



NATIONAL TRANSPORTATION SAFETY BOARD

**Office of Aviation Safety
Washington, D.C. 20594**

November 3, 2014

Group Chairman's Factual Report

METEOROLOGY

CEN14FA300

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A. ACCIDENT

Location: Lehman, Texas

Date: June 18, 2014

Time: About 1635 central daylight time (2135 UTC¹)

Airplane: Piper PA-46-310P Malibu; registration N2428Q

B. METEOROLOGY GROUP

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C. SUMMARY

On June 18, 2014, about 1635 Central daylight time, a Piper PA 46-310P, N2428Q, crashed in an open field 1/2 mile east of Lehman, Texas. The private pilot and two passengers were fatally injured. The airplane was substantially damaged. The airplane was registered to Flying Lazy T, LLC., and operated by a private individual under the provisions of 14 Code of Federal Regulations Part 91 as a personal flight. Instrument meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan. The cross country flight originated from Aspen-Pitkin County Airport/Sardy Field (KASE), Aspen, Colorado, at 1326, and was en route to Brenham Municipal Airport (11R), Brenham, Texas, at flight level (FL) 270 when the aircraft was lost from radar.

Data from the Federal Aviation Administration indicated that the airplane was at flight level (FL) 270, deviating to the east due to weather, when the airplane climbed to an altitude of FL293 before starting a descent.

The wreckage was located in an open field by the land owner. The wreckage came to rest upright, on an approximate heading of west. The main wreckage included the fuselage, empennage, both wings, and the engine and propeller assembly. The empennage and the outboard portion of the right wing separated partially from the main wreckage but came to rest immediately adjacent to the main wreckage. There were no ground scars nor was there a debris field associated with the accident.

According to witnesses in the area at the time of the accident, there was a severe thunderstorm in the immediate vicinity of the accident. The witnesses described high winds, heavy rain, and low visibility.

¹ UTC – is an abbreviation for Coordinated Universal Time.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene in Lehman, Texas, but conducted a portion of this investigation at the Federal Aviation Administrations (FAA) Albuquerque and Dallas Fort Worth Air Route Traffic Control Center's (ARTCC) and their respective Center Weather Service Units (CWSU). The major portion of the meteorology phase of the investigation was conducted from the Washington D.C. office. Data was collected from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are central daylight time (CDT) based upon the 24 hour clock, local time +5 hours to UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS airport and station identifiers use standard International Civil Aviation Organization (ICAO) 4-letter station identifiers versus International Air Transport Association (IATA) 3-letter identifiers which deletes the initial country code designator "K" for U.S. airports. Both codes are both used intermittently in this report, depending on the source of the data.

The N2428Q's cruising altitude was at 27,000 feet or Flight Level 270 (FL270) and the accident site was located at latitude 33° 37' 32.0" N and longitude 102° 46' 59.8" W.

E. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) and the Weather Prediction Center (WPC) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45G.

1.1 Surface Analysis Chart

The south central section of the NWS Surface Analysis Chart for 1600 CDT (2100Z) on June 18, 2014 centered over Texas is included as figure 1 with the approximate accident site marked by a red star. The chart depicted a low pressure system over Colorado at 1000-hectopascals (hPa) along a stationary front, with a dry line² extending southward from the low across southeast Colorado and into eastern New Mexico. Ahead or east of the dry line the chart depicted a relatively warm moist airmass flowing northward from the Gulf of Mexico into northwestern Texas. The station models over the Texas Panhandle depicted southerly winds, partly cloudy skies, with temperatures in the 90's degrees Fahrenheit (F), and dew point

² Dry line - is a line or boundary separating a warm moist airmass and a warm dry airmass. A density discontinuity exists between a dry line with warm moist air being less dense than the warm drier air. The density discontinuity is an important boundary associated with the development of thunderstorms. Dry air entrainment or air entering into the thunderstorm typically enhances the separation of updrafts and downdrafts, and enhances evaporational cooling within the storm and increases downdraft strength and results in strong outflow winds.

temperatures above 60° F. Over New Mexico behind the dry line temperatures were also in the 90's with dew point temperatures below 40° F. The accident site was located in an area of general confluent wind flow ahead of the dry line.

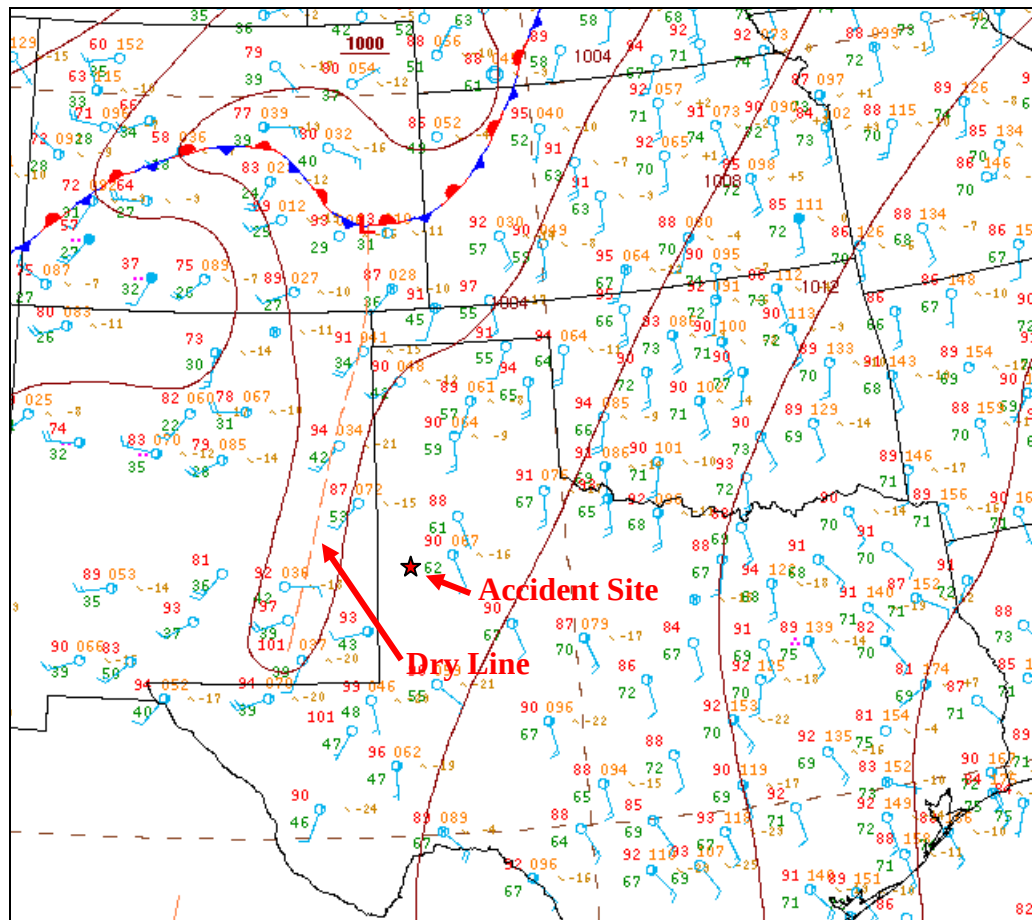


Figure 1 - NWS Surface Analysis Chart for 1600 CDT

1.2 Weather Radar Mosaic's

The National Center for Atmospheric Research (NCAR) - Research Application Laboratory (RAL) regional radar mosaic was reviewed and documented. The regional radar mosaic image for 1635 CDT (2135Z) is included as figure 2 and depicted several bands of intense radar echoes oriented in a general north-northeast to south-southwest bands across western Texas. The accident site was located in the immediate vicinity of one of the intense echoes. Additional scattered echoes continuing to the south-southwestward into southeastern New Mexico and extreme southwestern Texas. The radar also depicted several areas of ground clutter immediately around the individual radar sites, which were associated with false echoes and are so noted on the image.

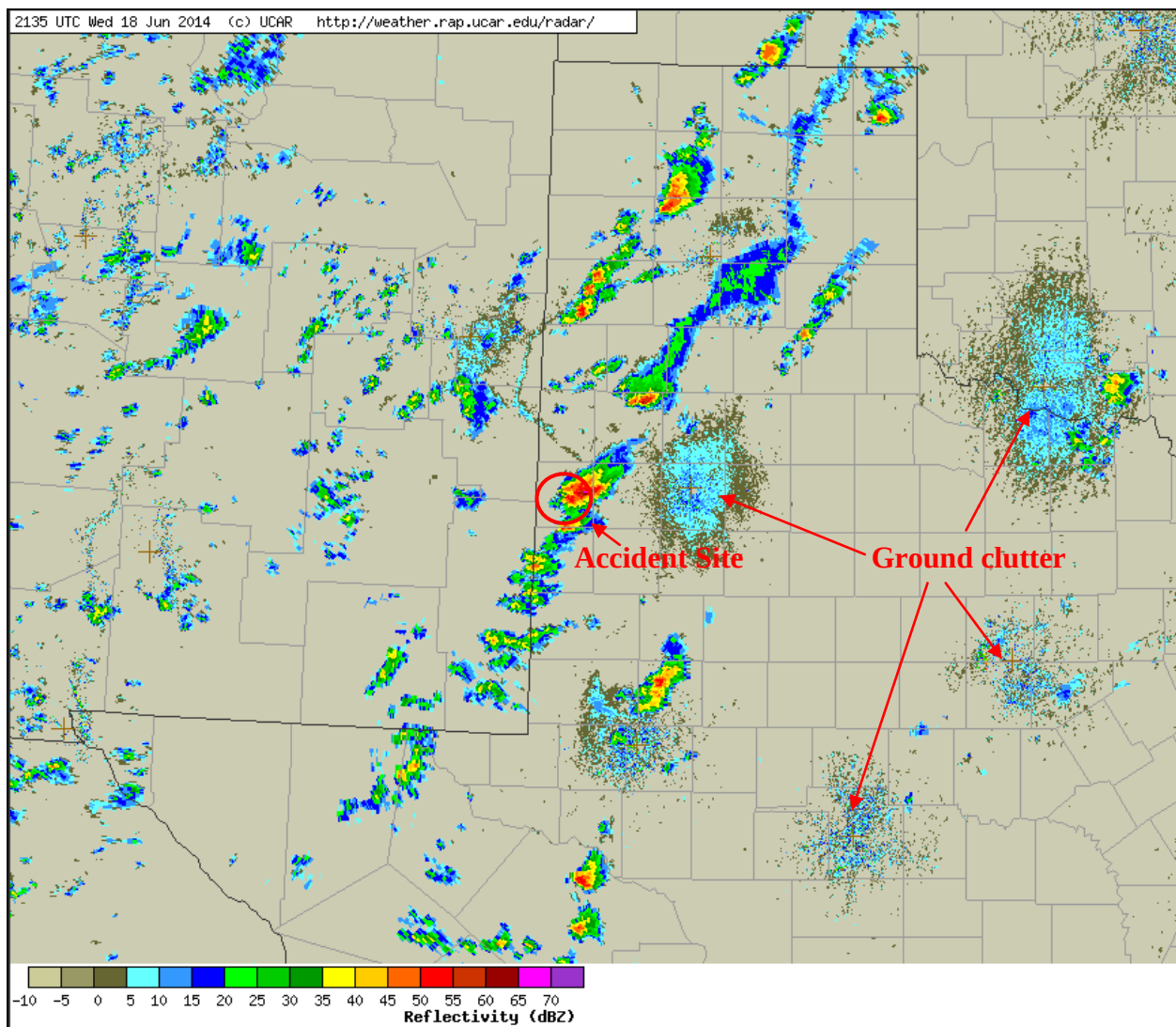


Figure 2 - NCAR regional radar mosaic for 1635 CDT

The NOAA National Climatic Data Center (NCDC) National radar reflectivity mosaic was also reviewed and documented, once the likelihood of weather echoes was identified over the region. The National composite reflectivity image for the same period of 1635 CDT (2135Z) with a higher resolution map of the area is included as figure 3. The image depicts a large organized area of echoes directly over Lehman, Texas, and immediately south, which were associated with an area of strong to severe multicellular to supercell type thunderstorms.

As convective weather was likely encountered by the accident aircraft, the closest NWS weather radar will be further documented in section 5.0 of this report.

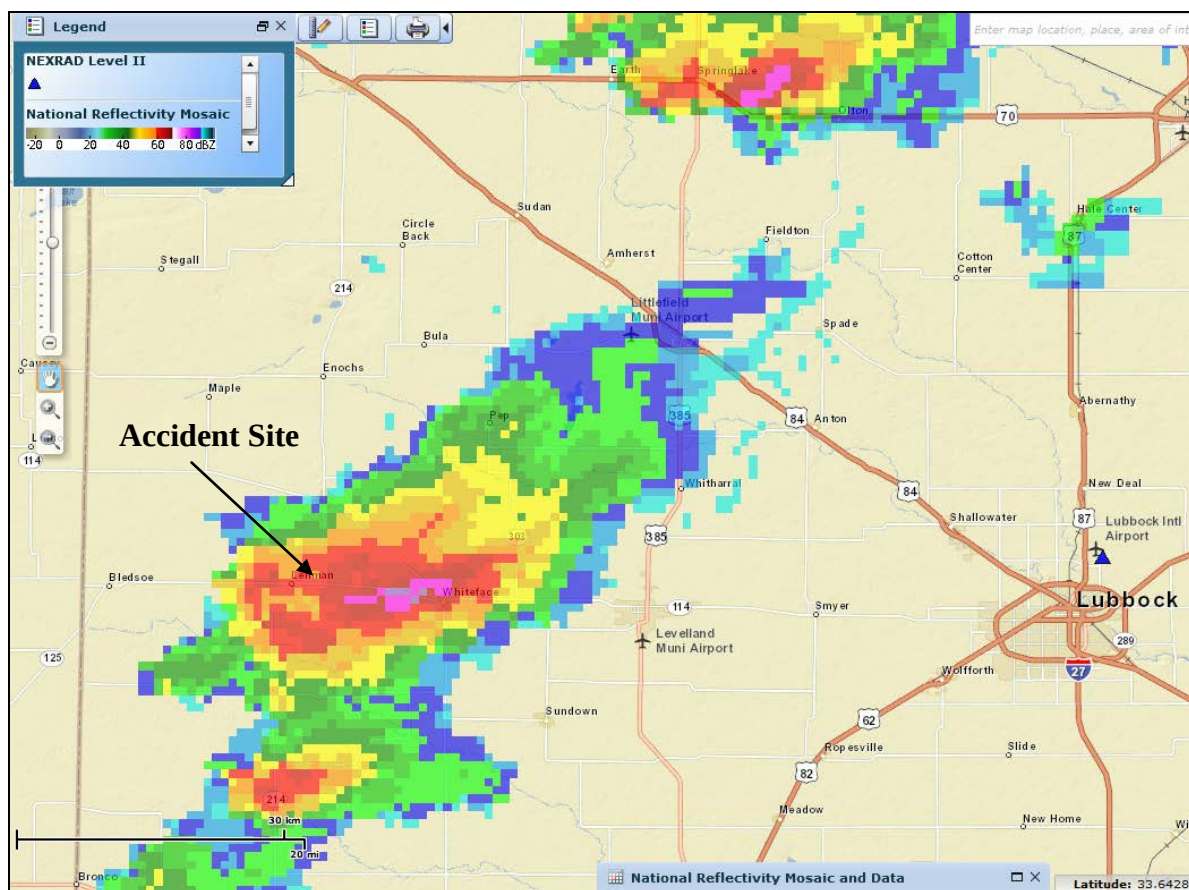


Figure 3 - The NCDC National Reflectivity Mosaic for 1635 CDT

1.3 NWS Convective Outlook Graphic

The NWS Storm Prediction Center (SPC) is responsible for provide timely and accurate forecasts and watches for severe thunderstorms and tornadoes over the contiguous United States. One of their primary products designed for aviation is the Convective Outlook, which identifies locations where general and severe thunderstorm formation is expected in the United States. The outlook is updated several times a day at regular scheduled intervals. The Convective Outlook issued at 1440 CDT (1940Z) and available for preflight briefing is included as figure 4, with the accident site and approximate direct route of flight highlighted. The chart indicated that general thunderstorm activity was expected over the general route of flight with a slight risk³ of severe thunderstorms over northwestern Texas.

A severe thunderstorm is one that has the potential to produce a tornado, large hail of 1" in diameter or larger, and/or organized wind gusts in excess of 50 knots. A severe thunderstorm

³ A Slight (SLGT) risk implies that well-organized severe thunderstorms are expected but in relatively small numbers/coverage, or a small chance of a more significant severe event. Not all severe storm events will be covered with a slight risk, especially during the summer when short-lived, "pulse-type" severe storms are relatively common during the afternoon.

also implies severe to extreme turbulence, severe icing, low-level wind shear, heavy rain, lightning and localized instrument flight rule (IFR) conditions to aviation. Of the approximately 100,000 thunderstorms impacting the United States each year only 10 to 20% are defined as severe storms. Severe thunderstorms produce an average of 1,200 tornadoes a year, and also tend to have a longer life spans, deviate from the mean steering current, and produce more lightning activity than ordinary thunderstorms. Severe storms are further broken down into the number and strength of the updrafts, and are defined as a single cell “pulse” thunderstorms, severe multicellular type storms, lines or squall lines, mesoscale convective systems (MCS), and supercells.

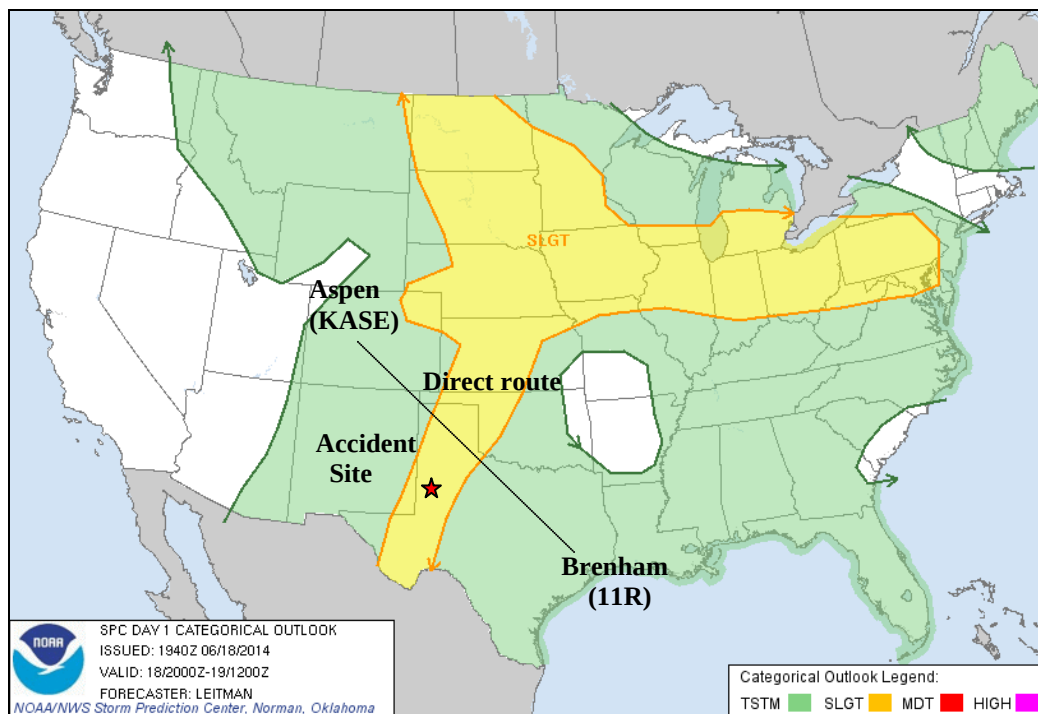


Figure 4 - NWS Convective Outlook issued at 1440 CDT

1.4 NWS Constant Pressure Charts

The NWS 850-, 700-, 500-, 300-, and 200-hPa Constant Pressure Charts for June 18, 2014 at 1900 CDT (0000Z on June 13, 2012) are included as figures 5 through 9 respectively, and document the upper air conditions of pressure, wind, temperature and moisture immediately after the accident. Above 18,000 feet aircraft fly by reference to pressure altitude set to 29.92 inches of mercury, and thus fly constant pressure surfaces. The charts represented the following approximate altitudes:

Chart	Altitude	Comments
850-hPa	~ 5,000 feet	
700-hPa	~10,000 feet	
500-hPa	~18,000 feet – mean atmosphere	
300-hPa	~30,000 feet – isotachs or lines of equal wind speed added	
250-hPa	~34,000 feet – isotachs, jet stream identification	

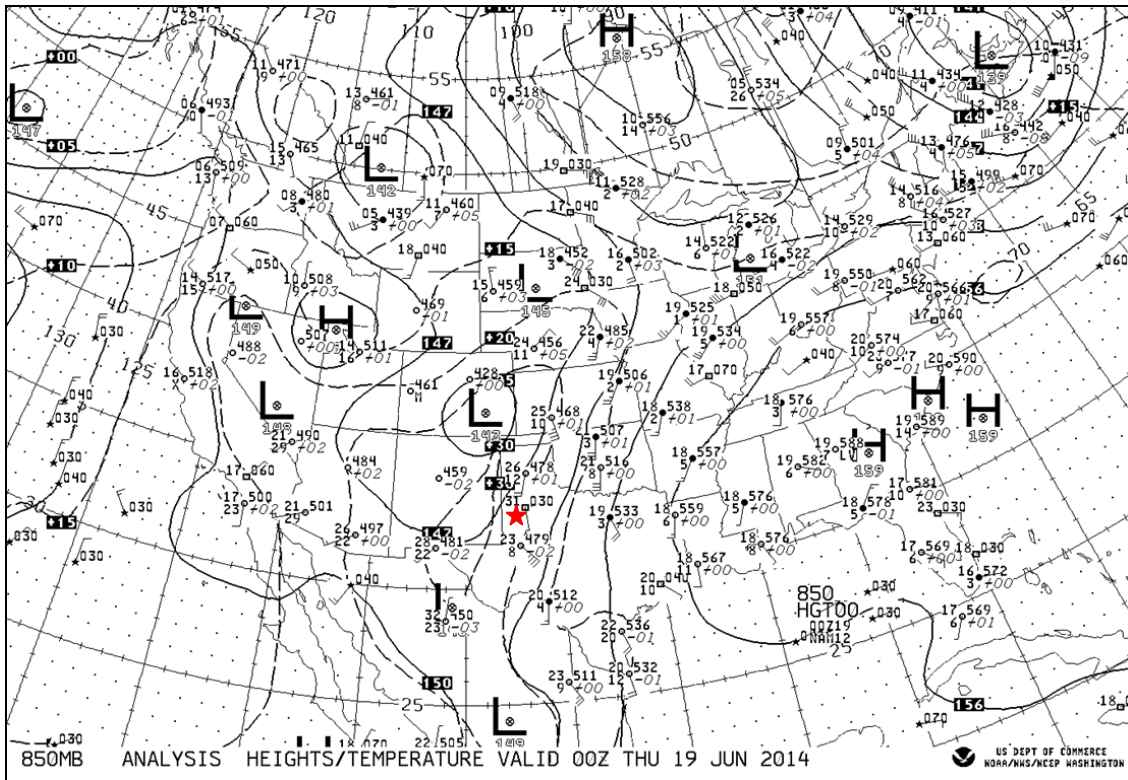


Figure 5 - NWS 850-hPa constant pressure chart for 1900 CDT

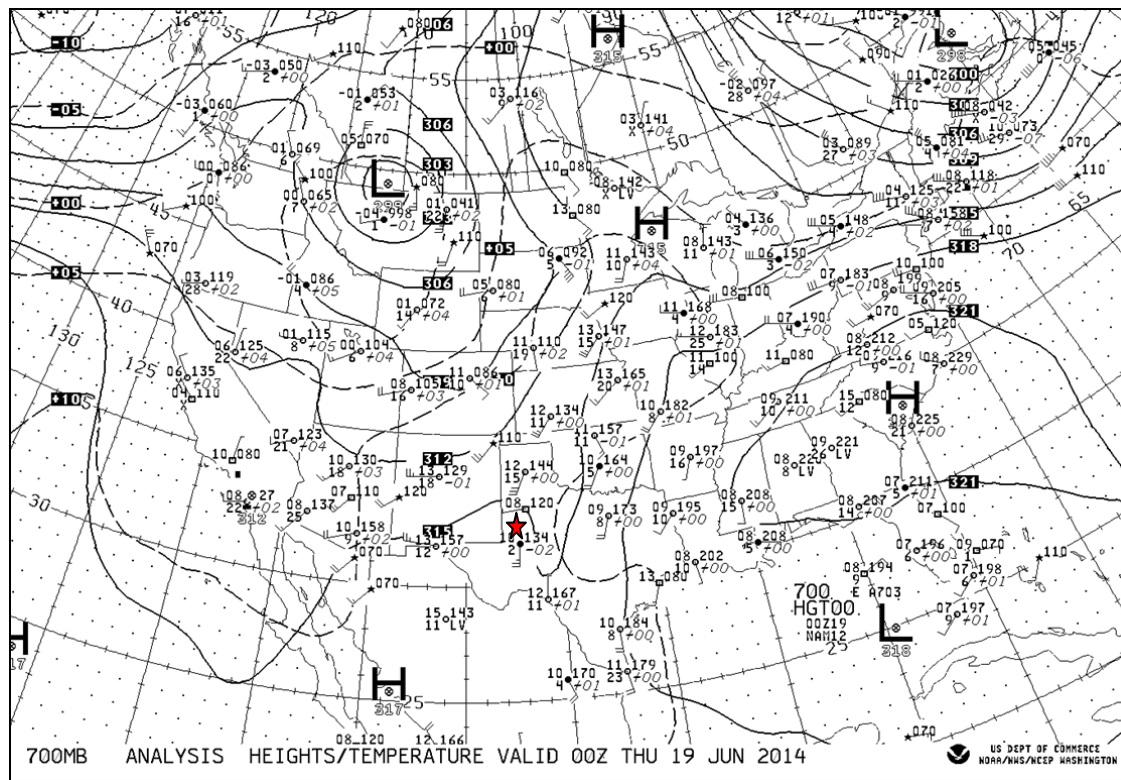


Figure 6 - NWS 700-hPa constant pressure chart

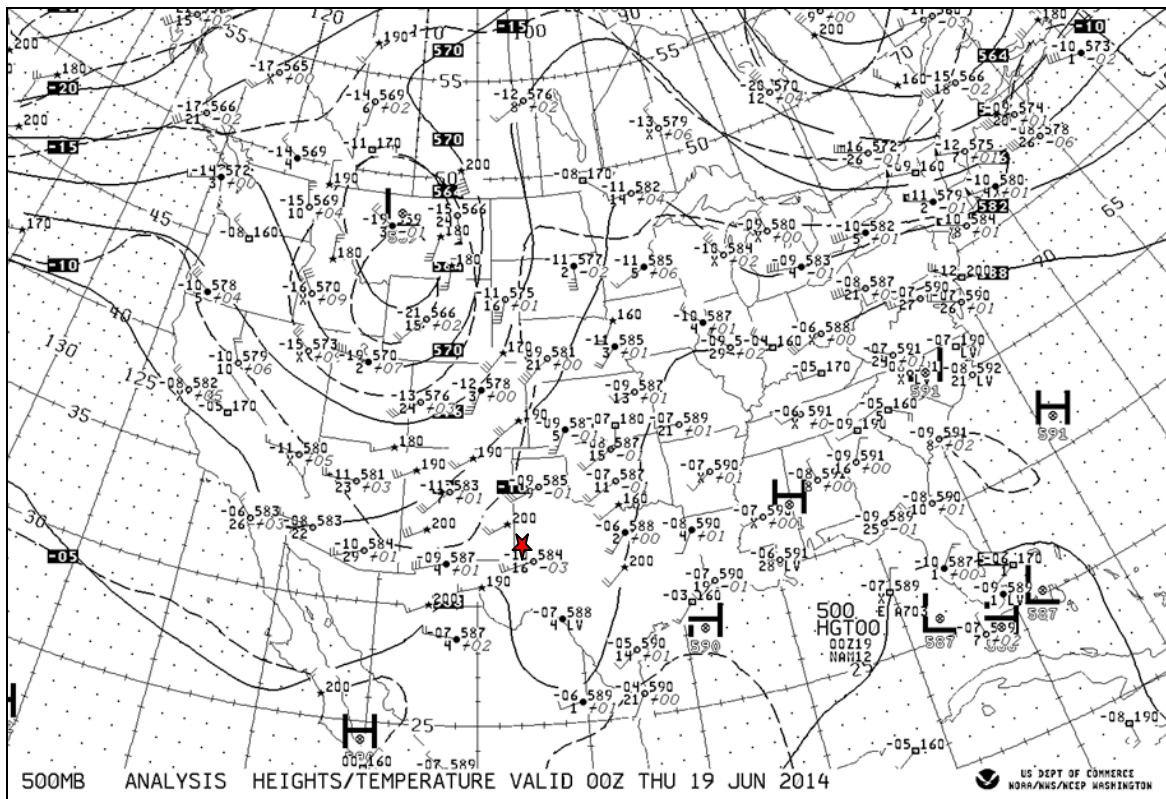


Figure 7 - NWS 500-hPa constant pressure chart

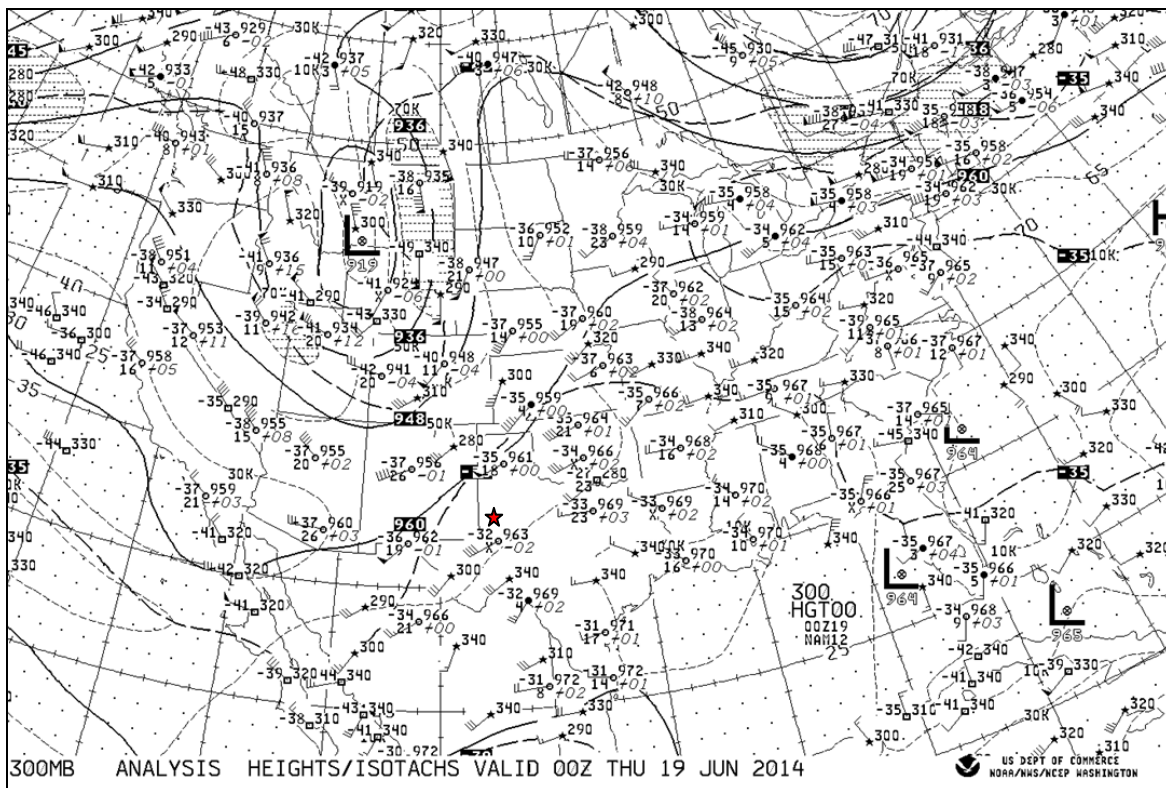


Figure 8 - NWS 300-hPa constant pressure chart

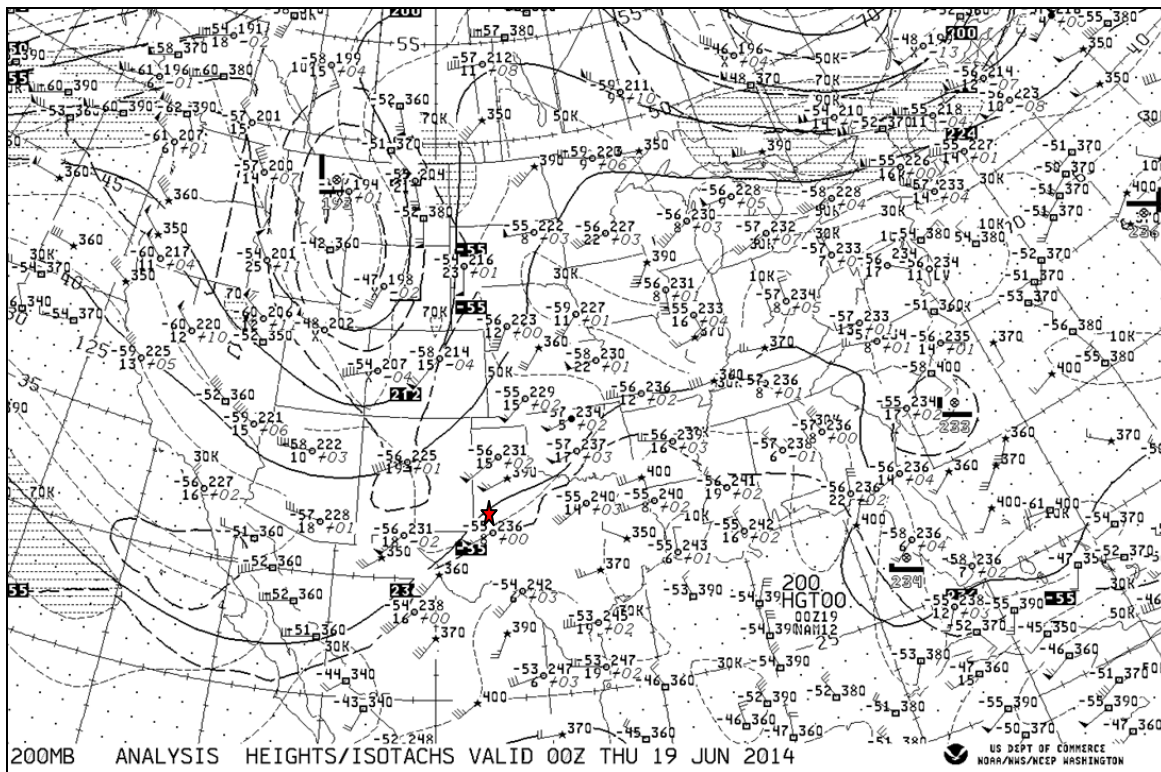


Figure 9 - NWS 250-hPa constant pressure chart

A review of the constant pressure charts indicated that the 850- and 700-hPa charts depicted southerly winds at 20 to 35 knots over the region, with wind veering or shifting to the west-southwest through 500- and 300-hPa with increasing wind speeds with altitude and reached a maximum of 65 knots at 250-hPa or 34,000 feet. A strong vertical wind shear was noted in the change in wind direction and speeds with height over the region. The southerly low level winds allowed warm moist air from the Gulf of Mexico to flow northward over central and western Texas, with drier air indicated immediately west over New Mexico. An upper level low pressure system was located over Colorado, which tilted to the northwest with height with a trough of low pressure extending southward over New Mexico. The low and troughs location supported upper level divergence and general rising air over the region, which supported convection.

1.5 12-hour Significant Weather Prognostic Chart

The NWS 12-hour Significant Weather Prognostic Chart for the period issued at 1036 CDT and valid for 0000 CDT on June 19, 2014 is included as figure 10. The chart depicted low pressure systems over western Kansas and extreme southern New Mexico with a trough or the dry line extending between them over western Texas. The area expected scattered thunderstorms and rain showers over the route of flight.

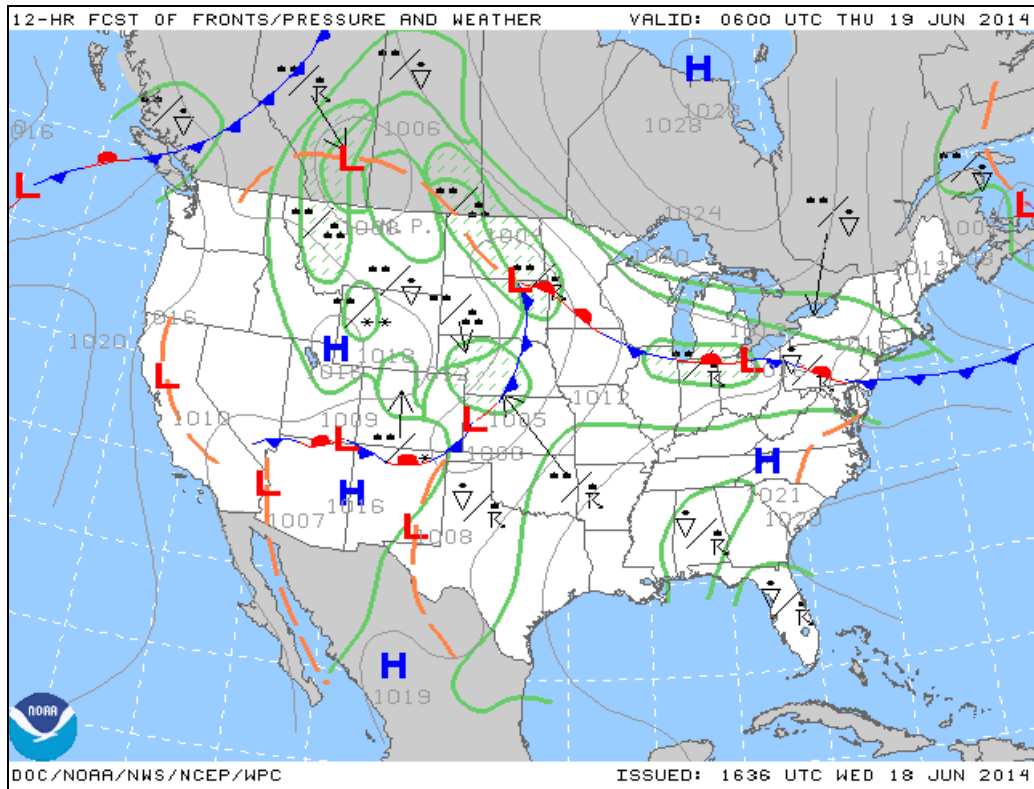


Figure 10 – NWS 12-hour Significant Prognostic Chart

2.0 Surface Observations

The official NWS Aviation Routine Weather Reports (METAR)⁴ and Special Reports (SPECI) in the immediate vicinity of the accident site were also documented. The cloud heights are reported above ground level (agl) in the following section.

2.1 Lubbock Preston Smith International Airport (KLBB), Lubbock, Texas

The closest official NWS reporting location to the accident site was from Lubbock Preston Smith International Airport (KLBB), Lubbock, Texas approximately 50 miles east of the accident site at an elevation of 3,282 feet. The airport listed a magnetic variation of 9°E. The airport had an Automated Surface Observation System (ASOS) and was augmented by certified NWS weather observer during the period. The following conditions were reported near the time of the accident:

Lubbock Preston Smith International Airport (KLBB) weather observation at 1553 CDT, wind from 160° at 8 knots, visibility unrestricted at 10 statute miles, a few clouds at 6,000 feet agl, scattered 18,000 feet, scattered at 30,000 feet, temperature 32° Celsius (C), dew point temperature 17° C, altimeter 29.91 inches of mercury (Hg). Remarks: automated observation system, sea level pressure 1006.7-hPa, cumulonimbus clouds (CB) distant south and southwest

⁴ METAR – is an abbreviation for Meteorological Aerodrome Report and is the International Civil Aeronautics Organization (ICAO) standard term for observations and is interchangeable with the United States Aviation Routine Weather Report.

through northwest, moving northeast slowly, towering cumulus clouds (TCU) distant northeast, altocumulus castellanus (ACC)⁵ distant northwest, temperature 32.2° C, dew point 16.7° C, 3-hour pressure tendency fallen 1.6-hPa.

The raw observations surrounding the period with the general flight categories⁶ were as follows:

VFR METAR KLBB 181953Z 17012G17KT 10SM FEW055 SCT180 SCT270 32/18 A2992 RMK AO2 SLP073 T03170183=

VFR METAR KLBB 182053Z 16008KT 10SM FEW060 FEW140 SCT180 SCT300 32/17 A2991 RMK AO2 SLP067 CB DSNT S AND SW-NW MOV NE SLO TCU DSNT NE ACC DSNT NW T03220167 58016=

Accident 2135Z

VFR METAR KLBB 182153Z 16005G16KT 10SM FEW065 FEW140 FEW180 SCT300 33/15 A2989 RMK AO2 SLP061 CB DSNT S AND SW-NW-N MOV E SLO T03280150=

VFR METAR KLBB 182253Z 16007KT 10SM FEW060 FEW130 SCT180 BKN300 31/14 A2988 RMK AO2 SLP062 OCNL LTGICCG DSNT SW-NW CB DSNT SW-NW MOV E SLO TCU DSNT NE-SE-S T03110144=

VFR SPECI KLBB 182314Z 15008KT 10SM TS FEW065CB BKN130 BKN240 BKN300 31/14 A2988 RMK AO2 TSB14 FRQ LTGICCG SW-NW TS SW-NW MOV E SLO T03110139=

VFR METAR KLBB 182353Z 12011KT 10SM TS SCT075CB SCT090 BKN110 BKN300 32/12 A2986 RMK AO2 RAB37E50 TSB14 PRESFR SLP054 FRQ LTGICCG NE-SE-SW TS NE-SE-SW MOV E SLO CB DSNT NW MOV E VCSH P0000 60000 T03170122 10328 20283 58015=

⁵ Altocumulus Castellanus (ACC) clouds are named for its tower-like projections that billow upwards from the base of the cloud. They are very similar to cumulus congestus or towering cumulus (TCU) clouds, but at a higher or midlevel. Castellanus clouds are evidence of mid-atmospheric instability and a mid-altitude unstable lapse rate. They may be a harbinger of heavy showers and thunderstorms and, if surface-based convection can connect to the mid-tropospheric unstable layer, continued development of castellanus clouds can produce cumulonimbus clouds. Altocumulus Castellanus clouds are typically accompanied by moderate turbulence as well as potential icing conditions. For these reasons, flight through Altocumulus Castellanus clouds is often best avoided by aircraft.

⁶ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling or lowest layer of clouds reported as broken, overcast or the vertical visibility into a surface based obscuration below 500 feet agl and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 feet agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 feet agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 feet agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 feet agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

VFR SPECI KLBB 190021Z 15021G33KT 8SM FEW070 SCT130 BKN250 BKN300 29/16 A2987 RMK AO2 PK WND 14033/0019 TSE20 CB DSNT NE-SE-SW MOV E SLO BLDU N-E T02940161=

VFR METAR KLBB 190053Z 12012KT 10SM FEW060 FEW130 BKN250 BKN300 28/17 A2989 RMK AO2 PK WND 14033/0019 TSE20 SLP066 CB DSNT NE-SE-SW MOV E T02830172=

VFR SPECI KLBB 190126Z 15016KT 9SM -TSRA FEW060CB SCT120 BKN250 BKN300 26/16 A2991 RMK AO2 PK WND 16027/0116 WSHFT 0107 RAB26 TSB26 FRQ LTGICCG E TS E MOV E TCU ALQDS P0000 T02610161=

VFR SPECI KLBB 190151Z 12016KT 8SM FEW060 SCT120 BKN250 BKN300 26/18 A2991 RMK AO2 PK WND 16027/0116 WSHFT 0107 RAB26E34 TSB26E51 OCNL LTGICCG DSNT E CB DSNT E MOV E CB DSNT SW MOV NE P0000=

VFR METAR KLBB 190153Z 12015KT 8SM FEW060 SCT120 BKN250 BKN300 26/18 A2991 RMK AO2 PK WND 16027/0116 WSHFT 0107 RAB26E34 TSB26E51 SLP074 OCNL LTGICCG DSNT E CB DSNT E MOV E CB DSNT SW MOV NE P0000 T02560178=

VFR SPECI KLBB 190223Z 14015KT 9SM -TSRA FEW055CB SCT110 BKN250 BKN300 27/18 A2992 RMK AO2 RAB23 TSB23 FRQ LTGIC SE-S TS SE-S MOV N P0000 T02670183=

VFR SPECI KLBB 190245Z 15018KT 9SM -RA FEW055 FEW110 BKN250 BKN300 26/19 A2991 RMK AO2 PK WND 14026/0242 RAB23 TSB23E45 CONS LTGICCG DSNT SE CB DSNT SE MOV NE CB DSNT SW AND NW MOV NE P0000 T02610189=

The observations indicated that while VFR conditions prevailed at the surface at the airport, high based thunderstorms were reported in the distance or beyond 10 miles and intermittently at the station between 1553 through 0253 CDT on June 19, 2014. A peak wind gust of 33 knots was reported at KLBB associated with a thunderstorm. While the peak wind was below the classification of a severe thunderstorm, it still suggested a strong outflow from the storm. There was also a period of blowing dust reported, also indicative of strong outflow winds and/or potential microburst activity. There was also a high frequency of lightning activity reported during the period with the cumulonimbus clouds, which varied from occasional, to frequent, and after the accident was reported as continuous lightning activity. The following table defines the type and frequency of lightning reports from the AC 00-45G section 3.1.3.13.10 and also in Federal Meteorological Handbook (FMH) number 1.

Lightning Frequency and Type

Frequency	Contraction	Definition
Occasional	OCNL	Less than 1 flash/minute
Frequent	FRQ	About 1 to 6 flashes/minute
Continuous	CONS	More than 6 flashes/minute
Type	Type of Lightning	
Cloud-ground	CG	Lightning occurring between cloud and ground
In-cloud	IC	Lightning which takes place within the cloud
Cloud-cloud	CC	Streaks of lightning reaching from one cloud to another
Cloud-air	CA	Streaks of lightning which pass from a cloud to the air, but do not strike the ground

3.0 Upper Air Data

The closest upper air sounding or rawinsonde observation (RAOB) was from the NWS Amarillo (KAMA) Weather Service Forecast Office (WSFO), site number 72363, located approximately 107 miles northeast of the accident site in Amarillo, Texas, at an elevation of 3,606 feet.

The 1900 CDT (0000Z on June 19, 2014) sounding was plotted on a standard Skew-T log P diagram⁷ utilizing RAOB⁸ software and is included as figure 11 from the surface to 100-hPa or 53,000 feet. The KAMA sounding depicted a warm low-level environment with a surface temperature of 86.7° F (30.4° C), and a dew point temperature of 59.7° F (15.4° C), with a relative humidity of 40%. The significant levels identified were a lifted condensation level (LCL)⁹ at 714-hPa or at 6,205 feet agl, a level of free convection (LFC)¹⁰ at 682-hPa or 7,466 feet agl, and a convective condensation level (CCL)¹¹ at 663-hPa or 8,221 feet agl. The equilibrium level (EL)¹² or expected top of convective clouds was at 44,880 feet with the tropopause at 46,300 feet. The freezing level was identified at 15,414 feet and supported icing in clouds above that level.

⁷ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

⁸ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

⁹ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁰ Level of Free Convection (LFC) -The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

¹¹ Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

¹² Equilibrium Level (EL) - On a sounding, the level above the level of free convection (LFC) at which the temperature of a rising air parcel again equals the temperature of the environment. The height of the EL is the height at which thunderstorm updrafts no longer accelerate upward. Thus, to a close approximation, it represents the height of expected (or ongoing) thunderstorm tops. However, strong updrafts will continue to rise past the EL before stopping, resulting in storm tops that are higher than the EL. This process sometimes can be seen visually as an overshooting tops or anvil dome. The EL typically is higher than the tropopause, and is a more accurate reference for storm tops.

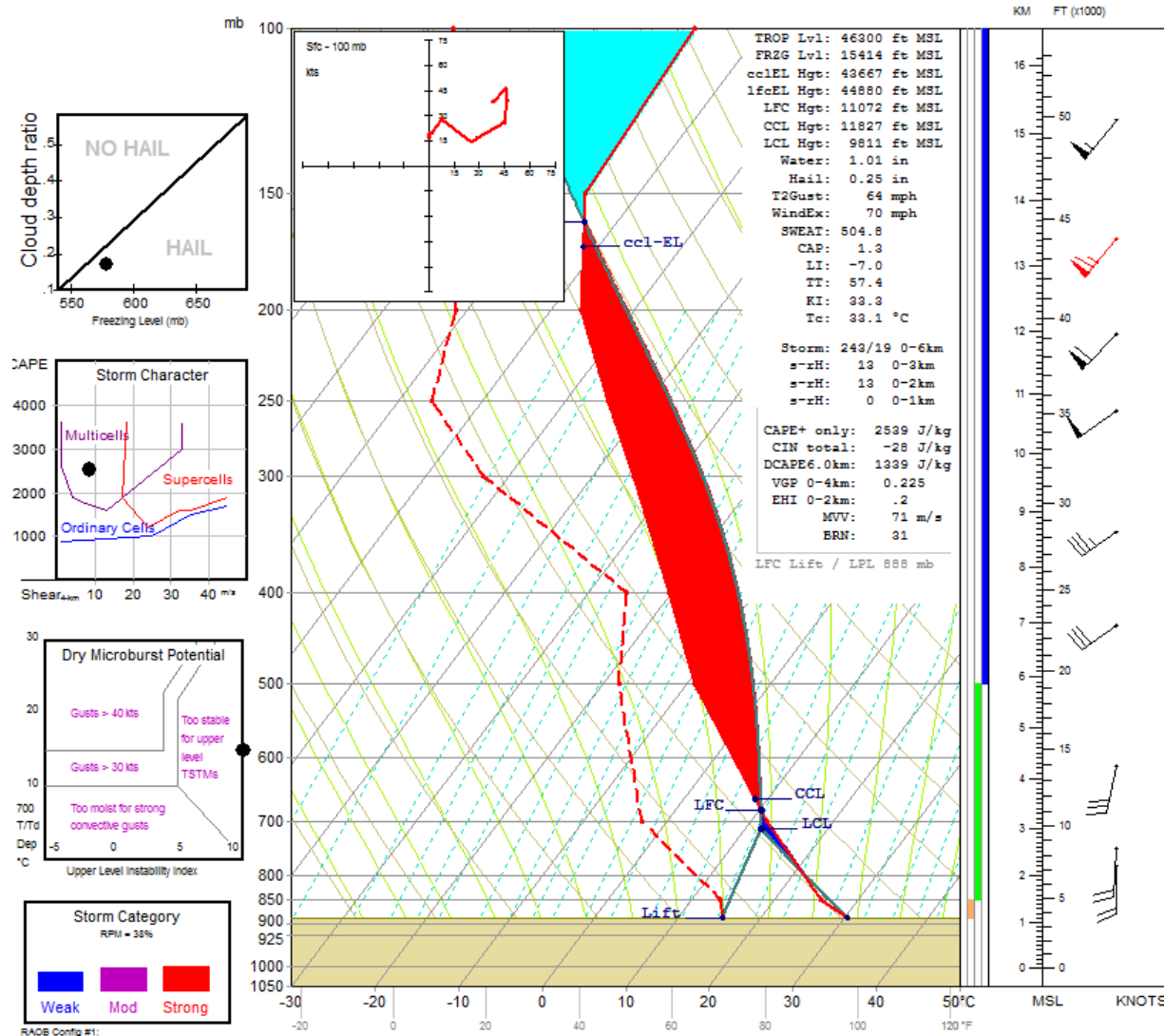


Figure 11 - KAMA sounding at 1900 CDT

The stability parameters indicated a Lifted Index (LI)¹³ of -7.0, a K-Index¹⁴ of 33.3, and a Convective Available Potential Energy (CAPE)¹⁵ of 2,539 Joules/kilogram (J/kg). The Severe

¹³ Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

¹⁴ K-Index - The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The higher the K-Index, the greater the probability of air mass type thunderstorms development.

¹⁵ Convective Available Potential Energy (CAPE) - is a measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.

Weather Threat Index (SWEAT) was 504.8, which indicated a moderate risk of severe thunderstorm development. The maximum vertical velocity of the potential updrafts was calculated at 71 meters per second (m/s) or 142 knots. The sounding also supported hail of 1/4 inch and a precipitable water value of 1.01 inches. The microburst index or WINDEX indicated potential outflow of 61 knots and indicated a high probability of microbursts and/or downbursts with the potential thunderstorms developing across the region. The Bulk Richardson Number (BRN)¹⁶ was 31 and the BRN Shear value was 81.3 (m²/s²). The stability indices indicated a moderate to strong risk of severe multicellular type thunderstorm development across the region. A full listing of the KAMA severe weather stability indices reviewed is included in appendix 1.

The wind profile was depicted on the right side of the sounding chart and indicated southerly winds from the surface through 19,000 feet with wind veering to the southwest with height with increasing wind speeds. A low level jet stream was identified at 4,850 feet agl with wind from 185° at 20 knots, with the level of maximum wind at 225° at 65 knots located below the tropopause at 43,990 feet. The mean 0 to 6 kilometer or 18,000 feet wind was from 213° at 25 knots. The mean storm motion was estimated from 243° at 19 knots. At the accident airplane's cruising level of 27,000 feet the wind was identified from 240° at 32 knots, with a temperature of -25° C. The sounding supported potential clear to mixed icing at 27,000 feet, especially with the convective updrafts which would have likely increased the icing potential at altitude.

The figure 12 is the observed parameters of height, pressure, temperature, dew point, relative humidity, and wind from the KAMA sounding:

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD/FF (deg/kts)
3606	888	30.4	15.4	40	
4881	850	25.6	13.6	47	
7211	783				180/18
8455	749				185/20
10355	700	12.0	-3.0	35	
13921	612				195/29
19251	500	-9.1	-18.1	48	
22799	433				240/29
24798	400	-20.3	-25.3	64	
28310	345				240/33
31586	300	-35.1	-53.1	14	
35135	256				240/52
35671	250	-44.9	-65.9	8	
39203	212				230/61
40443	200	-56.3	-71.3	14	
43993	168				225/65
46300	150	-66.3	-82.3	9	
49833	125				225/54
54324	100	-68.1	-97.1	1	
57904	83				195/29

Figure 12 - KAMA sounding parameters

¹⁶ Bulk Richardson Number (BRN) - is the ratio of the buoyancy (CAPE) of a lifted parcel to the vertical wind shear of the environment in which the parcel is lifted. It correlates well with observed storm type (single, multicellular, and supercells), especially for CAPEs between 1500 and 3000 J/kg. BRN's less than 45 tend to support supercell structures, with multicellular convection favored over 45. While the BRN has shown some value as a predictor of storm type, it is a poor predictor of storm rotation.

4.0 Satellite Data

The Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison (UW) in Madison, Wisconsin, and processed using the Safety Board's Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible band imagery were obtained surrounding the time of the accident and documented. The infrared long wave imagery (band 4) at a wavelength of 10.7 microns (μm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km. The visible imagery (band 1) at a wavelength of 0.65 μm provided a higher resolution of 1 km.

Figure 13 is the GOES-13 infrared image for 1630 CDT at 4X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops associated with deep convection and high cirriform clouds. Also add to the image was the frontal and dry line boundaries identified at 1600 CDT by the NWS. The last radar contact is identified by a white square and was identified on the southwestern side of a band of cumulonimbus clouds with a radiative cloud top temperature of 228° Kelvin (K) or -45.16° C over the position, which corresponded to tops near 36,000 feet based on the KAMA sounding. Higher cloud tops were identified 6 miles north with a radiative temperature of 216° K or -57° C, which corresponded to tops near 41,000 feet. The anvil tops of the cumulonimbus cloud extended northeastward and merged into another large cumulonimbus cloud system, which extended across most of the northern portion of the panhandle of Texas.

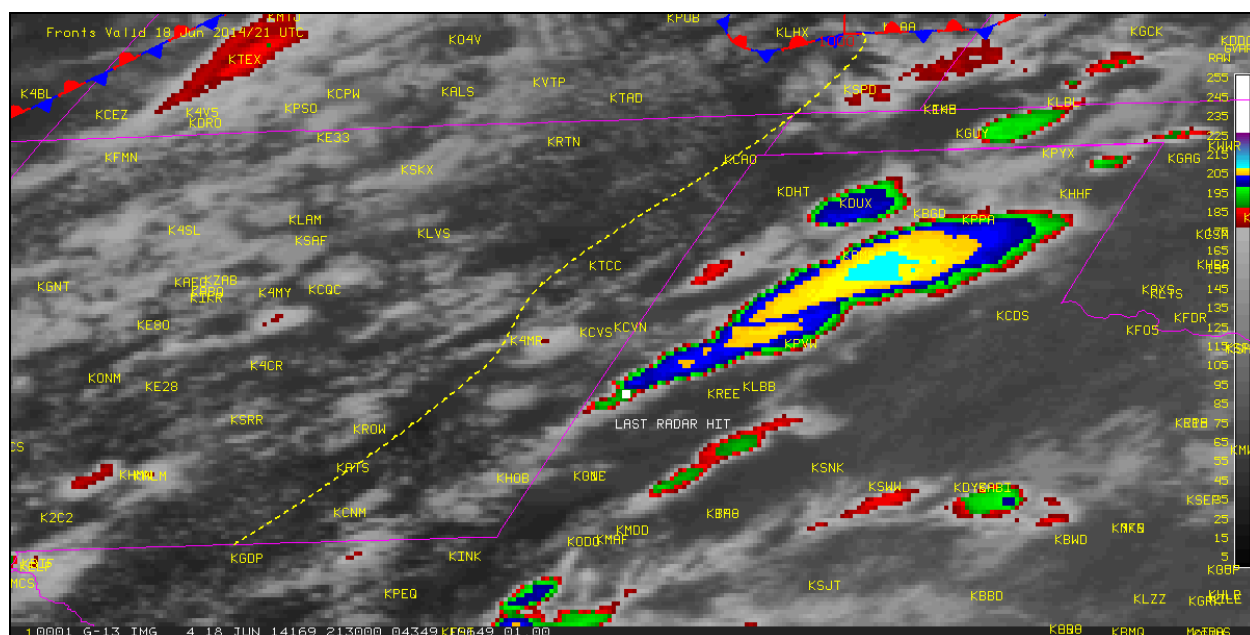
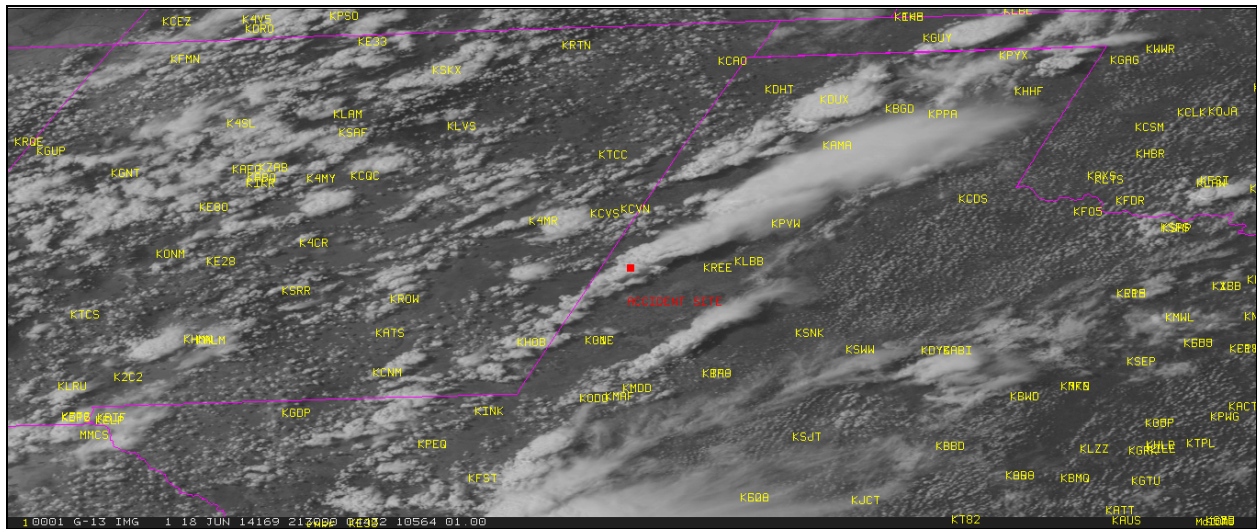


Figure 13 - GOES-13 infrared image at 1630 CDT with MB temperature enhancement curved

Figure 14 is the GOES-13 visible image at 1630 CDT at 2X magnification, which approximates the above area size of the infrared image above. The image depicts several cumulonimbus clouds over western Texas oriented in a north-northeast to south-southwest bands. The accident site is identified on the southwestern side and within a cumulonimbus cloud.



Immediately surrounding the period the GOES-13 satellite was in a severe weather or rapid scan mode, which allowed for more frequent images available during the period. Figures 15 through 22 are the GOES-13 visible images at 4X magnification at times 1545, 1615, 1625, 1630, 1637, 1645, 1655, and 1700 CDT respectively. A red dot is the accident site location for reference and the 1637 CDT image has the flight track of N2428Q from 1617 to 1634 CDT overlaid. The images depict the rapid development and growth of the cumulonimbus cloud during the period, and movement to the east-northeastward as estimated by the KAMA sounding storm motion. The vertical extensive cumulonimbus cloud heights are also evident by the shadows under and immediately east of the clouds, and also depicted several overshooting cloud tops with the anvils.

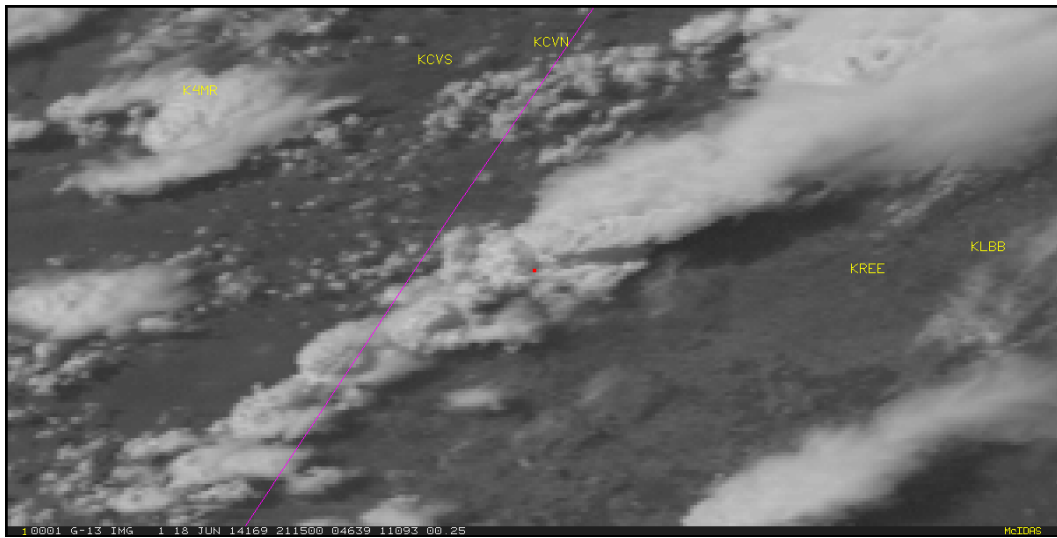


Figure 16 - GOES-13 visible image at 1615 CDT

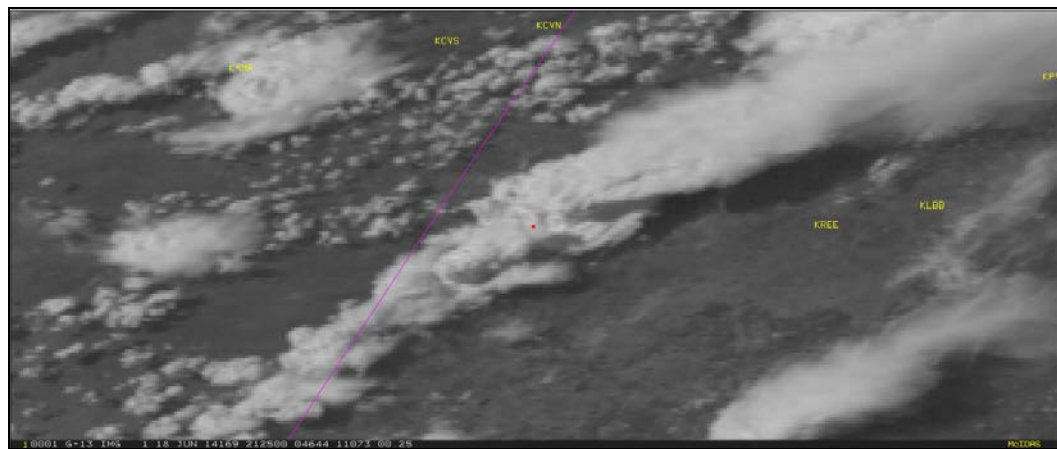


Figure 17 - GOES-13 visible image at 1625 CDT

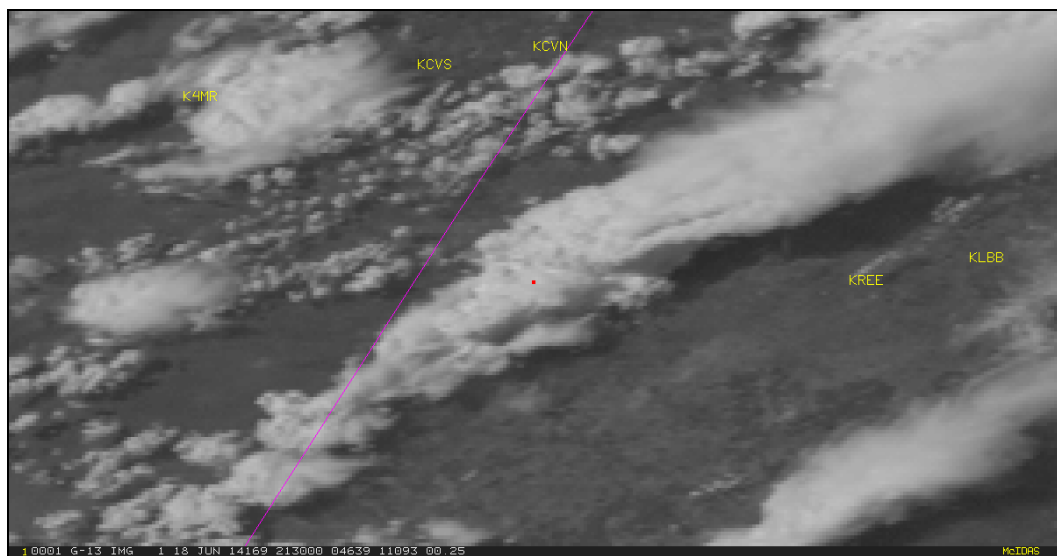


Figure 18 - GOES-13 visible image at 1630 CDT

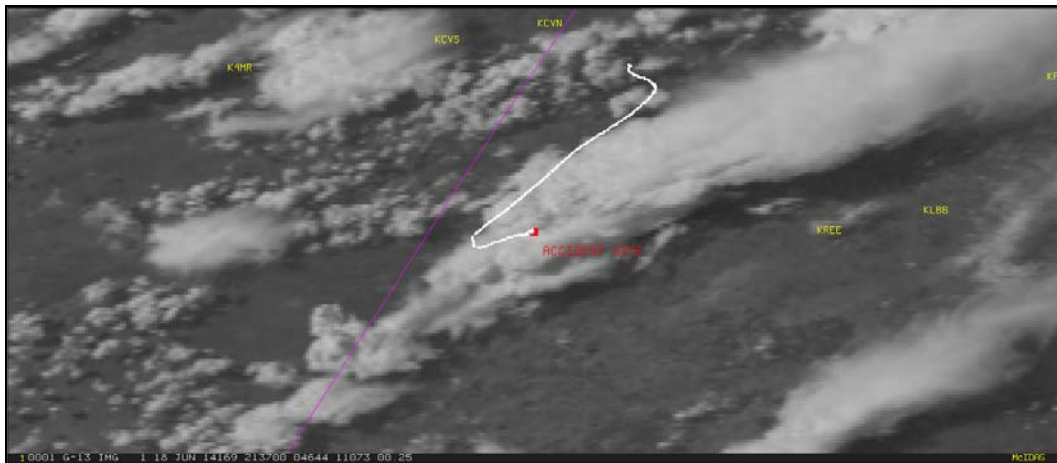


Figure 19 - GOES-13 visible image at 1637 CDT with flight track overlaid

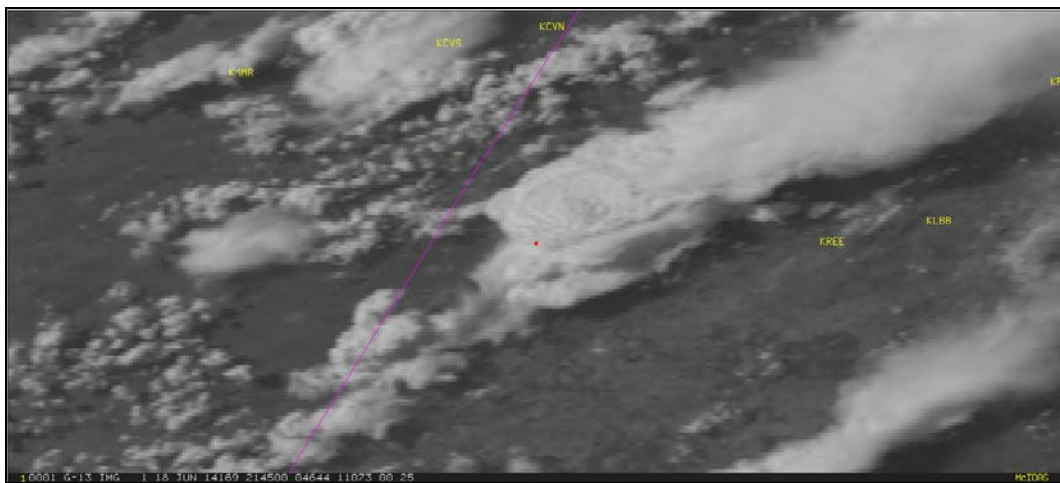


Figure 20 - GOES-13 visible image at 1645 CDT

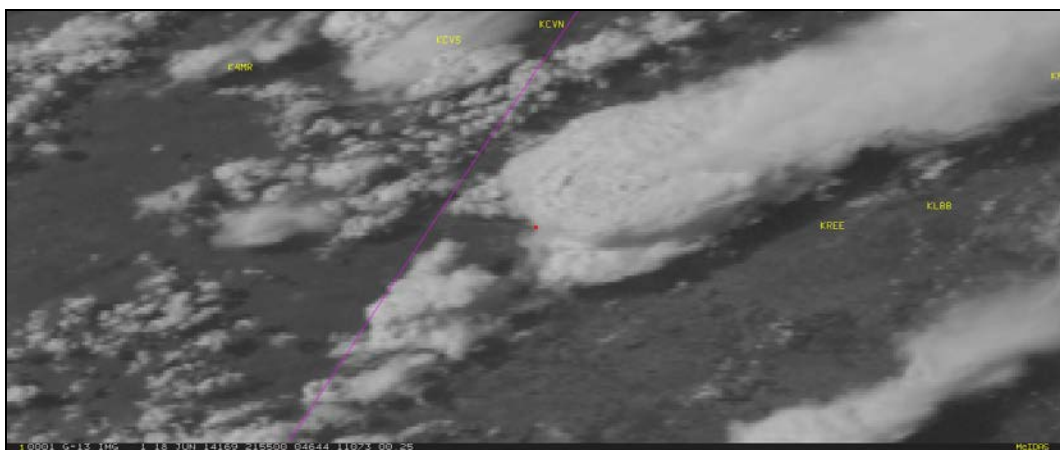


Figure 21 - GOES-13 visible image at 1655 CDT

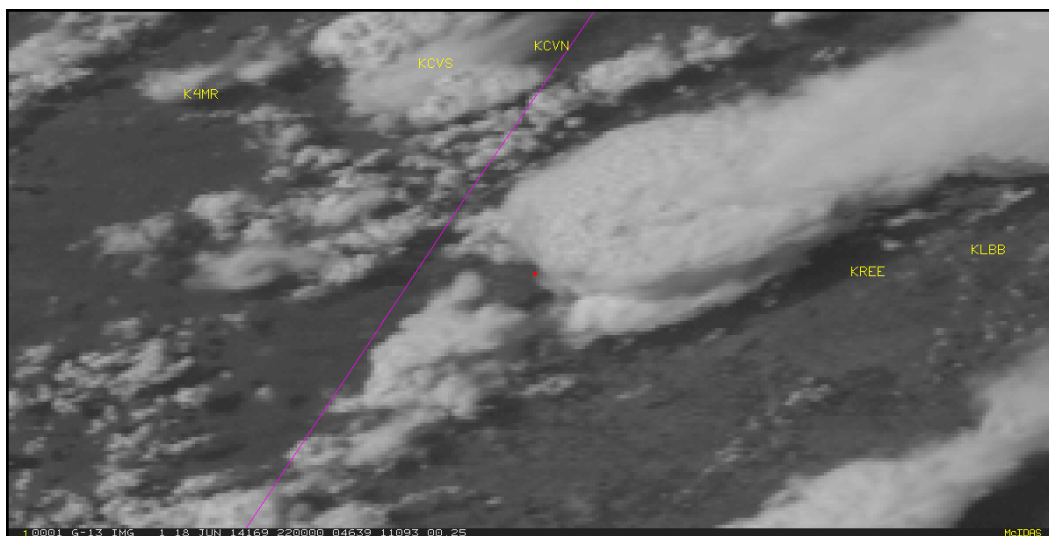


Figure 22 - GOES-13 visible image at 1700 CDT

5.0 Weather Radar Information

The closest Weather Surveillance Radar-1988, Doppler (WSR-88D) to the accident site was from the NWS Lubbock (KLBB) located approximately 49 miles east of the accident site. The level II and III archive data was obtained from the National Climatic Data Center (NCDC) utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

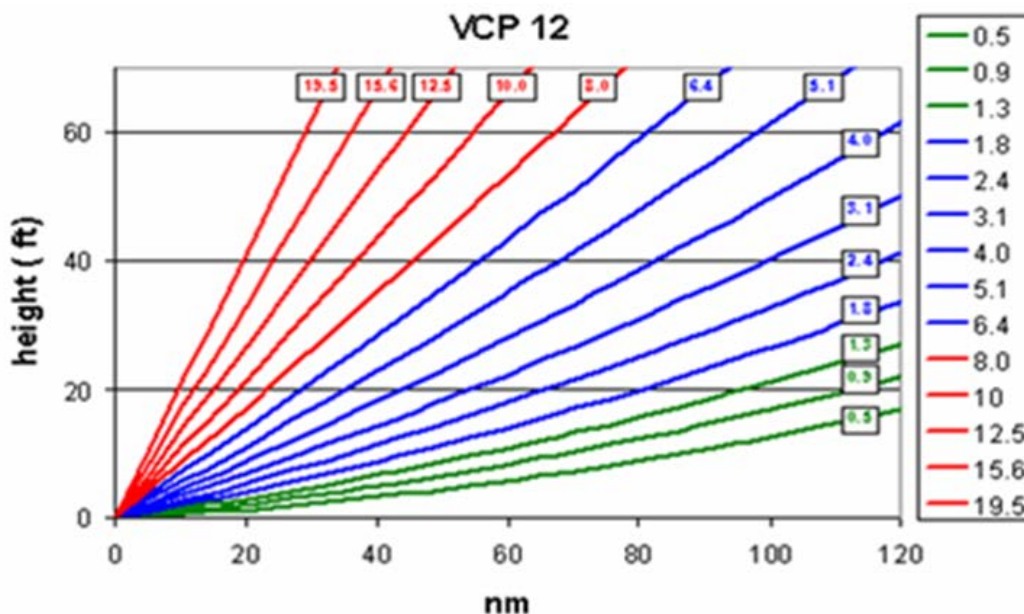
The WSR-88D is a S-band 10 centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

5.1 Volume Scan Strategy

The WSR-88D is a computer controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is the non-severe convective mode where the radar makes 9 elevation scans from 0.50° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident the KLBB WSR-88D radar was operating in the precipitation mode VCP-12 where the radar makes 14 different elevation scans in 4 ½ minutes. This mode is typically used by the NWS during periods when rapidly evolving wide spread severe convection is expected, and allows for improved low-level

vertical resolution of the storms. The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.



5.2 Beam Height Calculation

Assuming standard refraction¹⁷ of the 0.95° radar beam of the KLBB WSR-88D with an antenna height of 3,378 feet and a distance of 49 miles and an azimuth of 268° from the radar, the following table shows the approximate beam height and width information of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	7,660 feet	5,220 feet	10,110 feet	4,890 feet
0.88°	9,460 feet	7,020 feet	11,910 feet	4,890 feet
1.33°	11,780 feet	9,330 feet	14,220 feet	4,890 feet
1.81°	14,240 feet	11,800 feet	16,690 feet	4,890 feet
2.41°	17,330 feet	14,880 feet	19,770 feet	4,890 feet
3.13°	21,020 feet	18,580 feet	23,470 feet	4,890 feet
4.01°	25,540 feet	23,090 feet	27,980 feet	4,890 feet
5.10°	25,540 feet	28,220 feet	33,100 feet	4,890 feet

Based on the radar height calculations, the 4.01° elevation scan depicted the conditions between 23,090 and 27,980 feet over the accident site.

¹⁷ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁸ it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ¹⁹), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0	< 5	
	1	5 to 9	
	2	10 to 14	
1 Very Light	3	15 to 19	.01 in/hr
	4	20 to 24	.02 in/hr
	5	25 to 29	.04 in/hr
2 Light to Moderate	6	30 to 34	.09 in/hr
	7	35 to 39	.21 in/hr
3 Strong	8	40 to 44	.48 in/hr
4 Very Strong	9	45 to 49	1.10 in/hr
5 Intense	10	50 to 54	2.49 in/hr
6 Extreme	11	55 to 59	>5.67 in/hr
	12	60 to 64	
	13	65 to 69	
	14	70 to 74	
	15	> 75	

Air traffic control (ATC) weather display systems also use radar weather processors with the ability to determine precipitation intensity, with controllers instructed to describe the intensity to pilots based on the following scale:

¹⁸ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth's surface; also, any water particles blown by the wind from the earth's surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth's surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glaze ice.

¹⁹ dBZ - $10 \log Z_e$

- | | |
|----------------|---|
| (a) "Light" | (< 30 dBZ, NWS VIP level 1 – not displayed on WARP) |
| (b) "Moderate" | (30 to 40 dBZ, NWS VIP level 2) |
| (c) "Heavy" | (> 40 to 50 dBZ, NWS VIP level 3 and 4) |
| (d) "Extreme" | (> 50 dBZ, NWS VIP level 5 and 6) |

5.4 Base Reflectivity

Figures 23 through 33 are images of the NWS Lubbock (KLBB) WSR-88D base reflectivity images at various elevation scans from 2.4° and 4.0° to best capture the weather conditions at N2428Q's cruising altitude of 27,000 feet as it progressed across the area. The flight track has been overlaid and matches the approximate time of the radar image to the nearest minute. Details of the specific image scans and reflectivity values identified, echo tops, and characteristics of the echoes follows after the images. The raw flight track data has also been added as appendix 2 at the end of this report.

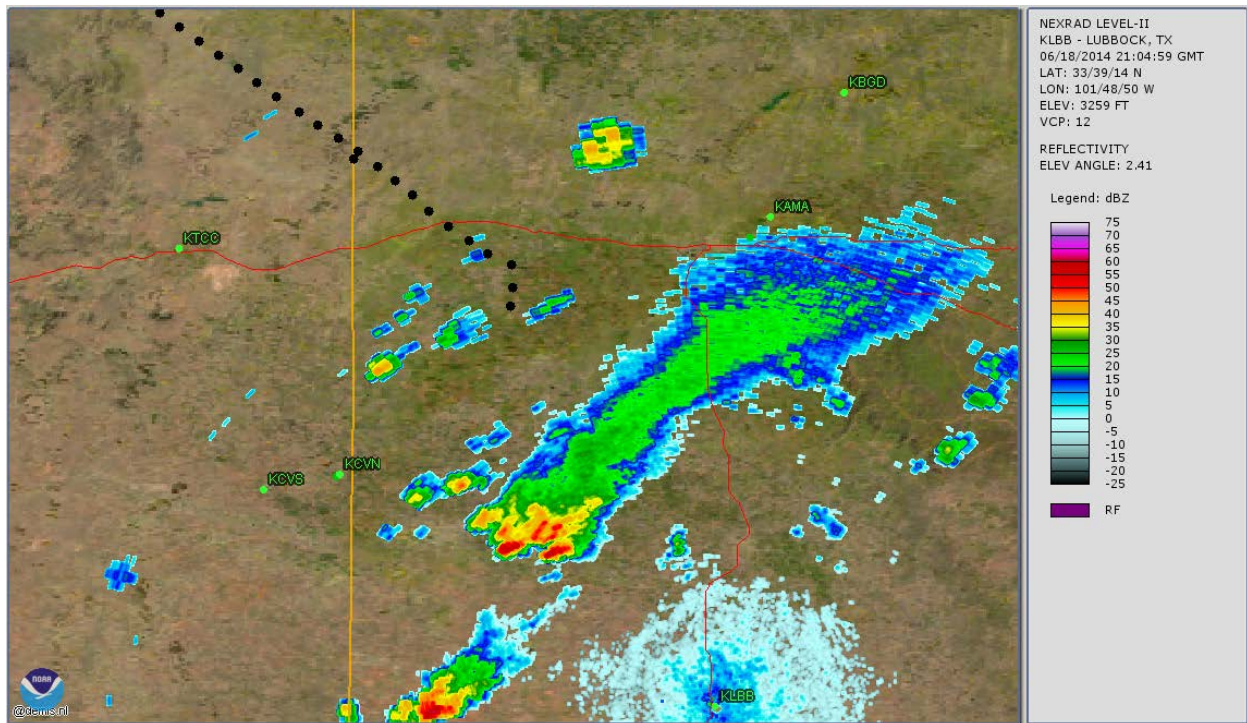


Figure 23 - KLBB WSR-88D 2.4° base reflectivity image at 1604 CDT

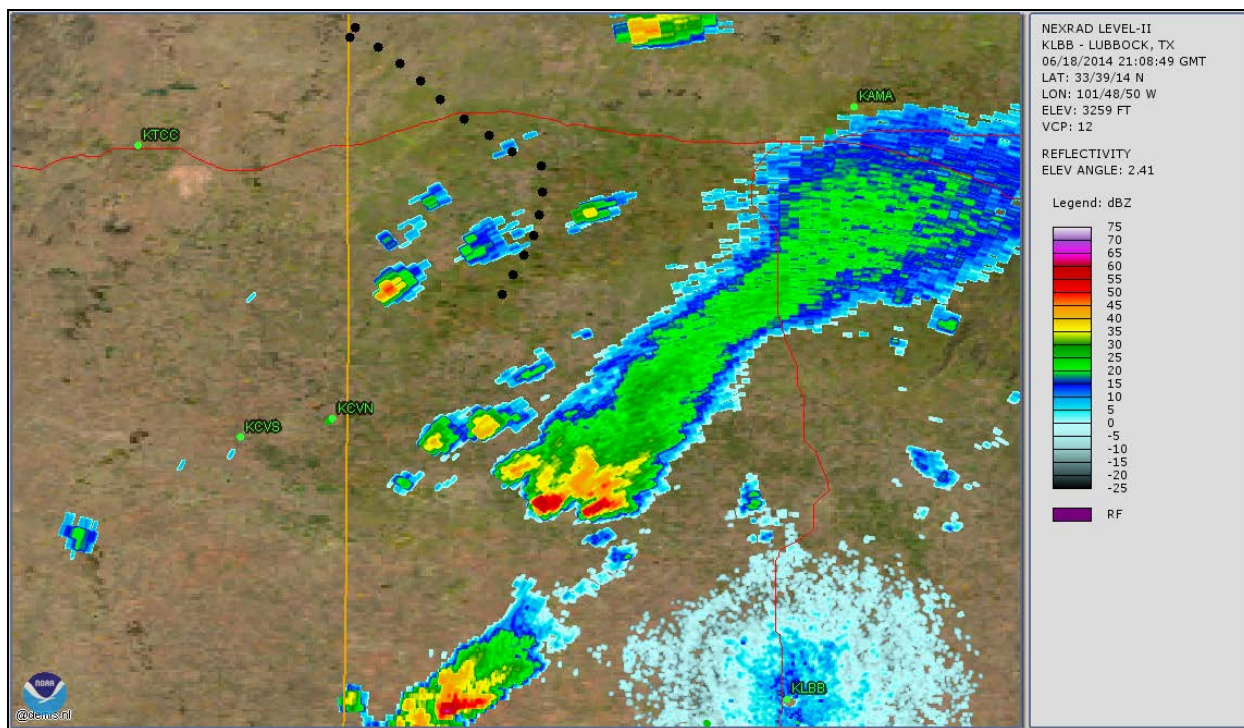


Figure 24 - KLBB WSR-88D 2.4° base reflectivity image at 1608 CDT

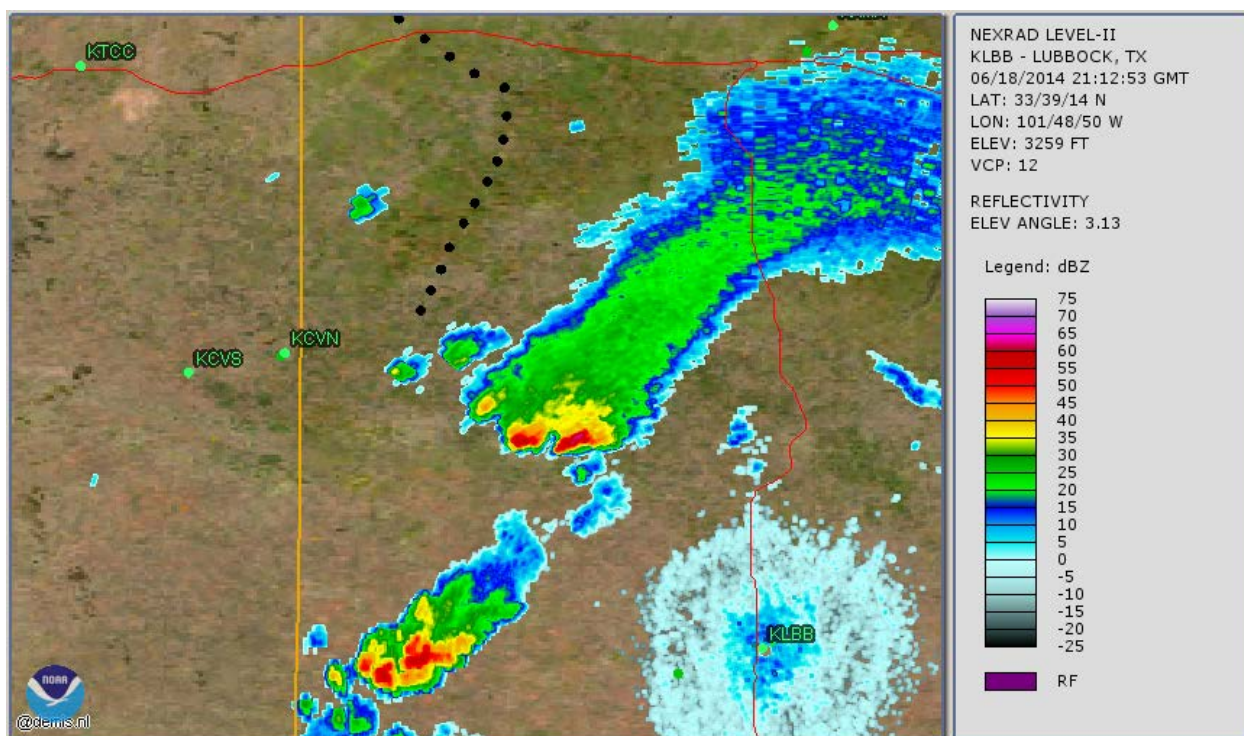


Figure 25 - KLBB WSR-88D 3.13° base reflectivity image at 1612 CDT

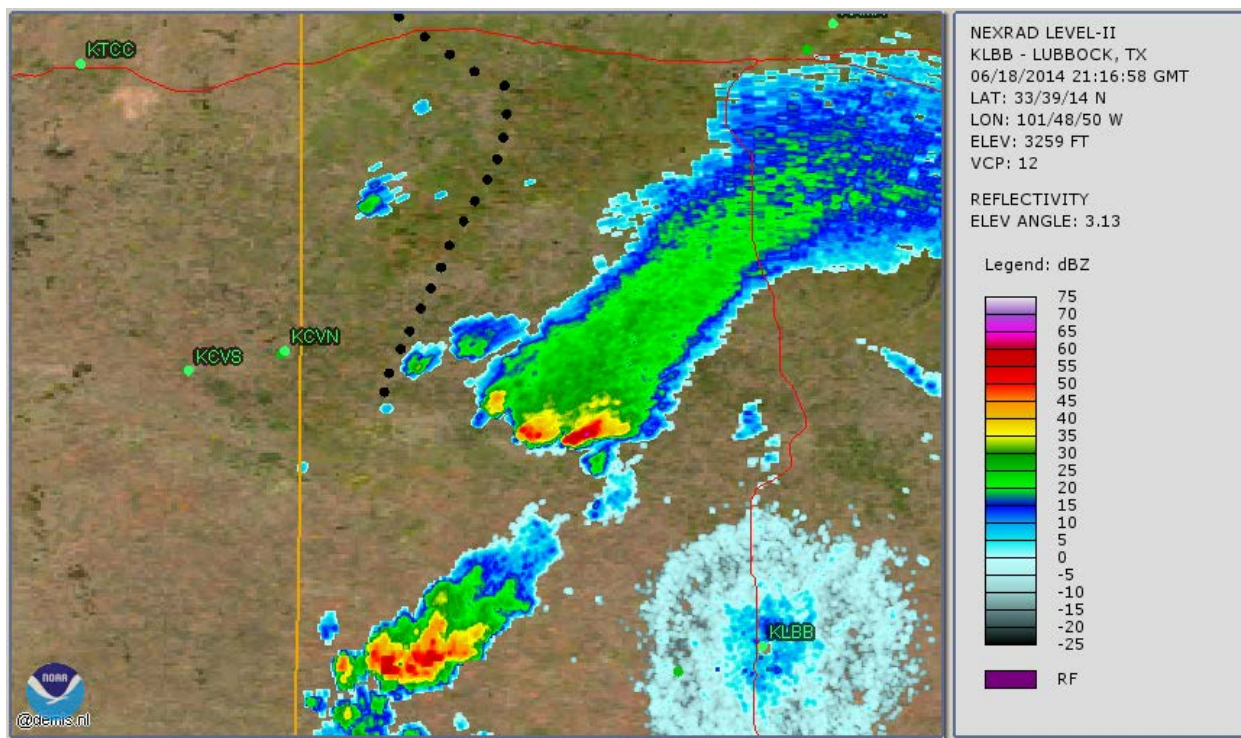


Figure 26 - KLBB WSR-88D 3.13° base reflectivity image at 1616 CDT

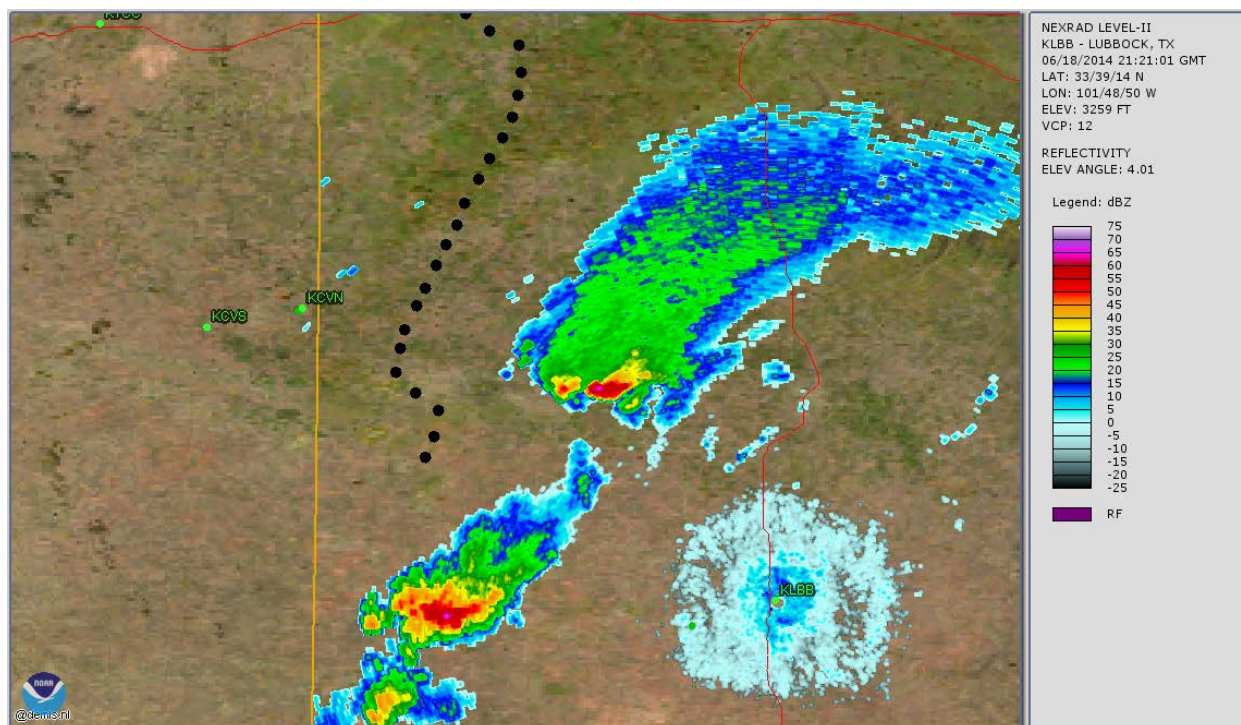


Figure 27 - KLBB WSR-88D 4.0° base reflectivity image at 1621 CDT

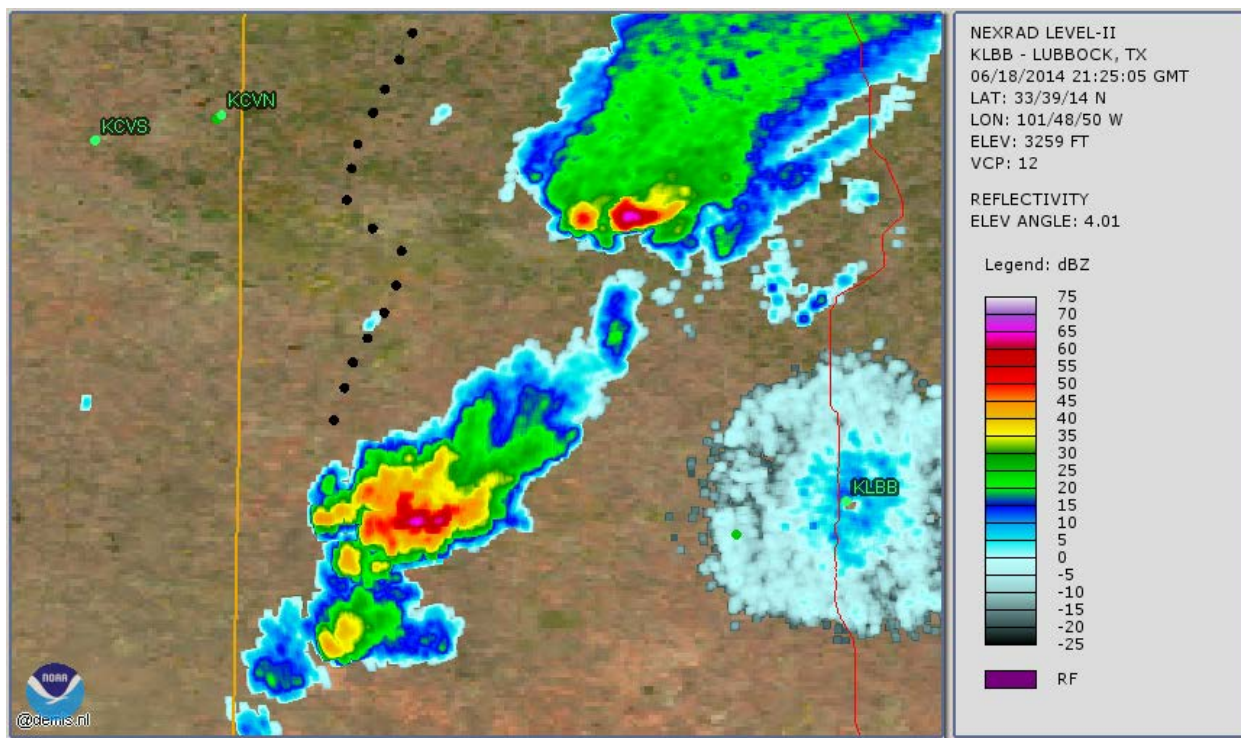


Figure 28- KLBB WSR-88D 4.0° base reflectivity image at 1625 CDT

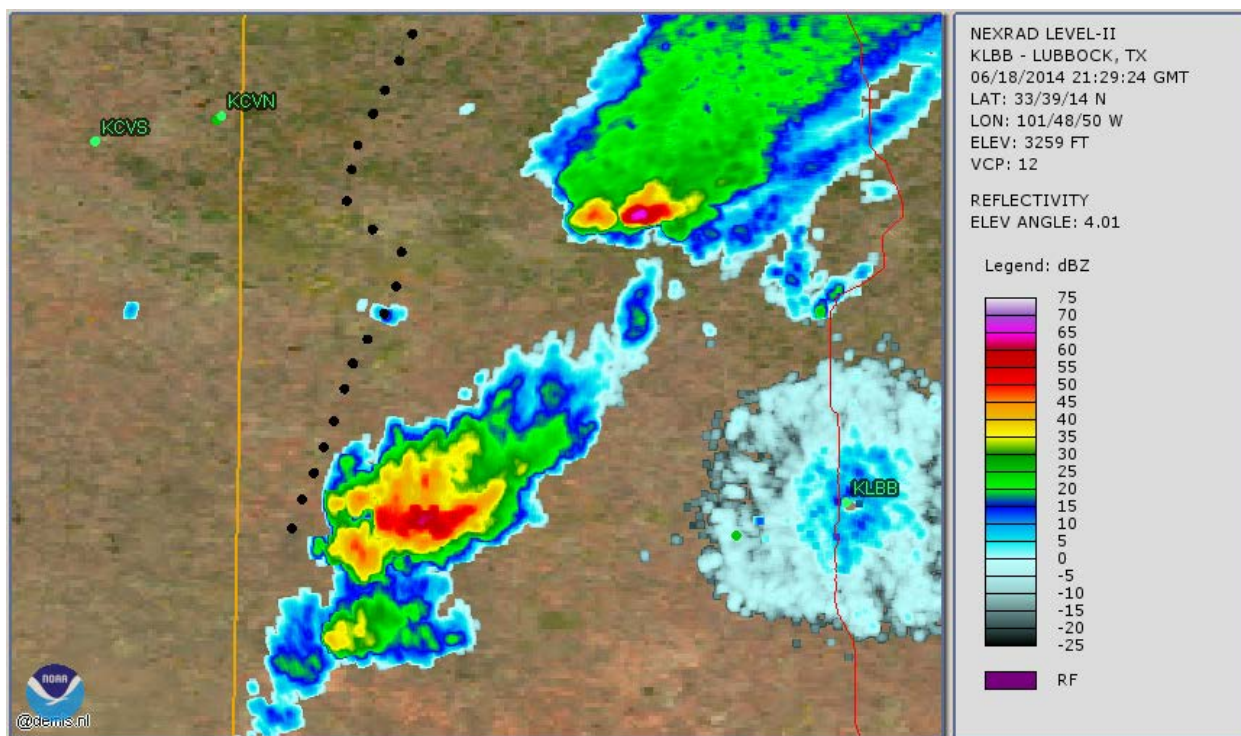


Figure 29 - KLBB WSR-88D 4.0° base reflectivity image at 1629 CDT

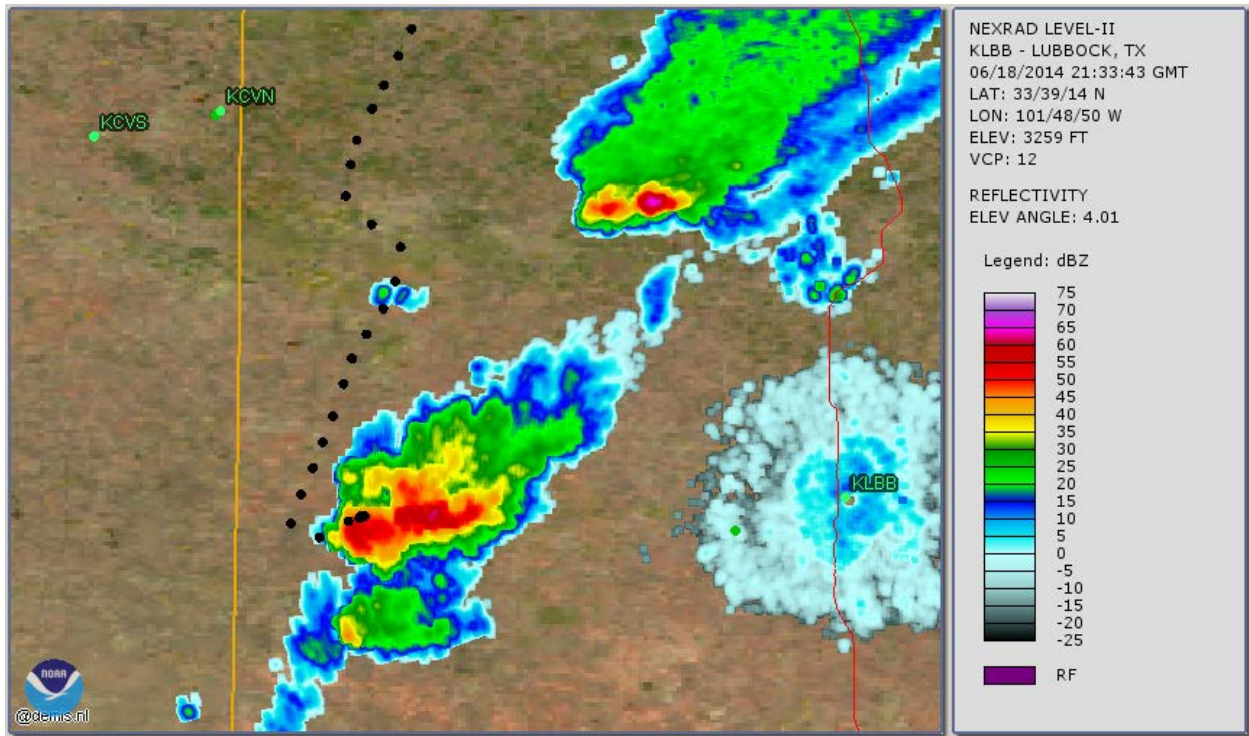


Figure 30 - KLBB WSR-88D 4.0° base reflectivity image at 1633 CDT

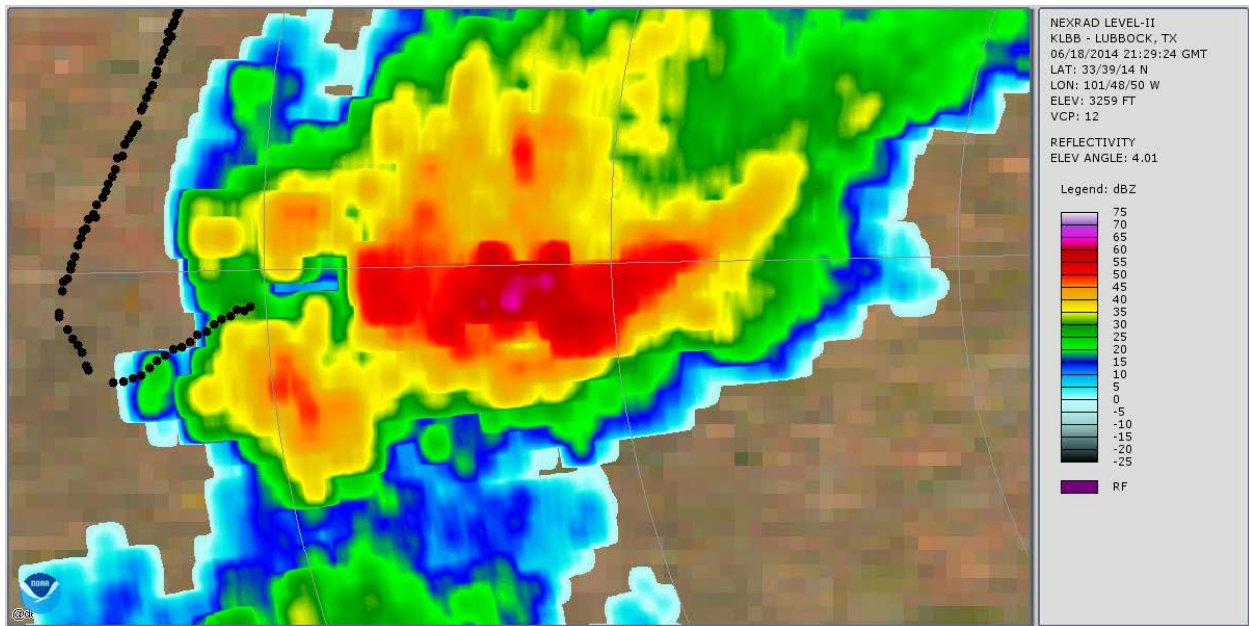


Figure 31 – High resolution KLBB WSR-88D base reflectivity image and track at 1631 CDT

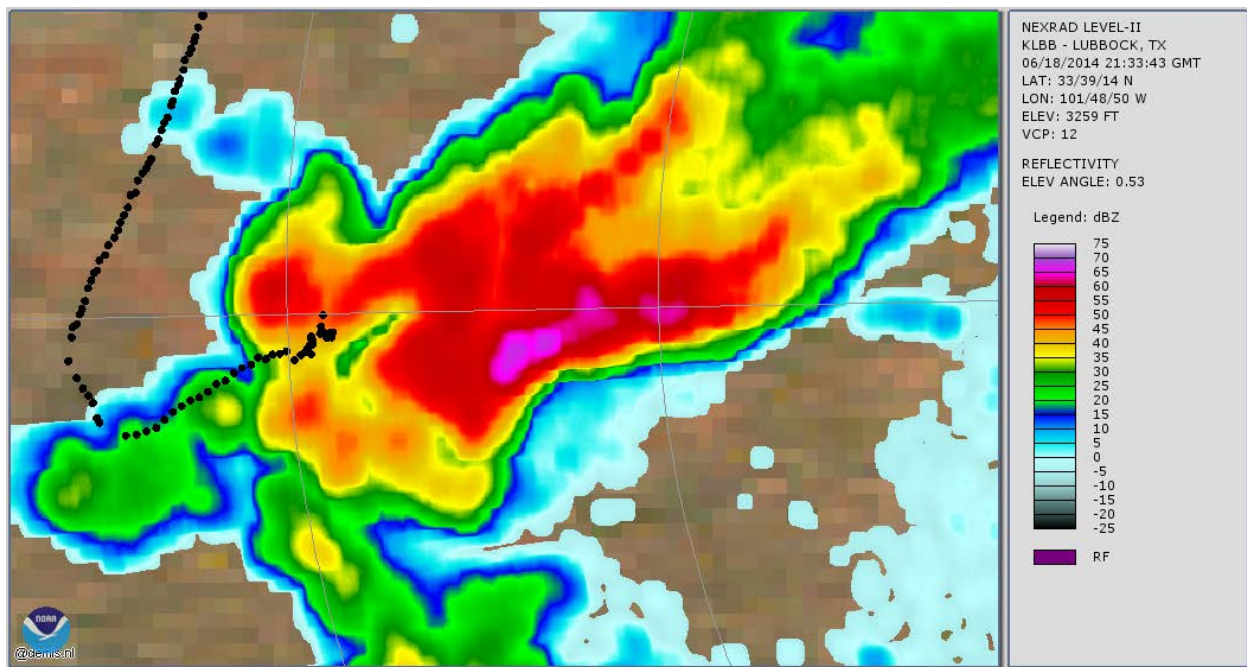


Figure 32 - High resolution KLBB WSR-88D base reflectivity image and track at 1633 CDT

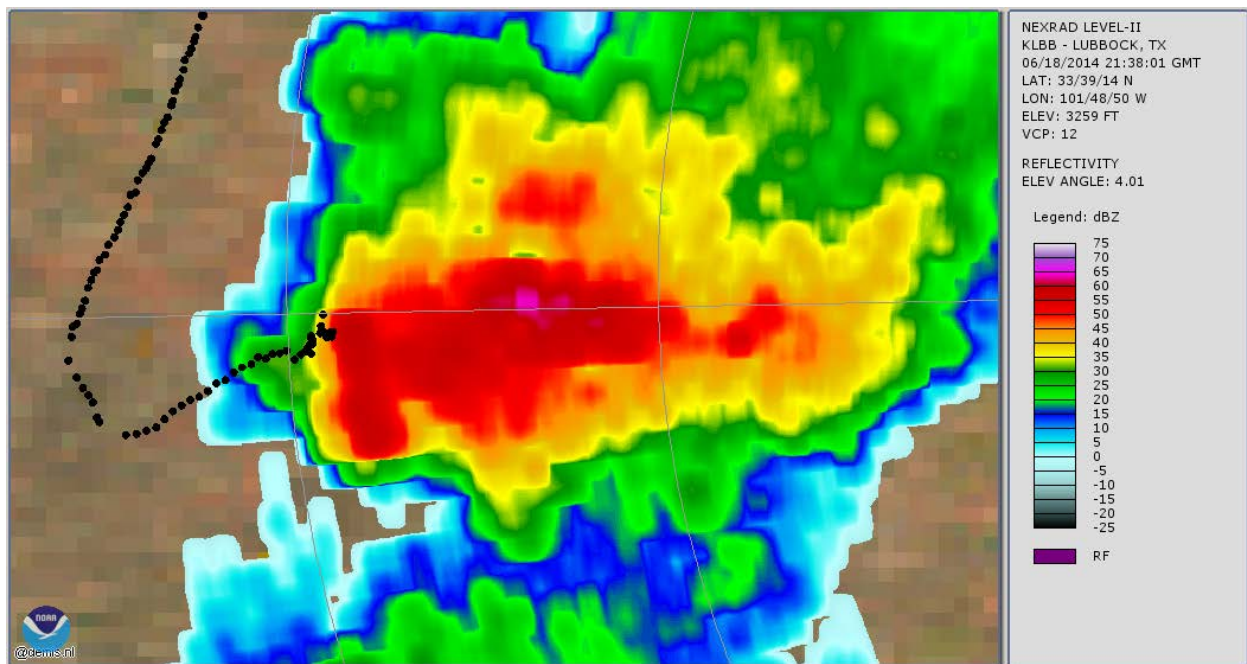


Figure 33 - High resolution KLBB WSR-88D base reflectivity and flight track image at 1638 CDT

The following discussions provide further details on the individual radar images documented above. Figure 23 depicts the KLBB WSR-88D 2.4° base reflectivity image at 1604 CDT, with the track of N2428Q to the southeast and appears to overflies a developing cell with reflectivity value of 14.5 dBZ at the aircraft's altitude and with echo tops²⁰ of 29,000 feet. The flight path of

²⁰ Echo top – is the height of the convective cloud is related to the updraft strength and the degree of instability in

N2428Q then turns to the south as the flight deviates between two cells with echo tops of 34,000 and 27,500 feet respectively.

Figure 24 is the KLBB WSR-88D 2.4° base reflectivity image at 1608 CDT with the flight track of N2428Q continuing to track to the south-southwest and on a course that supports the finding that the flight deviating from the defined echoes visually. The echo immediate west continued to strengthen to a 50 dBZ core with an echo top near 35,000 feet with 0.89" diameter hail, and the intense echo south-southeast had a reflectivity value at 63 dBZ, echo top near 48,000 feet, and 1.72" hail. The echo immediately south associated with the accident has reached an intensity of 60 dBZ, echo top of 44,000 feet, and also indicated 1.4" hail.

Figure 25 is the KLBB WSR-88D 3.13° base reflectivity image at 1612 CDT with the track of N2428Q continuing to track clear of the echoes to the south-southwest. The echoes north-northwest of the aircraft indicated hail to 0.99", the intense echo to the southeast had a value of 64 dBZ, hail to 1.58", and echo tops of 44,000 feet. Further to the south, two intense cells with value of 59.5 dBZ, hail to 1.15", and echo tops to 45,000 feet.

Figure 26 is the KLBB WSR-88D 3.13° base reflectivity image at 1616 CDT with the track turning to the southeast around the back or western edge of the large area of intense echoes. The echo to the east-southeast had a maximum value of 64.0 dBZ, and indicated hail to 1.52", and echo tops to 42,000 feet. Further to the south, the several intense echo associated with the accident had a maximum value of 60.5 dBZ, and indicated hail to 1.32", and echo tops to 47,000 feet.

Figure 27 is the KLBB WSR-88D 4.0° base reflectivity image at 1621 CDT with the track of N2428Q having turned to the southeast and then back to the southwest towards the western edge of the intense echoes to the south. The intense echoes to the east had a maximum value of 67.5 dBZ, hail to 2.17", and echo tops near 47,000 feet. The intense area of echoes to the south having reached a maximum value of 66.5 dBZ and indicated hail to 2.09" and echo tops of 46,000 feet.

Figure 28 is the KLBB WSR-88D 4.0° base reflectivity image at 1625 CDT with the track turning more towards the south and towards the back of the western edge of the intense area of echoes, which had a maximum reflectivity value of 67.5 dBZ, hail to 2.63", and echo tops near 46,600 feet.

Figure 29 is the KLBB WSR-88D 4.0° base reflectivity image at 1629 CDT with the track of N2428Q immediately west of the area of intense echoes, with a maximum value of 66.0 dBZ located approximately 10 miles east of the aircraft's position. The area indicated a high potential for severe hail to 2.35" and maximum echo top near 46,500 feet.

Figure 30 is the KLBB WSR-88D 4.0° base reflectivity image at 1633 CDT with the flight track of N2428Q having turned to the east-northeast and into the growing area of echoes. A small maximum reflectivity core of 73 dBZ was identified approximately 7 miles east of the last

the atmosphere. The radar echo tops product available with the WSR-88D depicts the maximum height of the 18.5 dBZ echo.

radar contact of N2428Q likely associated with hail with reflectivity's of 65.0 dBZ associated with the storm at the accident airplanes cruising level. The 20 mile wide cell also had a high probability of severe hail and indicated 2.27" diameter hail and echo tops of 46,000 feet immediately east of the accident site. The echo intensity directly along the route of flight reached 47 dBZ at the point where N2428Q's altitude reached 29,300 feet, and then continued into reflectivity of 52 dBZ as the aircraft descended. The echo tops were 36,000 feet at that location, and N2428Q continued into the echo with tops to 44,000 feet along the flight track.

Figures 31, 32, and 33 are high resolution images of the KLBB WSR-88D images at 4.0° elevation scans at 1629, 1633 and 1638 CDT and flight track data, with 10 mile radials included on the radar. The 1629 CDT base reflectivity image has the track ending at 1631:44 CDT or the time of the 4.0° elevation scan was completed over the area completely linking the elevation and time. The next image (figure 32) includes the accident airplanes sudden increase in altitude to 29,300 feet and its final flight track overlaid. The 1638 CDT image showing large growth of the echo with reflectivity of 60.0 dBZ located approximately 1 miles east and with the maximum reflectivity's of 68.0 dBZ located 5 miles east near the location of the hail core.

5.5 Composite Reflectivity Images

The NWS composite reflectivity images are completed at the end of the 4 ½ minute VCP scan and depicts the maximum reflectivity in dBZ of each of the 14 different elevation scans. Composite reflectivity images show the highest reflectivity value retrieved for a column from the individual radar sweeps for a single volume scan. Composite reflectivity provides a plan view of the most intense portions of thunderstorms, and can be compared with the lowest elevation base reflectivity scan images to help determine the 3-dimensional structure of a thunderstorm.

Figure 34 is the KLBB WSR-88D composite reflectivity image at the end of the VCP scan at 1633 CDT which shows the flight track of N2428Q within the northern portions of the 50 dBZ echo.

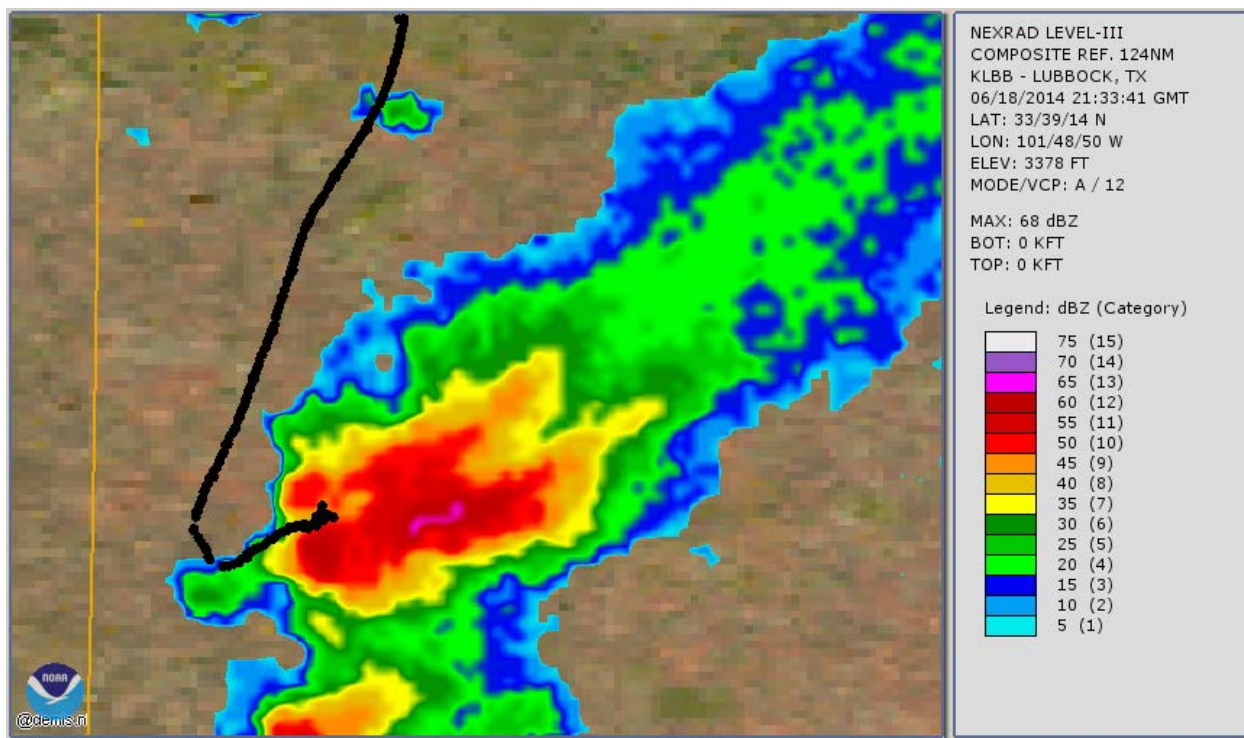


Figure 34 - KLBB WSR-88D composite reflectivity image at 1633 CDT

5.6 GR2 Radar Analysis of Radar Data

The Level II data from KLBB WSR-88D was also analyzed utilizing the Gibson Ridge Software, specifically “GRLevel2” or referred to in this report as GR2 Analysis, which also allowed for a cross section and general three dimensional (3D) presentations of the echoes.

Figures 35 through 37 are the GR2 Analysis depiction of the KLBB WSR-88D 4.0° base reflectivity and echo tops product for 1629, 1633, and 1638 CDT respectively, with the flight track included to match the time of the images. The echo tops height scale is on the left side of the chart in thousands of feet. A purple diamond signifies radar indicated hail. The image shows a gap between two echoes immediately east of the aircraft’s position at their altitude with only echoes of 30 dBZ along the flight path and echo tops of 24,300 feet at 1629 CDT. By 1633 CDT the echoes on the western side has rapidly developed and increased to reflectivity’s in the range from 40 to 51.5 dBZ along the flight track and echo tops to 45,300 feet. Higher echo tops continue to be identified to the east. By 1638 CDT the echo has reached 60 dBZ immediately bordering east of the accident site with echo tops of 46,300 feet over the flight track, and higher tops to 48,900 feet 3 miles east.

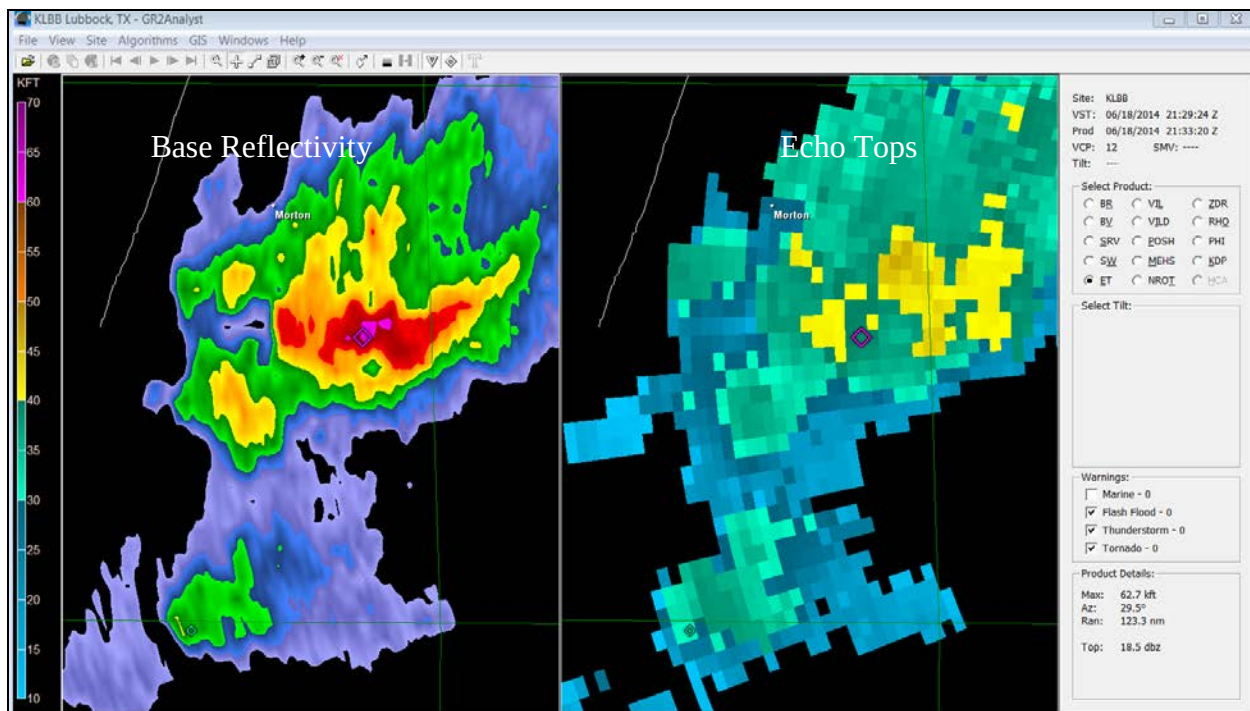


Figure 35 - GR2 Analysis KLBB WSR-88D 4.0° base reflectivity and echo tops at 1629 CDT

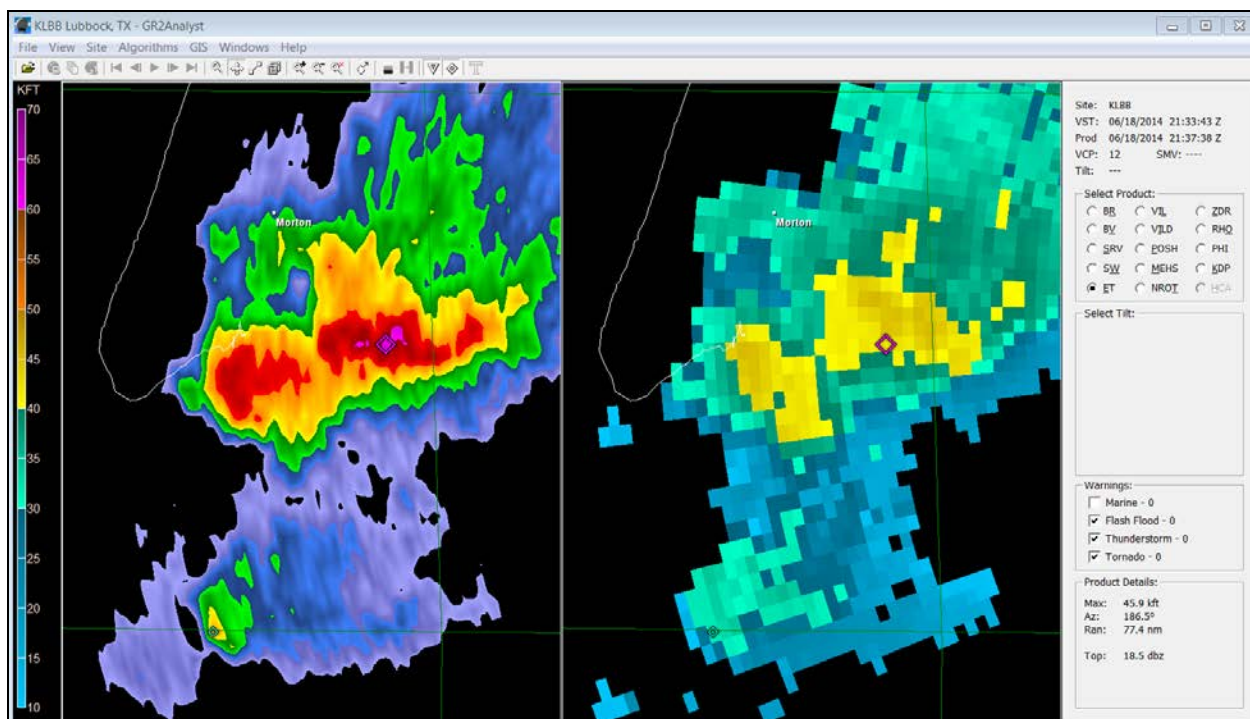


Figure 36 - GR2 Analysis KLBB WSR-88D 4.0° base reflectivity and echo tops at 1633 CDT

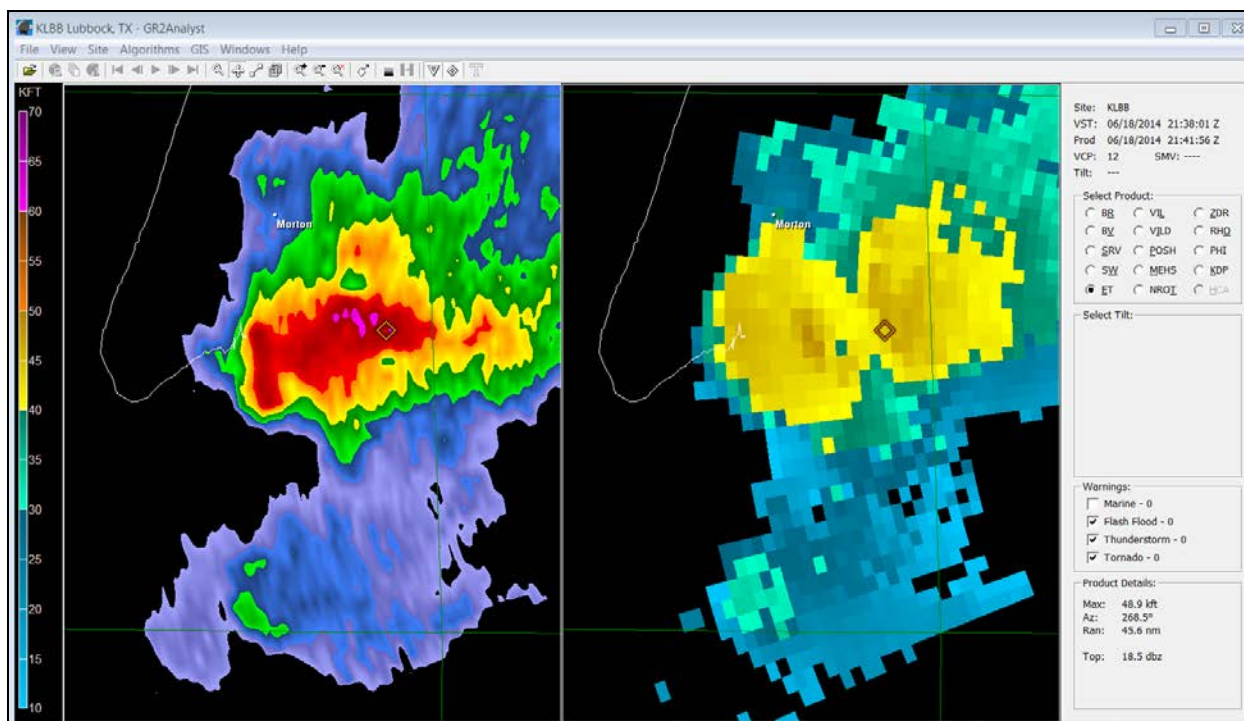


Figure 37 - GR2 analysis KLBB WSR-88D base reflectivity and echo tops at 1638 CDT

Figure 38 is the GR2 Analysis cross section of the flight track turning east-northeastward for approximately 20 miles through the echo, with the flight track at 1629 CDT on the top, 1633 CDT in the middle, and 1638 CDT on the bottom. The image depicts the rapid development of the echo on the western side of the echo with tops rising from 30,000 to over 48,000 feet over the route during the 9 minute period. Stronger echoes were also located immediately south of the track during the period.

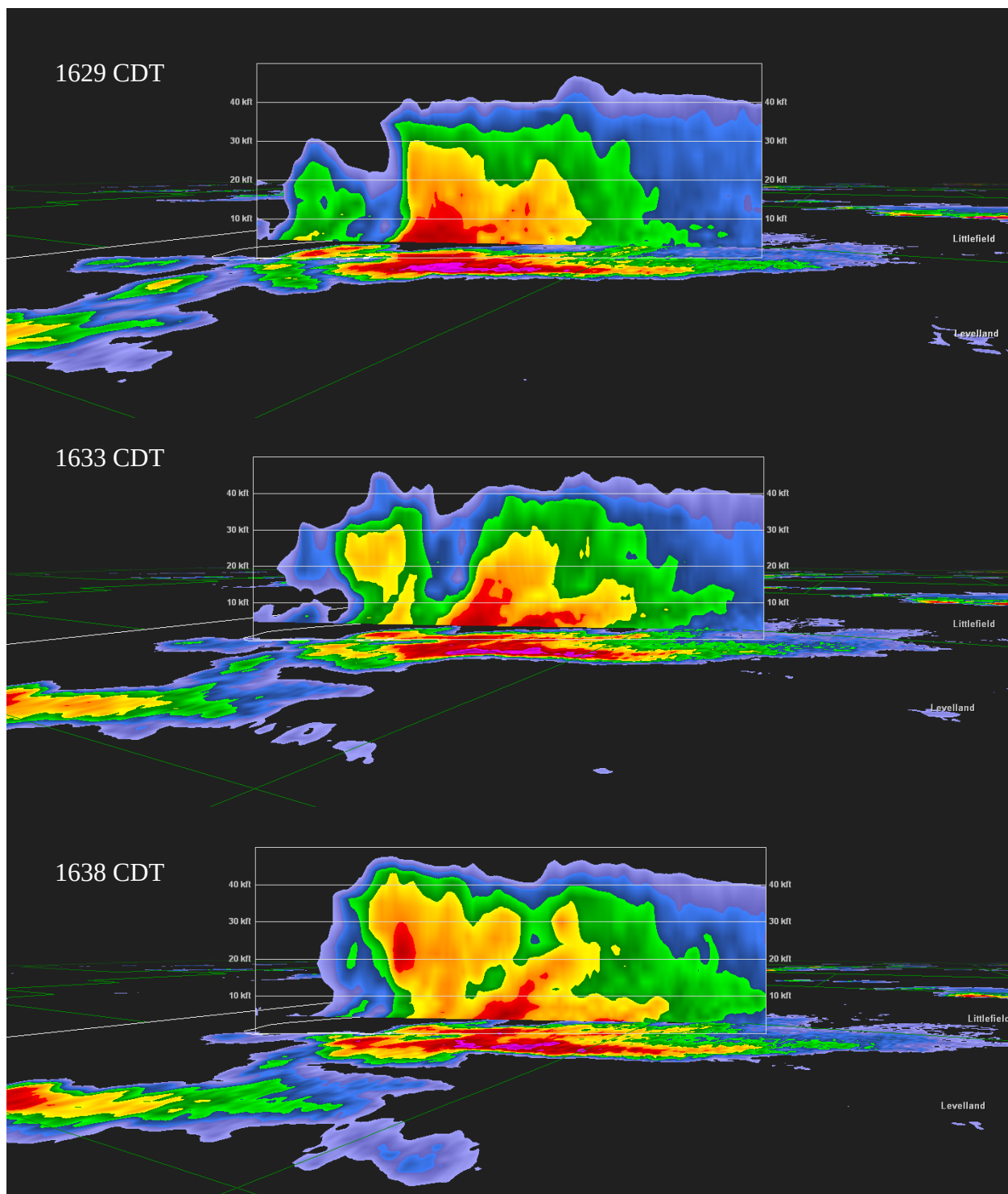


Figure 38 - GR2 Analysis cross section over the flight track at 1629, 1633, and 1638 CDT

Figures 39 and 40 are the GR2 Analysis three dimensional (3D) depiction of the echoes at 1629 and 1633 CDT respectively.

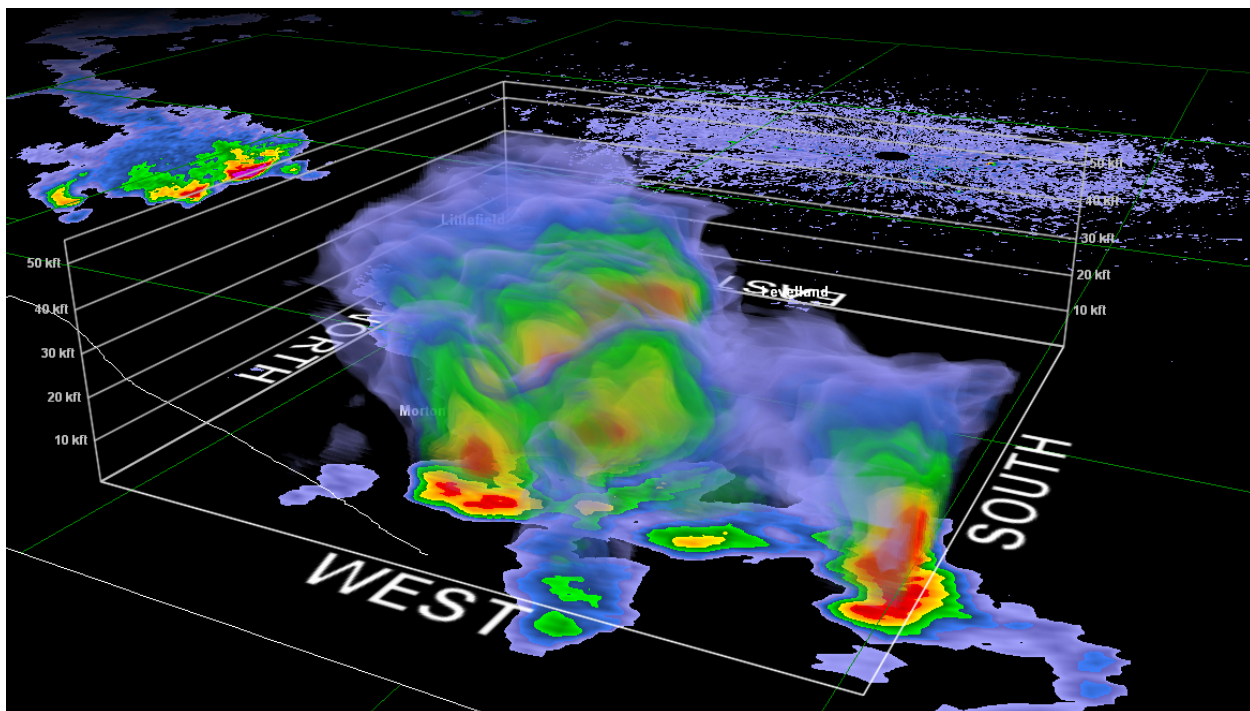


Figure 39 - GR2 Analysis 3D base reflectivity image at 1629 CDT

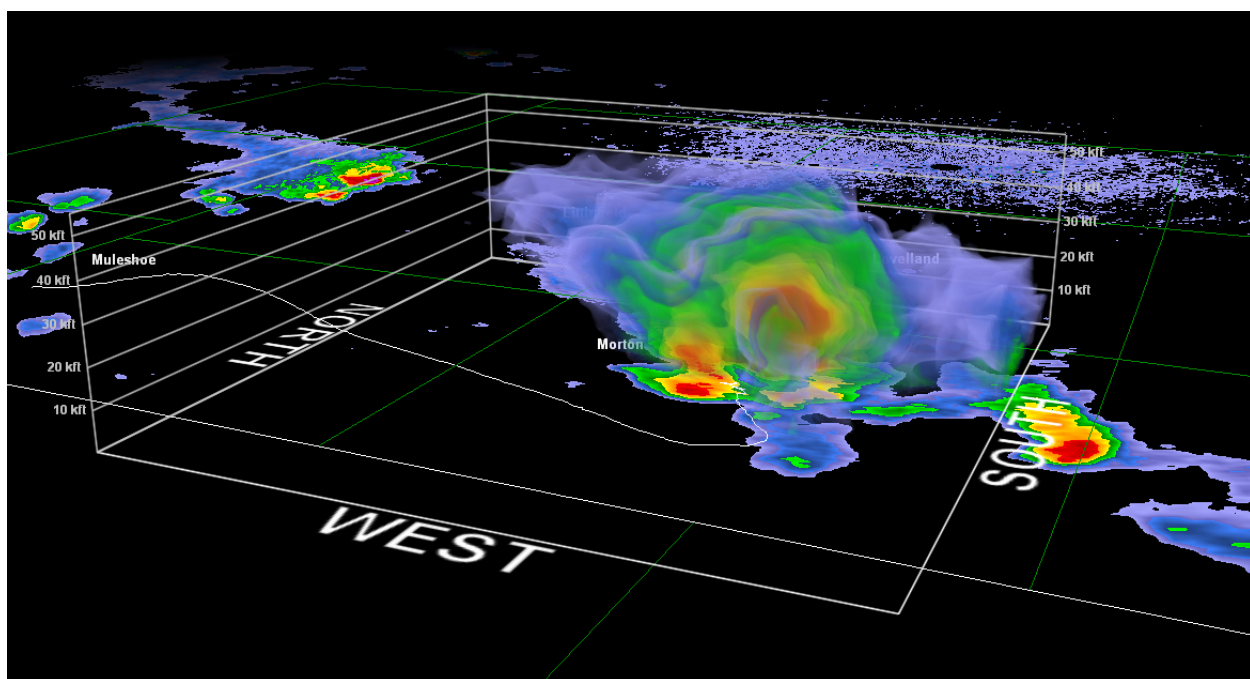


Figure 40 - GR2 Analysis 3D base reflectivity at 1633 CDT

6.0 Lightning Data

The accident airplane was equipped with an Eventide ARGUS 500 mapping system to display lightning activity. A review of the Earth Networks total lightning archive indicated that in an approximately 25 mile radius of the accident site there was 36 cloud-to-ground (CG) lightning strikes during the period from 1600 to 1645 CDT, and 2,117 in-cloud (IC) lightning strikes. Figure 41 is the KLBB WSR-88D composite reflectivity image at 1633 CDT with the flight track displayed, and lightning strikes overlaid. The white dots are the cloud-to-ground strikes and the pink dots the in-cloud lightning strikes.

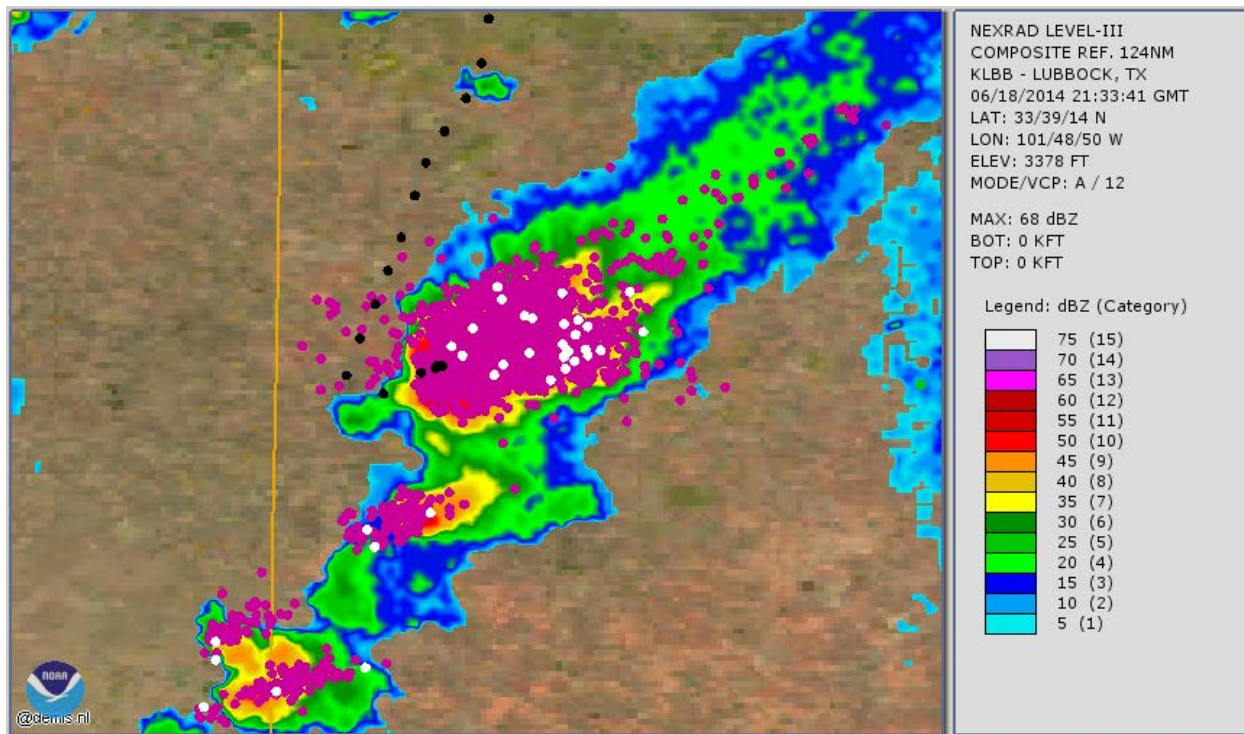


Figure 41 - KLBB WSR-88D composite reflectivity image and lightning activity at 1633 CDT

7.0 Pilot Reports

The only formal pilot reports (PIREPs) recorded over New Mexico and western Texas surrounding the period between 1200 and 1900 CDT were as follows:

Las Vegas (LVS), New Mexico, routine pilot report (UA); Over – between Tucumcari (TCC) to 10 miles south of Las Vegas (LVS), New Mexico; Time – 1220 CDT (1720Z); Flight level – 10,500 feet; Type aircraft – Cessna Centurion single engine turbocharge airplane (C210); Turbulence – light to occasional moderate turbulence.

Midland (MAF), Texas, routine pilot report (UA); Over – Midland (MAF); Time – 1535 CDT (2035Z); Flight level – 20,000 feet; Type aircraft – Beechcraft King Air (BE9T); Sky cover

– overcast with unknown tops; Temperature – 9° C²¹; Wind – from 240° at 23 knots; turbulence – negative.

El Paso (ELP), Texas, routine pilot reports (UA); Over – El Paso (ELP); Time – 1549 CDT (2049Z); Flight level - 15,000 feet; Type aircraft – Boeing 737 air carrier jet (B737); Turbulence – intermittent moderate turbulence at 15,000 feet; Remarks – turbulence encountered from 15,000 feet to the surface.

Accident 1635 CDT.

Roswell (ROW), New Mexico, routine pilot reports (UA); Over – 41 miles east of Chisum VORTAC²² (CME), Roswell, NM; Time – 1733 CDT (2233Z); Flight level - 18,700 feet; Type aircraft – Embraer regional jet (E145); Temperature – minus 10° C; Icing – trace of icing.

Truth of Consequences (TCS), New Mexico, routine pilot reports (UA); Over – 33 miles west of TCS; Time – 1755 CDT (2255Z); Flight level - 16,000 feet; Type aircraft – Beech Bonanza single engine airplane (B36); Temperature – minus 6° C; Icing – light to moderate rime icing; Remarks – entered by Albuquerque Center.

The raw reports in standard code and abbreviations were as follows:

LVS UA /OV TCC-LVS180010 /TM 1720 /FL105 /TP C210 /TB LGT OCNL MOD=

MAF UA/ OV MAF/ TM 2035/ FL200/ TP BE9T/ SK OVC-TOP/TA 09/WV 24123KT/TB NEG

ELP UA/OV ELP/TM 2049/FL150/TP B737/TB INTMT MOD 150/RM FL150-SFC

ROW UA /OV CME091041 /TM 2233 /FL187 /TP E145 /TA M10 /IC TRACE=

TCS UA /OV TCS290033/TM 2255/FL160/TP BE36/TA -6C/IC LGT TO MOD RIME/RM ZAB=

8.0 Terminal Aerodrome Forecast

The closest NWS Terminal Aerodrome Forecast (TAF) to the accident site was issued for Lubbock Preston Smith International Airport (KLBB), Lubbock, Texas. The forecast available at the time of departure issued at 1220 CDT was as follows:

*TAF KLBB 181720Z 1818/1918 18016G25KT P6SM SCT050 BKN150
TEMPO 1823/1903 VRB25G35KT 6SM TSRA BKN040CB
FM191000 17013KT P6SM FEW025 BKN120=*

The forecast expected VFR conditions to prevail with a southerly wind at 16 knots gusting to 25 knots, visibility better than 6 miles, scattered clouds at 5,000 feet agl, and a ceiling broken at

²¹ The pilot report indicated a temperature of 9° C and likely dropped the minus sign in the translation of the information, as the sounding at that level indicated a temperature of -9° C. Other pilot reports in the area all reflect below freezing temperatures and support the sounding temperature readings.

²² VORTAC – is a very high frequency (VHF) omnidirectional range (VOR) and tactical air navigation (TACAN) beacon systems which provide azimuth and distance information from the beacons, and are used for air navigation.

15,000 feet, with a temporarily between 1800 and 2200 CDT of a 30% probability of wind variable at 25 knots gusting to 35 knots in thunderstorms and moderate rain, with a ceiling broken at 4,000 feet in cumulonimbus clouds.

9.0 Area Forecast Discussion

The NWS Lubbock Area Forecast Discussion (AFD) current for the period was issued at 1235 CDT and was intended to provide a well-reasoned discussion of the meteorological thinking which went into the preparation of the forecast products, or specifically for aviation the Lubbock TAF. The discussion was as follows:

FXUS64 KLUB 181735

2014169 1735

AFDLUB

AREA FORECAST DISCUSSION

NATIONAL WEATHER SERVICE LUBBOCK TX

1235 PM CDT WED JUN 18 2014

.UPDATE...

SCATTERED THUNDERSTORMS LOOK TO BE ON DECK BY LATE AFTERNOON INTO THE EVENING HOURS...WITH INITIATION OCCURRING ON THE CAPROCK. WATER VAPOR IMAGERY SHOWS A SHORTWAVE IMPULSE PUSHING INTO CENTRAL-EASTERN NEW MEXICO. ADDITIONALLY...ANOTHER WAVE CAN BE SEEN MOVING INTO EASTERN ARIZONA...POSSIBLY ENHANCING THE LEAD WAVE OR PROVIDING FOR A SECOND ROUND OF STORM GENERATION. SURFACE ANALYSIS SHOWS DEWPOINTS REMAINING IN THE 60S ALL THE WAY BACK TO THE NEW MEXICO STATE LINE AS TEMPERATURES WARM INTO THE LOW-MID 80S UNDERNEATH SCATTERED TO BROKEN CLOUD COVER. LARGE HAIL TO THE SIZE OF GOLF BALLS ALONG WITH WIND GUSTS UPWARDS OF 65 MPH WILL BE POSSIBLE WITH ANY STORMS THAT DEVELOP. HEAVY RAINFALL AND LOCALIZED FLOODING WILL ALSO BE A CONCERN WITH THE CONTINUED PLUME OF DEEP LEVEL MOISTURE IN PLACE.

&&

.AVIATION...

PREVAILING VFR CONDITIONS EXPECTED THROUGH THE PERIOD WITH BREEZY SOUTHERLY WINDS. SCATTERED THUNDERSTORMS LOOK TO DEVELOP ON THE CAPROCK LATE THIS AFTERNOON AND THIS EVENING...SO HAVE TRANSITIONED PROB30 AT KLBB TO A TEMPO HEADLINE FROM 23-03Z. NOT AS CONFIDENT IN STORMS IMPACTING KCDS...SO HAVE LEFT MENTION OUT OF THE FORECAST AT THIS TIME. LOW LEVEL JET SHOULD CRANK UP THIS EVENING KEEPING WINDS BREEZY...BUT SHOULD SEE CONDITIONS BECOME LESS GUSTY BY EARLY THURSDAY MORNING AS PERHAPS A FEW LOW CLOUDS ATTEMPT TO EASE IN NEAR THE TERMINALS.

&&

PREV DISCUSSION... /ISSUED 408 AM CDT WED JUN 18 2014/

SHORT TERM...

SCATTERED SHOWER AND T-STORM ACTIVITY CONTINUES ACROSS THE FAR SW TX PANHANDLE AND WRN SPLNS EARLY WED MORNING...SUSTAINED BY A 30-40 KT LLJ AND A RIBBON OF WEAK MID-LVL ASCENT RUNNING FROM AZ NEWD INTO THE SRN PLAINS. WE EXPECT THIS ACTIVITY TO GRADUALLY WANE THROUGH THE MORNING...BUT MAY NOT DIE OFF COMPLETELY ACROSS OUR NORTHERN ZONES FOR A FEW MORE HOURS.

THE CWA WILL REMAIN IN A DEEP MOISTURE REGIME TODAY WITH PWATS PROGGED TO RANGE FROM ABOUT AN INCH IN THE FAR SW TX PANHANDLE TO 1.5 INCHES IN THE ROLLING PLAINS. ALOFT...IT APPEARS THAT A WEAK DISTURBANCE OR TWO WILL TRACK AROUND THE SRN FLANK OF A SLOW-MOVING UPPER LOW OVER THE NRN ROCKIES...PASSING ACROSS ERN NM AND WTX WITHIN A BELT OF MODERATE SWERLY FLOW. GUIDANCE SUGGESTS THAT THE CWA WILL SEE WEAK HEIGHT FALLS THROUGH THE COURSE OF THE DAY...BUT IT IS DIFFICULT TO PIN DOWN A PERIOD OF ENHANCED LIFT. THERE SHOULD BE AT LEAST A WEAK LOW-LVL FOCUSING MECHANISM IN THE FORM OF A SFC TROUGH AND DIFFUSE DRYLINE IN THE VICINITY OF THE STATE LINE. WITH TEMPS RISING INTO THE LOWER 90S...PERHAPS A FEW DEGREES COOLER THAN

TUES...THE CAP SHOULD ERODE SUFFICIENTLY BY LATE AFTERNOON FOR SCATTERED T-STORM DEVELOPMENT. THE ACTIVITY SHOULD BE FOCUSED ACROSS WRN AREAS AT FIRST...THEN SPREAD AND EXPAND NEWD THROUGH THE EVENING. MLCAPE VALUES IN THE 1500 TO 2500 J/KG BALLPARK AND 0-6 KM

DEEP LAYER SHEAR AROUND 30 TO 40 KTS...A INCREASE FROM YSTDY...SHOULD SUPPORT SOME VIGOROUS UPDRAFTS AND STORM ORGANIZATION...BRINGING A SEVERE WEATHER THREAT...INCLUDING LOCALLY HEAVY RAINFALL GIVEN THE RELATIVELY MOIST TROPOSPHERE. ONCE AGAIN...THE LOW-LEVEL JET KICKING IN TONIGHT MAY HELP SUSTAIN SOME CONVECTIVE ACTIVITY...PERHAPS A LOOSELY ORGANIZED CONVECTIVE COMPLEX...WHICH MAY PROGRESS ACROSS OUR NRN TIER OF COUNTIES AS INDICATED BY SOME GUIDANCE.
&&

The discussion warned that scattered thunderstorms were expected to develop during the afternoon and into the evening, with the initiation along the Caprock, or the boundary line between the High Plains and the lower rolling plains of West Texas. The Caprock is basically located approximately 100 miles southeast of Amarillo. An upper level impulse or trough was observed on the water vapor satellite imagery moving over New Mexico. The current surface analysis indicated temperatures in the high 80's and the dew points temperatures in the 60's was expected to support thunderstorms development. Large hail to the size of golf balls (1.75" in diameter) along with wind gusts upwards to 65 mph was possible with any of thunderstorms that develop. The thunderstorms also were expected to produce heavy rainfall and localize flooding.

10.0 Area Forecast

The Area Forecast (FA) is a forecast of visual Flight Rules (VFR) clouds and weather conditions over an area as large as the size of several states. It must be used in conjunction with the AIRMET Sierra (IFR) bulletin for the same area in order to get a complete picture of the weather. The area forecast together with the AIRMET Sierra bulletin are used to determine forecast enroute weather and to interpolate conditions at airports which do not have a terminal forecast (TAF) issued. The NWS Aviation Weather Center (AWC) located in Kansas City, Missouri, issues the FA at regular intervals and issues specials reports as necessary usually in the form of an AIRMET. The Dallas-Fort Worth (KDFW) regional forecast that was current at the time of the accident was issued at 1345 CDT and valid through 0200 CDT on June 19, 2014. The forecast was as follows:

FAUS44 KKCI 181845 2014169 1830

FA4W

DFWC FA 181845

SYNOPSIS AND VFR CLDS/WX

SYNOPSIS VALID UNTIL 191300

CLDS/WX VALID UNTIL 190700...OTLK VALID 190700-191300

OK TX AR TN LA MS AL

.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.

TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.

NON MSL HGTS DENOTED BY AGL OR CIG.

.
SYNOPSIS...19Z DRYLN NW KS-W PTN OK PNHDL-SE NM-FAR W TX CONTG SWD. RDG FM THE SRN ATLC CSTL WTRS TO CNTRL TX. 13Z CDFNT EXTRM SERN ND-NERN NEB THRU LOW NW KS CONTG ACRS OK PNHDL THRU LOW NERN NM CONTG WWD. HIGH EXTRM NERN TN.

.
NWRN TX

SCT150 WITH BKN CI ABV. TIL 05Z WND S G25KT. BECMG 2022 BKN100 TOP FL250. SCT-TSRA POSS SEV. CB TOP FL420. 05Z SCT120 WITH BKN CI ABV. OTLK...VFR NW 1/4 PNHDL...VFR BECMG 1012 MVFR CIG RMNDR.

.
SWRN TX

FAR W TX-WRN 1/2 BIG BEND...SCT150 WITH SCT CI ABV. ISOL -TSRA DVLPG 19-21Z. CB TOP FL420. 05Z SCT CI. OTLK...VFR.

ERN 1/3 TRANSPECOS...SCT050 BKN120 TOP FL200. ISOL -TSRA DVLPG 19-21Z. CB TOP FL450. 03Z BKN CI. OTLK...VFR BECMG 0709 MVFR CIG.

RMNDR...SCT120 WITH BKN CI ABV. BECMG 1921 BKN100 TOP FL250. SCT -TSRA POSS SEV. CB TOP FL450. 05Z SCT-BKN CI. OTLK...VFR.

*.
N CNTRL TX*

WRN 1/2...BKN050 LYRD FL200. WDLY SCT -SHRA/ISOL -TSRA BECMG 2022 SCT -SHRA/WDLY SCT -TSRA. CB TOP FL450. 03Z SCT050 WITH BKN CI ABV. OTLK...VFR BECMG 1012 MVFR CIG.

ERN 1/2...BKN040 LYRD FL200. WDLY SCT -SHRA/ISOL -TSRA BECMG 2022 SCT -SHRA/WDLY SCT -TSRA. CB TOP FL450. 03Z SCT050 WITH BKN CI

ABV. OTLK...VFR BECMG 0709 MVFR CIG.

*.
NERN TX*

SCT-BKN040 LYRD FL200. SCT -SHRA/ISOL -TSRA. CB TOP FL450. 01Z SCT CI. OTLK...VFR BECMG 0810 MVFR CIG.

*.
SERN TX*

SCT-BKN040 TOP 100. SCT -TSRA. CB TOP FL450. 01Z SCT CI. BECMG 0507 BKN020. OTLK...MVFR CIG.

*.
S CNTRL TX*

WRN 1/2...BKN050 LYRD FL200. SCT -SHRA. ISOL -TSRA BECMG 2022 SCT -TSRA. CB TOP FL450. BECMG 0305 OVC020-030. OTLK...MVFR CIG.

ERN 1/2...SCT-BKN040 TOP 100. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL450. WND SE G25KT. 01Z SCT020. BECMG 0305 BKN020. OTLK...MVFR CIG.

The NWS Aviation Weather Center's (AWC) Area Forecast synopsis indicated that a dry line was the key surface feature moving across the area, the enroute forecast for northwest Texas expected broken clouds at 10,000 feet with tops to 22,000 feet, with scattered thunderstorms and light rain showers developing and potentially becoming severe, with cumulonimbus cloud tops to 42,000 feet.

11.0 In-Flight Weather Advisories

The NWS issues in-flight weather advisories designated as Severe Weather Forecast Alerts, Convective Significant Meteorological information (SIGMET), non-convective SIGMET's, Center Weather Advisories, and Airmen's Meteorological information (AIRMET's). In-flight advisories serve to notify enroute pilots of the possibility of encountering hazardous flying conditions, which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

11.1 Severe Weather Forecast Alert

Severe Weather Forecast Alert (AWW) are preliminary messages issued by the NWS Storm Prediction Center to alert users that a Severe Weather Watch (WW) is being issued for areas of possible severe thunderstorm or tornado activity. They are unscheduled and issued as required.

The NWS issued AWW number 323 at 1447 CDT and was valid through 2200 CDT for severe thunderstorms over portions of Oklahoma and western Texas. The area was identified from 65 miles east and west of a line from 12 miles east-northeast of Lubbock, TX, to 39 miles

east of Liberal (LBL), Kansas. The area was issued for a few severe thunderstorms with hail to 2 inches, extreme turbulence, and surface wind gusts to 60 knots. A few of the cumulonimbus clouds had a potential with maximum tops to 55,000 feet. The mean storm motion was from 240° at 20 knots. A plot of the advisory is included with the other advisories in figure 42 and with the radar image at the time of issuance in figure 44. The advisory was as follows:

*SPC AWW 181947
WW 323 SEVERE TSTM OK TX 181950Z - 190300Z
AXIS..75 STATUTE MILES EAST AND WEST OF LINE..
25S PVW/PLAINVIEW TX/ - 55NNW GAG/GAGE OK/
..AVIATION COORDS.. 65NM E/W /12ENE LBB - 39E LBL/
HAIL SURFACE AND ALOFT..2 INCHES. WIND GUSTS..60 KNOTS.
MAX TOPS TO 550. MEAN STORM MOTION VECTOR 24020.*

11.2 Convective SIGMET

The NWS issues Convective SIGMETs (WST) for areas of thunderstorms affecting an area greater than 3,000 square miles, lines of thunderstorms, severe thunderstorms, or embedded thunderstorms affecting any area that are expected to last 30 minutes or longer. The advisories are issued hourly at 55 minutes past the hour and are valid for 2 hours. The following advisories were issued surrounding the period at 1455, 1555, and 1655 CDT:

*MKCC WST 181955
CONVECTIVE SIGMET 82C
VALID UNTIL 2155Z
TX
FROM 10ENE GGG-50ENE LFK-40S IAH-20ESE ACT-10ENE GGG
AREA TS MOV FROM 19015KT. TOPS TO FL440.
.
CONVECTIVE SIGMET 83C
VALID UNTIL 2155Z
TX
FROM 40WNW AMA-10ENE AMA-40WNW LBB-20SSW TXO-40WNW AMA
AREA SEV TS MOV FROM 21015KT. TOPS ABV FL450.
HAIL TO 1.5 IN...WIND GUSTS TO 50KT POSS.
OUTLOOK VALID 182155-190155
AREA...FROM 40NNW GCK-ACT-50S EIC-40ESE IAH-CRP-70NW LRD-60WNW DLF-LAA-40NNW GCK
REF WW 323.
WST ISSUANCES POSS. REFER TO MOST RECENT ACUS01 KWNS FROM STORM PREDICTION CENTER FOR
SYNOPSIS AND METEOROLOGICAL DETAILS.*

The advisories were updated at 1555 CDT and were as follows:

*MKCC WST 182055
CONVECTIVE SIGMET 85C
VALID UNTIL 2255Z
LA AR TX
FROM 20ESE ELD-40SE AEX-40WSW IAH-50SE TTT-20ESE ELD
AREA TS MOV FROM 19010KT. TOPS ABV FL450.
.
CONVECTIVE SIGMET 86C
VALID UNTIL 2255Z
TX
20SE TXO
ISOL SEV TS D20 MOV FROM 27005KT. TOPS TO FL420.*

HAIL TO 2 IN...WIND GUSTS TO 60KT POSS.

*AREA...FROM OBH-ABI-ELD-BTR-70NW LRD-INK-GLD-OBH
REF WW 323.*

*WST ISSUANCES POSS. REFER TO THE MOST RECENT ACUS01 KWNS FROM THE STORM PREDICTION CENTER
FOR SYNOPSIS AND METEOROLOGICAL DETAILS.*

At 1556 CDT, the Albuquerque controller advised on frequency that Convective SIGMET 86C was current and advised users to tune to HIWAS²³ for further details. It is unknown of the accident airplane obtained the details of the advisory from HIWAS.

Immediately after the accident at 1655 CDT (2155Z) the following advisories were issued, of which Convective SIGMET 90C was current over the accident site for a line of severe thunderstorms. The advisories were as follows:

*MKCC WST 182155
CONVECTIVE SIGMET 89C
VALID UNTIL 2355Z
TX
FROM 30N GGG-40NNE LFK-40E ACT-30ESE TTT-30N GGG
DMSHG AREA TS MOV FROM 19010KT. TOPS ABV FL450.*

*CONVECTIVE SIGMET 90C
VALID UNTIL 2355Z
TX OK NM
FROM 30ESE LBL-10ENE TXO-50SW LBB
LINE SEV TS 20 NM WIDE MOV FROM 22015KT. TOPS TO FL420.
HAIL TO 2 IN...WIND GUSTS TO 60KT POSS.*

*CONVECTIVE SIGMET 92C
VALID UNTIL 2355Z
TX
FROM 40N MAF-50NE MAF-80WNW DLF-60ESE MRF-20NNE FST-40N MAF
DVLPG AREA TS MOV FROM 24010KT. TOPS TO FL440.
OUTLOOK VALID 182355-190355
AREA 2...FROM OBH-ABI-ELD-BTR-70NW LRD-INK-GLD-OBH
REF WW 323.
WST ISSUANCES POSS. REFER TO THE MOST RECENT ACUS01 KWNS FROM THE STORM PREDICTION CENTER
FOR SYNOPSIS AND METEOROLOGICAL DETAILS.*

11.3 SIGMET

SIGMET (WS) are issued at unscheduled interval for areas over 3,000 square miles of severe turbulence, icing, dust storms, or volcanic ash. None were expected or observed outside of convective activity during the period.

²³ Hazardous Inflight Weather Advisory Service (HIWAS) is a continuous broadcast of hazardous weather information which is transmitted over selected VORs. This hazardous weather includes AIRMETs, SIGMETs, Convective SIGMETs, and urgent PIREPs.

11.4 Center Weather Advisory

A Center Weather Advisory (CWA) is another aviation weather warning issued for conditions meeting or approaching SIGMET or AIRMET criteria and are valid for a 2 hour period. The following advisories were issued by Albuquerque (KZAB) and the Dallas-Ft. Worth (KZFW) CWSU's surrounding the period:

FAUS21 KZFW 181904	2014169 1904
ZFW1 CWA 181905	
ZFW CWA 101 VALID UNTIL 182015	
20S TXO	
ISOLD TS...DIAM 10NM...MOV FM 21015KT.	
TOP TO FL460.	
=	
FAUS21 KZFW 181933	2014169 1934
ZFW1 CWA 181933	
ZFW CWA 102 VALID UNTIL 182015	
15SSE TXO	
ISOLD SEV TS...DIAM 15NM...MOV FM 21015KT.	
TOP ABV FL450. HAIL AND WIND GUSTS TO 50KT POSS.	
=	
FAUS22 KZFW 182024	2014169 2025
ZFW2 CWA 182025	
ZFW CWA 201 VALID UNTIL 182130	
FROM 50W LBB-20NE MAF-25NW INK-45E CME-50W LBB	
AREA WDLY SCT TS MOV FM 21015KT. TOPS TO FL450.	
=	
FAUS22 KZFW 182130	2014169 2131
ZFW2 CWA 182130	
ZFW CWA 202 VALID UNTIL 182230	
FROM 40WNW LBB-30ENE MAF-40NW INK-65W LBB-40WNW LBB	
AREA WDLY SCT TS MOV FM 21015KT. TOPS ABV FL450.	
=	
FAUS21 KZAB 182133	2014169 2133
ZAB1 CWA 182132	
ZAB CWA 101 VALID UNTIL 182200	
FROM 65N AMA TO 20N TXO	
LN DVLPG SCT TS. SOME SEV. 30NM WIDE. TOPS TO FL400. LRG HAIL PSBL.	

11.5 AIRMETs

AIRMETs (WA) are issued by the NWS AWC for conditions that may affect aircraft safety, such as moderate turbulence and icing outside of convective activity, sustained surface winds of 30 knots or more, or widespread restricted visibility. The advisories are issued at regular intervals and are valid for a 6 hours period. The following AIRMETs were issued surrounding the period:

WAUS44 KKCI 181445	2014169 1438
WA4S	
DFWS WA 181445	
AIRMET SIERRA UPDT 2 FOR IFR VALID UNTIL 182100	
AIRMET IFR...TX LA	
FROM 20SSE ELD TO 20SE AEX TO 30WSW AEX TO 20NW LFK TO 20SSW GGG TO 20SSE ELD	
CIG BLW 010/VIS BLW 3SM BR. CONDS ENDG 15-16Z.	
....	
WAUS44 KKCI 181445	2014169 1435
WA4T	

DFWT WA 181445
AIRMET TANGO UPDT 2 FOR TURB VALID UNTIL 182100
NO SGFNT TURB EXP OUTSIDE OF CNVTV ACT.

WAUS44 KPCI 181445 2014169 1448
WA4Z
DFWZ WA 181445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 182100
NO SGFNT ICE EXP OUTSIDE OF CNVTV ACT.
FRZLVL...RANGING FROM 135-160 ACRS AREA

WA5Z
-SLCZ WA 181445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 182100
.
AIRMET ICE...ID MT WY NV UT CO WA OR
FROM 70SSW YYN TO 20NE BPI TO 20SW DDY TO 20NNW CHE TO 60E MTU TO 30NNW BVL TO 50N BAM TO
30SSE PDT TO 90WSW YXC TO 70SSW YYN
MOD ICE BTN FRZLVL AND FL200. FRZLVL 070-100. CONDS CONTG BYD 21Z THRU 03Z.
.
FRZLVL...RANGING FROM 070-155 ACRS AREA
080 ALG 40WSW BOI-70ESE REO-60SSW TWF-40SSW JAC-LWT-20SW FCA- 60SW MLP
120 ALG 40WNW BTY-40NNW LAS-50SSE BCE-DVC-30SSW DBL-30NE DBL- 60NW RAP
....

WAUS44 KPCI 181714 AAA
WA4S
-DFWS WA 181714 AMD
AIRMET SIERRA UPDT 3 FOR IFR VALID UNTIL 182100
.
AIRMET IFR...TX LA...UPDT
FROM 20SSE ELD TO 20SE AEX TO 30WSW AEX TO 20NW LFK TO 20SSW GGG TO 20SSE ELD
CANCEL AIRMET. CONDS HV ENDED.
....

11.6 Broadcast of Advisories

The Albuquerque Air Route Traffic Control Center (KZAB) controller at 1530 CDT broadcasted the issuance of KZFW CWA 201 and at 1549 CDT of Convective SIGMET 83C on the frequency and advised users to obtain further information on the nearest Hazardous Inflight Weather Advisory Service (HIWAS) broadcast. No other information relating to the nature of the hazard or the location of the advisories were provided, or mention of the weather watch 323 was made at that time. CWA 202 was issued prior to the accident at 1630 CDT and was not broadcasted by air traffic control until after the accident. A plot of the advisories over the satellite image is included as figure 42, with the accident site within the northern boundary of CWA 201 (green line) and immediately south of the Convective SIGMET 86C (red circle) which was for a severe thunderstorm with a diameter of 20 miles, and within Weather Watch 323 (yellow parallelogram). Center Weather Advisory 202 (red dash line) is also included extending over the accident site.

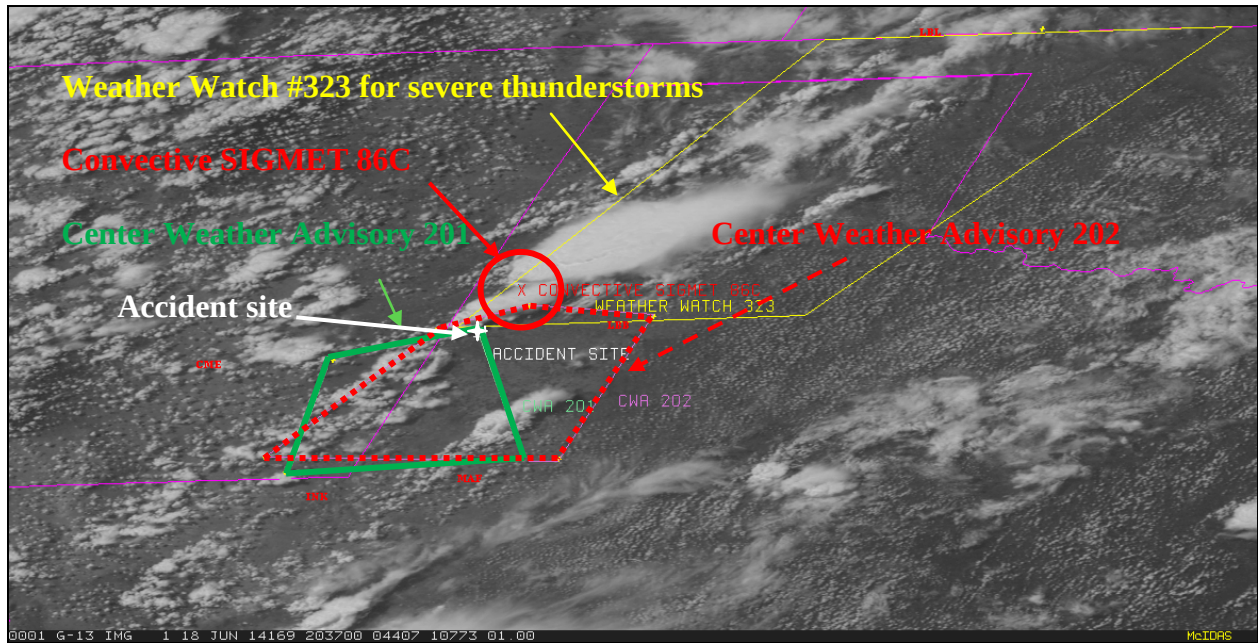


Figure 42 – plot of advisories current at the time of the accident

12.0 Winds and Temperatures Aloft Forecast

The winds and temperature aloft forecast (FD) available at the time of the briefing was as follows:

DATA BASED ON 181200Z

VALID 181800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000	45000	53000
GJT			2408+06	2228+00	2352-15	2366-27	218240	218749	226452	223955	241258
DEN			1909+13	2217+04	2232-10	2044-23	215739	206348	226357	231860	201260
ALS				2324+05	2435-10	2337-22	214138	214347	225457	245965	211562
PUB			2417+13	2418+04	2327-09	2132-22	214638	204948	225457		
TCC		2516	2519+15	2426+06	2232-09	2332-21	233636	245244	245556		
AMA		2514	2614+15	2313+07	2234-10	2129-20	243436	245344	245556	244764	242868
LBB		2112+20	3109+15	2408+08	2126-10	2331-20	244233	245344	245856		
SPS	1924	2126+18	2023+12	2017+07	2016-08	2329-19	253434	244343	254656		
ABI		2028+17	2111+12	2207+07	2111-07	2224-17	253333	243543	243756	254266	242369
DAL	2023	2128+16	1923+11	1818+05	1812-07	2211-17	252433	263443	264056	263365	242172
CLL	1918	1919+16	1821+11	1818+06	1714-07	2207-17	261632	261943	262255		
HOU	1812	1816+16	1919+10	1915+06	1913-07	1907-17	291232	301642	292354	293764	240875
PSX	1821	1821+16	1721+12	1714+06	2013-07	2217-17	230632	300642	292154		

The forecast wind in the vicinity of Lubbock for 27,000 feet was from 235° at approximately 36 knots with a temperature of -26° C.

13.0 Storm Prediction Center Products

The NWS Storm Prediction Center (SPC) located in Norman, Oklahoma and responsible for issuing forecasts and warnings of severe thunderstorms across the United States issued the following products surrounding the period related to the conditions along the flight path of N2428Q.

13.1 Convective Outlook Bulletin

To following Convective Outlook Bulletin supplement the graphic chart (figure 4 in section 1) and was issued at 1124 CDT. The application sections to the accident are highlighted in bold type:

*SPC AC 181624
DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1124 AM CDT WED JUN 18 2014*

VALID 181630Z - 191200Z

...THERE IS A SLGT RISK OF SVR TSTMS FROM PARTS OF THE GREAT PLAINS THROUGH THE GREAT LAKES AND OH VALLEY TO MID ATLANTIC...

...SUMMARY...

SEVERE THUNDERSTORMS ARE EXPECTED OVER MUCH OF THE NORTHERN AND CENTRAL PLAINS AND UPPER MISSISSIPPI VALLEY...AND FROM THE MID-MISSISSIPPI VALLEY AND SOUTHERN GREAT LAKES EASTWARD INTO THE MID-ATLANTIC STATES. MORE ISOLATED SEVERE STORMS MAY OCCUR FROM WESTERN AND CENTRAL KANSAS SOUTHWARD INTO WEST TEXAS. LARGE HAIL AND DAMAGING WINDS WILL BE THE MAIN THREATS...BUT TORNADES ALSO MAY OCCUR...ESPECIALLY OVER PARTS OF SOUTH DAKOTA.

...SYNOPSIS...

A MID TO UPPER-LEVEL LOW AND ASSOCIATED TROUGH FROM THE NRN INTER-MOUNTAIN REGION TO SWRN DESERTS WILL ASSUME AN INCREASING NEGATIVE TILT IN RESPONSE TO THE PROGRESSION OF A POTENT VORTICITY MAXIMUM FROM THE GREAT BASIN INTO NRN HIGH PLAINS. DOWNSTREAM FROM THESE DEVELOPMENTS...A SERIES OF VORTICITY MAXIMA WILL PROGRESS SEWD AROUND AN UPPER LOW CENTERED OVER FAR NERN CANADA...ENHANCING MIDDLE LEVEL FLOW AND FORCING FOR ASCENT ACROSS THE NERN U.S.

AT THE SURFACE...AN AREA OF LOW PRESSURE OVER CNTRL NEB WILL DEVELOP NEWD INTO NERN SD/SERN ND BY 19/12Z...WHILE AN ASSOCIATED COLD FRONT ADVANCES EWD THROUGH THE DAKOTAS.. AND SEWD THROUGH THE CNTRL HIGH PLAINS. A DRYLINE WILL SHARPEN TODAY FROM THE VICINITY OF THIS LOW PRESSURE SSWWD THROUGH WRN OR CNTRL KS INTO WRN TX. MEANWHILE...A WARM FRONT WHICH HAS BEEN REINFORCED BY CONVECTIVE OUTFLOW WILL ATTEMPT TO MOVE NWD THROUGH PARTS OF THE MID MO VALLEY AND MIDWEST. THE LOCATION OF THIS BOUNDARY WILL LIKELY FLUCTUATE LATITUDINALLY ACROSS THE SRN GREAT LAKES/NRN OH VALLEY OWING TO THE EFFECTS OF CONVECTIVE OUTFLOW. FARTHER E...THIS BOUNDARY WILL SLOWLY SETTLE SWD INTO THE MID ATLANTIC STATES AS A COLD FRONT.

...DAKOTAS/MID MO VALLEY THIS AFTERNOON INTO TONIGHT...

THE CO-LOCATION OF A VERY MOIST BOUNDARY LAYER WITH A PRONOUNCED EML WILL ONCE AGAIN YIELD STRONG TO EXTREME INSTABILITY TODAY FROM PARTS OF ERN NEB/WRN IA INTO SERN SD WITH MLCAPES APPROACHING 3000-4500 J/KG. WHERE STRONGER HEATING CAN OCCUR FROM CNTRL SD INTO ND

ALONG THE EWD-MOVING COLD FRONT OR INVERTED TROUGH...AFTERNOON MLCAPE MAY RISE INTO THE 1000-2000 J/KG RANGE.

THE ERN EDGE OF HEIGHT FALLS/FORCING FOR ASCENT ATTENDANT TO THE UPPER TROUGH EDGING EWD INTO THE NRN HIGH PLAINS WILL ENHANCE DEEP-LAYER ASCENT ALONG THE INVERTED ROUGH/COLD FRONT TO FOSTER WIDELY SCATTERED SURFACE-BASED TSTMS THIS AFTERNOON FROM CNTRL SD INTO PARTS OF WRN/CNTRL ND. OTHER MORE ISOLATED STORMS WILL BE POSSIBLE THIS AFTERNOON INTO EVENING AHEAD OF THE SURFACE LOW AND ALONG THE WARM FRONT OVER SERN SD INTO SWRN MN/NWRN IA. THE MOST FAVORABLE OVERLAP OF VERTICAL SHEAR AND INSTABILITY WILL RESIDE FROM S-CNTRL ND INTO CNTRL SD WHERE SUPERCELLS CAPABLE OF LARGE HAIL...DAMAGING WINDS A FEW TORNADOES ARE POSSIBLE.

FARTHER E ALONG THE WARM FRONT...STRONGER VERTICAL SHEAR WILL LARGELY BE CONFINED TO THE LOWEST 3-4 KM WITH GENERALLY WEAK FLOW IN THE UPPER TROPOSPHERE. NONETHELESS...THE PRESENCE OF EXTREME INSTABILITY AND AMPLE LOW-LEVEL SHEAR INVOF OF THE SURFACE LOW AND WARM FRONT SUGGEST A VERY LARGE HAIL AND TORNADO THREAT GIVEN STORM DEVELOPMENT AND SUSTENANCE.

...CNTRL/SRN PLAINS THIS AFTERNOON/EVENING...

MORNING WATER VAPOR IMAGERY INDICATES THE PRESENCE OF A WEAK PERTURBATION OVER NM WHICH WILL PRECEDE THE STRONGER GREAT BASIN IMPULSE INTO THE CNTRL/SRN HIGH PLAINS TODAY. FORCING FOR ASCENT ASSOCIATED WITH THIS FEATURE WILL LIKELY PROMOTE WIDELY SCATTERED TSTM DEVELOPMENT ALONG THE DRYLINE THIS AFTERNOON FROM PORTIONS OF S-CNTRL NEB/N-CNTRL KS INTO WRN TX. THE 12Z ABQ SOUNDING SAMPLED 40 KT SWLY FLOW IN THE 4-5 KM AGL LAYER WHICH SHOULD ENHANCE VERTICAL SHEAR AMIDST A THERMODYNAMIC ENVIRONMENT CHARACTERIZED BY MLCAPE OF 2000-3000+ J/KG. AS SUCH...THE POTENTIAL WILL EXIST FOR SUPERCELL AND ORGANIZED MULTICELL MORPHOLOGIES WITH A RISK FOR DAMAGING WINDS AND LARGE HAIL.

A SEPARATE AREA OF TSTMS MAY EVOLVE THIS AFTERNOON WITHIN AN INCREASING LOW-LEVEL UPSLOPE REGIME DEVELOPING WITHIN THE POST-FRONTAL ENVIRONMENT FROM THE CHEYENNE RIDGE TO PALMER DIVIDE. AMPLE VERTICAL SHEAR AND SUFFICIENT BUOYANCY WILL EXIST FOR ORGANIZED STORMS INCLUDING SUPERCELLS WITH A LARGE HAIL AND DAMAGING WIND THREAT DEVELOPING FROM SERN WY/NERN CO INTO PARTS OF WRN NEB BY LATE THIS EVENING.

...GREAT LAKES/MIDWEST INTO MID ATLANTIC THIS AFTERNOON INTO TONIGHT...

REGIONAL RADAR IMAGERY SHOWS A WELL-DEFINED BOW ECHO AND ASSOCIATED MCV OVER WI AND ADJACENT LAKE MI WITH THE TRAILING EXTENSION OF THIS SYSTEM STRETCHING INTO NRN IL. EXPECT THIS MCS TO CONTINUE ESEWD TODAY...LIKELY INCREASING IN INTENSITY ALONG ITS SRN FLANK INVOF THE SURFACE FRONT WHERE DAYTIME HEATING AND BOUNDARY-LAYER DEWPOINTS IN THE UPPER 60S TO LOWER 70S WILL BOOST MLCAPE TO 2000-3000+ J/KG. WHEN COUPLED WITH A UNIDIRECTIONAL WIND PROFILE WITH MODEST DEEP-LAYER SPEED SHEAR...THE SETUP WILL BE SUPPORTIVE OF DAMAGING WINDS AND SOME HAIL.

PERSISTENT LOW-LEVEL WAA IN THE WAKE OF THIS MCS MAY SUPPORT RENEWED TSTM DEVELOPMENT LATER TODAY INTO TONIGHT ALONG AND TO THE N OF THE OUTFLOW-WARM FRONT COMPOSITE BOUNDARY OVER PORTIONS OF IA...IL...SERN MN...WI WHERE SOME LARGE HAIL AND/OR DAMAGING WINDS ARE POSSIBLE.

FARTHER TO THE E FROM THE LOWER GREAT LAKES INTO MID ATLANTIC...CONVECTIVE EVOLUTION IS A BIT MORE UNCLEAR. HOWEVER...THE PRESENCE OF THE SYNOPTIC FRONT...CONVECTIVE OUTFLOW BOUNDARY ASSOCIATED WITH A RECENTLY DECAYED MCS OVER CNTRL PA AND GRADUAL HEIGHT FALLS ON THE SRN PERIPHERY OF THE ERN CANADA TROUGH MAY FOSTER WIDELY SCATTERED TSTMS THIS AFTERNOON INTO EVENING. MLCAPE OF 1500-2500 J/KG COUPLED WITH STRENGTHENING MIDLEVEL FLOW AND RESULTANT VERTICAL SHEAR WILL BE SUPPORTIVE OF ORGANIZED STORM MODES CAPABLE OF DAMAGING WINDS AND LARGE HAIL.

..MEAD/MOSIER.. 06/18/2014

13.2 Mesoscale Discussion

The NWS SPC issued a Mesoscale Discussion (MCD) number 1063 at 1419 CDT for an area from western Kansas and Oklahoma southwestward into western Texas for an area they were monitoring for severe thunderstorm development and the issuance of a weather watch in the next several hours. Figure 43 is the graphic with the bulletin following. The accident site was located within the region of the area where scattered strong to severe thunderstorms were expected and immediately along the dry line.

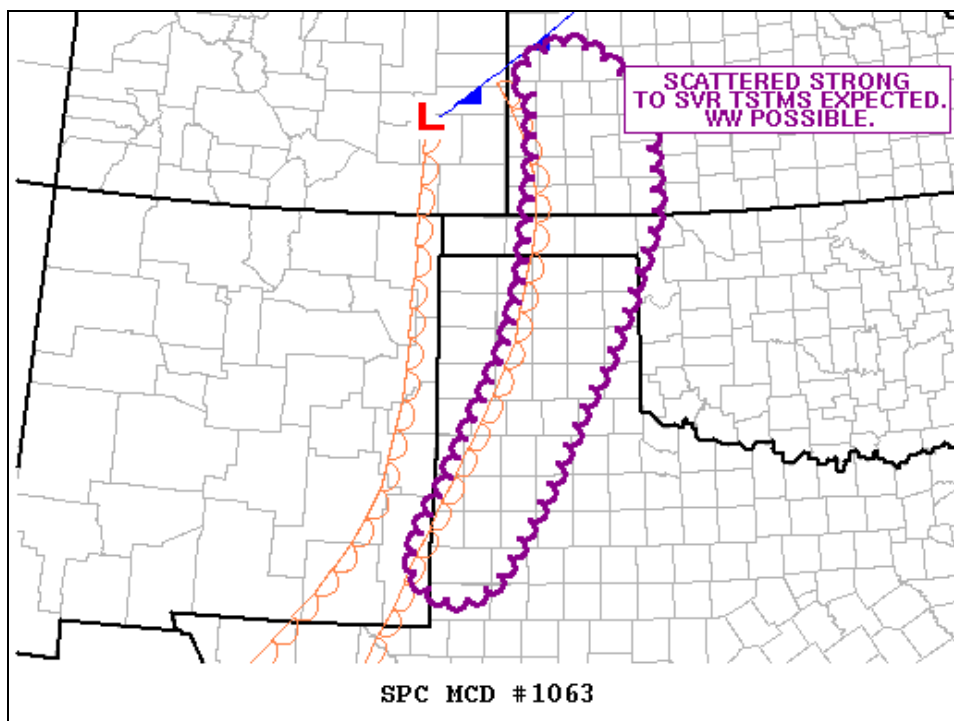


Figure 42- Mesoscale Discussion #1063 issued at 1419 CDT

MESOSCALE DISCUSSION 1063
NWS STORM PREDICTION CENTER NORMAN OK
0219 PM CDT WED JUN 18 2014

AREAS AFFECTED...WRN KS...OK/TX PANHANDLE...TX S PLAINS

CONCERNING...SEVERE POTENTIAL...WATCH POSSIBLE

VALID 181919Z - 182015Z

PROBABILITY OF WATCH ISSUANCE...60 PERCENT

SUMMARY...CONVECTIVE INITIATION IS EXPECTED WITHIN THE NEXT HOUR OR TWO ACROSS THE SRN HIGH PLAINS. SCATTERED STRONG TO SVR TSTMS ARE EXPECTED WITH ONE OR MORE WATCHES POSSIBLY NEEDED TO COVER THE THREAT. PRIMARY SVR THREAT WILL LIKELY BE SVR HAIL WITH A SECONDARY THREAT OF DAMAGING WINDS.

DISCUSSION...VISIBLE SATELLITE IMAGERY SHOWS INCREASED CU ACROSS SW KS AND ALONG THE TX/NM BORDER E OF CVS. MID/UPPER LEVEL CLOUDINESS MAY BE OBSCURING SOME CU AROUND AMA AS WELL. DIURNAL HEATING CONTINUES TO DESTABILIZE AN ENVIRONMENT CHARACTERIZED BY DEWPOINTS

IN THE LOW TO MID 60S AND STEEP MID-LEVEL LAPSE RATES. SURFACE ANALYSIS REVEALS A DUAL DRYLINE STRUCTURE WITH THE LEADING DRYLINE EXTENDING FROM SW KS SSWWD ACROSS THE OK AND TX PANHANDLES AND TX S PLAINS. THE SECONDARY DRYLINE EXTENDS SWD FROM A LOW IN SE CO ACROSS FAR WRN NM. TSTM DEVELOPMENT IS MOST LIKELY ALONG THE LEADING DRYLINE BUT SOME ADDITIONAL DEVELOPMENT IS POSSIBLE ALONG THE SECONDARY DRYLINE. SATELLITE IMAGERY ALSO REVEALS A SHORTWAVE TROUGH OVER NE NM MOVING INTO SW KS.

OBJECTIVE ANALYSIS ESTIMATES MLCAPE FROM 1500 TO 2500 J PER KG ALONG AND AHEAD OF THE LEADING DRYLINE. LOW-LEVEL SWLY FLOW IS GENERALLY AROUND 10 TO 15 KT WITH REGIONAL VAD WIND PROFILES SUGGESTING MID-LEVEL SWLY FLOW AROUND 20 KT. THE RESULT IS A WEAKLY SHEARED PROFILE. HOWEVER...BULK SHEAR WILL GRADUALLY INCREASE THROUGHOUT THE AFTERNOON AND INTO THE EVENING WITH STORMS EXPECTED TO GRADUALLY INTENSIFY AS THEY MOVE EWD.

SCATTERED STRONG TO SEVERE TSTMS ARE EXPECTED WITH THE PRIMARY THREAT OF SEVERE HAIL. SOME DAMAGING WINDS ARE ALSO POSSIBLE. ONE OR MORE WATCHES MAY BE NEEDED TO ADDRESS THIS SVR THREAT.

..MOSIER/MEAD.. 06/18/2014

ATTN...WFO...OUN...DDC...GLD...LUB...AMA...MAF...

LAT...LON 35930182 38310157 38780183 39160100 38559996 37399971
36809979 35100060 32480223 32720331 34100267 35930182

13.3 Weather Watch

The NWS SPC issued Weather Watch number 323 at 1450 CDT for sections of western Oklahoma and western Texas, and included the accident site. The advisory warned that conditions were favorable for the development of severe thunderstorms with the potential for large hail and damaging winds. Figure 44 is the weather watch and counties under the advisory along with the initial radar mosaic across the region at the time of issuance. Note that Cochran County where the accident occurs is within the general weather watch, and immediately bordered south of the aviation Severe Weather Forecast Alert box indicated in light purple.

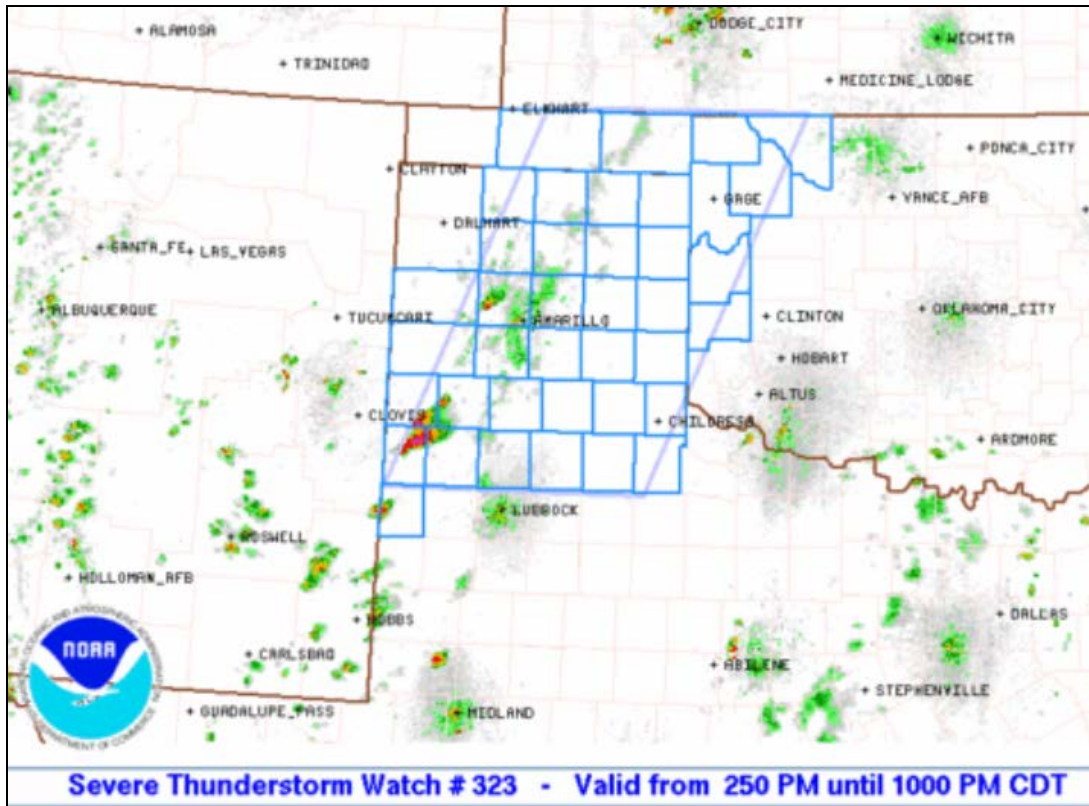


Figure 43 - Weather Watch number 323 issued at 1450 CDT

The advisory indicated that thunderstorms were already developing along and ahead of the dry line and were expected to increase in coverage and intensity while moving northeastward across the watch area during the afternoon and into the evening. The thunderstorms were expected to produce large hail to potentially 2 inches and damaging winds of 60 knots, and extreme turbulence. While a watch means conditions are favorable for severe thunderstorms in or close to the watch area, individuals in those areas are recommended to remain on the lookout for threatening weather conditions and stay alert for additional statements and warnings. The full text of the advisory was as follows:

SEL3

*URGENT - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WATCH NUMBER 323
NWS STORM PREDICTION CENTER NORMAN OK
250 PM CDT WED JUN 18 2014*

THE NWS STORM PREDICTION CENTER HAS ISSUED A

** SEVERE THUNDERSTORM WATCH FOR PORTIONS OF
WESTERN OKLAHOMA INCLUDING MUCH OF THE PANHANDLE
WESTERN TEXAS INCLUDING THE PANHANDLE*

** EFFECTIVE THIS WEDNESDAY AFTERNOON AND EVENING FROM 250 PM UNTIL 1000 PM CDT.*

** PRIMARY THREATS INCLUDE...
ISOLATED VERY LARGE HAIL EVENTS TO 2 INCHES IN DIAMETER POSSIBLE ISOLATED
DAMAGING WIND GUSTS TO 70 MPH POSSIBLE*

THE SEVERE THUNDERSTORM WATCH AREA IS APPROXIMATELY ALONG AND 75 STATUTE MILES EAST AND WEST OF A LINE FROM 25 MILES SOUTH OF PLAINVIEW TEXAS TO 55 MILES NORTH NORTHWEST OF GAGE OKLAHOMA. FOR A COMPLETE DEPICTION OF THE WATCH SEE THE ASSOCIATED WATCH OUTLINE UPDATE (WOUS64 KWNS WOU3).

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A SEVERE THUNDERSTORM WATCH MEANS CONDITIONS ARE FAVORABLE FOR SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDITIONS AND LISTEN FOR LATER STATEMENTS AND POSSIBLE WARNINGS. SEVERE THUNDERSTORMS CAN AND OCCASIONALLY DO PRODUCE TORNADOES.

&&

OTHER WATCH INFORMATION...CONTINUE...WW 321... WW 322...

DISCUSSION...THUNDERSTORMS DEVELOPING ALONG THE DRYLINE ARE EXPECTED TO INCREASE IN COVERAGE AND INTENSITY WHILE MOVING NORTHEAST ACROSS THE WATCH AREA THIS AFTERNOON INTO EVENING. LARGE HAIL AND DAMAGING WINDS WILL BE THE PRIMARY HAZARDS WITH THESE STORMS.

AVIATION...A FEW SEVERE THUNDERSTORMS WITH HAIL SURFACE AND ALOFT TO 2 INCHES. EXTREME TURBULENCE AND SURFACE WIND GUSTS TO 60 KNOTS. A FEW CUMULONIMBI WITH MAXIMUM TOPS TO 550. MEAN STORM MOTION VECTOR 24020.

...MEAD

14.0 Severe Weather Statements

The NWS Lubbock Weather Service Forecast Office (WSFO) issued two hazardous weather outlooks at 1117 and 1516 CDT for the potential development of severe thunderstorms and then several severe weather alerts for the general public of northwest Texas for existing severe storms. The accident site was located in Cochran County, Texas, and where located within the boundaries of several of the advisories, which were as follows:

FLUS44 KLUB 181617

2014169 1617

HWOLUB

HAZARDOUS WEATHER OUTLOOK

NATIONAL WEATHER SERVICE LUBBOCK TX

1117 AM CDT WED JUN 18 2014

TXZ021>044-191630-

PARMER-CASTRO-SWISHER-BRISCOE-HALL-CHILDRESS-BAILEY-LAMB-HALE-FLOYD-MOTLEY-COTTLE-COCHRAN-HOCKLEY-LUBBOCK-CROSBY-DICKENS-KING-YOAKUM-TERRY-LYNN-GARZA-KENT-STONEWALL-

1117 AM CDT WED JUN 18 2014

THIS HAZARDOUS WEATHER OUTLOOK IS FOR THE EXTREME SOUTHERN TEXAS PANHANDLE...SOUTH PLAINS AND ROLLING PLAINS.

.DAY ONE...THIS AFTERNOON AND TONIGHT

CONVECTIVE

SCATTERED THUNDERSTORMS ARE EXPECTED TO DEVELOP LATER THIS AFTERNOON...MAINLY ON THE CAPROCK. A FEW OF THESE STORMS COULD BE SEVERE WITH DAMAGING WIND GUSTS UP TO 65 MPH...GOLF BALL SIZED HAIL...AND LOCALIZED FLOODING.

.DAYS TWO THROUGH SEVEN...THURSDAY THROUGH TUESDAY

A CHANCE OF ISOLATED TO SCATTERED THUNDERSTORMS ACROSS THE HAZARDOUS OUTLOOK AREA...MAY OCCUR EVERY AFTERNOON AND EVENING FROM THURSDAY THROUGH SATURDAY. ALTHOUGH WIDESPREAD SEVERE WEATHER IS NOT EXPECTED...AN ISOLATED STRONG OR SEVERE THUNDERSTORM WILL BE POSSIBLE. IN ADDITION...SLOW MOVING THUNDERSTORMS MAY BRING THE THREAT FOR LOCALLY HEAVY RAIN.

.SPOTTER INFORMATION STATEMENT...

SPOTTER ACTIVATION MAY BE REQUESTED LATE THIS AFTERNOON OR EARLY THIS EVENING.

\$\$

FLUS44 KLUB 182016

2014169 2016

HWOLUB

HAZARDOUS WEATHER OUTLOOK

NATIONAL WEATHER SERVICE LUBBOCK TX

316 PM CDT WED JUN 18 2014

TXZ021>044-192030-

PARMER-CASTRO-SWISHER-BRISCOE-HALL-CHILDRESS-BAILEY-LAMB-HALE-FLOYD-MOTLEY-COTTLE-
COCHRAN-HOCKLEY-LUBBOCK-CROSBY-DICKENS-KING-YOAKUM-TERRY-LYNN-GARZA-KENT-STONEWALL-
316 PM CDT WED JUN 18 2014

THIS HAZARDOUS WEATHER OUTLOOK IS FOR THE EXTREME SOUTHERN TEXAS PANHANDLE...SOUTH PLAINS
AND ROLLING PLAINS.

.DAY ONE...THIS AFTERNOON AND TONIGHT

CONVECTIVE

SCATTERED THUNDERSTORMS WILL DEVELOP THIS AFTERNOON AND EVENING...MAINLY ON THE CAPROCK
THROUGH THE FAR SOUTHERN TEXAS PANHANDLE AND NORTHERN ROLLING PLAINS. A FEW OF THESE
STORMS WILL BE SEVERE WITH DAMAGING WIND GUSTS UP TO 65 MPH...GOLF BALL SIZED HAIL...AND
LOCALIZED FLOODING.

.DAYS TWO THROUGH SEVEN...THURSDAY THROUGH TUESDAY

A CHANCE OF ISOLATED TO SCATTERED THUNDERSTORMS ACROSS THE HAZARDOUS OUTLOOK AREA...MAY
OCCUR EVERY AFTERNOON AND EVENING FROM THURSDAY THROUGH SATURDAY. ALTHOUGH
WIDESPREAD SEVERE WEATHER IS NOT EXPECTED...AN ISOLATED STRONG OR SEVERE THUNDERSTORM
WILL BE POSSIBLE. IN ADDITION...SLOW MOVING THUNDERSTORMS MAY BRING THE THREAT FOR LOCALLY
HEAVY RAIN.

.SPOTTER INFORMATION STATEMENT...

SPOTTER ACTIVATION IS REQUESTED THIS AFTERNOON AND EVENING ON THE CAPROCK AND THROUGH
THE FAR SOUTHERN TEXAS PANHANDLE INTO THE NORTHERN ROLLING PLAINS.

\$\$

The first severe weather advisory was issued at 1542 CDT for the counties immediately north of the accident site along the general flight path of N2428Q, followed by a severe thunderstorm warning issued at 1621 CDT for the Lehman area. The advisory warned of severe thunderstorms with large hail to 1.25 inches or "half dollar" size hail and wind gusts to 60 mph. The advisories were as follows:

WUUS54 KLUB 182042

2014169 2042

SVRLUB

TXC017-279-182130-

/O.NEW.KLUB.SV.W.0082.140618T2042Z-140618T2130Z/

BULLETIN - IMMEDIATE BROADCAST REQUESTED

SEVERE THUNDERSTORM WARNING

NATIONAL WEATHER SERVICE LUBBOCK TX

342 PM CDT WED JUN 18 2014

THE NATIONAL WEATHER SERVICE IN LUBBOCK HAS ISSUED A

* SEVERE THUNDERSTORM WARNING FOR...

NORTHEASTERN BAILEY COUNTY IN NORTHWEST TEXAS...

NORTHERN LAMB COUNTY IN NORTHWEST TEXAS...

* UNTIL 430 PM CDT

* AT 339 PM CDT...A SEVERE THUNDERSTORM WAS LOCATED 9 MILES WEST OF EARTH...AND MOVING EAST
AT 15 MPH.

HAZARD...60 MPH WIND GUSTS AND HALF DOLLAR SIZE HAIL.

SOURCE...RADAR INDICATED.

IMPACT...HAIL DAMAGE TO VEHICLES IS EXPECTED. EXPECT WIND DAMAGE TO ROOFS...SIDING AND
TREES.

* LOCATIONS IMPACTED INCLUDE... EARTH AND SPRINGLAKE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

FOR YOUR PROTECTION MOVE TO AN INTERIOR ROOM ON THE LOWEST FLOOR OF A BUILDING.

&&
LAT...LON 3428 10272 3432 10254 3431 10221 3412 10217 3410 10272
TIME...MOT...LOC 2042Z 261DEG 14KT 3421 10255&
HAIL...1.25IN
WIND...60MPH
\$\$
RCB

WUUS54 KLUB 182121 2014169 2122
SVRLUB
TXC079-219-182145-
/O.NEW.KLUB.SV.W.0083.140618T2121Z-140618T2145Z/
BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE LUBBOCK TX
421 PM CDT WED JUN 18 2014
THE NATIONAL WEATHER SERVICE IN LUBBOCK HAS ISSUED A
* SEVERE THUNDERSTORM WARNING FOR...
EAST CENTRAL COCHRAN COUNTY IN NORTHWEST TEXAS...
WEST CENTRAL HOCKLEY COUNTY IN NORTHWEST TEXAS...
* UNTIL 445 PM CDT
* AT 421 PM CDT...A SEVERE THUNDERSTORM WAS LOCATED 6 MILES EAST OF LEHMAN...AND MOVING EAST
AT 20 MPH.
HAZARD...60 MPH WIND GUSTS AND HALF DOLLAR SIZE HAIL.
SOURCE...RADAR INDICATED.
IMPACT...HAIL DAMAGE TO VEHICLES IS EXPECTED. EXPECT WIND DAMAGE TO ROOFS...SIDING AND
TREES.
* LOCATIONS IMPACTED INCLUDE...WHITEFACE.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
FOR YOUR PROTECTION MOVE TO AN INTERIOR ROOM ON THE LOWEST FLOOR OF A BUILDING.

&&
LAT...LON 3374 10239 3351 10240 3356 10280 3374 10279
TIME...MOT...LOC 2122Z 273DEG 16KT 3364 10269
HAIL...1.25IN
WIND...60MPH
\$\$
RCB

WUUS54 KLUB 182144 2014169 2144
SVRLUB
TXC079-219-182230-
/O.NEW.KLUB.SV.W.0084.140618T2144Z-140618T2230Z/
BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE LUBBOCK TX
444 PM CDT WED JUN 18 2014
THE NATIONAL WEATHER SERVICE IN LUBBOCK HAS ISSUED A
* SEVERE THUNDERSTORM WARNING FOR...
EAST CENTRAL COCHRAN COUNTY IN NORTHWEST TEXAS...
WEST CENTRAL HOCKLEY COUNTY IN NORTHWEST TEXAS...
* UNTIL 530 PM CDT
* AT 442 PM CDT...A SEVERE THUNDERSTORM WAS LOCATED 7 MILES EAST OF LEHMAN...AND MOVING EAST
AT 10 MPH.
HAZARD...60 MPH WIND GUSTS AND HALF DOLLAR SIZE HAIL.
SOURCE...RADAR INDICATED.
IMPACT...HAIL DAMAGE TO VEHICLES IS EXPECTED. EXPECT WIND DAMAGE TO ROOFS...SIDING AND
TREES.
* LOCATIONS IMPACTED INCLUDE... WHITEFACE.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
FOR YOUR PROTECTION MOVE TO AN INTERIOR ROOM ON THE LOWEST FLOOR OF A
BUILDING.

&&
LAT...LON 3376 10240 3351 10239 3353 10278 3371 10278
TIME...MOT...LOC 2144Z 268DEG 8KT 3362 10266
HAIL...1.25IN
WIND...60MPH
\$\$
RCB

15.0 Center Weather Service Unit Briefings

The Albuquerque (ZABQ) Center and Center Weather Service Unit (CWSU) were visited on June 24-25 by the NTSB investigators and the Dallas-Fort Worth (ZDFW) on June 26-27, 2014. During the visits the Safety Board investigators were provided a general briefing of the Center's general flight activity, area responsibility, and their activities on the day of the accident, along with a play back of the radar display, weather and audio of the event relating to N2428Q. The individual controllers handling the flight were interviewed by the Air Traffic Control Chairmen and working group, while the Meteorology Chairman interviewed the CWSU.

Both CWSU's were adequately staffed for their normal hours of operation from 0530 to approximately 2200 daily. At the Dallas center it was discovered that the CWSU has a standing agreement from FAA management to authorize extra hours as needed to staff the unit after or prior to normal hours during periods when adverse weather conditions are anticipated to significantly impact the center's airspace or major terminals, thus extending their operations as weather conditions threaten the region.²⁴ The CWSU indicated this has helped them to manage their schedule and coordinate between personnel when adverse weather conditions threaten, and provided an extra level of meteorological expertise to the center during off hours.

The CWSU's primary responsibility is to provide formal weather briefings to the FAA supervisors within the center for the day and evening shifts, and also provide verbal briefings to individual controllers and other air traffic control facilities in their airspace, as well as other meteorological support as necessary. The CWSU meteorologists described their primary 2 types of formal forecast products issued; a Meteorological Impact Statement (MIS)²⁵ and a Center Weather Advisory (CWA)²⁶, which is equivalent to a SIGMET but issued for a smaller region and for a shorter duration period. Both center's actively issued alerts during the period warning of potential convective activity ahead of the dry line and are included in the adverse weather advisories documented in section 11-4 of this report.

²⁴ The NTSB had made a similar recommendation for staffing of CWSU as a result of the American Airlines flight 1420 accident in Little Rock, Arkansas, on June 1, 1999. The FAA was not able to implement that recommendation due to budget constraints, and was closed by the NTSB as unacceptable action.

²⁵ A Meteorological Impact Statement (MIS) is a 4 to 12 hour planning forecast of weather conditions expected to impact the center airspace.

²⁶ The Center Weather Advisory (CWA) is a short-term warning of hazardous weather conditions provided to all aviation interests, including pilots, towers, flight service stations, and commercial airlines. Thus, a CWA is similar to, but more localized than, the AIRMETs and SIGMETs issued by the AWC.

Both the ZAB and ZFW CWSU meteorologists in their briefings during the period discussed potential thunderstorms for the afternoon period. There was no mention of the potential for severe thunderstorm development, or large hail or damaging winds from the storms. The Meteorologist-In-Charge (MIC) in both centers indicated that they treated all thunderstorms the same with regards to their briefings, which they indicated implied moderate and greater turbulence potential and all should be avoided. The briefings from each CWSU's are included below.

Both CWSU's also participate and help create the Collaborative Convective Forecast Product (CCFP) every 2-hours with the NWS Aviation Weather Center, the Washington Command Center, other NWS forecast offices and other air carrier meteorology groups for example in the Texas area typically includes American and Southwest Airlines input. The CCFP products are also usually included in the daily weather briefings.

Both CWSU's indicated that they produce their briefing products and indicate weather areas where controllers are urged to solicit pilot reports. While they do not receive the pilot reports directly themselves, the controllers are provided pilot report forms to fill out, and provide to the Traffic Management Unit (TMU) for entry into the FAA Enroute Decision Support Tool (EDST), which displays and delivers the data into the FAA and NWS database. Both Center Weather Service Units were not aware of any significant pilot reports issued surrounding the period.

While at the KZAB Center and during the replay of the radar and communication events relating to N242Q it was noted that at approximately 1600 CDT a United States Marine Corps F-18 Hornet, with a call sign "Cowboy 31" penetrated an area of precipitation within 20 miles of N2428Q, which they had previously deviated around. The pilot of Cowboy 31 reported encountered significant clear icing conditions at 25,000 feet and immediately requested a lower altitude to avoid the icing conditions. The controller operating the sector approved the descent and continued with his normal duties. No pilot report was submitted regarding this event.

15.1 Albuquerque CWSU Briefing

The regional outlook for pilot report solicitation issued by the KZAB CWSU during the period is included as figure 45. The chart was used in the general weather briefing to the supervisors and the chart posted at all sectors of the facility for reference. The chart indicated that after 1430 CDT (19130Z) isolated to scattered thunderstorms were expected over the eastern portion of the centers airspace, which included the accident site. No organized areas of icing or turbulence were expected outside of convective activity.

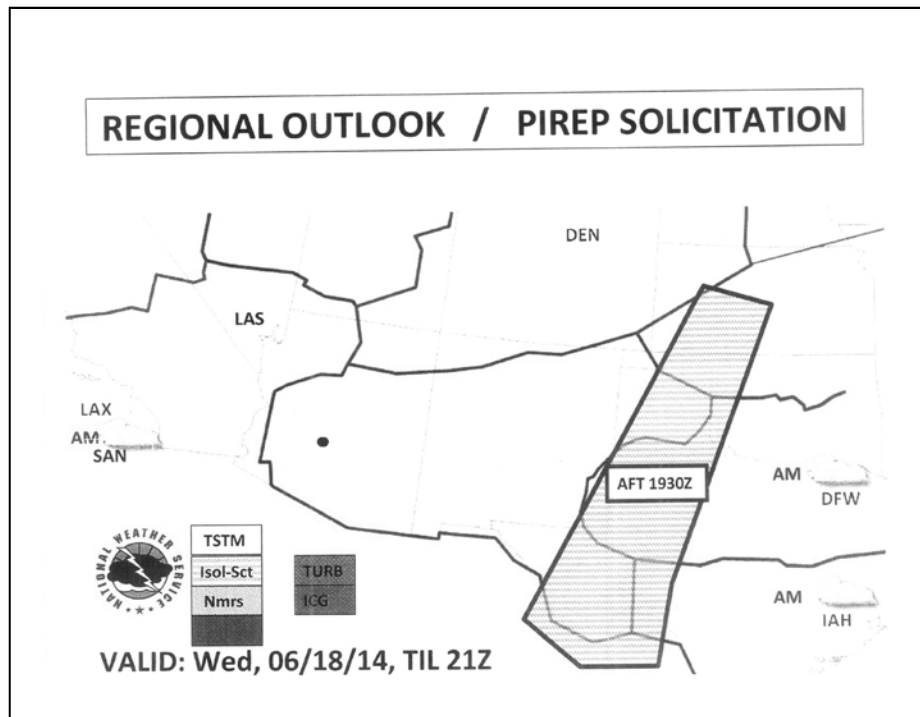


Figure 45- KZAB CWSU briefing slide for June 18, 2014

15.2 Ft. Worth CWSU Briefing

Several of the relevant KZFW CWSU afternoon briefing slides are included below discussing potential convective activity over the region and the Collaborative Convective Forecast Product (CCFP) issued surrounding the period.

Figure 46 was the first briefing slide of the initial synoptic conditions over the area at 1400 CDT (1900Z) on June 18, 2014, and displayed the primary surface features and wind over a GOES-13 visible satellite image. The dry line position over eastern New Mexico was identified with a scalloped area ahead of the dry line from western Kansas, Oklahoma panhandle, and western Texas, where scattered rain showers were identified moving northeast at 15 knots, with tops to 20,000 to 26,000 feet. A small area was identified within that area that warned of an isolated thunderstorm moving northeast at 15 knots with tops above 45,000 feet, which was in the immediate vicinity of the accident site. VFR conditions were expected to prevail across the region outside of convective activity.

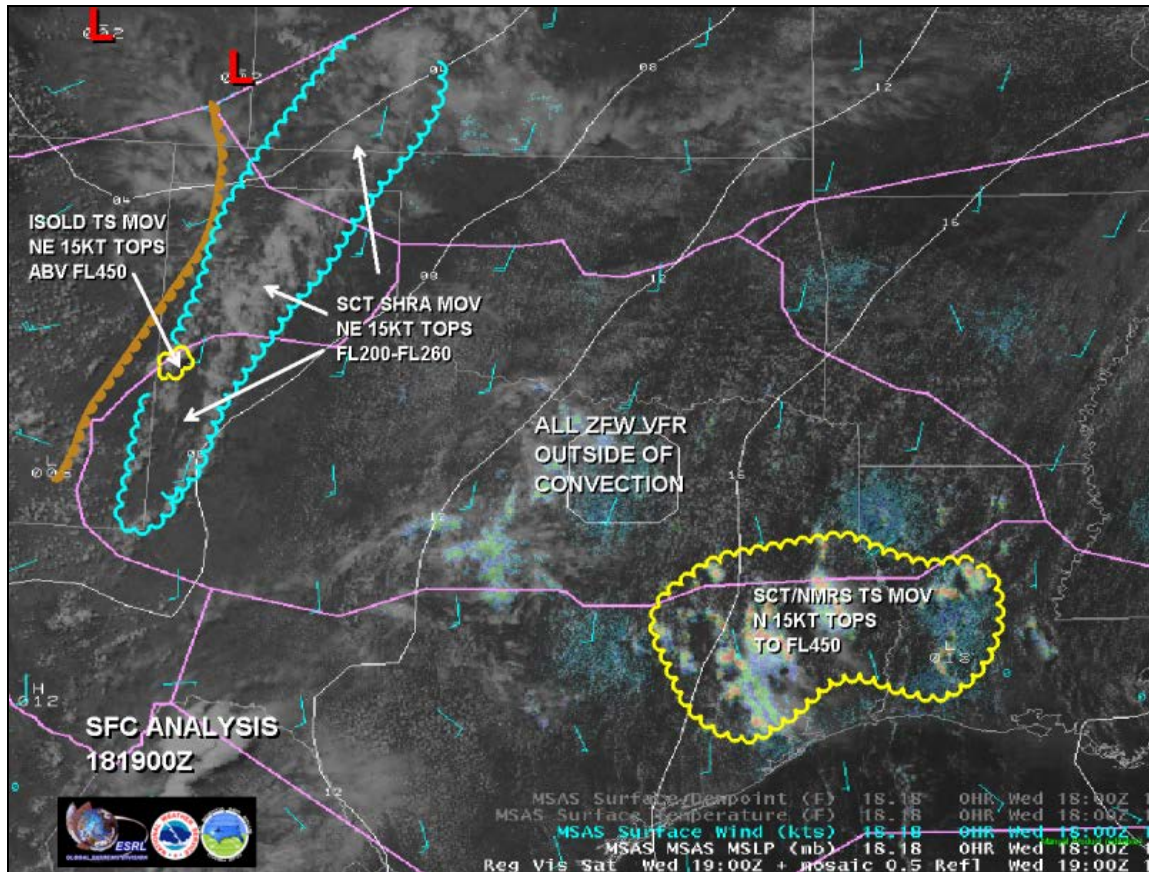


Figure 44 - KZFW synoptic conditions briefing slide at 1400 CDT

Figure 47 is the KZFW CWSU surface forecast for the afternoon on June 18, 2014. The forecast graphic depicted the dry line in western Texas panhandle with an area of numerous rain showers and scattered thunderstorms increasing in coverage along and ahead of the dry line over western Texas, moving northeast at 15 knots. The tops of the thunderstorms were expected to be occasionally above 45,000 feet. The activity was expected to diminish after 2300 CDT.

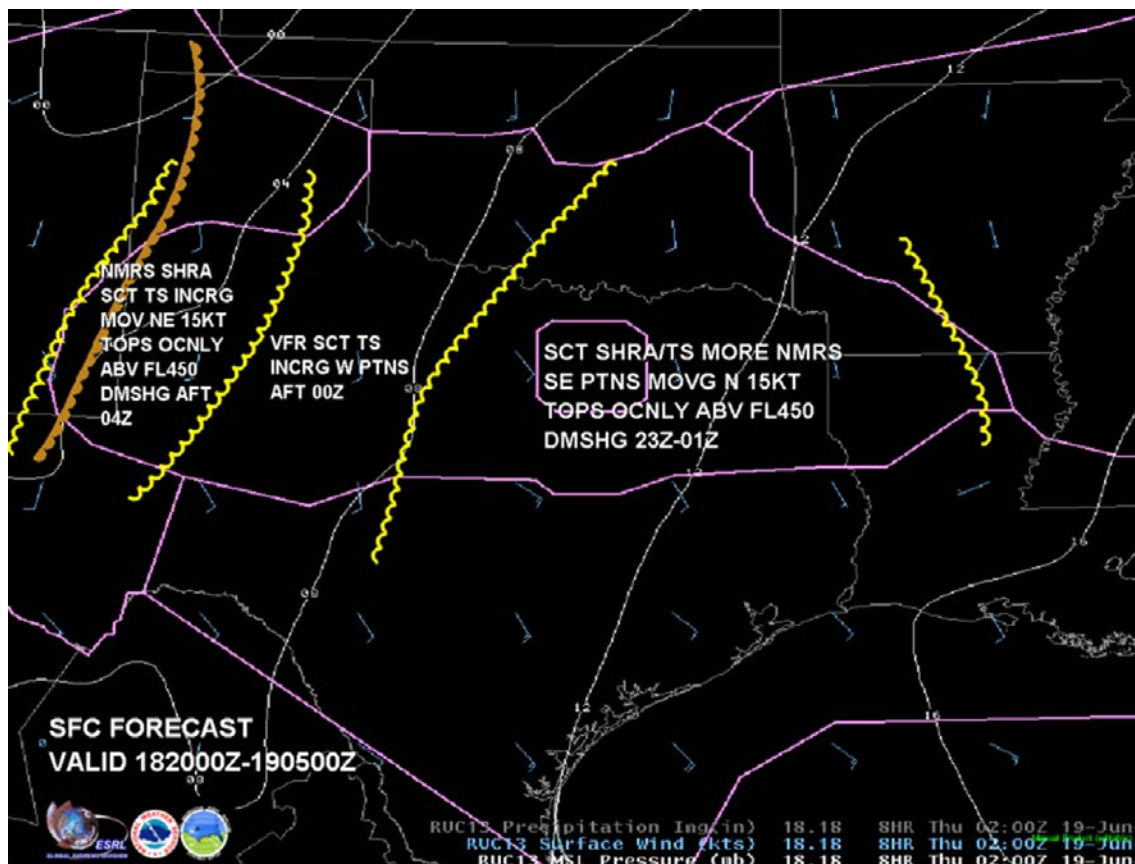
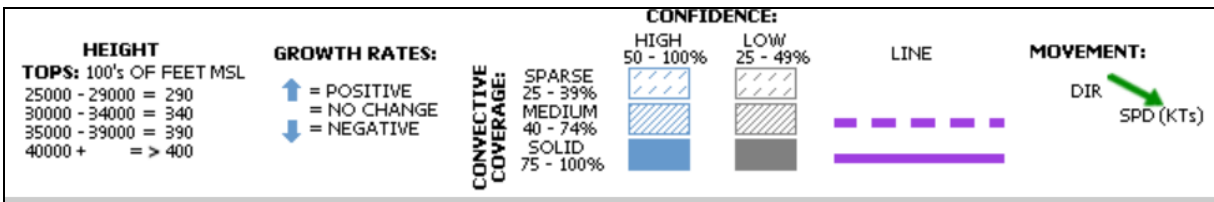


Figure 47 – KZFW forecast for 1500 to 2400 CDT June 18, 2014

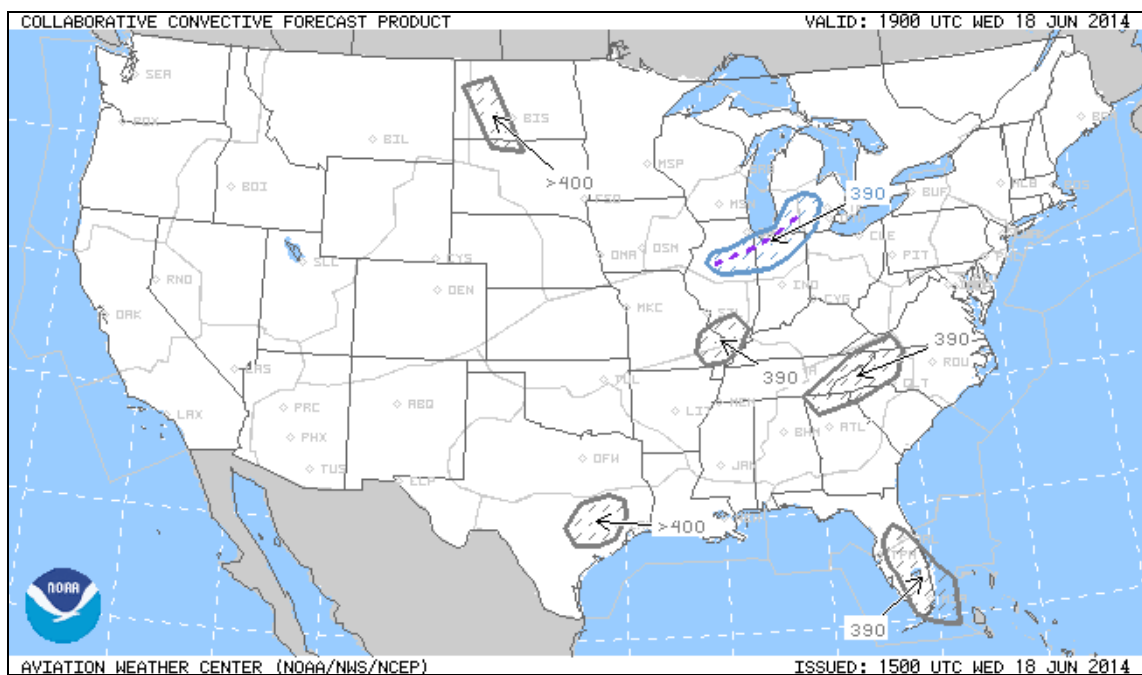
15.3 Collaborative Convective Forecast Products

Both CWSU's participated in the creation of the Collaborative Convective Forecast Product (CCFP) issued by the NWS Aviation Weather Center for expected convective activity during the period, and both centers displayed the forecast charts for air traffic controllers use in their appropriate sectors. These products are then displayed on the AWC's web page for convective weather forecasts. While the CCFP is a strategic forecast of convection designed to guide traffic managers in their system-wide approach to managing air traffic in the National Airspace System (NAS). The CCFP forecast suite is a set of 3 forecast maps with lead times of 4, 6 and 8 hours, and are updated every 2 hours.

The CCFP thunderstorm area coverage is considered low for 25 to 39% coverage and has a slight hatching, medium for 40 to 74% coverage is stripped hatching, and high for greater than 75% coverage and filled in solid. The confidence of the forecast is provided by the color of the enclosed line; a gray line represents a low confidence of 25 to 49%, while a blue line represents a high confidence of 50 to 100% of thunderstorm development. The legend of the charts is provided in figure 48.



The 4 and 6 hour CCFP forecasts issued at 1000 CDT are included as figures 49 and 50 respectively. The initial 4-hour forecast valid at 1400 CDT expected no significant thunderstorm coverage for the route of flight over western Texas, while the 6-hour forecast valid for 1600 CDT expected a low coverage of thunderstorms with tops from 35,000 to 39,000 feet over the region.



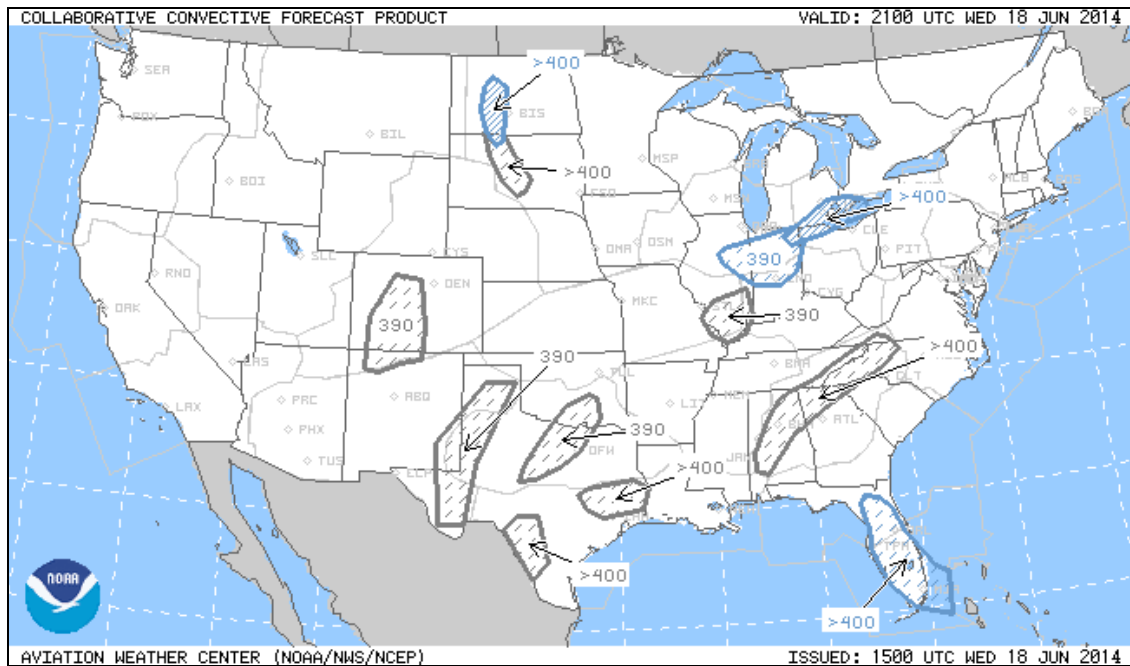


Figure 50 - Morning CCFP 6-hour forecast valid for 1600 CDT

The afternoon updates at 1200 CDT are included as figures 51 and 52. The 4-hour forecast valid at 1600 CDT remained the same as the previously issued chart for that period (figure 47) for the south central region, but showed modifications to the forecast over the Ohio Valley. The 6-hour CCFP forecast increased the coverage and confidence of the storms over northwestern Texas with a medium coverage of 49 to 74% coverage with tops above 40,000 feet. Other changes to the forecast were evident over the eastern section of the chart, but were not applicable to the accident.

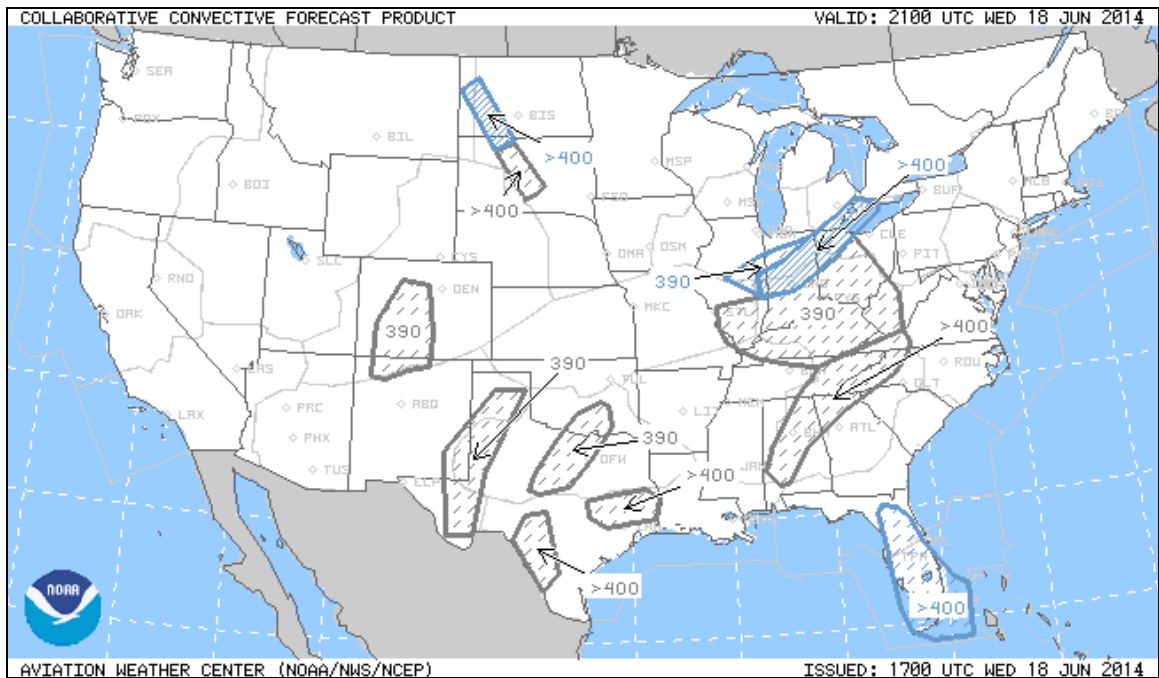


Figure 51 – Afternoon CCFP 4-hour forecast valid at 1600 CDT

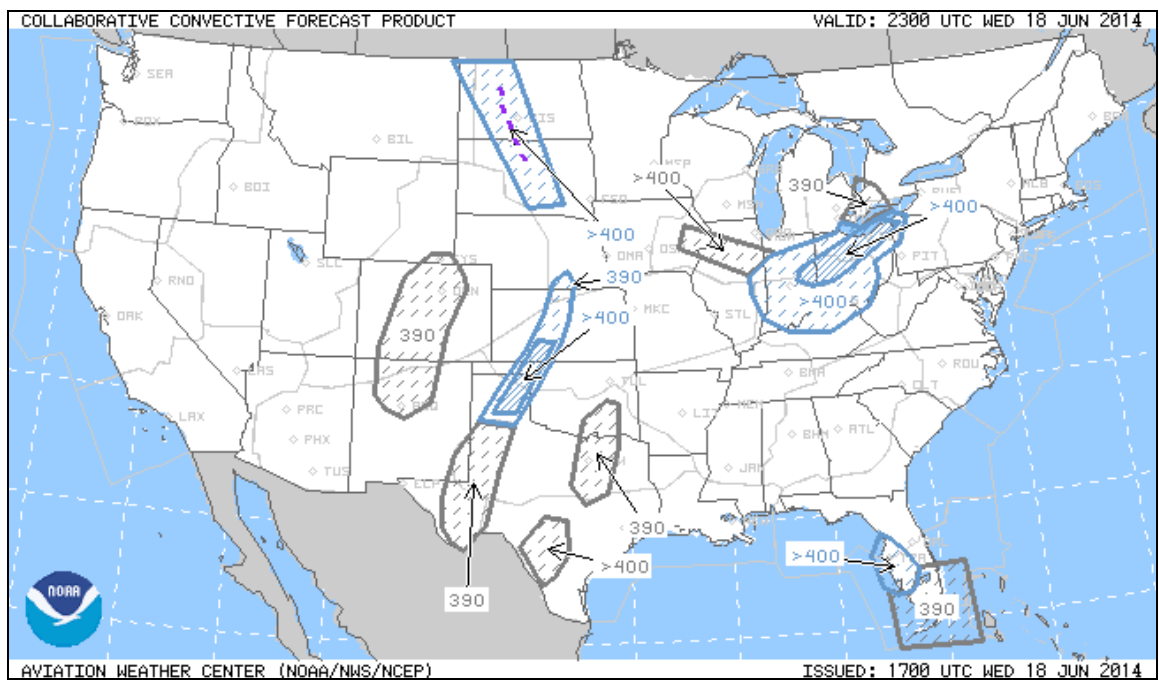


Figure 46 – Afternoon CCFP 6-hour forecast valid at 1800 CDT

16.0 Consolidated Storm Prediction for Aviation Display

Another tool available at the KZAB and KZFW Centers was the FAA provided Consolidated Storm Prediction for Aviation (CoSPA)²⁷ and the Corridor Integrated Weather System (CIWS), which were documented surrounding the time of the accident. These radar images are primary used by the FAA ARTCC Traffic Managers, and provide more detail than what the controllers see on their displays with 6 reflectivity values versus only the highest 3 precipitation intensity levels on the individual controller sectors screens displayed through their Weather And Radar Processor (WARP) displays.

The following CoSPA images do not use base or composite reflectivity, but base the precipitation images on vertical integrated liquid (VIL), which is a WSR-88D radar estimate of the total amount of liquid precipitation water (in kg/m²) in the atmospheric column over a given location. The amount of liquid precipitation water in a given volume can be calculated from the radar reflectivity using a so-called Z-R relation. The calculated liquid water content must be assumed to extend over the vertical column represented by a given elevation scan; then the amounts from each elevation scan at a given grid location can be summed up (integrated) vertically to obtain the total over that location. The calculation assumes that the reflectivity is only from liquid water, and not ice. Since hail can have very high reflectivity, it may cause the VIL calculation to overestimate the actual amount of liquid water; this means also that hail can yield very high VIL values. This makes VIL useful in severe thunderstorm detection and assessment because VIL is correlated with updraft strength which typically is correlated with storm severity.

Figures 53 through 57 are the CIWS displays of precipitation based upon VIL from 2100 through 2145 CDT at approximately 15 minute intervals, with an additional image at 2135 CDT or the approximate time of the accident with precipitation intensity and cloud-to-ground lightning strikes added.

Figure 58 is the CoSPA echo tops product for 1635 CDT, which shows an extensive area with tops over 40,000 feet over the region and maximum echo tops between 45,000 and 50,000 feet immediately east of the accident site. Figure 60 is the CoSPA echo tops with projected movement and growth and decay added. The image shows a region of rapid growth over the accident site area with maximum echo tops near 51,000 feet immediately east of the site, with movement eastward.

²⁷ Consolidated Storm Prediction for Aviation (CoSPA) Program was established by the Federal Aviation Administration's (FAA's) Aviation Weather Research Program (AWRP) in order to integrate several experimental systems into one high-quality expert system. The system integrated several prototype products such as the Corridor Integrated Weather System (CIWS), Integrated Terminal Weather System (ITWS), Collaborative Convective Forecast Product (CCFP), Convective SIGMETs, Numerical Weather Prediction (NWP), AutoNowcaster, and National Convective Weather Forecast (NCWF).

Figure 60 is the CoSPA image at 1635 CDT provided by the FAA during the center briefings, and displays the composite radar image, over the visible satellite image, along with maximum tops and movement, and controller sectors.

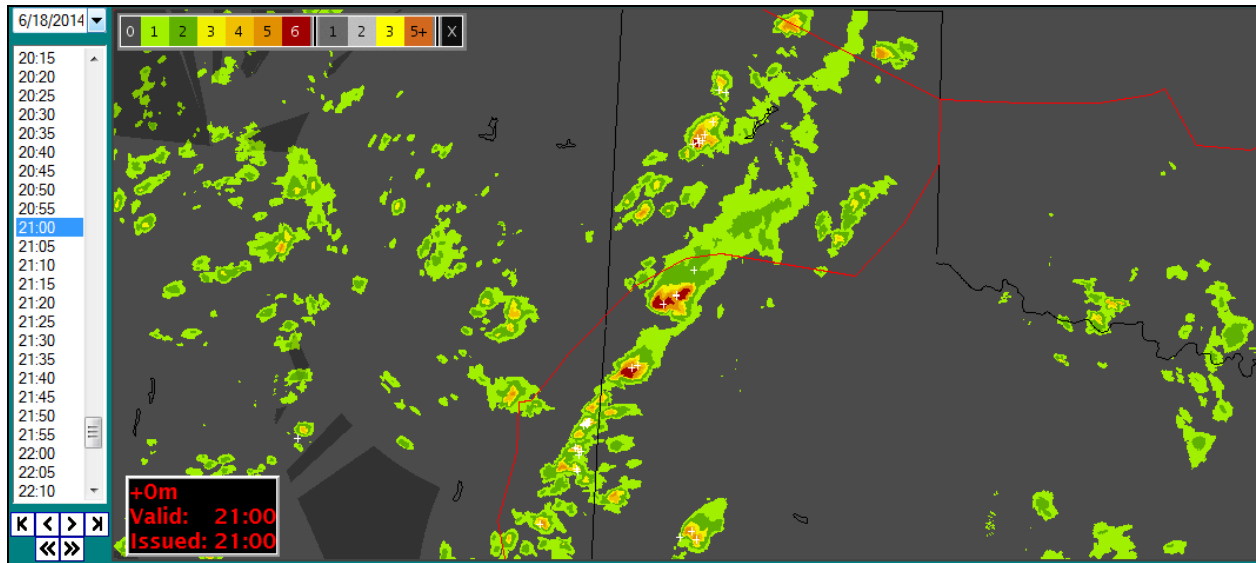


Figure 47 - CoSPA radar image at 1600 CDT

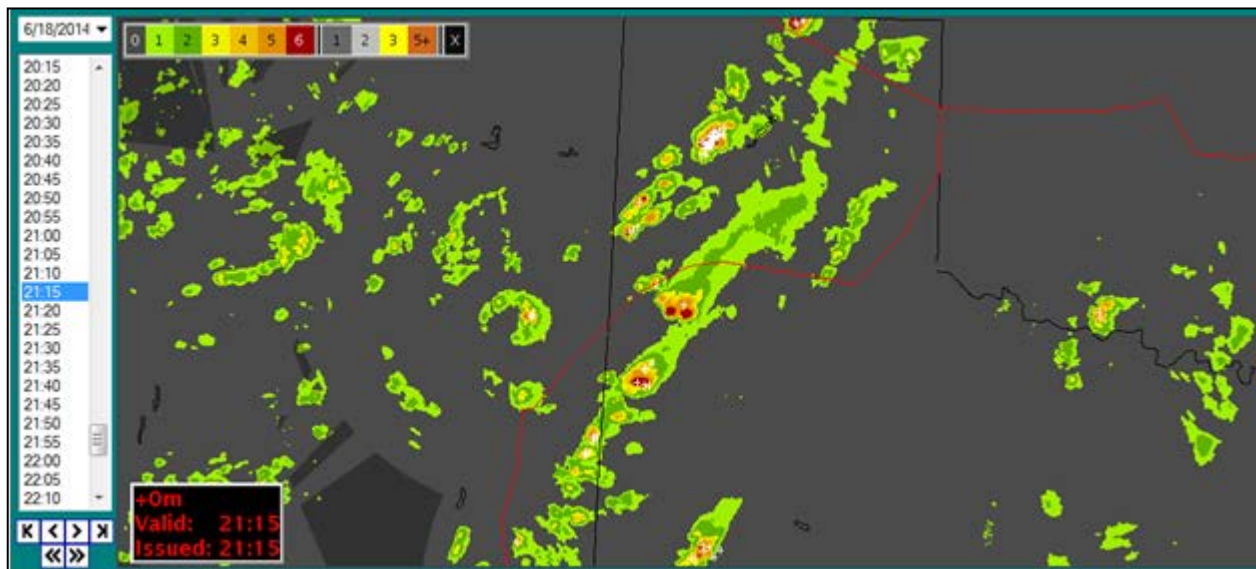


Figure 54 - CoSPA radar image at 1615 CDT

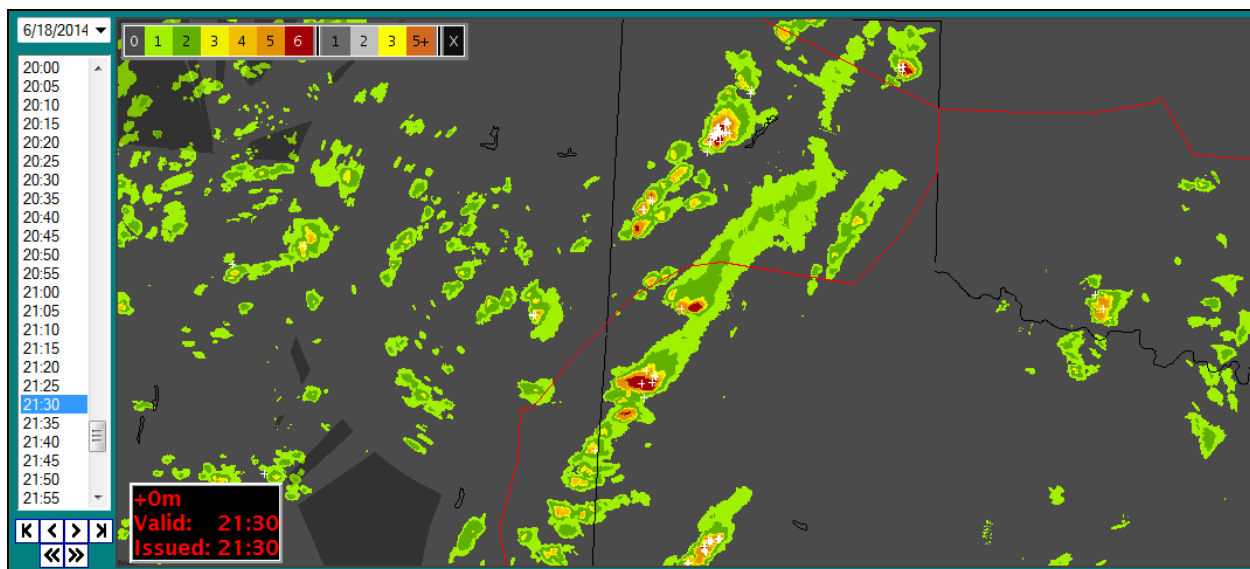


Figure 55 - CoSPA radar image at 1630 CDT

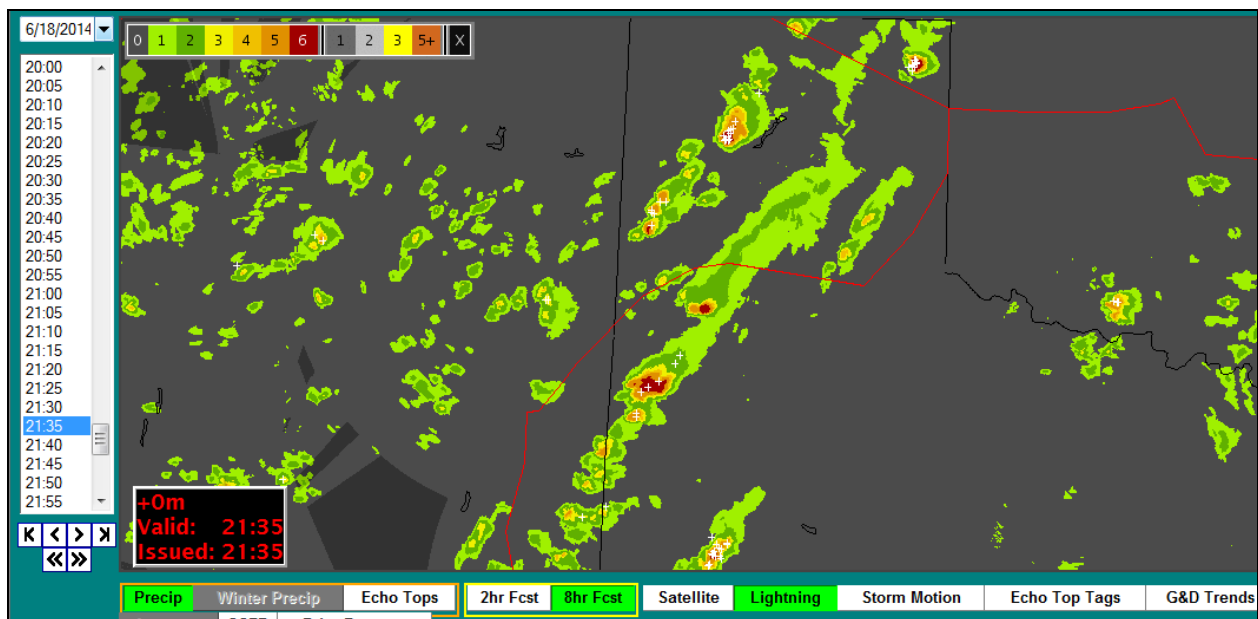


Figure 48 - CoSPA radar image at 1635 CDT

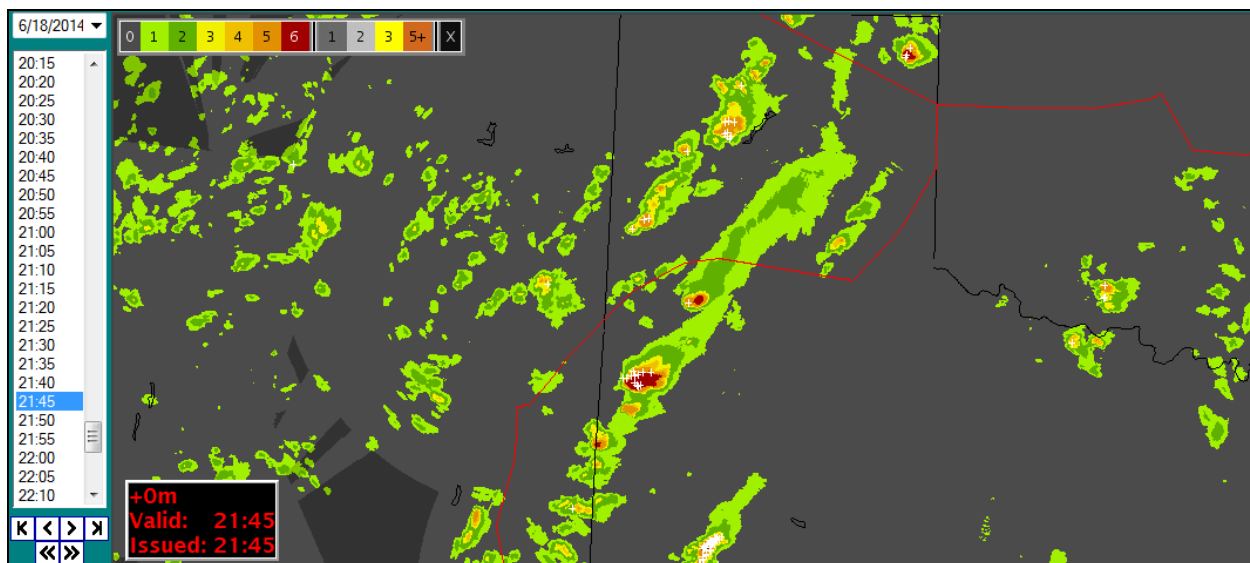


Figure 49 - CoSPA radar image at 1645 CDT

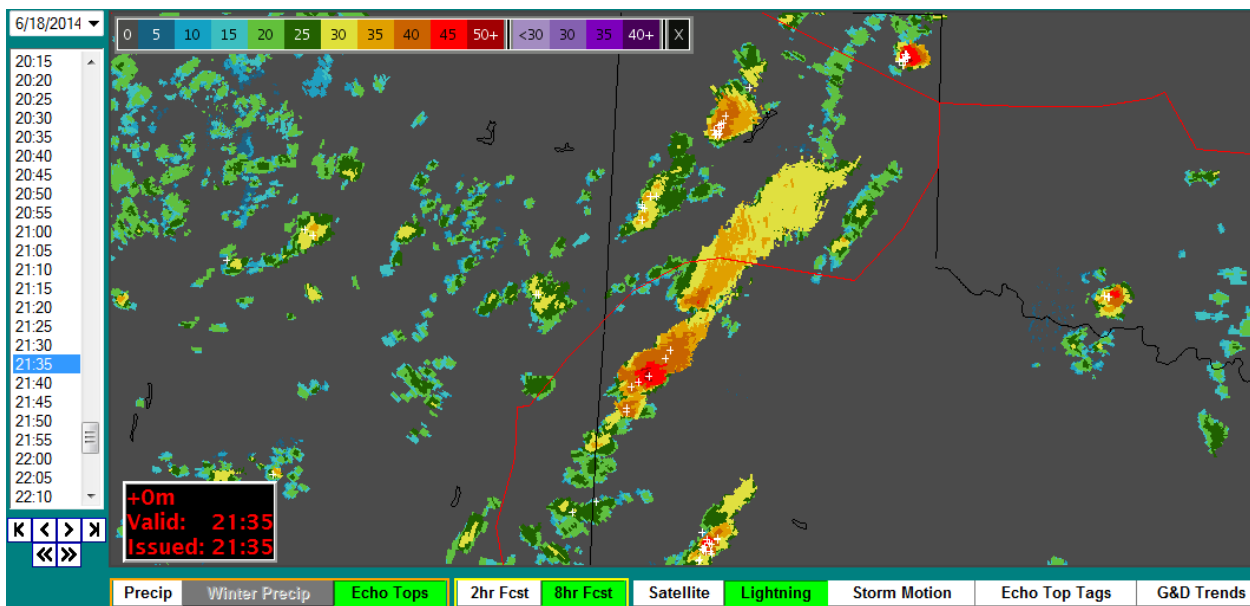


Figure 50 - CoSPA Echo Tops Product for 1635 CDT

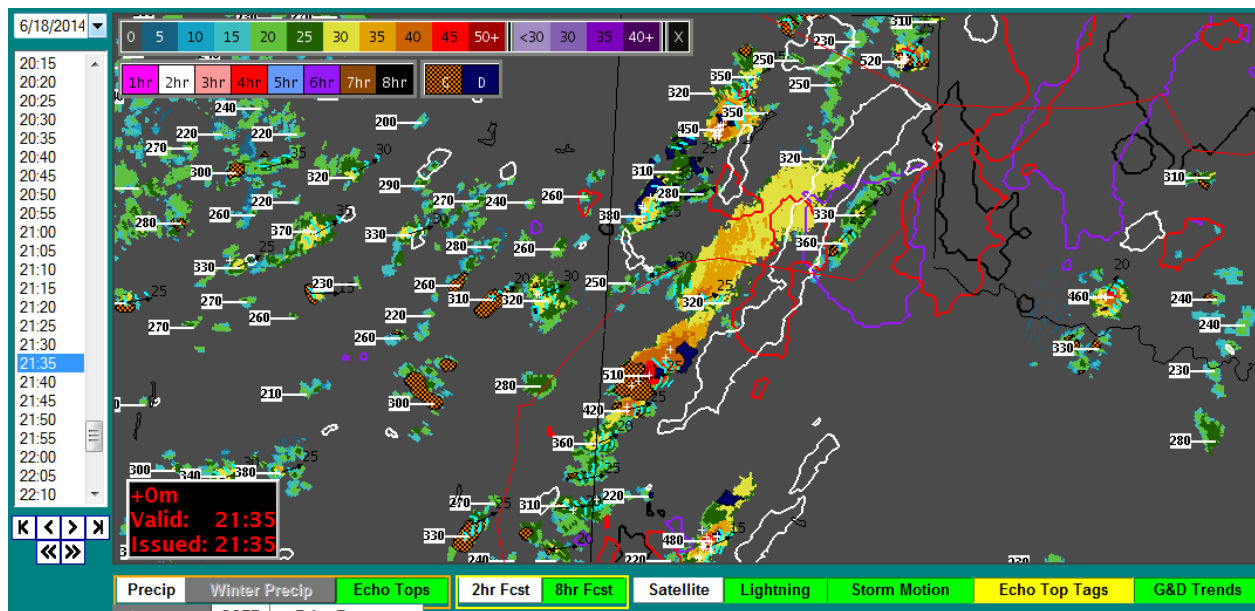


Figure 51 - CoSPA image at 1635 CDT with forecast movement and growth/decay trends

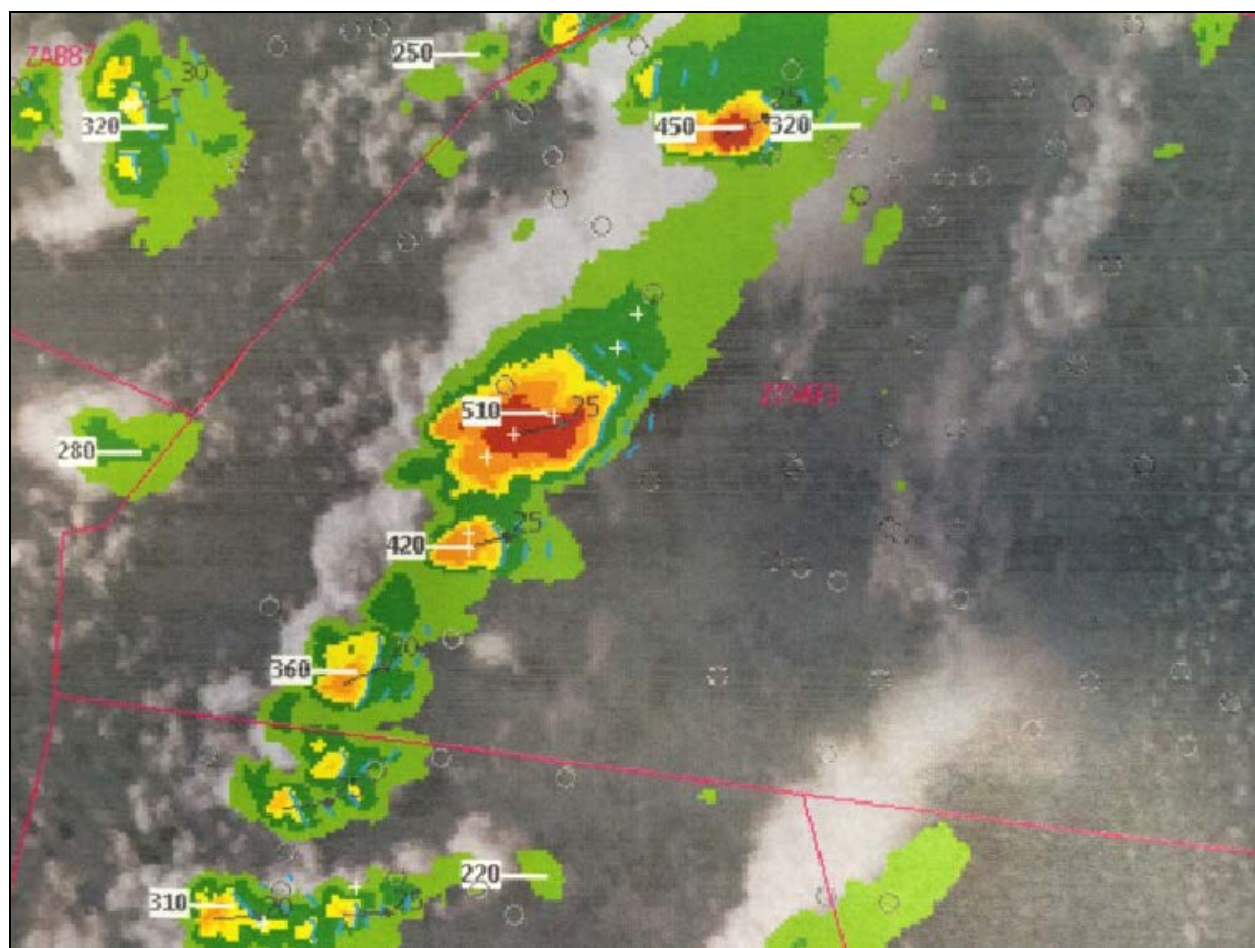


Figure 60 - CoSPA image provided by the FAA at 1635 CDT

17.0 Preflight Weather Briefing

The pilot of N2428Q contacted the FAA Prescott Contract Automated Flight Service Station (AFSS) provider Lockheed Martin Flight Services at 1306 CDT (1806Z) on June 18, 2014 to file an instrument flight plan and requested an abbreviated weather briefing²⁸, which consisted of the current observations for the destination (METARs), pilot reports, the current AIRMETs and Convective SIGMET along the route of flight, and current Notices to Airmen (NOTAMs).

For the flight plan the pilot indicated a departure time of approximately 30 minutes or at approximately 1338 CDT (1838Z) from Aspen (KASE) direct to Brenham (11R), Texas, with an estimated time enroute of 3:30 and :30 of reserve fuel on board, with three people on board. The requested flight level was FL270, and no alternate was filed.

During the abbreviated weather briefing, the briefer discussed the dry line with moisture from the Gulf of Mexico flowing northward and the expected precipitation. The pilot of N2428Q acknowledged he was familiar with the expected conditions. During this period the briefer provided Convective SIGMET 76C, which related to a developing line of thunderstorms over southern Texas near the Houston area with the storms moving northward. At the time of the briefing no advisories for thunderstorms were current over western Texas or in the vicinity of the accident site, and the briefing did not mention or comment on the risk of severe thunderstorms expected during the period or forecast. The transcript is included as attachment 1.

A review of the observations provided by the FAA on Form 8020-6 provided in the briefing package regarding the weather conditions surrounding the accident provided the observations from Lubbock (KLBB) surrounding the period without the remarks section of the observation. In researching the issue with the Prescott FCFSS it was discovered that the FAA software program associated with the Accident Package Generator (APG) does not have the remarks field and cannot reproduce the full observation. The FAA guidance in 8900.10 section 3-2051 require the remarks section of the weather observation as operational significant as that of the main body of the report, and must be considered when making operational decisions. The observations provided by the FAA on Form 8020-6 are therefore not the official NWS observations as issued and can be misleading not identifying significant elements included in the remarks section.

18.0 Witness Statement

On July 1, 2014 the NTSB conducted an informal telephone interview with Mr. Fred Phillips of Phillips Energy, Inc. of Shreveport, LA. Mr. Phillips was the pilot of an Eclipse jet, N656FP, which was operating in the vicinity of N2428Q when the flight encountered the weather. Mr. Phillips was also the pilot who relayed information to the KZFW Center regarding the N2428Q report that they were spinning and unable to see the ground or the horizon.

²⁸ An abbreviated weather briefing is intended to supplement or update a previous received weather briefing, updating the observation and forecasts, in-flight weather advisories, and Notices to Airmen (NOTAM). A standard weather briefing is typically received within 6 hours of the intended flight and provides a complete weather and aeronautical information for flight planning. It includes adverse weather conditions, a synopsis of the weather systems and boundaries impacting the route, current conditions, enroute and destination forecasts, winds aloft forecast, and NOTAMs, and any known ATC delays.

Mr. Phillips indicated he was operating at flight level 410 and had departed from Albuquerque International Sunport Airport (KABQ), Albuquerque, New Mexico, and was destined to Shreveport Regional Airport (KSHV), Shreveport, Louisiana. He indicated his aircraft was equipped with X-band airborne weather radar, a Storm Scope for lightning detection, and XM Satellite weather for uplinked NEXRAD radar images, and he had received a weather briefing prior to flight. He also had to deviate around a line of weather, which extended over the accident location. He further indicated that it appeared to him while monitoring the weather that two cells appeared to merge in the vicinity, and he deviated to the south of the intense echo which was displaying as purple or echoes greater than 50 dBZ on his airborne radar, he estimated the cloud tops to be in the range of 48,000 feet with overshooting cloud tops and with a “lenticular” appearing cloud on top. Although he doesn’t like to enter clouds while deviating around thunderstorms, he briefly encountered instrument meteorological conditions as he skirted the echoes. He also took several pictures of the clouds as he deviated around them enroute. He indicated that while he did not see any cloud-to-ground lightning, his Storm scope had the area well highlighted with activity. He did not recall any weather advisories being broadcasted by air traffic control during the period.

After he deviated around the weather, he heard N2428Q on frequency and indicated that he was “going through a window” in the weather and shortly thereafter heard air traffic control indicated he was in moderate to intense echoes. He also heard N2428Q call his mayday and indicated that he was spinning. After not hearing any response from the air traffic controller, he then relayed N2428Q’s situation. He also then attempted to contact N2428Q and queried him if he could see the ground or the horizon. He indicated the sector controller was busy during the period, and in his option did not provide any support or suggested deviations to N2428Q during the period. He indicated that the weather was very deceptive during the period with the cells growing rapidly and merging, and believed the accident airplane was in instrument meteorological conditions or not clear of the weather at the time of the event.

Figure 61 are the photographs of the clouds taken by the pilot of the Eclipse jet N656FP at 1624 CDT immediately prior to the accident as he deviated south of the main area of echoes at 41,000 feet. A pileus or cap cloud can be observed over the overshooting cloud tops.



Figure 52 - Photographs taken by the pilot of N656FP at FL410 deviating south of the echoes

19.0 Time Line of Events

The following is a time line of events associated with N2428Q related to this accident. All times are provided in local time (CDT).

- | | |
|------|--|
| 1306 | N2428Q contacts AFSS and requests an abbreviated weather briefing and files an IFR flight plan. |
| 1338 | N2428Q departs KASE. |
| 1404 | KZFW issues CWA #101 for an isolated thunderstorm with a diameter of 10 miles immediately south of Texico. |
| 1419 | NWS SPC issues a Mesoscale Discussion #1063 for a potential strong to severe thunderstorms developing along and ahead of dry line over northwestern Texas. |
| 1433 | KZFW CWSU issues CWA #102 for an isolated severe thunderstorm south-southeast of Texico. |
| 1450 | NWS issues Weather Watch #323 for severe thunderstorms which extended over northwest Texas and the accident site. |

1455 NWS issued Convective SIGMET 83C for an area of severe thunderstorms.

1530 KZAB controller advises that CWA 201 was current and advised flights to tune to HIWAS for further information. N2428Q is on frequency at this time.

1554 KZAB controller queries N2428Q altitude, after a 200 feet deviation. Pilot of N2428Q advises he is having autopilot issues.

1555 NWS issues Convective SIGMET 86C for isolated severe thunderstorm southeast of Mexico.

1556 KZAB controller advises all aircraft that Convective SIGMET 86C was current over Texas.

1556 N2428Q requests and is approved deviations of course for weather.

1606 N2428Q observed deviating around an area of weather.

1615 N2428Q is handoff to KZFW center sector.

1617:51 N2428Q contacts ZFW at FL260 for FL270 and is turning to deviate around weather.

1630:51 KZFW controller asks N2428Q if he is going north around weather. Pilot replies he is trying to “go through a window”.

1631:41 KZFW controller asks N2428Q if he needs a higher altitude²⁹. No response from aircraft.

1632:28 KZFW controller advises N2428Q that he is in the middle of moderate to extreme precipitation and asks if he needs a different altitude. No response from aircraft.

1632:57 KZFW controller receives mayday from pilot and asks for his altitude. Pilot of N2428Q states “19”.

1633:20 Another pilot asks if center received the mayday call. Controller continues to call N2428Q.

1633:33 American Airlines flight 1536 also advises they heard a mayday call. Controller does not acknowledge and continues trying to contact N2428Q and asks if he can hear Fort Worth Center, with no response.

1634:45 KZFW controller continues attempting to contact N2428Q with no response. Controller asks Alaska Airlines flight 670 if he can reach N2428Q.

²⁹ N2428Q’s altitude is observed to deviated from the assigned 27,000 to 29,300 feet.

1634:59 N2428Q answers and advises that he is spinning. Controller acknowledges.

1635:29 Another pilot forwards a report that N2428Q cannot see the ground or the horizon.

1635:59 KZFW controller attempts to contact N2428Q again. Another pilot says that N2428Q's last call was that he was spinning and that he couldn't see the ground or the horizon.

1637:20 American Airlines flight 2394 advises they heard N2428Q indicate that he was spinning. Controller asks American flight 2461 if he heard N2428Q calling. American flight 2461 advised they were not sure what he had said. United Airlines flight 1604 advises they heard him say that he was spinning and that he had lost sight of the ground and the horizon.

1638:01 KZFW controller attempts again to contact N2428Q, with no response.

20.0 Severe Weather Reports

Figure 62 is a plot of the reported severe weather across the United States on June 18, 2014 from thunderstorms as reported by the NWS.

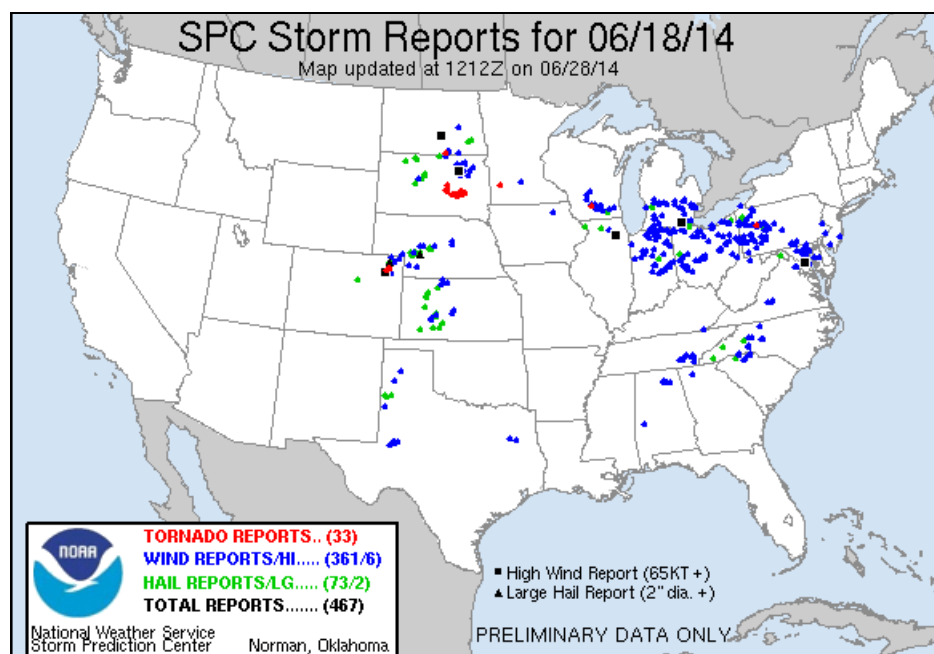


Figure 62 - NWS Severe weather reports

A breakdown of the NWS severe weather reports across western portion of Texas surrounding the period were as follows, time has been converted from UTC to CDT:

Time	Event	Location	County	Coordinates	Remarks
1436	1.00" hail	Muleshoe	Bailey, TX	34.23° -102.73°	LUB
1458	1.25" hail	Muleshoe	Bailey, TX	34.23° -102.73°	LUB
1525	1.00" hail	4 SE Muleshoe	Bailey, TX	34.19° -102.68°	LUB
1608	1.00" hail	Earth	Lamb, TX	34.23° -102.41°	Abundant small pea to marble size hail, with occasional 1" hailstones
1957	0.88" hail	Midland	Midland, TX	32.00° -102.08°	Midland, TX (MAF)
2020	1.00" hail	Midland	Midland, TX	32.00° -102.08°	Pea to quarter size hail
1908	55KT winds	3 N Dawn Deaf	Smith, TX	34.96° -102.21°	AMA
1957	55KT winds	Midland	Midland, TX	32.00° -102.08°	Loop 250 & Wadley, Midland, TX
2002	59KT winds	Midland Airport	Midland, TX	31.94° -102.19°	(MAF)
2025	UNK winds	Midland	Midland, TX	32.00° -102.08°	11 travel trailers blown over in northwest Midland (MAF)
2026	UNK winds	3 NW Midland	Midland, TX	32.00° -102.12°	Spotter reports 1.5" diameter tree branches broken off due to wind
2027	UNK winds	1 NE Midland	Midland, TX	32.01° -102.07°	Tractor trailer overturned from strong winds (MAF)
2030	UNK winds	Odessa	Ector, TX	31.85° -102.37°	20 Power poles blown down at Yukon & Grandview in Odessa
2035	UNK winds	Greenwood	Midland, TX	32.03° -101.90°	5' diameter tree snapped and another uprooted (MAF)
2446	53KT winds	15 NNW Amarillo	Potter, TX	35.40° -101.92°	West Texas Mesonet (AMA)
0230	54KT winds	1 ENE Morton	Cochran, TX	33.73° -102.74°	West Texas Mesonet (LUB)

There was one significant report from Morton, located immediately north of the accident site in Cochran County, Texas of wind gusts of 54 knots at 2030 CDT. According to witnesses in the area at the time of the accident, they reported a severe thunderstorm in the immediate vicinity at the time of the accident, and reported high winds, heavy rain, and low visibility with the storm.

21.0 Thunderstorm References

The FAA Advisory Circular AC 00 – 24C “Thunderstorms” dated January 30, 2013 provides a basic review of thunderstorms and general guidance avoidance policy. The advisory circular describes basic thunderstorm development, life cycle, organization or types of storms; from single cell, multicellular storms or clusters, to squall lines, and supercell type thunderstorms. A supercell is a single long-lived thunderstorm which is responsible for nearly all of the significant tornadoes produced in the United States and for most of the hailstones larger than golf ball-size.

The advisory circular also discusses thunderstorm terminology such as the use of the Convective Outlook (AC) and the perceived level of threat for convection and severe thunderstorms, and the general hazards within and near thunderstorms. Also included in the updated advisory circular with the use of ground-based weather radar, echo intensity or reflectivity, and the use of data link into the cockpit, as well as airborne weather radar and it's primary limitation of attenuation and the need for proper tilt management. Avoidance of any heavy to extreme intensity echoes or one identified as severe by at least 20 miles was also emphasized.

The basic thunderstorm guidelines or do's and don'ts of thunderstorms avoidance were also included; with some of the applicable rules to this investigation included were as follows:

- Don't attempt to fly under the anvil of a thunderstorm. There is a potential for severe and extreme clear air turbulence.
- Don't fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually can be visually circumnavigated.
- Don't trust the visual appearance to be a reliable indicator of the turbulence inside a thunderstorm.
- Don't assume that ATC will offer radar navigation guidance or deviations around thunderstorms.
- Don't use data-linked weather next generation weather radar (NEXRAD) mosaic imagery as the sole means for negotiating a path through a thunderstorm area (tactical maneuvering).
- Do remember that the data-linked NEXRAD mosaic imagery shows where the weather was, not where the weather is. The weather conditions may be 15 to 20 minutes older than the age indicated on the display.
- Do ask ATC for radar navigation guidance or to approve deviations around thunderstorms, if needed.
- Do use data-linked weather NEXRAD mosaic imagery (e.g., Flight Information Service-Broadcast (FIS-B)) for route selection to avoid thunderstorms entirely (strategic maneuvering).
- Do advise ATC, when switched to another controller, that you are deviating for thunderstorms before accepting to rejoin the original route.
- Do remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.
- Do regard as extremely hazardous any thunderstorm with tops 35,000 feet or higher whether the top is visually sighted or determined by radar.
- Do divert and wait out the thunderstorms on the ground if unable to navigate around an area of thunderstorms.

22.0 Astronomical Conditions

The United States Naval Observatory's website provided the following astronomical conditions for June 18, 2014 for Cochran County, Texas:

Beginning of civil twilight	0611 CDT
Sunrise	0640 CDT
Sun transit	1352 CDT
Accident	1635 CDT
Sunset	2104 CDT
End of civil twilight	2133 CDT

At the time of the accident the Sun was 53° above the horizon and at an azimuth of 265°.

F. LIST OF APPENDICES AND ATTACHMENTS

Appendix 1: Amarillo severe weather stability parameters table from sounding

Appendix 2: N2428Q Flight Track

Attachment 1: AFSS transcript of the weather briefing

Submitted by:

Donald Eick
NTSB Senior Meteorologist

Appendix 1 – KAMA Severe Weather Stability Parameters for 1900 CDT on June 18, 2014 (0000Z on June 19, 2014).

Parameter	Weak	Moderate	Strong
200 mb Wind Speed (kt)		62	
500 mb Wind Speed (kt)	29		
700 mb Wind Speed (kt)	23		
700 mb Dewpoint Depression (C)			15.0
850 mb Wind Speed (kt)	18		
850 mb Dewpoint (C)			13.6
700 - 500 mb lapse rate (C/km)	-7.8		
Boyden Index			103.6
BRN - Bulk Richardson No.		31	
BRN Shear (m^2/s^2)			81.3
CAP Strength		1.3	
CAPE 0-3 km, AGL	29		
CAPE Total			2511
Craven SigSvr Parameter (mixed-layer lift)	17		
CT - Cross Totals		22.7	
DCAPE 6.0 km, AGL			1339
Delta Theta-e (ePT)			24.5
EH1 - Energy Helicity Index	0.2		
GOES HMI (Hybrid Microburst Index)	6		
Hail (inches)		0.25	
HI - Humidity Index		36.0	
JI - Jefferson Index			31
K Index		33.3	
KO Index			-22.0
LFC-LCL height (m)			384
LFC - Level of Free Convection (mb)		682	
LI - Lifted Index			-7.0
MDPI - Microburst Day Potential Index		0.8	
NCAPE (Normalized CAPE)		0.25	
S Index		42.4	
SCP - Supercell Composite Parameter	0.4		
Severity - Thunderstorm Severity Index		2.2	
SHIP - Significant Hail Parameter	0.6		
SI - Showalter Index			-5.7
srH - storm-relative Helicity (0-3 km)	13		
STP - Significant Tornado Parameter	0.0		
Surface Dewpoint (C)		15.4	
SWEAT Index		504.8	
T2 Gust (kt)			56
TI - Thompson Index			40
TQ Index			19
TT - Total Totals			57.4
VGP - Vorticity Generation Parameter		0.225	
VT - Vertical Totals			34.7
Waterspout Index	18		
WBZ - WetBulb Zero Hgt (ft,AGL)		9059	
Windex (kt)			61
WMSI - Wet Microburst Severity Index		62	
	====	=====	=====
Weighted Category Totals:	13	17	18

Appendix 2 – N2428Q Flight Track

Time	Latitude	Longitude	Altitude				
19:26	39.2722	-106.8831	10,000	20:34	36.3753	-104.2506	27,000
19:27	39.2808	-106.9317	11,000	20:35	36.3311	-104.1883	27,000
19:28	39.2894	-106.9811	12,700	20:36	36.2878	-104.1256	27,000
19:29	39.2972	-107.0353	14,000	20:37	36.2353	-104.0511	27,000
19:30	39.3039	-107.0700	16,200	20:38	36.1925	-103.9953	27,000
19:31	38.9922	-106.5532	17,000	20:39	36.1481	-103.9339	27,000
19:31	39.2742	-107.0530	17,700	20:40	36.1036	-103.8683	27,000
19:32	39.2425	-107.0508	19,400	20:41	36.0519	-103.7939	27,000
19:33	39.2119	-107.0530	21,100	20:42	36.0064	-103.7297	27,000
19:34	39.1789	-107.0586	21,800	20:43	35.9608	-103.6658	27,000
19:35	39.1436	-107.0553	23,200	20:44	35.9150	-103.6014	27,000
19:36	39.1175	-107.0544	24,200	20:45	35.8689	-103.5336	27,000
19:37	39.0850	-107.0550	24,700	20:46	35.8220	-103.4703	26,900
19:38	39.0453	-107.0564	25,600	20:47	35.7772	-103.4053	27,000
19:39	39.0044	-107.0556	26,000	20:48	35.7308	-103.3414	27,000
19:40	38.9514	-107.0542	26,400	20:49	35.6839	-103.2775	26,900
19:41	38.9064	-107.0522	27,000	20:50	35.6325	-103.2033	27,200
19:42	38.8572	-107.0525	27,000	20:51	35.5897	-103.1394	27,100
19:43	38.8061	-107.0372	27,000	20:52	35.5458	-103.0733	27,200
19:44	38.7625	-106.9714	27,000	20:53	35.5017	-103.0061	27,000
19:46	38.7106	-106.9333	27,000	20:54	35.4773	-103.0197	27,000
19:47	38.6578	-106.8900	27,000	20:54	35.4508	-102.9417	26,900
19:48	38.5925	-106.8375	27,000	20:55	35.4056	-102.8836	27,200
19:49	38.5369	-106.7942	27,000	20:56	35.3575	-102.8272	27,200
19:50	38.4811	-106.7497	27,000	20:57	35.3056	-102.7725	27,200
19:51	38.4267	-106.6989	27,000	20:58	35.2531	-102.7056	27,200
19:52	38.3750	-106.6494	27,000	21:00	35.2072	-102.6394	27,100
19:53	38.3214	-106.6053	27,000	21:01	35.1625	-102.5750	27,100
19:54	38.2558	-106.5525	27,000	21:02	35.1253	-102.4964	27,200
19:55	38.2014	-106.5075	27,000	21:03	35.0519	-102.4914	26,600
19:56	38.1464	-106.4603	27,000	21:04	34.9908	-102.5003	26,700
19:57	38.0914	-106.4142	27,000	21:05	34.9342	-102.5156	27,000
19:58	38.0303	-106.3653	27,000	21:06	34.8805	-102.5414	26,700
19:59	37.9756	-106.3203	27,000	21:07	34.8247	-102.5739	26,700
20:00	37.9161	-106.2706	27,000	21:08	34.7719	-102.6036	26,900
20:01	37.8728	-106.2297	27,000	21:09	34.7086	-102.6411	26,700
20:02	37.8158	-106.1817	27,000	21:10	34.6514	-102.6625	27,000
20:03	37.7572	-106.1314	27,000	21:11	34.5975	-102.6892	26,900
20:04	37.7019	-106.0861	27,000	21:12	34.5431	-102.7153	27,000
20:05	37.6481	-106.0403	27,000	21:13	34.4850	-102.7442	27,000
20:06	37.5928	-105.9950	27,000	21:14	34.4381	-102.7672	27,000
20:07	37.5403	-105.9514	27,000	21:15	34.3753	-102.7981	26,900
20:08	37.4783	-105.9017	27,000	21:16	34.3264	-102.8106	26,500
20:09	37.4272	-105.8550	27,000	21:17	34.2639	-102.8206	26,600
20:10	37.3756	-105.7836	27,000	21:18	34.2069	-102.7689	26,600
20:11	37.3339	-105.7161	27,000	21:19	34.1619	-102.7106	26,700
20:12	37.2864	-105.6422	27,000	21:20	34.0933	-102.7220	26,800
20:13	37.2472	-105.5822	27,000	21:21	34.0392	-102.7455	26,900
20:14	37.2036	-105.5158	27,000	21:22	33.9881	-102.7789	26,600
20:16	37.1519	-105.4400	26,900	21:23	33.9397	-102.8078	26,700
20:17	37.1069	-105.3781	27,000	21:24	33.8889	-102.8247	26,600
20:19	37.0178	-105.2536	27,200	21:25	33.8242	-102.8458	26,600
20:20	36.9744	-105.1892	27,200	21:26	33.7728	-102.8661	27,000
20:21	36.9303	-105.1200	27,100	21:27	33.7211	-102.8856	27,100
20:22	36.8883	-105.0533	27,100	21:28	33.6683	-102.9095	27,000
20:22	36.8586	-105.0000	27,100	21:29	33.6111	-102.9303	27,100
20:23	36.8100	-104.9183	27,200	21:30	33.5828	-102.8731	27,900
20:25	36.7708	-104.8497	27,400	21:31	33.6153	-102.8147	29,300
20:26	36.7339	-104.7789	27,400	21:32	33.6222	-102.7930	21,800
20:27	36.6914	-104.7094	27,000	21:33	33.6258	-102.7903	15,300
20:28	36.6469	-104.6450	27,000	21:34	33.6256	-102.7817	12,500
20:29	36.6031	-104.5803	27,000				
20:30	36.5500	-104.5055	27,000				
20:31	36.5075	-104.4428	27,000				
20:32	36.4633	-104.3789	27,000				
20:33	36.4189	-104.3136	27,000				

