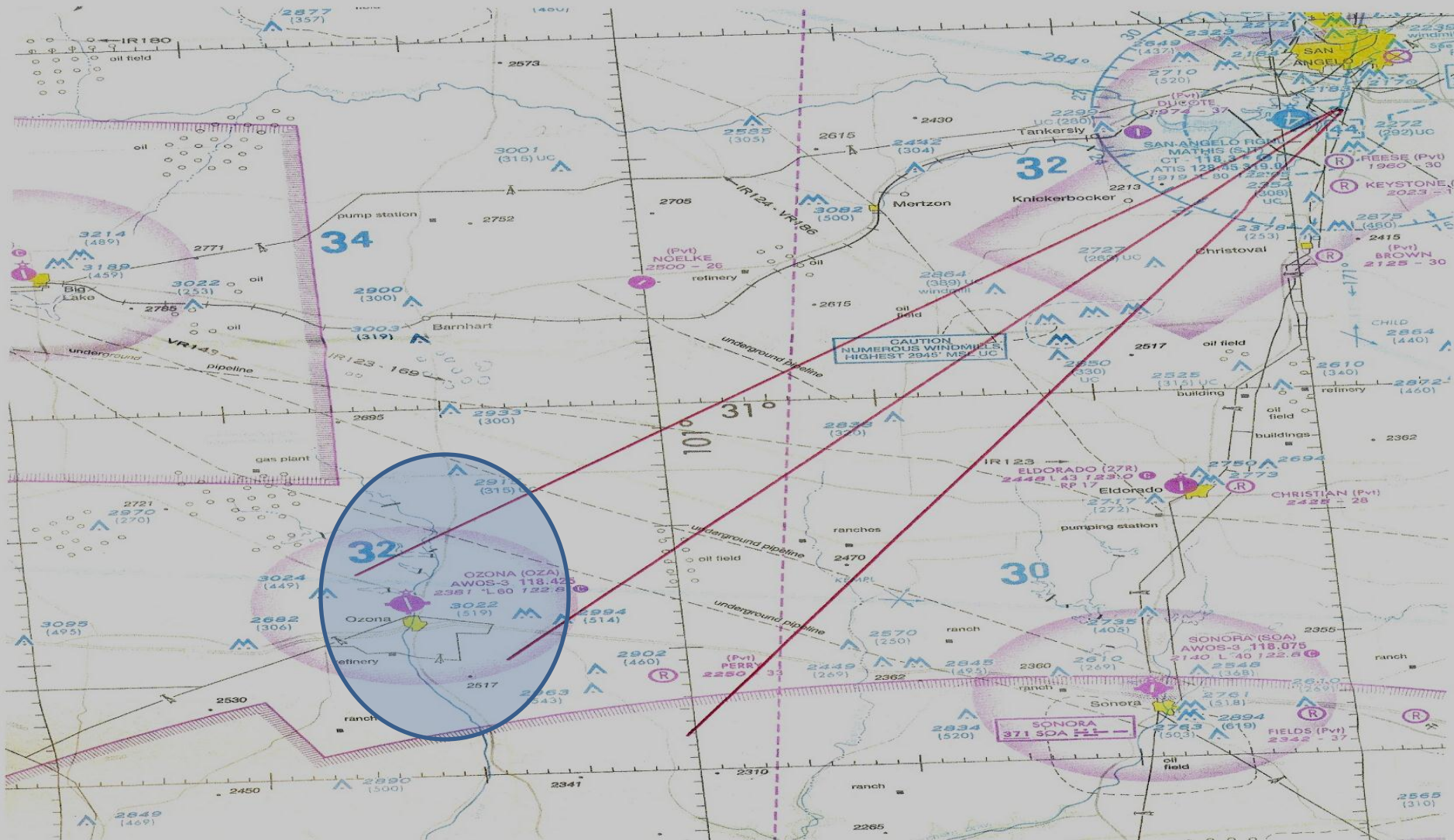
Profile 1



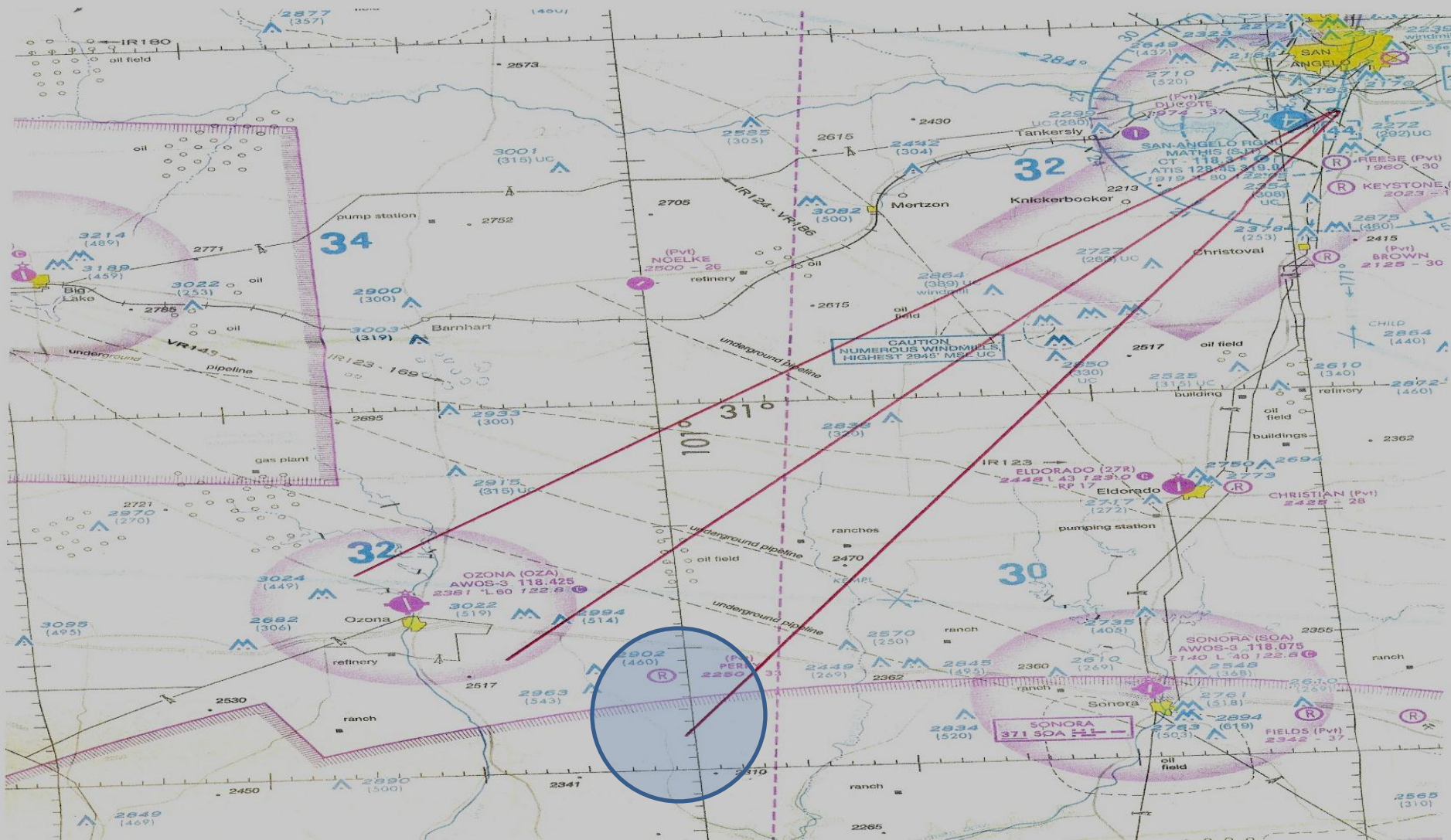
Profile 2



Profile 3

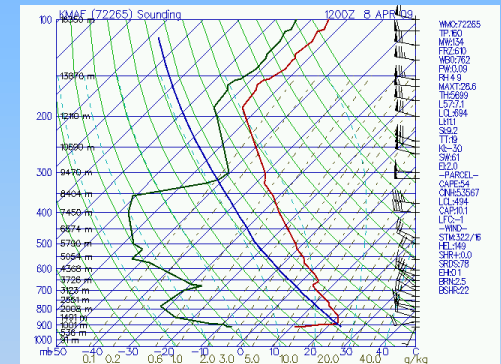


Profile “X”



2011/12 Opportunities

- 22 Target Days occurred during October 2011 through March 2012
 - Target days were found by:
 - METAR data
 - Archived Echo Tops
 - Skew-T Archives



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K0F2 161835Z AUTO 07008KT 10SM CLR 19/05 A3019 RMK AO2
K11R 161835Z AUTO 07006G15KT 10SM OVC100 20/14 A3010
K3R1 NIL
K6R3 161835Z AUTO 24003KT 3SM +TSRA BKN006 BKN050 OVC070 17/16 A3015 RMK
AO2 P0008
K6R6 161753Z AUTO 00000KT 26/M07 A3010 RMK AO2 SLP167 T02561072 10267 20100
58002 PWINO TSNO
KABI 161752Z 08011KT 10SM OVC060 19/04 A3019
KACT 161751Z 03012KT 10SM CLR 20/11 A3014
KADS 161752Z 07012G17KT 13SM SCT150 BKN200 21/04 A3017
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Target Days

Target Days Broken Down by Month

Month	Target Days
October	2
November	2
December	7
January	3
February	6
March	2

Conclusions

- Understand abilities and limitations of Hygroscopic Flares
 - Dual-seeding in stratocumulus clouds
- May need to experiment with meteorological parameters
- If successful, develop an operational plan

Thank You

- Comments, questions or suggestions are welcome!



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