



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

December 12, 2018

Specialist Factual Report

METEOROLOGY

CEN19FA004

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A. ACCIDENT

Location: Poolville, Texas
Date: October 12, 2018
Time: about 1608 central daylight time
2108 Universal Coordinated Time (UTC)
Airplane: Piper PA-32RT-300; Registration: N221MC

B. METEOROLOGIST

Don Eick
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On October 12, 2018, about 1608 central daylight time, a Piper PA-32RT-300, N221MC, was destroyed during an in-flight breakup and collision with terrain near Poolville, Texas. The pilot and passenger were fatally injured. The aircraft was registered to and operated by the pilot under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. Marginal visual meteorological conditions prevailed for the flight. No flight plan had been filed. The flight originated from the Sierra Blanca Regional Airport (SRR), Ruidoso, New Mexico, about 1326. The intended destination has not been determined.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are central daylight time (CDT) based upon the 24-hour clock, local time is -5 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was estimated at latitude 32.969444° N and longitude 97.878889° W at an elevation of approximately 1,190 ft.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

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) 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 00-45H.

1.1 Surface Analysis Chart

The southcentral section of the NWS Surface Analysis Chart for 1600 CDT is included as figure 1 with a red star depicting the approximate location of the accident site. The chart depicted a low pressure system at 1011-hectopascals (hPa)¹ over northern Texas along a stationary front which extended eastward across northern Texas into northern Louisiana, and a cold front extending westward from the low into northwestern Texas and New Mexico, where the front became stationary again. The accident site was located immediately east-northeast of the low and north of the stationary front on the cool air side of the front. Further to the north, a second cold front was depicted extending from Missouri southwestward into Oklahoma. Another low pressure system at 1000-hPa associated with the remains of Hurricane Sergio was depicted in northern Mexico south of the Arizona and New Mexico borders. A relatively weak pressure gradient was depicted over the area.

¹ Hectopascal (hPa) is the standard term for reporting sea level pressure and is interchangeable with the term millibar (mb) with the same units. The International Standard Atmosphere (ISA) is based on a sea level pressure is 1013.25-hPa with a temperature of 15° Celsius (C) or 59° Fahrenheit (F).

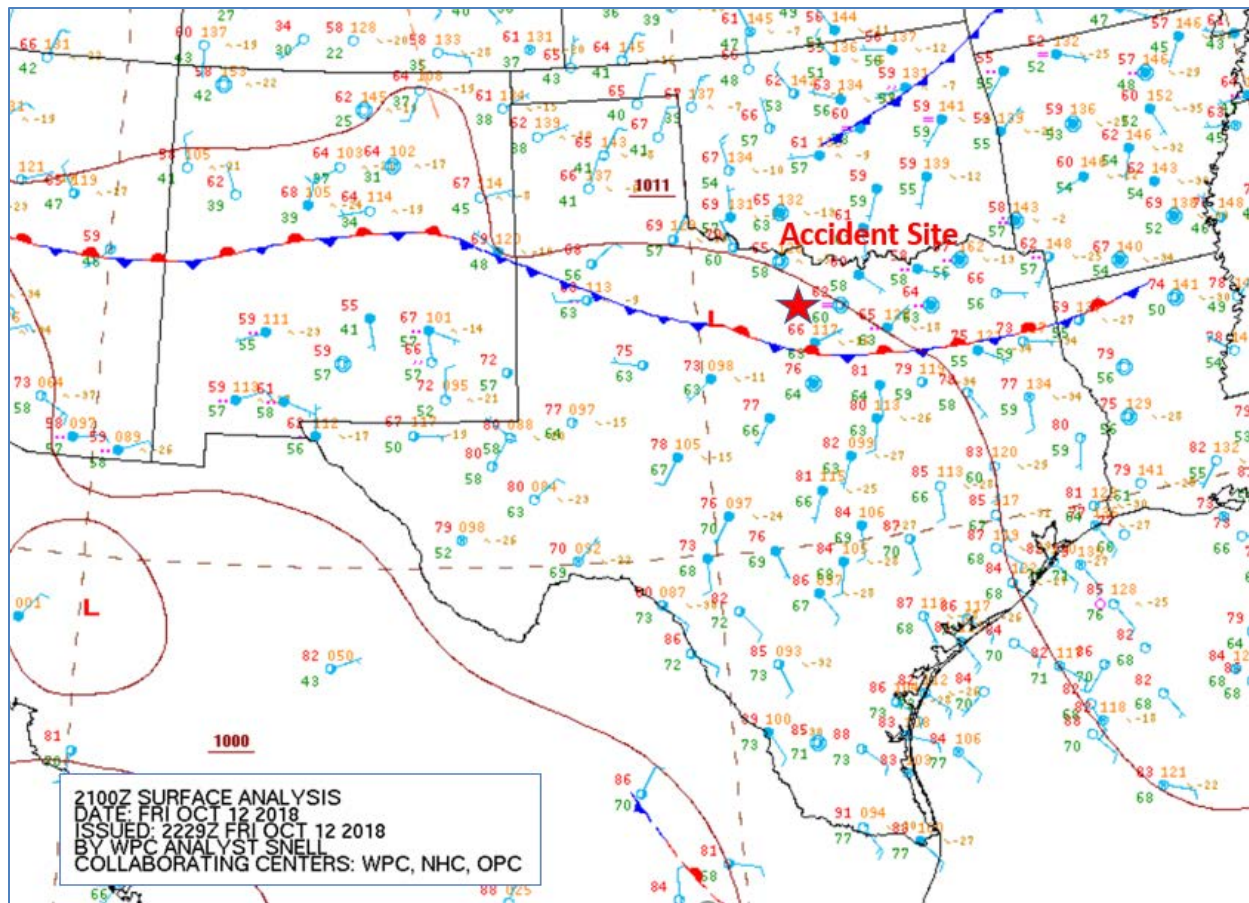


Figure 1 – Southcentral section of the NWS Surface Analysis Chart for 1600 CDT

The station models surrounding the accident site on the surface analysis chart depicted calm to light easterly winds of 5 knots or less, with several stations reporting visibility restricted in mist and/or light rain, with broken to overcast cloud cover, with a temperature of 62° F, and a dew point temperature of 60° F.

1.2 National Composite Radar Mosaic

A screen shot of the NWS NCEI National Composite Reflectivity image for 1610 CDT over the region is included as figure 2, with the approximate accident site marked. The chart depicted a band of echoes extending from immediately west of Fort Worth west-southwestward to Gordon, Texas, to the south of the accident site with several other small areas of scattered echoes across the region. A small area of echoes associated with light rain was located approximately 6 miles south-southeast of the accident site with no echoes over the accident site.



Figure 2 - Southcentral section of the NWS National Composite Radar Reflectivity image for 1610 CDT

1.3 12-hour Surface Prognostic Chart

The NWS 12-hour Surface Prognostic Chart valid for 0100 CDT on October 13, 2018 depicting the expected conditions during the period is included as figure 3. The chart continued to depict a low pressure system along the stationary front across Texas with a large area of rain and scattered thunderstorms expected (red cross-hatched area) with precipitation covering less than half the area over the accident site. A higher probability of rain and thunderstorms was depicted over western Texas and New Mexico by a dark green shading.

12 Hours Surface Prognostic

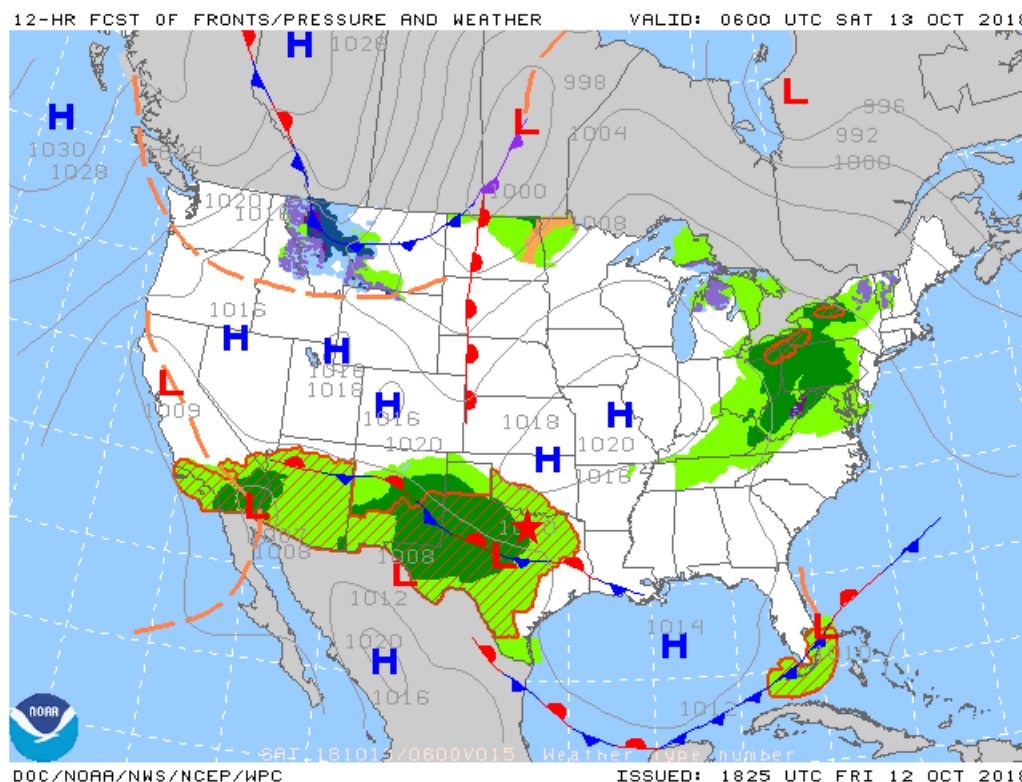


Figure 3 – NWS 12-hour Surface Significant Weather Prognostic Chart

1.4 Low-Level Significant Weather Prognostic Chart

The NWS 12- and 24-hour Low-Level Significant Weather Prognostic Chart current during the period is included as figure 4 and provided a general forecast of the general flight categories² (areas of VFR, MVFR, and IFR conditions), freezing levels, and areas of low-level turbulence below 24,000 ft. The 12-hour forecast (left side) valid for 1900 CDT indicated an extensive area of MVFR conditions extending over southern New Mexico, western and northern Texas, which extended over the accident site. An area of IFR conditions extended immediately north of the Dallas/Fort Worth area and extended into eastern Oklahoma, northwest Arkansas, into Missouri and southern Illinois. The freezing level was depicted between 12,000 and 16,000 ft over the area.

² 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 below 500 ft above ground level (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 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft 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 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

The 24-hour (right) forecast valid for 0700 CDT on October 13, 2018, expected an extensive area of IFR conditions over portions of Texas that included the accident site.

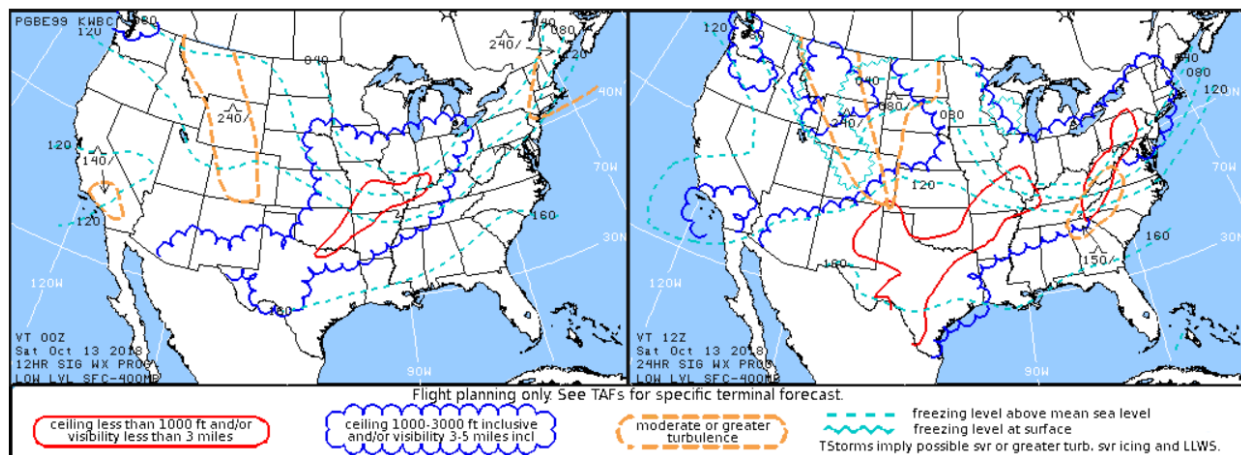


Figure 4 – Low-Level Significant Weather Prognostic Chart for 12- and 24-hours

1.5 Convective Outlook

The NWS Storm Prediction Center (SPC) Convective Outlook, which identified areas where strong to severe thunderstorm activity was expected during the period is included as figure 5. The chart depicted a slight risk of severe thunderstorm development over southwestern Texas and southeastern New Mexico, with a risk of general thunderstorms extending into northern Texas in the vicinity of the accident site. The Convective Outlook (AC) narrative follows the graphic and discusses the remains of Hurricane Sergio (referred to as a tropical cyclone) and the enhancement of strong shear over the area to enhance severe thunderstorm development.

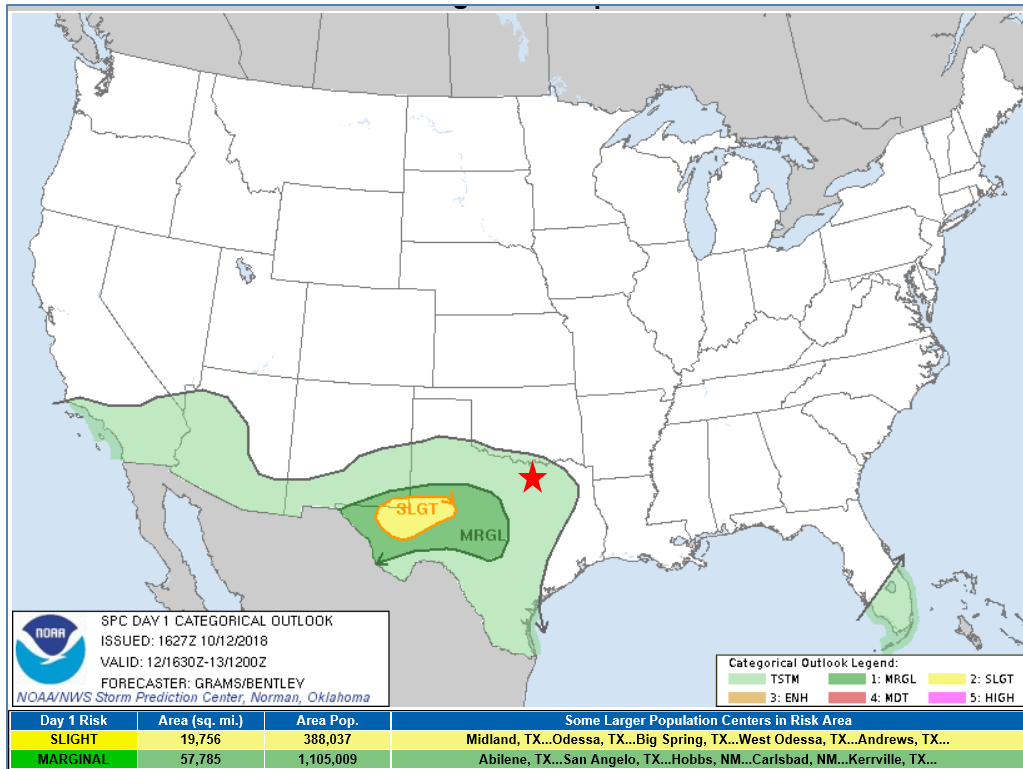


Figure 5 - NWS Convective Outlook depicting expected areas of organized thunderstorms

Convective Outlook (AC) narrative issued along with the graphic chart.

SPC AC 121627
 Day 1 Convective Outlook
 NWS Storm Prediction Center Norman OK
 1127 AM CDT Fri Oct 12 2018

Valid 121630Z - 131200Z

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS PERMIAN BASIN OF WEST TX...

...SUMMARY...

A cluster of severe storms with primary hazards of hail and tornado may develop tonight across the Permian Basin of west Texas.

...West TX...

Primary change is to add upgrade to Slight Risk for hail and tornado over the Permian Basin.

The remnants of TC Sergio will accelerate east-northeast from the northern Gulf of CA, reaching the Permian Basin late tonight. While low-level moisture advection will remain relatively weak through tonight, middle to upper 60s surface dew points are already prevalent across the Edwards Plateau and Lower Pecos Valley. A storm or two might develop in the late afternoon/early evening over the higher terrain of the Transpecos. However, more widespread storm development is likely late evening into the overnight, centered on the Permian Basin to Concho Valley, as a surge in low-level warm advection occurs with approach of the remnants of Sergio and baroclinicity increases along a west/east-oriented front.

Mid-level lapse rates should remain modest through the period, though rich low-level moisture will compensate to support a plume of MLCAPE from 500-1500 J/kg. Veering of the wind profile with height coupled with a confined belt of enhanced mid-level west-southwesterlies should support at least a few supercells. A couple supercells could become long-tracked as convection spreads east along the front, with warm-sector development to the south impeded by weaker large-scale ascent and modest MLCIN. While near-surface lapse rates should remain near-neutral given the time of day, increasing SRH overnight might support a nocturnal tornado or two, along with severe hail and locally severe wind.

..Grams/Bentley.. 10/12/2018

2.0 Observations

The surrounding area was documented using Meteorological Aerodrome Reports (METAR) and Specials observations (SPECI). The area had a magnetic variation of 4° East based on the sectional chart for the area. Cloud heights are reported in height above ground level (agl) in the following section.

2.1 Bridgeport, TX

The closest official weather reporting location was from Bridgeport Municipal Airport (KXBP), Bridgeport, TX, which was located approximately 12 miles north of the accident site at an elevation of 864 ft. The airport had an Automated Weather Observation System (AWOS) and issued observations every 20-minutes. The observation being reported at the time of the accident was as follows:

KXBP weather observation at 1555 CDT, automated, wind calm, visibility 10 miles or more, ceiling overcast at 2,800 ft agl, temperature 17° C, dew point temperature 17° C, altimeter 29.95 inches of mercury (Hg). Remarks: automated observation system with a precipitation discriminator, 3-hour precipitation amount 0.04-inches, temperature 17.2° C, dew point 17.2° C.

The following general flight categories and raw observations were reported surrounding the period from about 1200 through 1800 CDT. The flight categories are color coded black for VFR, blue for MVFR, red for IFR, and pink for LIFR conditions:

VFR METAR KXBP 121655Z AUTO 11005KT 10SM SCT008 OVC033 16/16 A3001 RMK AO2 P0001
T01590159

VFR METAR KXBP 121715Z AUTO 11005KT 10SM SCT008 OVC033 16/16 A3001 RMK AO2 T01600160

VFR METAR KXBP 121735Z AUTO 10005KT 10SM SCT008 OVC031 16/16 A3000 RMK AO2 T01600160

VFR METAR KXBP 121755Z AUTO 09004KT 10SM SCT008 OVC031 16/16 A3000 RMK AO2 60018
T01620162 10162 20148 T01630162

IFR METAR KXBP 121815Z AUTO 05003KT 10SM BKN006 BKN011 OVC031 16/16 A3000 RMK AO2
T01630162

IFR METAR KXBP 121835Z AUTO 05003KT 10SM -RA BKN006 BKN011 OVC031 17/17 A2999 RMK AO2

T01650165

MVFR METAR KXBP 121915Z AUTO 10003KT 10SM SCT006 OVC027 17/16 A2997 RMK AO2 T01650156

MVFR METAR KXBP 121935Z AUTO 13003KT 10SM RA OVC025 17/16 A2996 RMK AO2 T01660155

MVFR METAR KXBP 121955Z AUTO 13003KT 10SM -RA OVC025 17/17 A2995 RMK AO2 T01650165 PNO=

MVFR METAR KXBP 122015Z AUTO 14004KT 10SM OVC025 17/17 A2994 RMK AO2 T01700170 PNO=

MVFR METAR KXBP 122035Z AUTO 00000KT 10SM OVC025 17/17 A2995 RMK AO2 T01710169 PNO=

MVFR METAR KXBP 122055Z AUTO 00000KT 10SM OVC028 17/17 A2995 RMK AO2 60004 T01720172=

Accident 2108Z

MVFR METAR KXBP 122115Z AUTO 00000KT 10SM BKN030 OVC035 18/17 A2994 RMK AO2 T01750174=

MVFR METAR KXBP 122135Z AUTO 00000KT 10SM OVC030 18/18 A2994 RMK AO2 T01750175 PNO=

MVFR METAR KXBP 122155Z AUTO 00000KT 10SM OVC030 18/17 A2994 RMK AO2 T01760172 PNO=

MVFR METAR KXBP 122215Z AUTO 00000KT 10SM OVC028 18/17 A2994 RMK AO2 T01800172=

IFR METAR KXBP 122235Z AUTO 02004KT 10SM BKN007 OVC026 18/17 A2995 RMK AO2 T01800170
PNO=

IFR METAR KXBP 122255Z AUTO 00000KT 10SM OVC007 18/18 A2995 RMK AO2 T01780178=

2.2 Mineral Wells, TX

Mineral Wells Airport (KMWL), Mineral Wells, TX, was located about 15 miles south-southwest of the accident site at an elevation of 974 ft. The airport had an Automated Surface Observation System (ASOS) and reported the following conditions:

KMWL special weather observation at 1606 CDT, automated, wind from 070° at 3 knots, visibility 10 miles or more, ceiling overcast at 2,900 ft agl, temperature 19° C, dew point 17° C, altimeter 29.90 inches of Hg. Remarks: automated observation system with a precipitation discriminator, temperature 19.4° C, dew point 17.2° C.

The general flight categories and raw observations surrounding the period were as follows:

MVFR SPECI KMWL 121627Z AUTO 10003KT 10SM -RA OVC028 20/15 A2997 RMK AO2 RAB23 P0000
T02000150

MVFR METAR KMWL 121653Z AUTO 13005KT 10SM -RA OVC028 19/16 A2997 RMK AO2 RAB23 SLP140
P0000 T01940156

MVFR METAR KMWL 121753Z AUTO 12007KT 4SM +RA BR OVC025 19/17 A2995 RMK AO2 RAE1654B41
SLP134 P0006 60006 T01890167 10200 20156 58009

MVFR METAR KMWL 121853Z AUTO 04004KT 6SM -RA BR OVC027 19/17 A2993 RMK AO2 SLP128 P0005
T01890167

MVFR METAR KMWL 121953Z AUTO 05005KT 10SM OVC026 19/17 A2991 RMK AO2 RAE12B44E45 SLP120 P0001 T01890172=

MVFR SPECI KMWL 122043Z AUTO 06004KT 10SM OVC030 19/17 A2990 RMK AO2 T01890172=

MVFR METAR KMWL 122053Z AUTO 07004KT 10SM OVC030 19/17 A2990 RMK AO2 SLP117 60006 T01890172 56016=

MVFR SPECI KMWL 122106Z AUTO 07003KT 10SM OVC029 19/17 A2990 RMK AO2 T01940172=

Accident 2108Z

MVFR SPECI KMWL 122151Z AUTO 06004KT 10SM OVC030 19/17 A2990 RMK AO2=

MVFR METAR KMWL 122153Z AUTO 03004KT 10SM OVC030 19/17 A2990 RMK AO2 SLP118 T01940172=

MVFR SPECI KMWL 122203Z AUTO 04003KT 10SM OVC028 19/17 A2990 RMK AO2 T01940172=

MVFR SPECI KMWL 122224Z AUTO 02006KT 7SM FEW007 BKN028 OVC034 19/17 A2991 RMK AO2 T01890172=

MVFR METAR KMWL 122253Z AUTO 03006KT 9SM BKN026 OVC033 18/17 A2991 RMK AO2 RAB29E39 SLP121 P0000 T01830167=

2.3 Decatur, TX

Decatur Municipal Airport (KLUD), Decatur, TX, was the next closest reporting location approximately 23 miles north-northeast of the accident site at an elevation of 1,048 ft. The airport also had an AWOS and issued observations every 20-minutes. The following conditions were reported:

KLUD weather observation at 1555 CDT, automated, wind calm, visibility 3 miles in mist, scattered clouds at 500 ft agl, ceiling broken at 1,500 ft, broken at 2,300 ft, temperature 17° C, dew point 16° C, altimeter 29.93 inches of Hg. Remarks: automated observation system with a precipitation discriminator, 3-hour precipitation amount 0.12 inches, temperature 16.5° C, dew point 15.7° C.

KLUD weather observation at 1615 CDT, automated, wind calm, visibility 3 miles in mist, scattered clouds at 500 ft agl, ceiling broken at 800 ft, overcast at 1,500 ft, temperature 17° C, dew point 16° C, altimeter 29.93 inches of Hg. Remarks: automated observation system with a precipitation discriminator, temperature 16.7° C, dew point 16.0° C.

The general flight categories and raw observations surrounding the period were as follows:

MVFR METAR KLUD 121655Z AUTO 09004KT 7SM SCT007 BKN025 OVC035 16/15 A3000 RMK AO2 P0004 T01560149

IFR METAR KLUD 121715Z AUTO 00000KT 5SM BR BKN007 OVC033 16/15 A3000 RMK AO2 T01560148

VFR METAR KLUD 121735Z AUTO 10004KT 10SM SCT007 OVC031 16/15 A2999 RMK AO2 T01570147

MVFR METAR KLUD 121755Z AUTO 00000KT 7SM SCT007 SCT010 OVC029 16/15 A2999 RMK AO2 60040
T01560146 10157 20142

MVFR METAR KLUD 121815Z AUTO 00000KT 7SM OVC027 16/15 A2998 RMK AO2 T01600150

IFR METAR KLUD 121835Z AUTO 00000KT 7SM SCT004 BKN008 OVC027 16/15 A2999 RMK AO2
T01580149

MVFR METAR KLUD 121955Z AUTO 13006KT 5SM BR SCT003 BKN013 OVC029 16/15 A2993 RMK AO2
P0008 T01580150=

MVFR METAR KLUD 122015Z AUTO 12008KT 7SM SCT005 SCT008 BKN025 16/16 A2993 RMK AO2
T01630155=

MVFR METAR KLUD 122035Z AUTO 00000KT 10SM SCT005 BKN025 17/16 A2993 RMK AO2 T01650155=

MVFR METAR KLUD 122055Z AUTO 00000KT 3SM BR SCT005 BKN015 BKN023 17/16 A2993 RMK AO2
60012 T01650157=

Accident 2108Z

IFR METAR KLUD 122115Z AUTO 00000KT 3SM BR SCT005 BKN008 OVC015 17/16 A2993 RMK AO2
T01670160=

MVFR METAR KLUD 122135Z AUTO 00000KT 3SM BR SCT005 BKN011 OVC016 17/16 A2992 RMK AO2
T01680161=

MVFR METAR KLUD 122155Z AUTO 00000KT 5SM BR SCT003 BKN012 OVC023 17/17 A2991 RMK AO2
T01710165=

LIFR METAR KLUD 122215Z AUTO 00000KT 7SM BKN003 OVC025 17/16 A2993 RMK AO2 T01720164=

LIFR METAR KLUD 122235Z AUTO 00000KT 4SM BR BKN003 OVC020 17/16 A2993 RMK AO2
T01700163=

LIFR METAR KLUD 122255Z AUTO 00000KT 5SM BR BKN003 OVC022 17/17 A2994 RMK AO2
T01700165=

2.4 Fort Worth, TX

Fort Worth Alliance Airport (KAFW), Fort Worth, TX, located 25 miles east of the accident site at an elevation of 723 ft, had an ASOS and was augmented by observers, and reported hourly with specials as needed. The following conditions were reported:

KAFW weather observation at 1553 CDT, wind from 080° at 6 knots, visibility 10 miles or more, a few clouds at 1,500 ft agl, ceiling overcast at 3,100 ft, temperature 18° C, dew point 16° C, altimeter 29.92 inches of Hg. Remarks: automated observation system with a precipitation discriminator, rain ended at 1502 CDT, sea level pressure 1012.6-hPa, hourly precipitation less than 0.01 inches, 6-hour precipitation total 0.10 inches, temperature 17.8° C, dew point 15.6° C, 3-hour pressure tendency fallen 1,7-hPa.

KAFW special weather observation at 1625 CDT, wind from 070° at 6 knots, visibility 10 miles or more, a few clouds at 1,500 ft agl, ceiling overcast at 2,900 ft, temperature 18° C, dew point 16° C, altimeter 29.92 inches of Hg. Remarks: automated observation system with a precipitation discriminator, temperature 17.8° C, dew point 15.6° C.

The general flight categories and raw observations surrounding the period were as follows:

VFR METAR KAFW 121753Z 14009KT 10SM -RA OVC032 18/14 A2997 RMK AO2 RAB08 SLP144 P0003 60026 T01780144 10178 20161 58014

MVFR SPECI KAFW 121845Z 11004KT 7SM +RA BKN029 OVC036 18/14 A2996 RMK AO2 RAE1755B33 P0004 T01780144

MVFR METAR KAFW 121853Z 10003KT 7SM RA BKN029 OVC034 18/15 A2995 RMK AO2 RAE1755B33 SLP138 P0006 T01780150

VFR SPECI KAFW 121945Z 09006KT 7SM -RA OVC031 18/16 A2993 RMK AO2 P0004 T01780156

VFR METAR KAFW 121953Z 10005KT 10SM -RA OVC031 18/16 A2993 RMK AO2 SLP128 P0004 T01780156=

VFR METAR KAFW 122053Z 08006KT 10SM FEW015 OVC031 18/16 A2992 RMK AO2 RAE02 SLP126 P0000 60010 T01780156 56017=

Accident 2108Z

MVFR SPECI KAFW 122125Z 07006KT 10SM FEW015 OVC029 18/16 A2992 RMK AO2 T01780156=

MVFR METAR KAFW 122153Z 09005KT 5SM -RA BR FEW015 OVC029 18/16 A2992 RMK AO2 RAB40 SLP126 P0000 T01780156=

MVFR SPECI KAFW 122239Z 10004KT 3SM -RA BR FEW004 BKN027 OVC035 17/16 A2992 RMK AO2 P0001 T01720161=

MVFR SPECI KAFW 122251Z 11004KT 3SM -RA BR FEW004 SCT025 OVC032 17/16 A2991 RMK AO2 P0001

MVFR METAR KAFW 122253Z 11005KT 3SM -RA BR FEW004 FEW025 OVC032 17/16 A2991 RMK AO2 SLP124 P0001 T01720161=

2.5 METAR Display

The NWS Aviation Weather Center's website³ depiction of the observation at 1600 and 1630 CDT are depicted as figures 6 and 7 respectively. The observations are plotted by the station model with temperature and dew point temperatures in °F and are color coded by flight categories.

³ NWS AWC website is the primary aviation weather site at: <https://aviationweather.gov/metar>

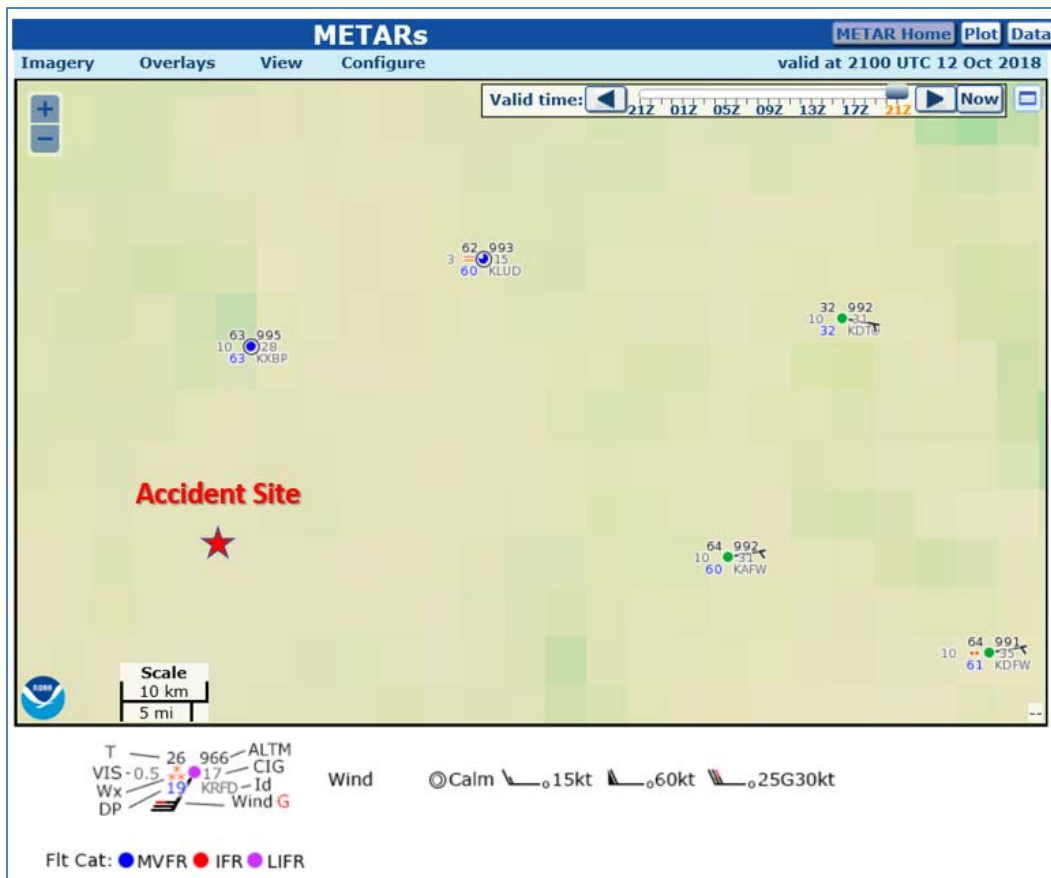


Figure 6 - METAR display at 1600 CDT over the area

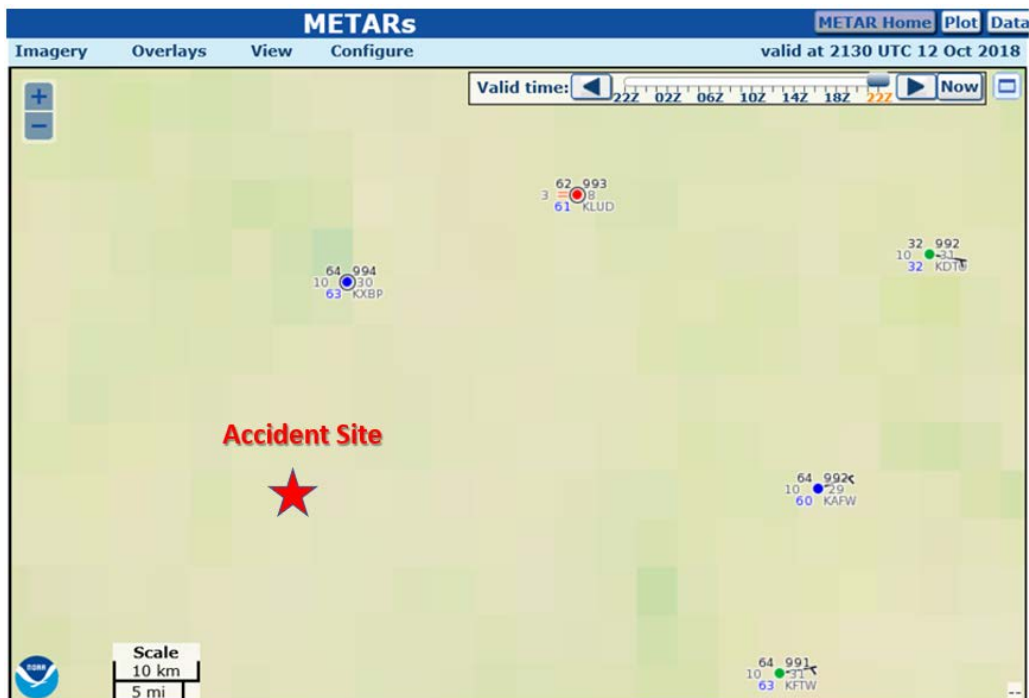


Figure 7 - METAR Display at 1630 CDT

3.0 Sounding

The NWS Fort Worth (KFWD) site number 72249, upper air observation for 1900 CDT was plotted on a standard Skew T log P diagram⁴ using the complete Rawinsonde Observation RAOB program software⁵ from the surface through 450-hPa (or approximately 21,000 ft) and is included as figure 8. The sounding site was located approximately 25 miles east and in the same general air mass of the accident, at an elevation of 643 ft.

The 1900 CDT KFWD sounding indicated a surface wind from 080° at 4 knots, with a temperature of 17.4° C, a dew point temperature of 16.8° C, a relative humidity of 96%, and a density altitude of 1,321 ft. The sounding depicted a lifted condensation level (LCL)⁶ at 252 ft agl (895 ft msl) at the base of a frontal inversion where temperature increased with height to 2,252 ft msl. Immediately above the low-level frontal inversion was the convective condensation level (CCL)⁷ at 3,308 ft agl (3,951 ft msl). The relative humidity exceeded 98% from the LCL through 17,800 ft and supported a deep layer of clouds, with the equilibrium level (EL)⁸ or potential cloud top to 27,000 ft. The freezing level or 0° C isotherm was at 14,486 ft and supported icing conditions above that level. Several other temperature inversions were also noted with height, which resulted in a Lifted Index of +4 and resulted in the atmosphere being characterized as stable and supported stratiform and nimbostratus type cloud formation.

⁴ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram 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.

⁵ RAOB software – The complete RAwinsonde OBservation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data.

⁶ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

⁷ Convective Condensation Level (CCL) - The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

⁸ Equilibrium Level (EL) - is the height where the temperature of a buoyantly rising parcel again reaches equal to the temperature of the environment.

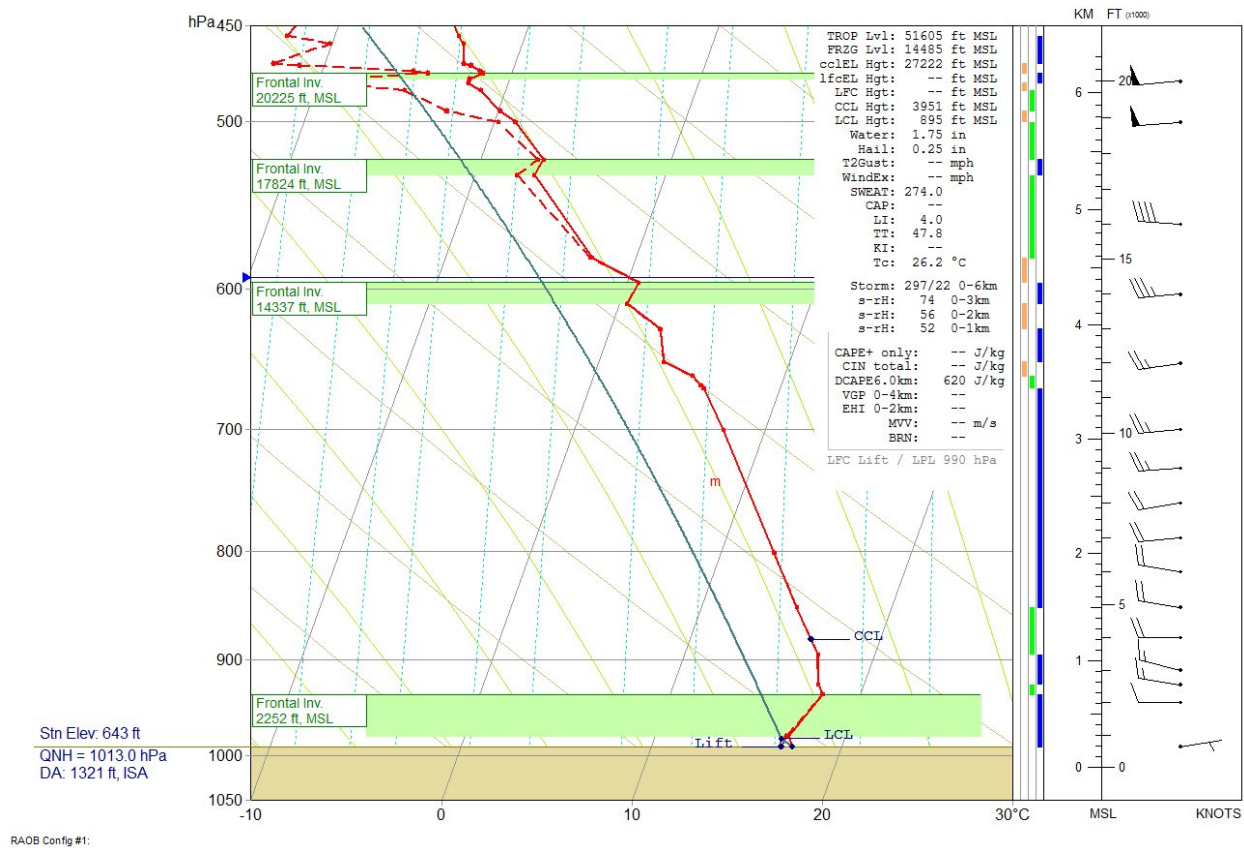


Figure 8 - NWS Fort Worth 1900 CDT upper air sounding

The sounding wind profile indicated surface winds from the east with winds shearing to the west immediately above the frontal inversion, with wind speed increasing with altitude. As a result of the abrupt wind shift and the change in the vertical wind speed, the RAOB sounding profile indicated a potential for moderate and greater low-level turbulence within the lowest 2,000 ft of the surface, otherwise no specific strong vertical shears were identified at altitude for anything other than light turbulence. The mean 0 to 6 kilometer (or ~18,000 ft) wind was from 267° at 30 knots. The level of maximum wind was identified at 39,000 ft with wind from 250° at 81 knots. At approximately 4,000 ft the wind was from 270° at 19 knots.

Figure 9 is a table of the observed height, pressure (Pres), temperature (T), dew point (Td), relative humidity (RH), wind direction and speed, and the RAOB algorithm derived clear air turbulence (CAT), low-level wind shear (LLWS), and icing intensity and type potential from the surface through 20,000 ft.

Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)
643	990	17.4	16.8	96	80 / 4			
957	979	17.0	16.9	99		SVR	LIGHT	
2000	943				270 / 10			
2252	935	18.0	18.0	100		LGT		
2555	925	17.6	17.6	100	280 / 13	LGT		
3000	910				285 / 17			
3483	895	17.0	17.0	100		LGT		
4000	879				270 / 19	LGT		
4928	850	15.0	15.0	100	280 / 21			
6000	818				280 / 20			
6578	801	12.8	12.8	100		LGT		
7000	788				265 / 21			
8000	759				260 / 19	LGT		
9000	730				265 / 23	LGT		
10099	700	7.8	m		265 / 27			
11262	669	6.0	m					
11342	667	5.8	5.8	100				
11626	660	5.2	5.2	100				
12035	650	3.4	3.4	100	260 / 24			
12995	627	2.6	2.6	100				
13724	610	0.4	0.4	100		LGT		
14000	604				265 / 34			
14337	596	0.6	0.6	100				
15052	580	-2.3	-2.4	99		LGT		MDT Clear
16000	559				275 / 41			
17385	530	-6.9	-7.8	93				LGT Rime
17824	521	-6.7	-7.0	98		LGT		MDT Clear
18876	500	-8.9	-9.8	93	265 / 52			MDT Mixed
19183	494	-9.9	-12.7	80				LGT Rime
19752	483	-11.3	-15.3	72				
19961	479	-12.1	-19.1	56	265 / 52			
20066	477	-12.1	-19.1	56				

Figure 9 - Table of the observed sounding parameters and derived parameters

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible band imagery were obtained for times surrounding the time of the accident. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The visible imagery (band 2) at a wavelength of 0.64 μm provided a nominal spatial resolution of 0.5 km. The frontal positions from the NWS WPC from 1600 CDT was also overlaid on the images.

Figure 10 is the GOES-16 infrared image at 1612 CDT at 2X magnification with the frontal position overlaid. The image depicted an area of low stratiform type clouds along and north of the frontal boundary over northern and northwestern Texas. The radiative cloud top temperature over the accident site was observed at 264° Kelvin or -9.16° C, which corresponded to cloud tops near 19,000 ft based on the KFWF sounding.

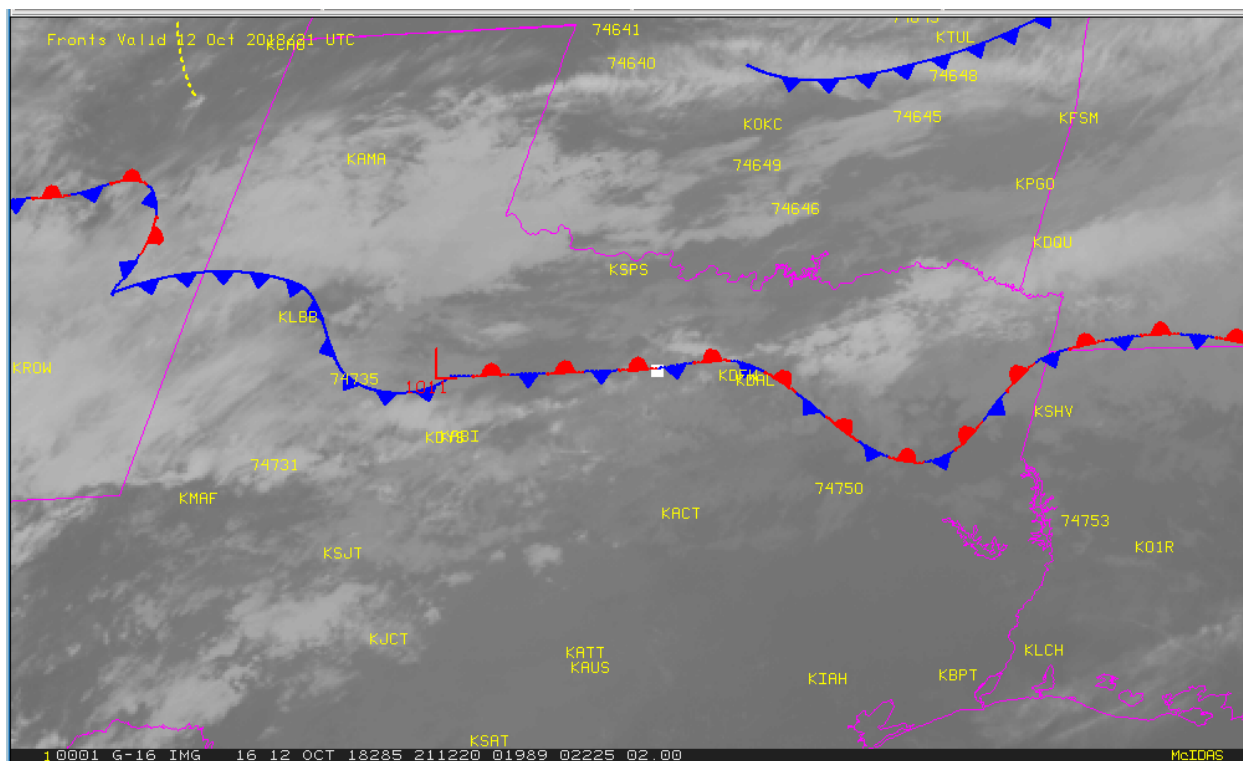
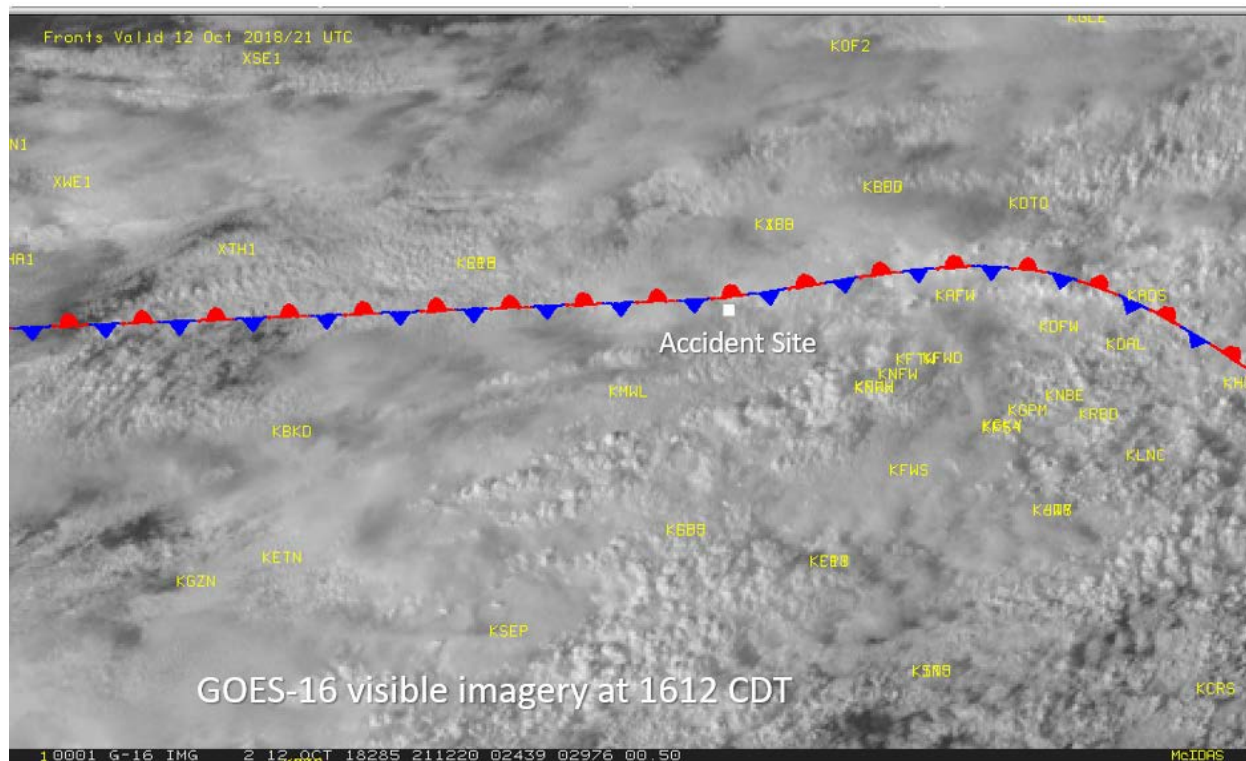


Figure 11 is the GOES-16 visible image for 1612 CDT at 2X magnification with the fronts overlaid. The accident marked by a white square was in the vicinity of the front and was obscured by low stratocumulus type clouds and mid-level cloud cover.



5.0 Weather Surveillance Radar Imagery

The closest Weather Surveillance Radar-1988 Doppler (WSR-88D)⁹ to the accident site was from the NWS Dallas/Fort Worth (KFWS) antenna site located 37 miles west-northwest of the accident site. The level II archive data was obtained from the NCEI using the Hierarchical Data Storage System and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors 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 (dBZ¹⁰) and is a general measure of echo intensity. Reflectivity rates are further described in Advisory Circular AC 00-24C – “Thunderstorms”. The following table is included in that advisory circular further describing reflectivity ranges and weather echo intensities. 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 table. One exception is that the Air Route Traffic Control Center’s

⁹ 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.

$$10 \text{ dBZ} - 10 \log Z_e$$

(ARTCC) weather and radar processor system does not display light intensity echoes below 30 dBZ.

Reflectivity (dBZ) Ranges	Weather Radar Echo Intensity Terminology
< 30 dBZ	Light
30 – 40 dBZ	Moderate
>40 – 50 dBZ	Heavy
>50 dBZ	Extreme

Figure 12 is the NWS KFWS WSR-88D 0.5° base reflectivity image at 1610 CDT with the flight track of N221MC overlaid¹¹. The image depicts a thin line of echoes in the range of -5 to 15 dBZ or very light intensity echoes along the flight track extending east-to-west north of KAFW, with no echoes over the accident site. Several small cells of echoes near 20 to 25 dBZ were located about 8 miles east and southeast of the accident site. Figure 13 is a closeup of the flight track and echoes in the vicinity of the accident site.



Figure 12 – NWS KFWS WSR-88D 0.5° base reflectivity image at 1610 CDT

¹¹ Based on the KFWS antenna height of 776 ft, distance of 37 miles, and assuming normal refraction of the beam, the 0.5° elevation scan beam was centered at about 3,650 ft with the base of the beam at 1,780 ft and the top at 5,510 ft. The flight track of N221MC indicated the accident reached its lowest altitude of 4,000 ft at this time.

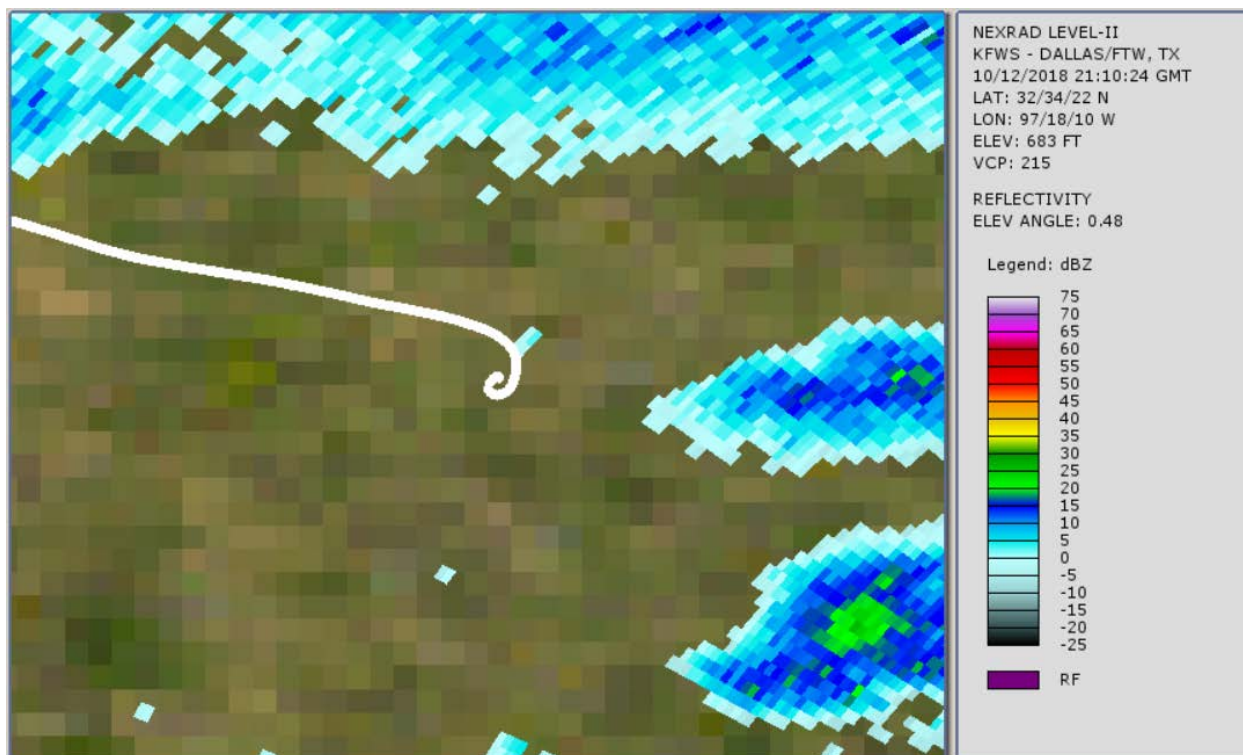


Figure 13 - NWS KFWS WSR-88D 0.5 base reflectivity image closeup with flight track at 1610 CDT

6.0 Pilot Reports

The following pilot reports (PIREPs) below 18,000 ft were noted within 100 miles of the accident site surrounding the period from 1300 through 2000 CDT:

DAL UA /OV 7 S LNC/TM 1850/FL060/TP PA28/RM VMC 060 BASES EST 100

DFW UA /OV 10 S DFW/TM 2005/FLDURC/TP A321/RM BASES 038 TOPS 120 MOD PRECIP

DAL UA /OV 10 N DAL/TM 2049/FL040/TP B737/TB LT-MOD CHOP/RM VFR

ACT UUA /OV 04525KACT/TM 2135/FL100/TP BE9L/TB MOD-EXTRM TURB 090-130/RM DURD¹²

FTW UA /OV MUFIN/TM 2140/FL023/TP FA50/SK BASES 027 MSL

DFW UA /OV 5 S DFW/TM 2205/FLDURC/TP B737/RM BASES VARIABLE 040 THRU 045

FTW UA /OV FTW340003/TM 2305/FL012/TP BE9T/SK BKN 012 MSL

FTW UA /OV 5 N FTW/TM 2307/FL005/TP BE20/SK BKN

¹² A review of the observations for Waco Regional Airport (KACT) indicated a thunderstorm at and in the vicinity of the airport immediately prior to the report, and lightning in the distance at the time of the report and implied the turbulence experienced was likely convectively induced. The station was located approximately 99 miles south of the accident site.

7.0 Terminal Aerodrome Forecast

The NWS Dallas/Fort Worth (KFWD) Weather Forecast Office (WFO), located in Fort Worth, TX was responsible for the region. The closest TAF was issued for KAFW approximately 25 miles east of the accident site. The following forecasts were issued 1200 CDT or prior to the accident airplanes departure, and may have been reviewed:

TAF AMD KAFW 121458Z 1215/1312 08009KT P6SM -SHRA BKN050

FM121700 12007KT P6SM -RA SCT025 BKN050

FM122200 11007KT P6SM VCSH SCT025 BKN040

FM130300 05006KT P6SM VCSH SCT015 BKN025

FM130900 05011KT 6SM BR VCSH BKN012

FM131100 06009KT 5SM SHRA OVC008=

TAF KAFW 121720Z 1218/1318 10007KT P6SM -SHRA SCT025 BKN050

TEMPO 1218/1219 4SM SHRA

FM122200 11007KT P6SM VCSH SCT025 BKN040

FM130100 05006KT P6SM VCSH SCT015 BKN025

FM130700 05007KT 6SM BR VCSH BKN012

FM131000 06009KT 5SM SHRA OVC008

FM131600 09011KT 5SM SHRA VCTS OVC011CB=

AMD TAF KAFW 121942Z 1220/1318 10006KT P6SM -SHRA SCT025 BKN050

TEMPO 1220/1222 4SM SHRA

FM122200 11007KT P6SM VCSH SCT025 BKN040

FM130200 05006KT P6SM VCSH SCT015 BKN025

FM130700 05007KT 6SM BR VCSH BKN012

FM131000 06009KT 5SM SHRA OVC008

FM131600 09011KT 5SM SHRA VCTS OVC011CB=

AMD TAF KAFW 122101Z 1221/1318 10006KT P6SM -SHRA SCT025 BKN050

FM122200 11007KT P6SM VCSH SCT025 BKN040

FM130200 05006KT P6SM VCSH SCT015 BKN025

FM130700 05007KT 6SM BR VCSH BKN012

FM131000 06009KT 5SM SHRA OVC008

FM131600 12011KT 5SM SHRA VCTS OVC009CB=

The forecasts expected VFR conditions to prevail with light easterly winds at 7 knots, visibility better than 6 miles in light rain showers, scattered clouds at 2,500 ft agl, with a ceiling broken at 5,000 ft. A temporary condition of MVFR conditions of 4 miles in moderate rain was expected for less than half of the period between initially from 1200 through 1300 CDT. The forecast was amended after the flight departed at 1342 CDT and expected light rain showers at the time of the accident.

8.0 Area Forecast Discussion

The NWS KDFW WFO issued the Area Forecast Discussion (AFD) at 1252 CDT. The NWS AFD product is intended to provide a well-reasoned discussion of the meteorological thinking which went into the preparation of the Zone Forecast Product and TAF. The forecaster will try to focus on the most particular challenges of the forecast. The text will be written in plain language or in proper contractions. At the end of the discussion, there will be a list of all advisories, non-

convective watches, and non-convective warnings. The term non-convective refers to weather that is not caused by thunderstorms. An intermediate Area Forecast Discussion will be issued when either significant forecast updates are being made or if interesting weather is expected to occur. The advisory current at the time was as follows:

FXUS64 KFWD 121752
AFDFWD

Area Forecast Discussion
National Weather Service Fort Worth TX
1252 PM CDT Fri Oct 12 2018

.AVIATION...
18z TAFs/

Scattered rain showers will continue moving across North Texas this afternoon, temporarily reducing visibilities to 3-5SM. A relative minimum in activity is expected through the late afternoon and early evening, although isolated rain showers will still be possible throughout this time period. An outflow boundary moved through the DFW area earlier this morning causing a brief north wind shift, but winds have since returned to the east or southeast where they will remain for the next few hours. However, the arrival of a weak cold front will cause winds to shift to the northeast later this evening at Metroplex airports.

While rain is currently falling from cloud bases around 5 kft, increasing low-level moisture should cause a gradual descent of cigs later this evening and overnight. Widespread MVFR cigs are expected at all TAF sites after midnight with IFR cigs likely prevailing into Saturday morning. During the overnight hours, convection should become fairly widespread to the west as intensifying low-level southerly flow interacts with the advancing cold front across much of West Texas and the Hill Country. Some of this activity should begin to spread eastward towards the TAF sites by mid morning. The potential for thunder will also increase as mid-level lapse rates steepen. Have introduced VCTS through the late morning hours at all airports, and carried it into the afternoon for the extended DFW TAF. Several hours of impacts to aviation are expected through the day Saturday, either from TS or from prolonged IFR conditions. By midday, winds may turn back to the east or southeast as the frontal zone retreats northward as a warm front.

-Stalley

*.SHORT TERM... /Issued 354 AM CDT Fri Oct 12 2018/
/Today and Tonight/*

Water vapor imagery shows high level moisture streaming into the Southern Plains ahead of Tropical Storm Sergio in the eastern Pacific along with a strong shortwave trough moving through the Central Plains. These two features will help strengthen the mid and upper level wind fields across the Plains today. In response, low level southerly flow will strengthen and help pull Gulf of Mexico moisture northward. Abundant mid and high cloud cover is already in place across the region indicative of the increase in moisture aloft from the eastern Pacific.

Strong isentropic ascent in the 295-310 K layer is ongoing across much of Central and North Texas and is already resulting in some spotty showers across our northwest counties. With continued moistening, the coverage of showers should increase through the mid morning hours with the best chances across the northern half of the region. There will be enough instability aloft for a few rumbles of thunder through the afternoon, but showers will generally prevail. Most of the precipitation will move off to the northeast late this afternoon as the northern stream shortwave quickly moves eastward and the low level jet veers and weakens.

A cold front will slide southward this evening and should make its way into the I-20 corridor prior to midnight. We'll hang onto some low rain chances right along the front through late evening. During the overnight hours, the remnant mid level circulation of Sergio will spread into West Texas. An ill-defined surface low over far West Texas will deepen overnight and should be centered somewhere north of Midland by early Saturday morning. Ahead of this feature, strong low level warm advection will again ramp up aided by a 45 kt low level jet. Unlike this morning, low level moisture will already be in place and a rapid development of showers and thunderstorms is expected across West Texas. This activity will spread eastward into our western counties prior to sunrise Saturday. We'll have high PoPs mainly west of I-35 for the late night hours into early Saturday morning. The aforementioned cold front will begin to spread back northward during this time. Right now, it doesn't appear that we'll be dealing with any severe weather overnight tonight, but that potential into the day Saturday will be discussed further below.

Dunn

*.FWD WATCHES/WARNINGS/ADVISORIES...
None.*

9.0 Graphic Forecast for Aviation

The NWS AWC Graphic Forecast for Aviation (GFA) of enroute clouds cover and tops current for the period are included below. The data for the chart comes from the NOAA Rapid Refresh Model (RAP). Cloud fraction (few, scattered, broken, overcast) is displayed for clouds below 18,000 ft. Grid circles indicate the coverage at that particular location. The chart also includes a graphic display of the AIRMET Sierra and Zulu for mountain obscuration (pink area) and icing conditions (light blue). The GFA forecast valid for 1600 CDT issued at 1100 and 1400 CDT are included as figures 14 and 15.

The GFA forecast issued at 1100 CDT and available prior to departure indicated overcast clouds over the route and the accident site with bases between 4,000 and 4,500 ft msl with tops between 6,000 and 8,000 ft. The forecast updated at 1400 CDT or after the flight's departure lowered the cloud layer to overcast at 3,000 to 3,500 ft msl with tops to 9,000 ft.

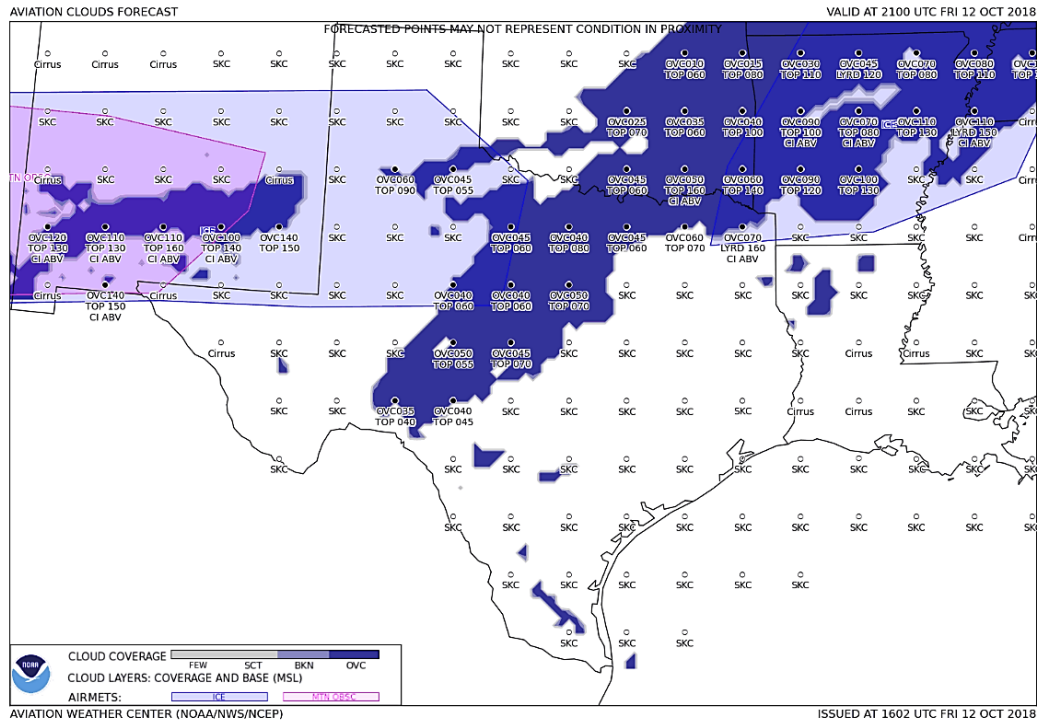


Figure 14 - GFA cloud cover and tops forecast issued at 1100 CDT and valid for 1600 CDT

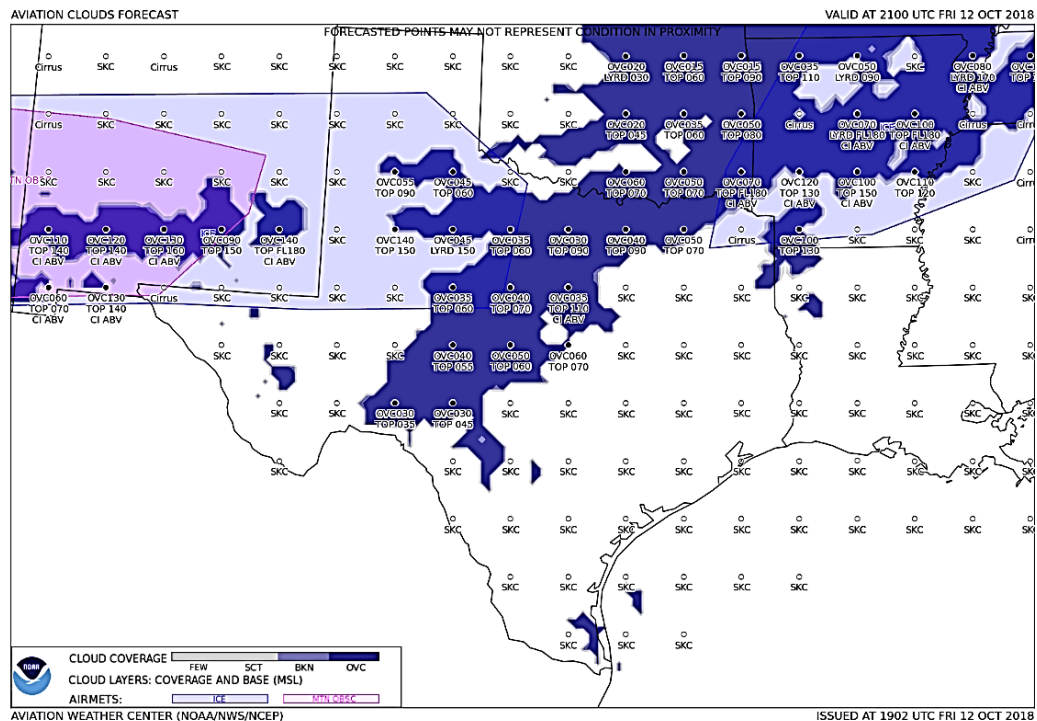


Figure 15 - GFA cloud cover and tops forecast issued at 1400 CDT and valid for 1600 CDT

10.0 Inflight Weather Advisories

A review of the NWS data base indicated that there were no Significant Meteorological Advisories (SIGMETs), Convective SIGMETs, Severe Weather Forecast Alerts (AWW), Center Weather Advisories (CWA), current at the time of the accident below 18,000 ft. The NWS AWC issued a series of Airmen's Meteorological Advisories (AIRMET) Sierra for IFR conditions during the period, which initially bordered the accident site and later included the site. Figure 16 is the GOES-16 satellite image with a plot of AIRMET Sierra update 4 at 1345 CDT. An advisory for IFR conditions bordered immediately north of the accident site. The text of the advisory immediately follows the graphic advisory.

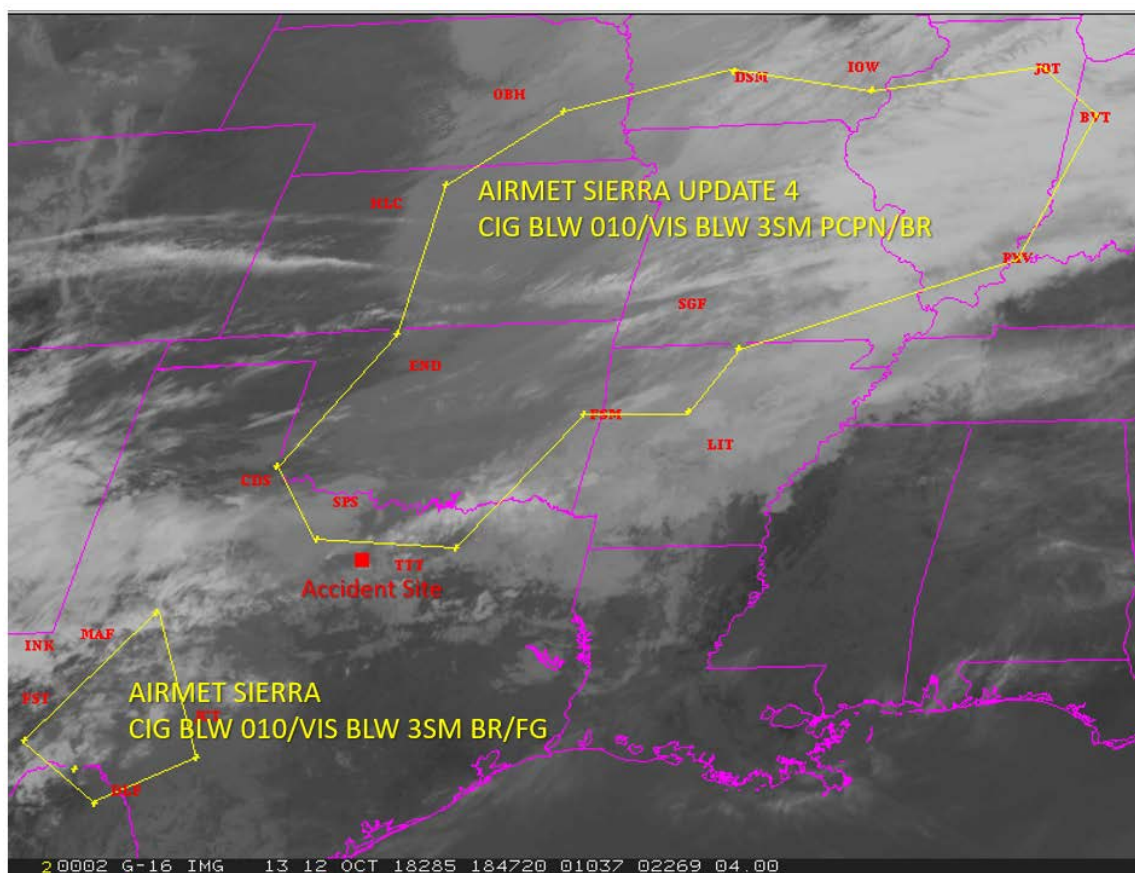


Figure 16 - AIRMET SIERRA for IFR conditions over GOES-16 satellite image at 1345 CDT

WAUS44 KPCI 121846 AAB

WA4S

-DFWS WA 121846 AMD

AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 122100

AIRMET IFR...OK TX AR NE KS IA MO IL IN KY...UPDT

FROM 20WNW DSM TO 30SSE IOW TO JOT TO BVT TO PXV TO 70SE SGF TO

50NW LIT TO 20W FSM TO 40ENE TTT TO 40SSW SPS TO 20NE CDS TO

50NW END TO 50ENE HLC TO 60ESE OBH TO 20WNW DSM

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z. *airme*

AIRMET IFR...TX...UPDT

FROM 50ENE MAF TO 40S JCT TO 30WSW DLF TO 40S FST TO 50ENE MAF
CIG BLW 010/VIS BLW 3SM BR/FG. CONDS ENDG BY 21Z.

AIRMET MTN OBSCN...TX

FROM 40WSW INK TO 60WNW DLF TO 100SSE MRF TO 50W MRF TO 40WSW INK
MTNS OBSC BY CLDS/BR. CONDS ENDG 18-21Z.

OTLK VALID 2100-0300Z...MTN OBSCN TX

BOUNDED BY 50W INK-70WNW DLF-90SSE MRF-ELP-50W INK
MTNS OBSC BY CLDS/PCPN/BR. CONDS DVLPG 00-03Z. CONDS CONTG THRU
03Z.

....

The advisories were updated at 1545 CDT as depicted in figure 17 and the text immediately below. The AIRMET Sierra update 5 included the accident site.

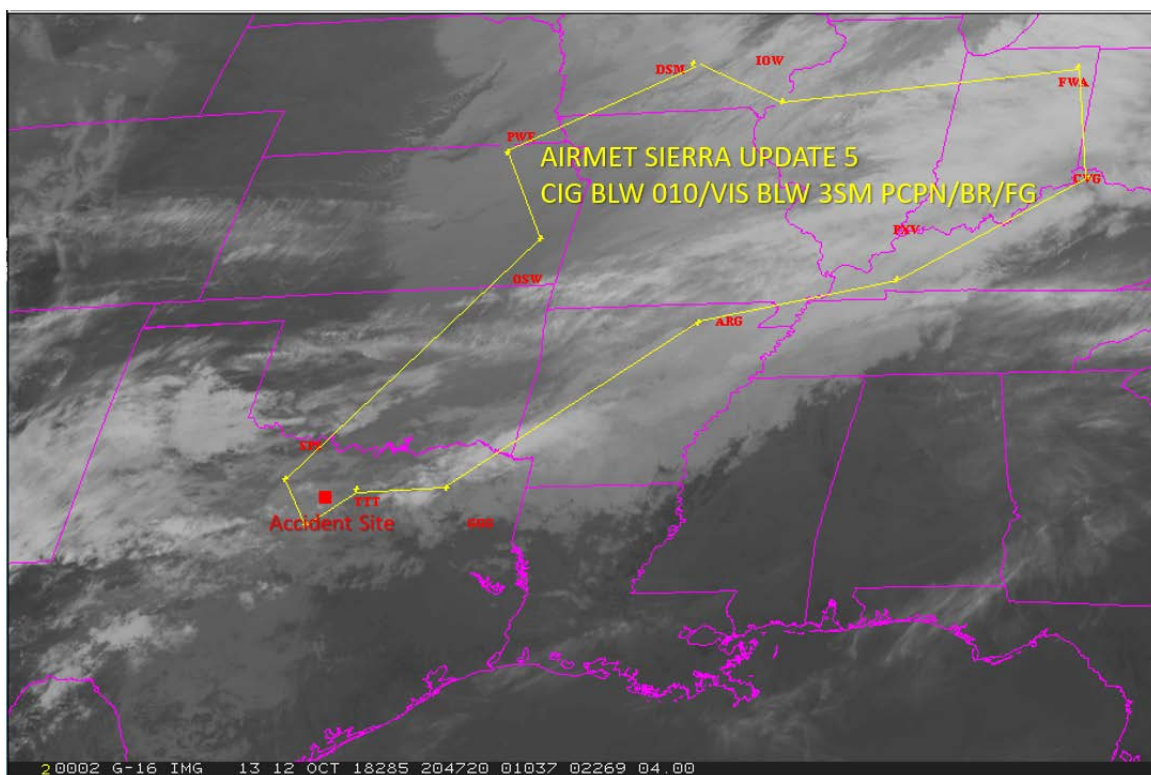


Figure 17 - AIRMET SIERRA update 5 for IFR conditions over the GOES-16 satellite image at 1547 CDT

WAUS44 KKCI 122045

WA4S

DFWS WA 122045

AIRMET SIERRA UPDT 5 FOR IFR AND MTN OBSCN VALID UNTIL 130300

AIRMET IFR...OK TX AR TN NE KS IA MO IL IN KY

FROM 20ENE DSM TO 60SSE IOW TO 20N FWA TO CVG TO 60S PXV TO 30W
ARG TO 60NW GGG TO 20NW TTT TO 60WSW TTT TO 40SSW SPS TO 50WSW
OSW TO 20SSW PWE TO 20ENE DSM

CIG BLW 010/VIS BLW 3SM PCPN/BR/FG. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET MTN OBSCN...TX
FROM 60W INK TO 70WNW DLF TO 90SSE MRF TO ELP TO 60W INK
MTNS OBSC BY CLDS/PCPN/BR. CONDS DVLPG 00-03Z. CONDS CONTG BYD
03Z THRU 09Z.

11.0 Preflight Weather Briefing

A search of the FAA contract Automated Flight Service Station (AFSS) provider Leidos, indicated that there was no record of any preflight weather briefing, flight plan being filed, or contact enroute by the accident pilot. A similar search from ForeFlight also indicated no contact with the pilot for any weather information. It is therefore unknown what the accident pilot may have used to familiarize himself on the weather conditions during the period.

12.0 Astronomical Conditions

The United States Naval Observatory's website provided the following astronomical conditions for October 12, 2018 for the Fort Worth, Tarrant County, Texas. The accident time has been added for reference in bold italic print.

<u>SUN</u>	
Beginning of civil twilight	0706 CDT
Sunrise	0731 CDT
Sun transit	1316 CDT
<i>Accident</i>	<i>1608 CDT</i>
Sunset	1900 CDT
End of civil twilight	1925 CDT

Submitted by:

Don Eick
Senior Meteorologist