

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



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METEOROLOGY

Specialist's Factual Report

July 16, 2024

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A. ACCIDENT

Location: Powell, Tennessee
Date: April 12, 2024
Time: 1633 eastern daylight time
2033 coordinated universal time (UTC)
Airplane: Piper PA-32R-301; Registration: N9236J

B. METEOROLOGY SPECIALIST

Paul Suffern
Senior Meteorologist
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

The NTSB's Senior Meteorologist did not travel for this investigation but gathered all data remotely. Data for this investigation were collected from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). This Specialist's Factual Report contains the meteorological factors pertinent to the weather surrounding the accident time. All times are eastern daylight time (EDT) and are based upon the 24-hour clock, where local time is -4 hours from UTC. Directions are referenced to true north and distances are in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS 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.

The accident site was located at approximate latitude 36.0438° N, longitude 84.09969° W, at an elevation of 980 feet (ft).

D. 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 and the WPC, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the Federal Aviation Administration (FAA) "Aviation Weather Handbook", FAA-H-8083-28.¹

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart centered over the southeastern United States for 1700 EDT is provided as figure 1 with the location of the accident site within the black circle. The chart depicted a trough² northwest of the accident site which stretched from a low-pressure system over Ontario, Canada (off the northern section of chart) southward through Lake Erie, Ohio, into central Kentucky. Another trough was located east of the accident site from central Virginia into southwestern North Carolina. A high-pressure system was located in southwestern Missouri at 1022-hectopascals (hPa). Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present.

The station model closest to the accident site depicted an air temperature of 58°F, a dew point temperature of 39°F, mostly cloudy sky cover, and a west-northwest wind at 15 knots.

¹ [FAA-H-8083-28](#)

² Trough - An elongated area of relatively low atmospheric pressure or heights.

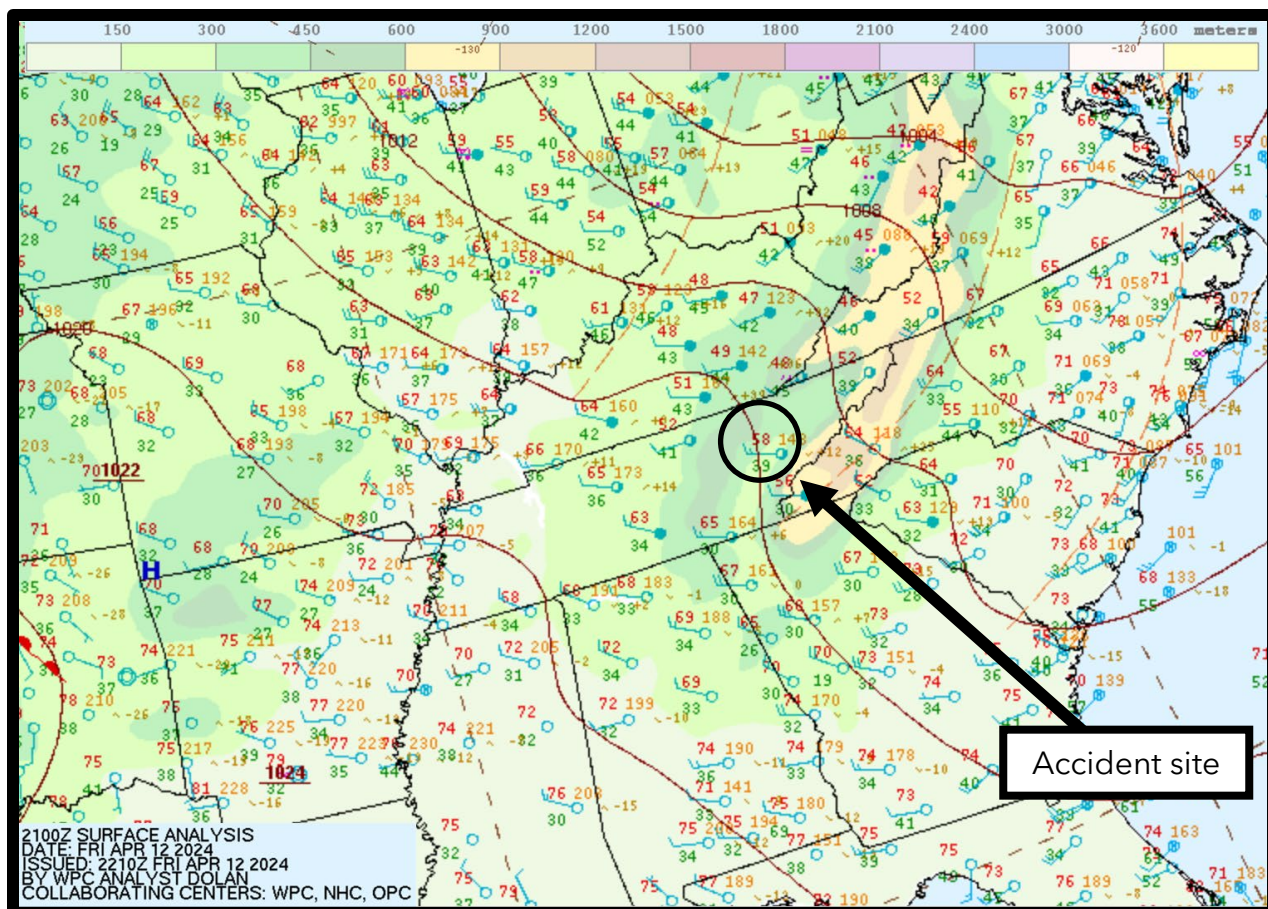


Figure 1. NWS Surface Analysis Chart for 1700 EDT.

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 2000 EDT at 925-, 850-, and 700-hPa are presented in figures 2 through 4. The charts indicated several low- and mid-level troughs at 925- through 700-hPa (figures 2 through 4) from the Ohio River Valley eastward to the western Atlantic Ocean. The 925-hPa constant pressure chart depicted a west wind around 25 knots (figure 2) becoming a northwest 35-knot wind by 700-hPa (figure 4).

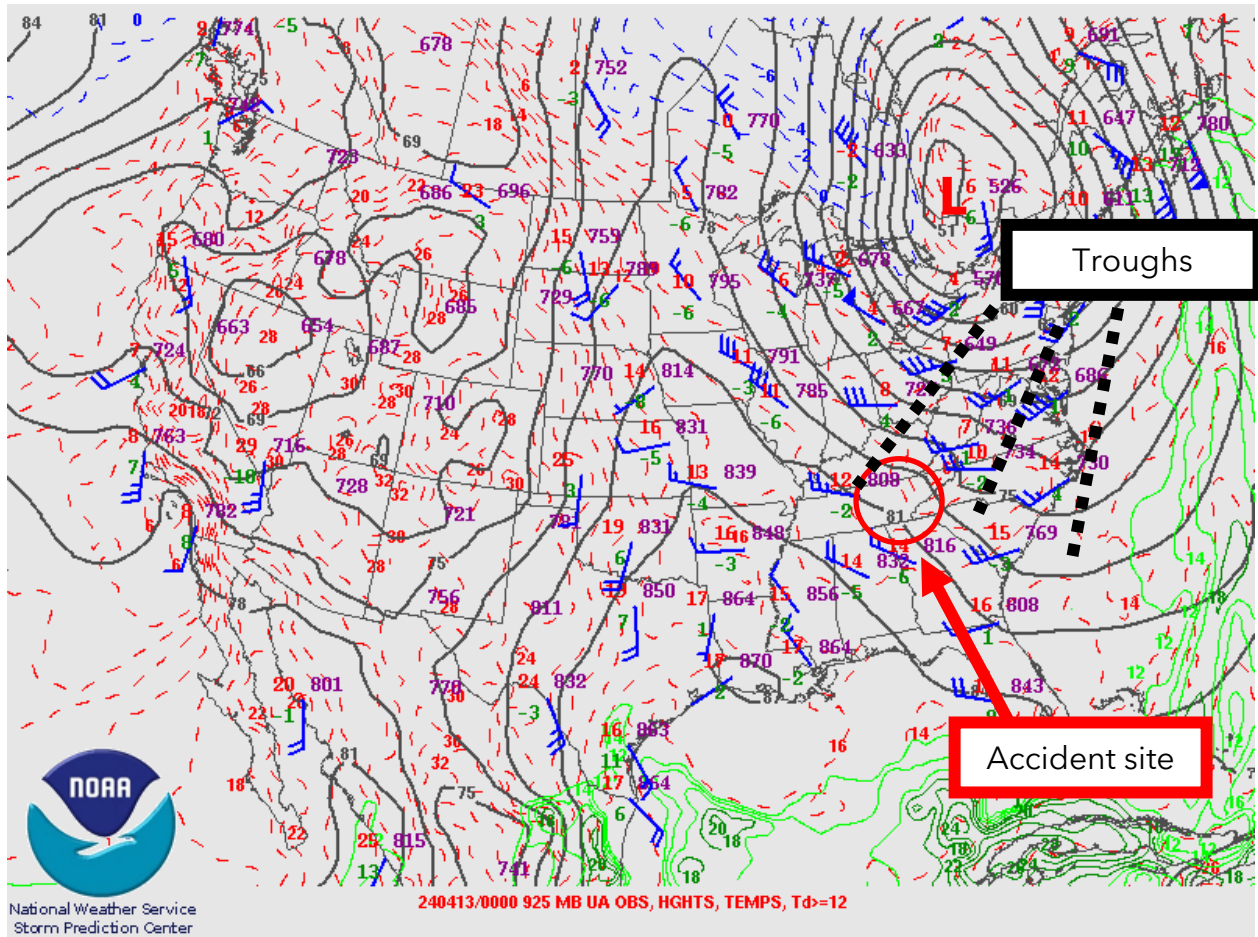


Figure 2. 925-hPa Constant Pressure Chart for 2000 EDT.

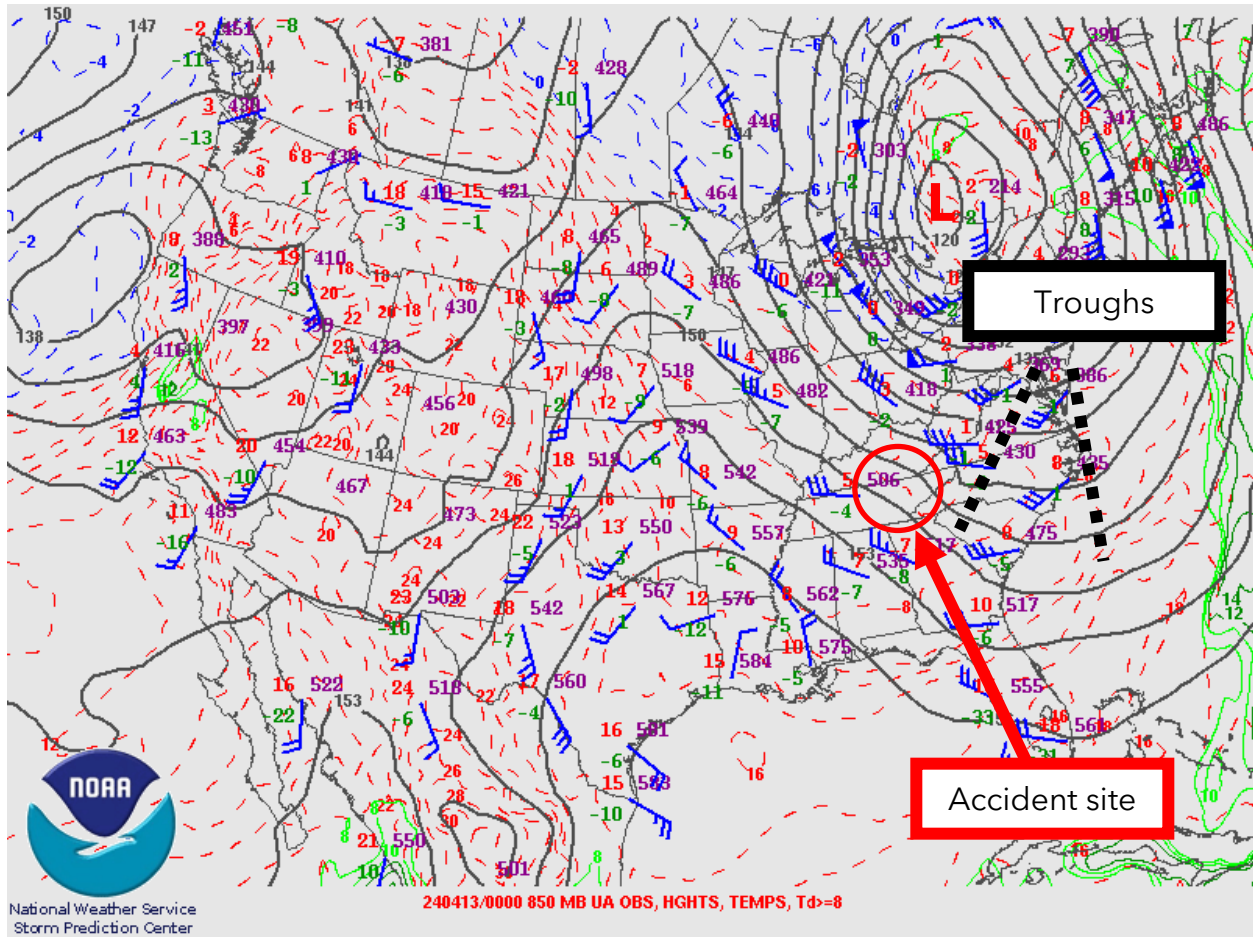


Figure 3. 850-hPa Constant Pressure Chart for 2000 EDT.

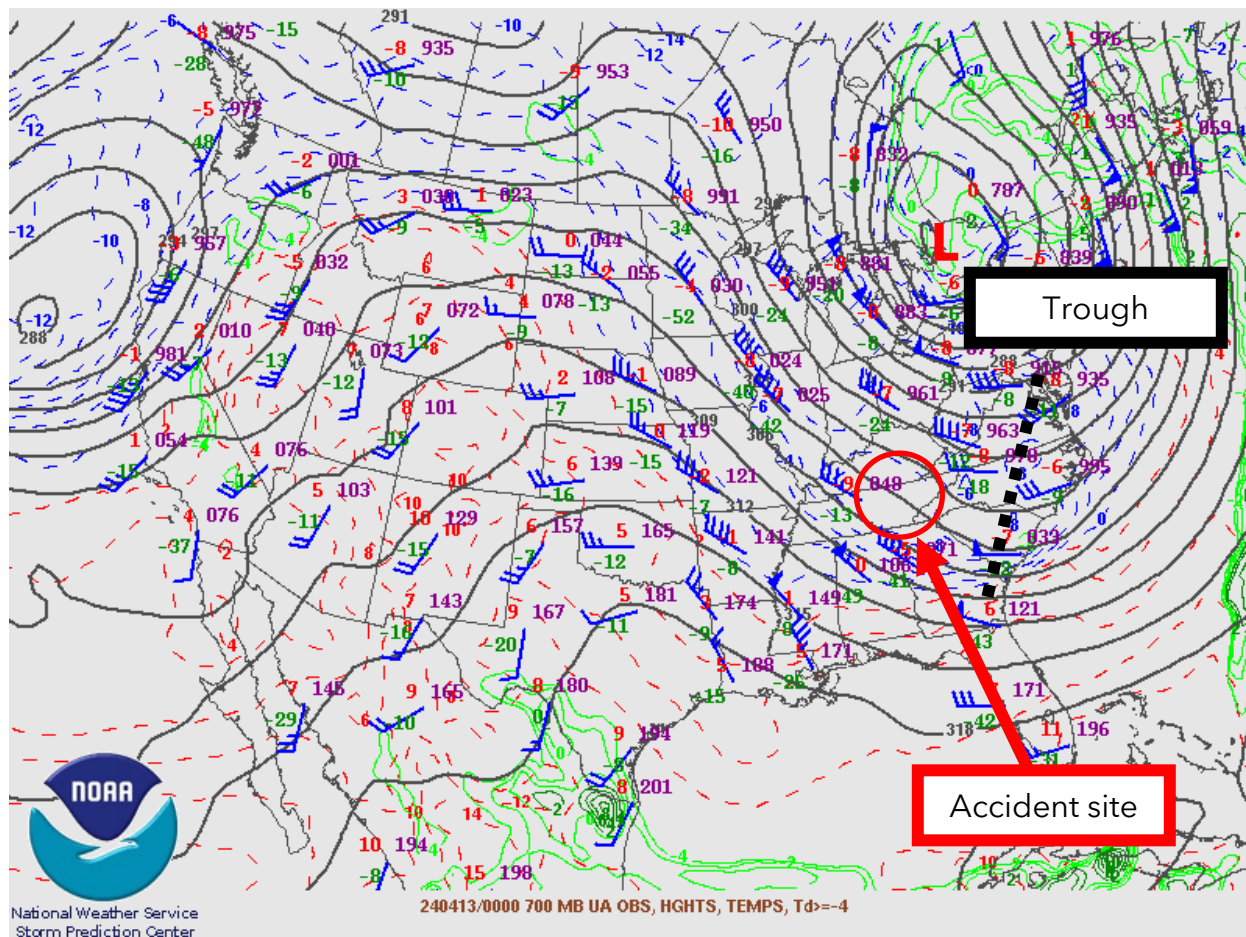


Figure 4. 700-hPa Constant Pressure Chart for 2000 EDT.

2.0 Storm Prediction Center Convective Outlook

SPC Day 1 Convective Outlook issued at 1543 EDT (figure 5) with the accident site noted by the red star was located in an area where a chance of general thunderstorms was predicted. The SPC defines the “TSTM” area as an area where a 10% or higher probability of thunderstorms is forecast during the valid period. A similar SPC forecast for the accident site was also issued in the 1230 EDT forecast.

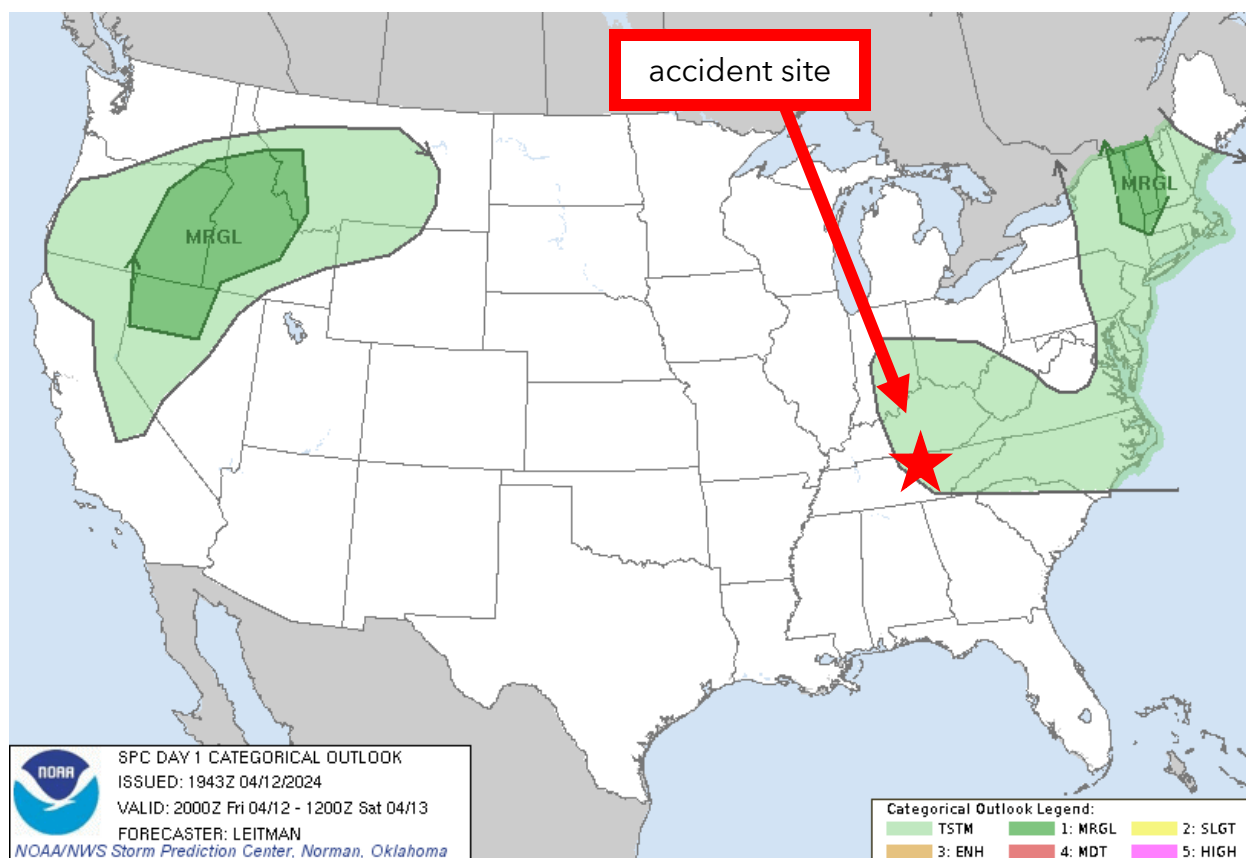


Figure 5. SPC day 1 Convective Outlook valid at the time of the accident.

3.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METARs) and Special Reports (SPECIs)³. The following observations were taken from standard code and are provided in plain language. Figure 6 is a local sectional chart with the accident site and the closest weather reporting location marked. A magnetic variation⁴ of 6° west was indicated over the area.

³ Latest criteria for SPECIs can be found in the Federal Meteorological Handbook: [Federal Meteorological Handbook Number 1, Surface Weather Observations and Reports \(icams-portal.gov\)](https://www.federalmetbook.com/)

⁴ Magnetic variation - The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

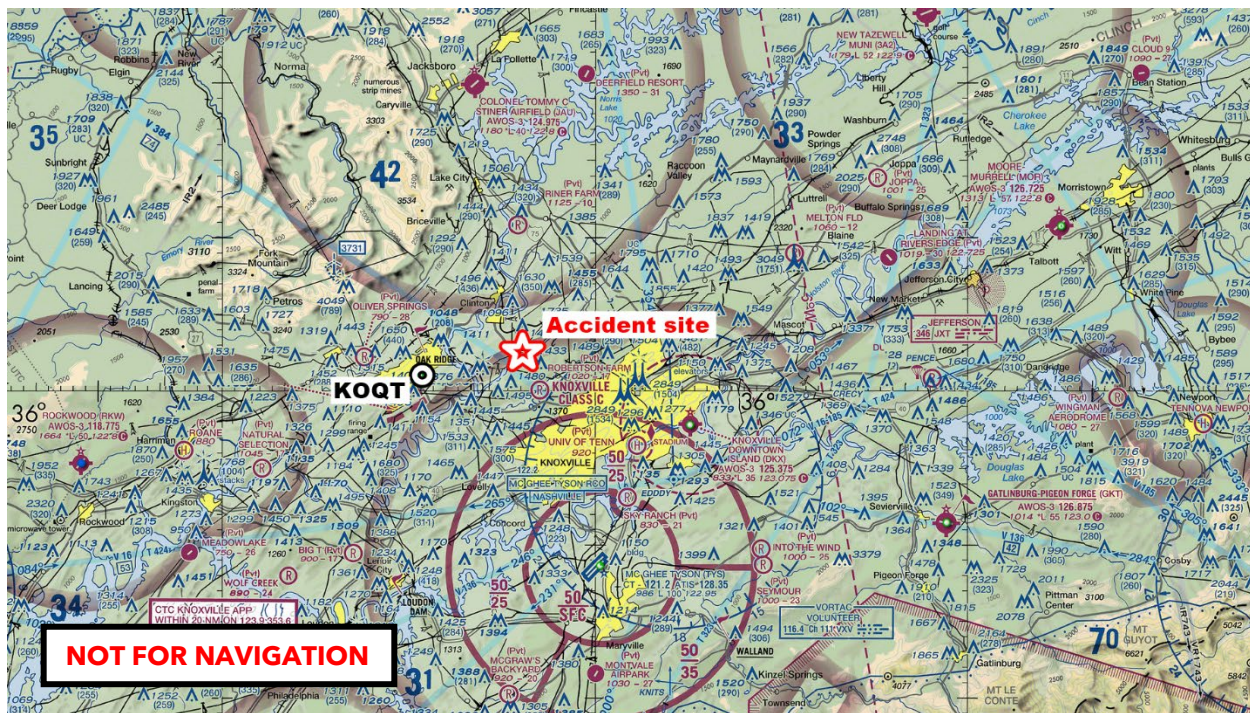


Figure 6. FAA sectional aeronautical chart of the accident area with the location of the accident site and surface observation site noted.

Oak Ridge, Tennessee (KOQT) had the closest official weather station to the accident site. KOQT had an Automated Surface Observing System (ASOS⁵) and its longline reports⁶ were not augmented. The KOQT ASOS was located 7 miles west-southwest of the accident site (figure 6) at an elevation of 915 ft, and issued the following observations surrounding the accident time:⁷

[1253 EDT] METAR KOQT 121653Z AUTO VRB06G18KT 10SM -RA
SCT055 OVC080 14/03 A2991 RMK AO2 RAB48 SLP128 P0000
T01390028

⁵ ASOS - Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, weather phenomena, ceiling, temperature, dewpoint, altimeter, and barometric pressure. ASOS are maintained by the NWS.

⁶ "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline dissemination of weather observations is the primary vehicle through which the weather observations are distributed.

⁷ The bold sections of products in this report are intended to highlight the text that directly reference the weather conditions that affected the accident region around the accident time. The local times in this section next to the METARs are provided for quick reference between UTC and local times.

[1353 EDT] METAR KOQT 121753Z AUTO 27009G27KT 6SM -RA
FEW041 BKN060 OVC100 12/03 A2994 RMK AO2 PK WND
25037/1723 RAE05B42 SLP138 P0000 60000 T01170028 10156 20111
53011

[1453 EDT] METAR KOQT 121853Z AUTO 28011G21KT 10SM FEW060
16/03 A2993 RMK AO2 RAE04 SLP133 P0002 T01560028

[1535 EDT] SPECI KOQT 121935Z AUTO 28010G25KT 260V330 10SM
-RA FEW048 BKN055 OVC075 13/05 A2998 RMK AO2 PK WND
29035/1925 WSHFT 1915 RAB18 PRESRR P0000 T01280050

**[1553 EDT] METAR KOQT 121953Z AUTO 27008G26KT 10SM
SCT050 BKN070 OVC080 13/04 A2997 RMK AO2 PK WND
29035/1925 WSHFT 1915 RAB18E51 SLP149 P0000 T01330039**

ACCIDENT TIME 1633 EDT

**[1653 EDT] METAR KOQT 122053Z AUTO 26008G29KT 180V290
10SM -RA BKN046 BKN055 OVC070 13/04 A2999 RMK AO2 PK
WND 26029/2029 RAB23 SLP156 P0000 60002 T01330039 53018**

[1753 EDT] METAR KOQT 122153Z AUTO 28007G20KT 250V330 10SM
OVC042 13/04 A3002 RMK AO2 PK WND 27032/2121 RAE2054
SLP166 P0000 T01330044

The bold type observations decoded in plain language were as follows:

KOQT weather at 1553 EDT, automated, wind from 270° at 8 knots with gusts to 26 knots, visibility 10 miles or greater, scattered clouds at 5,000 ft above ground level (agl), broken ceiling at 7,000 ft agl, overcast clouds at 8,000 ft agl, temperature of 13° Celsius (C), dew point temperature of 4°C, and an altimeter setting of 29.97 inches of mercury (inHg). Remarks, automated station with a precipitation discriminator, peak wind from 290° at 35 knots recorded at 1525 EDT, wind shift at 1515 EDT, rain began at 1518 and ended at 1551 EDT, sea-level pressure 1014.9-hPa, a trace of precipitation since 1453 EDT, temperature 13.3°C, dew point temperature 3.9°C.

KOQT weather at 1653 EDT, automated, wind from 260° at 8 knots with gusts to 29 knots, wind direction varying between 180° and 290°, visibility 10 miles or greater, light rain, broken ceiling at 4,600 ft agl, broken clouds at 5,500 ft agl, overcast clouds at 7,000 ft agl, temperature of 13°C, dew point temperature of 4°C, and an altimeter setting of 29.99 inHg. Remarks, automated station with a precipitation discriminator, peak wind from 260° at 29 knots at 1629 EDT, rain began at 1623 EDT, sea-level pressure 1015.6 hPa, a trace of precipitation since 1553 EDT, 6-hourly precipitation of 0.02 inches, temperature 13.3°C, dew point temperature 3.9°C, 3-hourly pressure tendency rise of 1.8 hPa.

The observations from the KOQT reported VFR⁸ conditions prevailing at the time of the accident with winds gusting as high as 35 knots at the surface in light rain, with multiple layers of broken to overcast clouds.

⁸ 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.

4.0 Upper Air Sounding

A High-Resolution Rapid Refresh (HRRR)⁹ model sounding was created¹⁰ for the approximate accident site coordinates for 1700 EDT. The HRRR sounding was plotted on a standard Skew-T Log P diagram¹¹ from the surface to 500-hPa (or approximately 18,000 ft) using the RAOB¹² software package and is included as figure 7. The sounding depicted an elevation of 988 ft over the grid point. The sounding depicted the lifted condensation level (LCL)¹³ and the level of free convection (LFC)¹⁴ at 4,104 ft, and the convective condensation level (CCL)¹⁵ at 4,978 ft. The freezing level was located at 5,448 ft. The precipitable water value was 0.62 inches.

⁹ The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

¹⁰ HRRR sounding was created using NOAA Air Resource Laboratory: [READY Archived Meteorology \(noaa.gov\)](https://ready.arl.noaa.gov/).

¹¹ 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.

¹² RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Esonde Research Services, The Villages, Florida.

¹³ LCL – The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁴ 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.

¹⁵ 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.

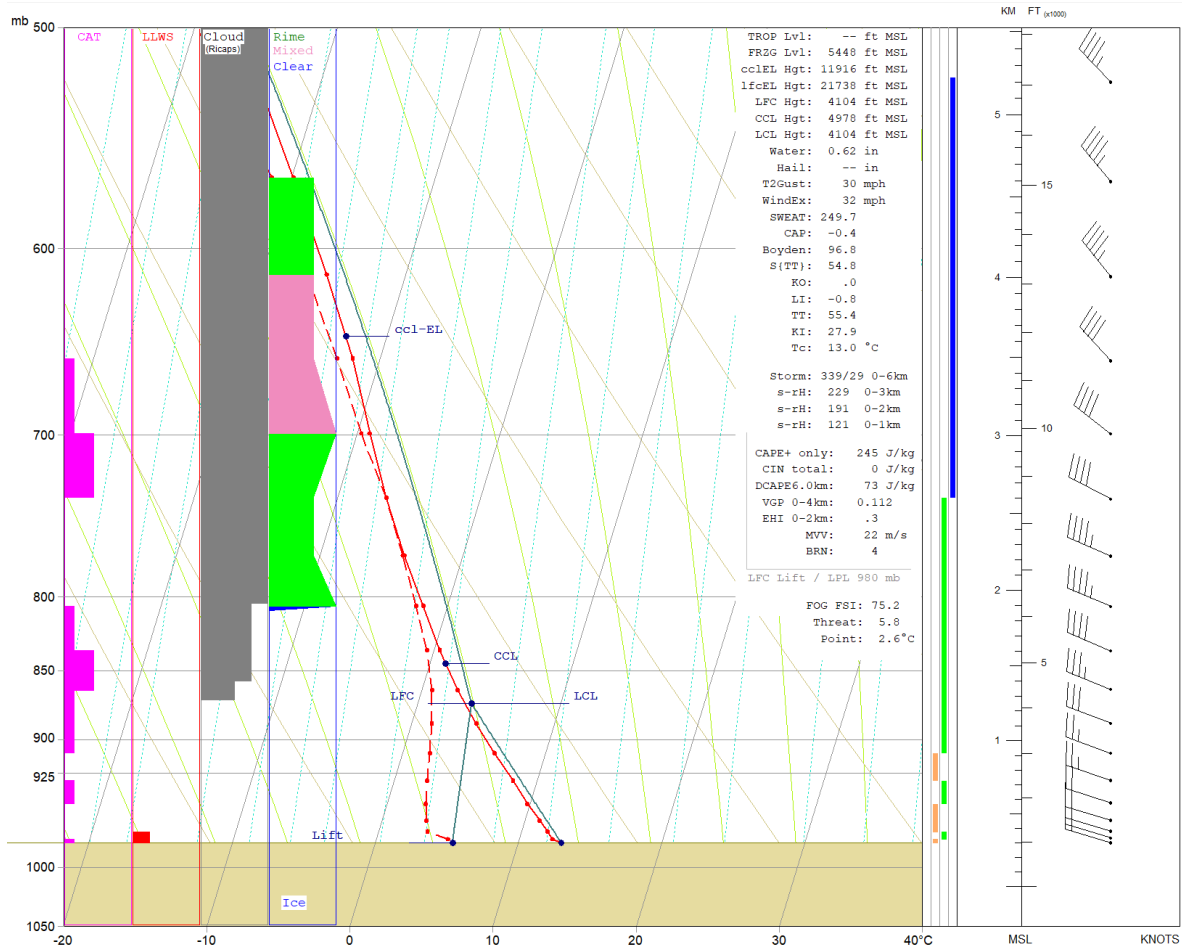


Figure 7. 1700 EDT HRRR sounding.

The 1700 EDT HRRR sounding identified both unstable and conditionally unstable environments from the surface through 8,500 ft, then a stable layer above 8,500 ft through 18,000 ft. RAOB indicated a cloud layer from 4,000 ft through 18,000 ft. Moderate clear, rime, and mixed icing was indicated by RAOB between 6,000 and 15,000 ft. There was a Convective Available Potential Energy (CAPE)¹⁶ of 245 Joules/kilogram (J/kg), with the maximum vertical velocity (MVV) for this atmosphere was calculated as 22 meters/second (about 4,331 ft per minute).¹⁷

¹⁶ Convective Available Potential Energy (CAPE) - CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

¹⁷ MVV is not usually considered a realistic estimate for maximum vertical velocity in a storm. Anecdotes suggest considering a value of MVV/2, however it is not well understood when or where such a half-value should be applied.

The 1700 EDT HRRR sounding wind profile indicated a near-surface wind from 290° at 13 knots with the wind remaining westerly through 5,000 ft. The wind speed increased to 25 knots by 2,500 ft. The wind backed¹⁸ to the northwest above 5,000 ft with the wind speed increasing to 40 knots by 5,250 ft. Light low-level wind shear (LLWS) was indicated by RAOB below 400 ft agl. RAOB indicated light to moderate clear air turbulence (CAT) in several layers between the surface and 12,000 ft. At the accident aircraft altitude before descent¹⁹ at approximately 8,000 ft, the wind was from 297° at 43 knots, the temperature was around -5.0°C, and the dew point temperature was around -5.0°C.

5.0 Satellite Data

Geostationary Operational Environmental Satellite number 16 (GOES-16) visible and infrared data were 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 software. Visible and infrared imagery (GOES-16 bands 2 and 13, respectively) at wavelengths of 0.64 microns (μm) and 10.3 μm, respectively, were retrieved for the period from 1300 EDT through 2000 EDT and reviewed, and the closest images to the time of the accident were documented.

Figure 8 presents the GOES-16 visible image at 1631 EDT at 3X magnification with the accident site highlighted with a red square. There was cloud cover indicated above the accident site with the cloud cover moving from northwest to southeast (attachment 1). The visible imagery indicated a transverse banding²⁰ in the cloud cover including above the accident site. Figure 9 presents the GOES-16 infrared image at 1631 EDT at 7X magnification with the accident site highlighted with a red square. Cloud cover was indicated above the accident site with lower brightness temperatures (green colors; higher cloud tops) located above the accident site. The brightness temperature of 245 Kelvin²¹ would have been near 18,500 ft based on the vertical temperature profile provided by the 1700 EDT HRRR sounding. It should be noted these figures have not been corrected for any parallax error.

¹⁸ Backed - Wind turning counter-clockwise with height.

¹⁹ For more information please see the ATC and track data in the docket for this accident.

²⁰ Transverse Bands - Bands of clouds oriented perpendicular to the flow in which they are embedded. They often are seen best on satellite photographs. When observed at high levels (i.e., in cirrus formations), they may indicate severe or extreme turbulence.

https://www.weather.gov/source/zhu/ZHU_Training_Page/Miscellaneous/gravity_wave/gravity_wave.html

²¹ around -28°C

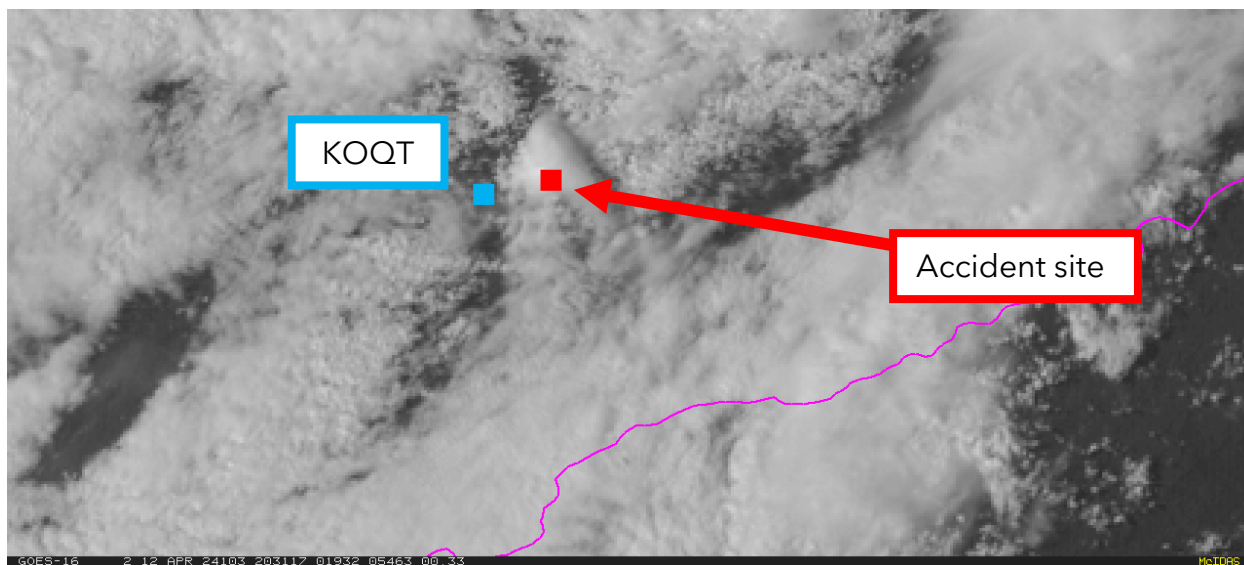


Figure 8. GOES-16 visible image at 1631 EDT.

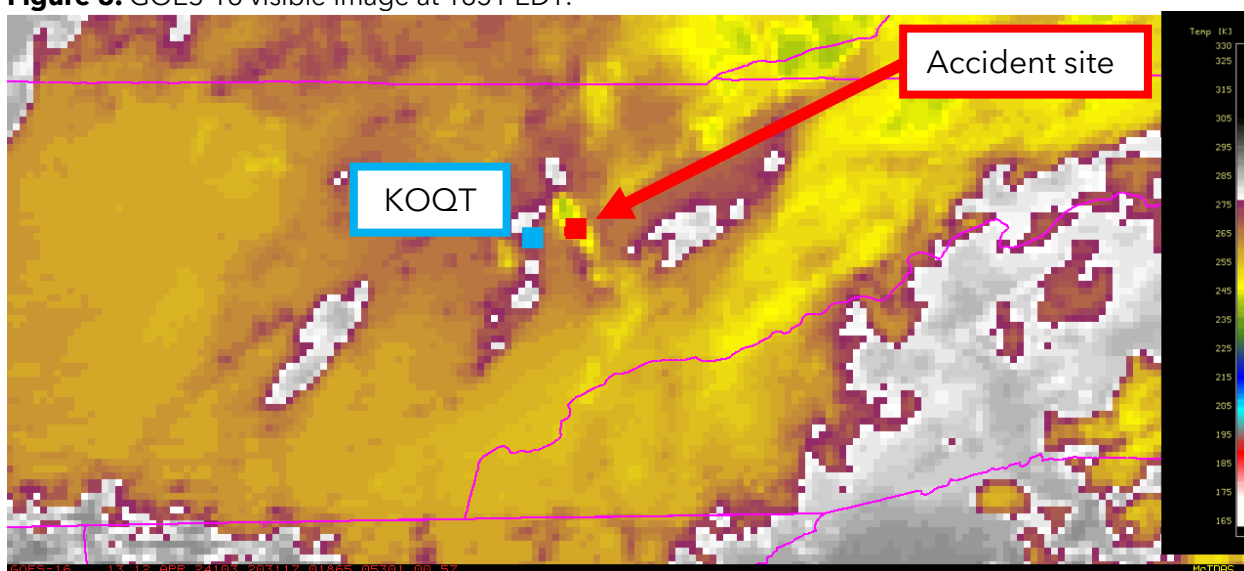


Figure 9. GOES-16 infrared image at 1631 EDT.

6.0 National Radar Imagery

A regional view of the NWS National Reflectivity Mosaic is included as figure 10 for 1635 EDT with the approximate location of the accident site marked by a red circle. The mosaic imagery depicted no echoes above the accident site.

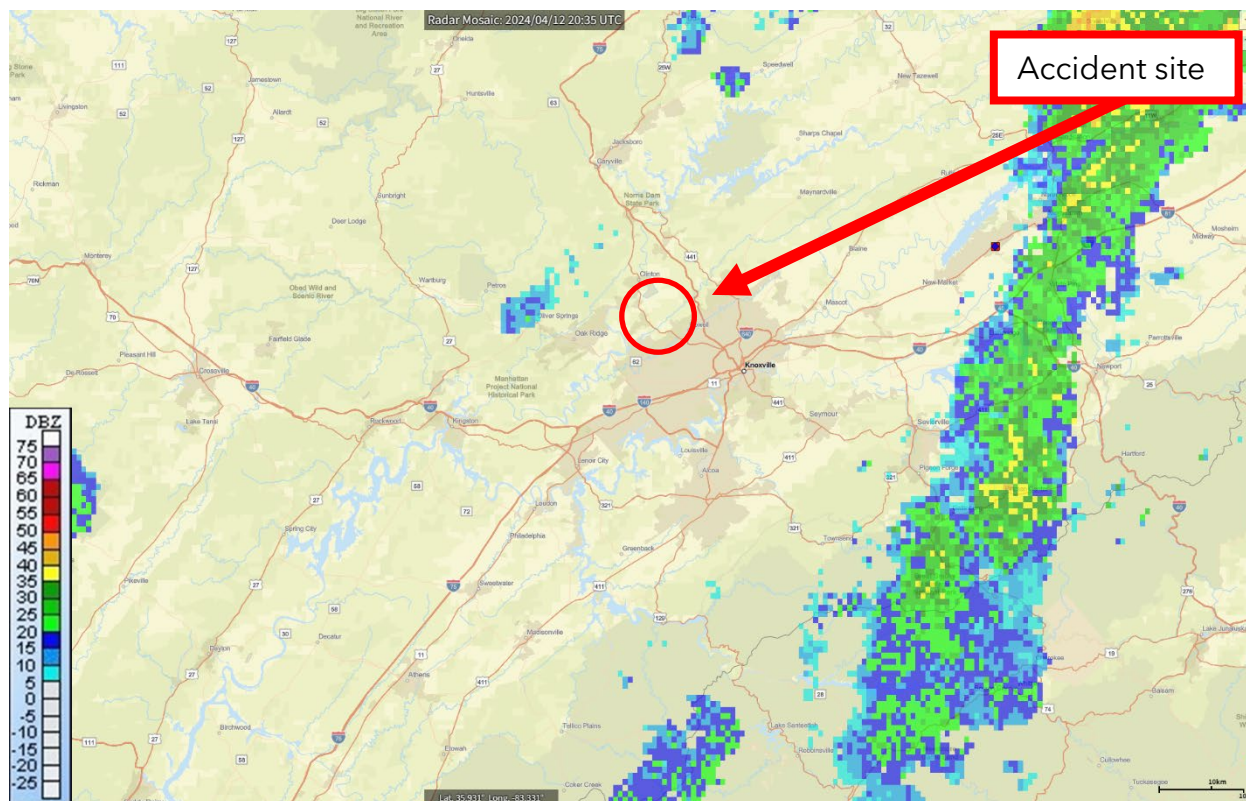


Figure 10. National Reflectivity Mosaic for 1635 EDT.

7.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar-1988 Doppler (WSR-88D)²² to the accident site was from the Morristown (KMRX), Tennessee, located 35 miles east-northeast of the accident site. The Level II archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

²² The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

7.1 Volume Scan Strategy

During the period surrounding the accident, the KMRX WSR-88D radar was operating in the precipitation mode VCP-215²³ (figure 11). The following figure 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.

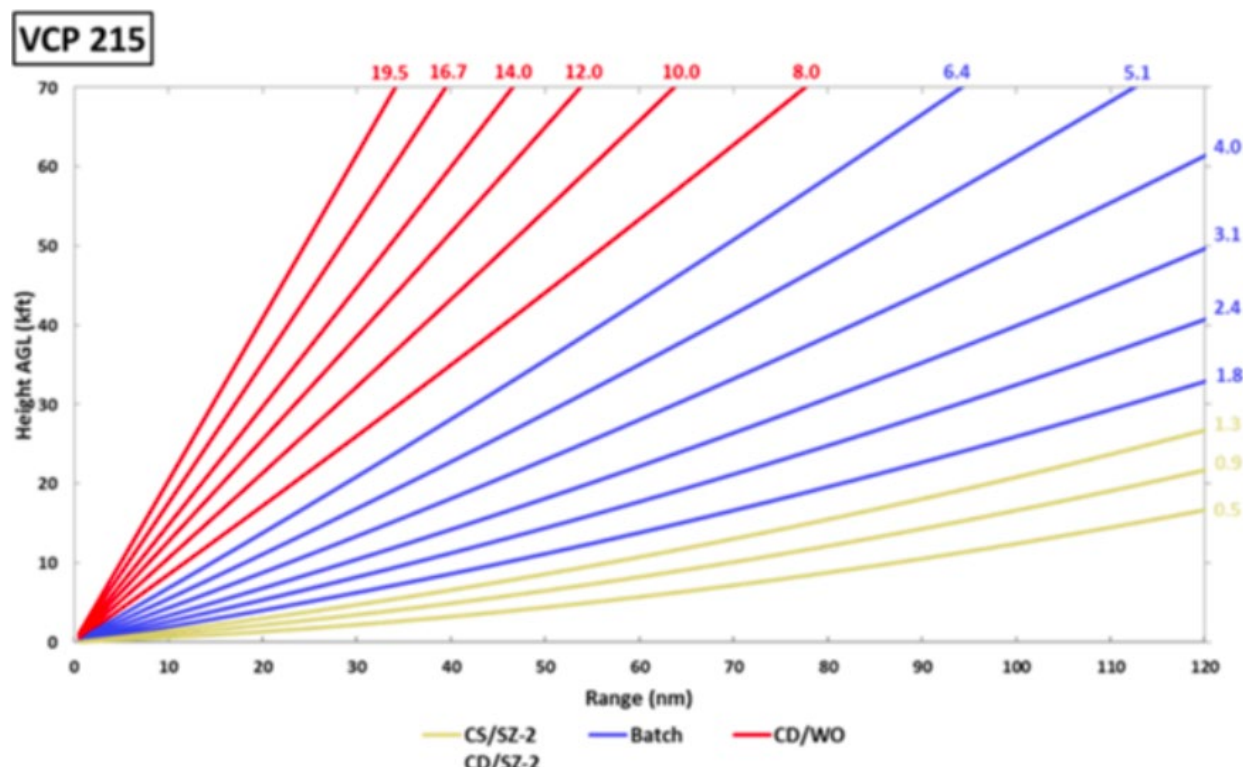


Figure 11. VCP-215 precipitation Mode Scan Strategy.

²³ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured.

Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values. Batch Mode - Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity.

Used in the middle elevation angles.

W - With range unfolding (W)

WO - Without range unfolding (WO)

7.2 Beam Height Calculation

Assuming standard refraction²⁴ of the KMRX WSR-88D radar beam with the antenna elevation at 1,434 ft, and considering a beamwidth²⁵ of 0.95°, the following table shows the approximate heights for the 1.32° radar beams' center, top and base over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KMRX 1.32°	7,070 ft	5,310 ft	8,830 ft

Based on the radar height calculations, the 1.32° elevation scan reviewed from KMRX listed in the above table combined to depict conditions between 5,310 ft and 8,830 ft over the accident site.

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁶ 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 dBZ²⁷ and is a general measure of echo intensity. The FAA Aviation Weather Handbook also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be "light." For dBZ values between 30 and 40, the terminology should be "moderate." "Heavy" terminology is used for dBZ values greater than 40 dBZ to 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as "extreme."

²⁴ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁵ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

²⁶ 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 glazed ice.

²⁷ dBZ - A non-dimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels or dB) with respect to radar reflectivity factor, Z.

7.4 Base Reflectivity Data and Lightning Data

Figures 12, 13, and 14 present the KMRX WSR-88D base reflectivity images for the 1.32° elevation scan initiated at 1620:30, 1627:33, and 1634:35 EDT with resolutions of 0.5° X 250 m. These images depicted reflectivity values between -5 and 25 dBZ above the accident site with the accident flight in a region of -5 to 20 dBZ values from 1626 EDT through the end of the flight track. The reflectivity targets were moving from west-northwest to east-southeast at the time of the accident (attachment 2).

There were no lightning flashes²⁸ reported within 40 miles of the accident site within 30 minutes of the accident time.²⁹

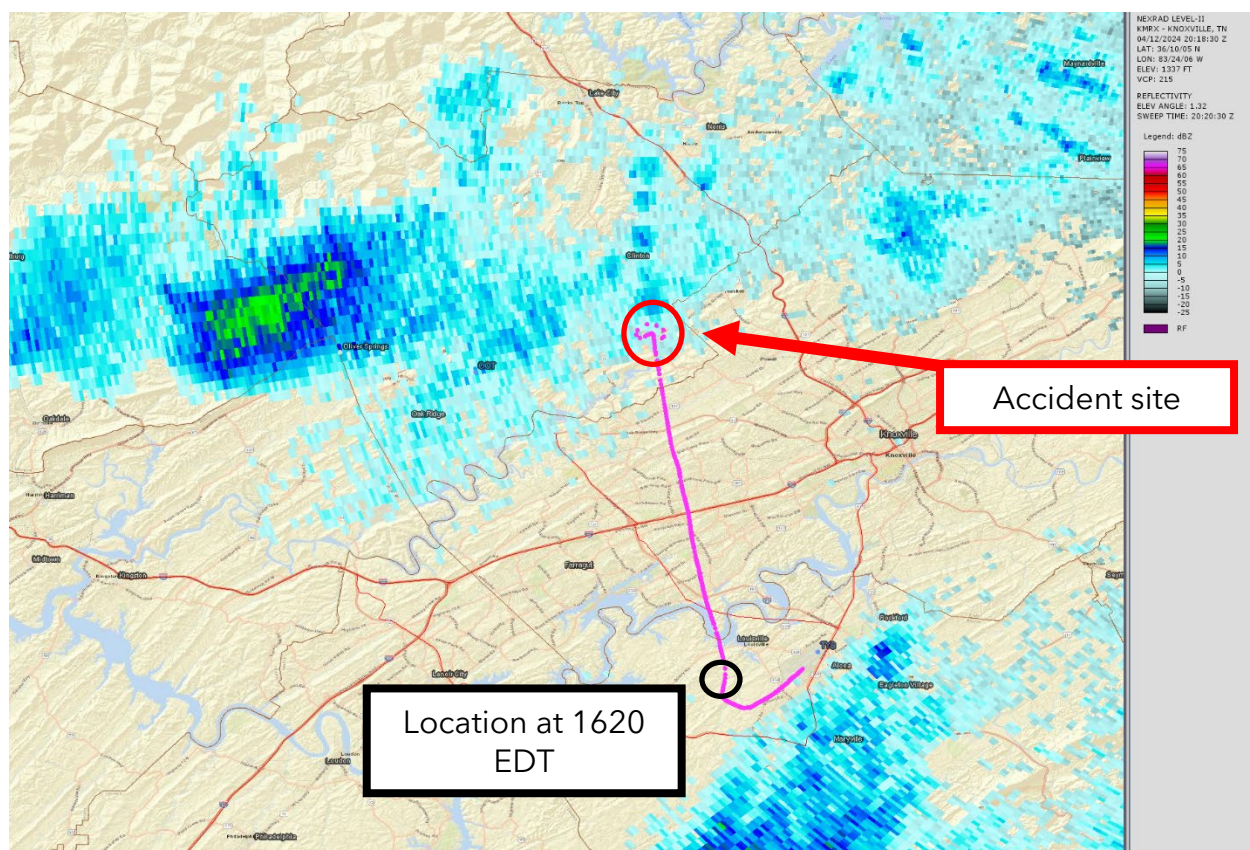


Figure 12. KMRX WSR-88D reflectivity for the 1.32° elevation scan initiated at 1620:30 EDT with the accident site marked with the red circle and the location of the accident aircraft in the black circle. The pink is the airplane flight track.

²⁸ Lightning Flash – This is one contiguous conducting channel and all the current strokes/pulses that flow through it. There are two types of flashes: ground flashes and cloud flashes.

²⁹ A review of Earth Networks Total Lightning network and GOES Geostationary Lightning Mapper was done.

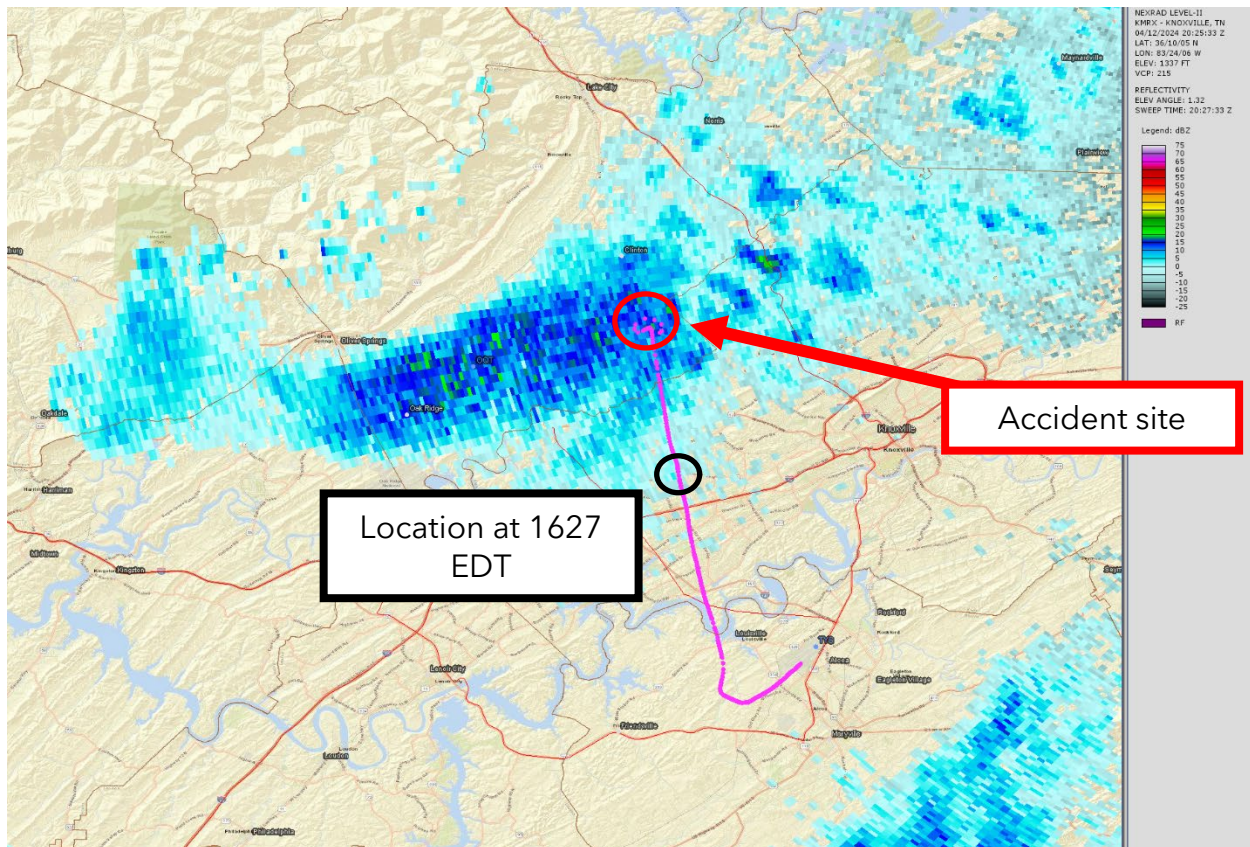


Figure 13. KMRX WSR-88D reflectivity for the 1.32° elevation scan initiated at 1627:33 EDT with the accident site marked with the red circle and the location of the accident aircraft in the black circle. The pink is the airplane flight track.

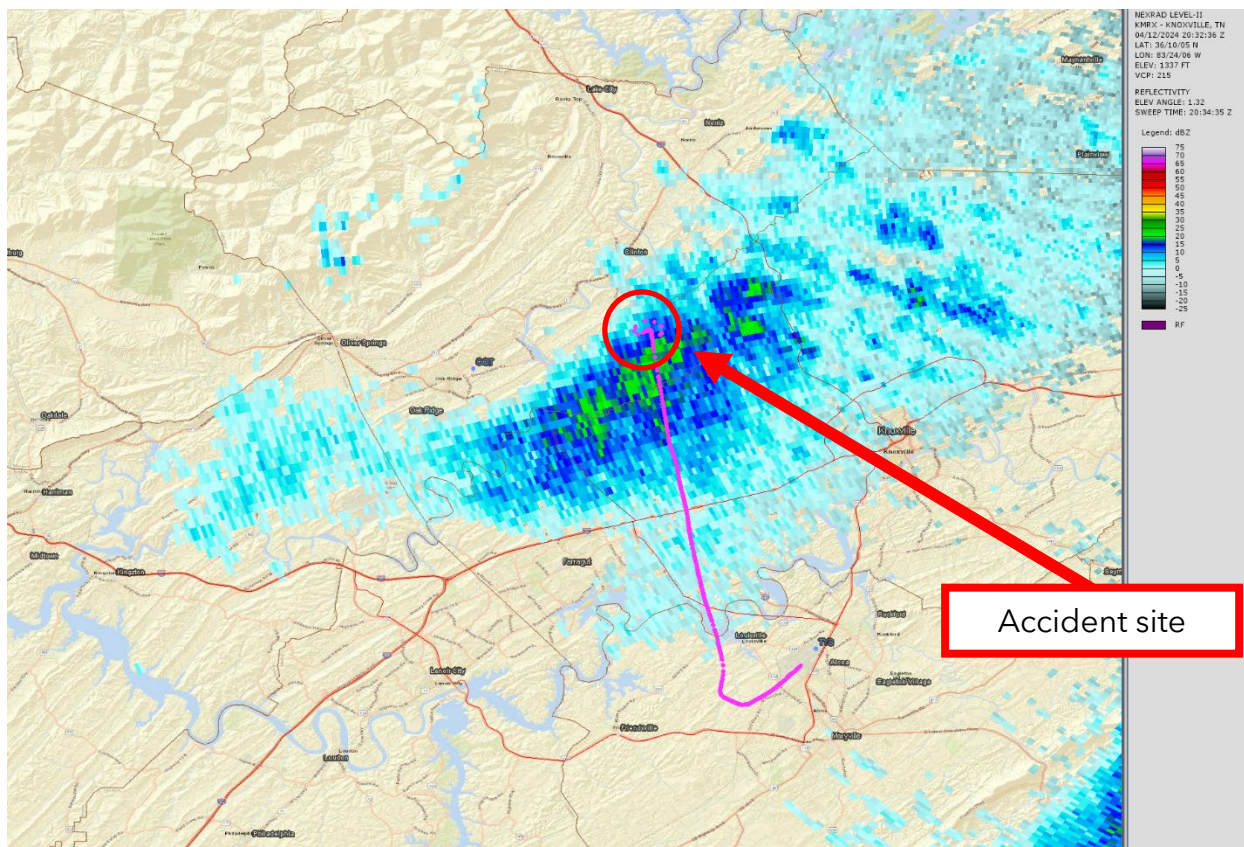


Figure 14. KMRX WSR-88D reflectivity for the 1.32° elevation scan initiated at 1634:35 EDT with the accident site marked with the red circle. The pink is the airplane flight track.

8.0 Pilot Reports

The longline-disseminated pilot reports³⁰ (PIREPs) distributed into the national airspace system (NAS) within 2 hours of the accident time and within 100 miles of the accident site are shown here for below 18,000 ft:

TYS UA /OV SOT190002/TM 2230/FL170/TP CRJ9/SK TOP160/TB NEG/RM ZTL FD 45
 CSV UA /OV HCH150005/TM 2230/FL060/TP T206/TB NEG/IC NEG/RM ZTL FD 41
 YYS UA /OV YYS135025/TM 2227/FL050/TP CRJ9/TA 06/IC MOD/RM 120-053
 YYS UA /OV YYS180025/TM 2143/FL060/TP A319/SK BASES 063/TA M11/TB
 MOD/RM 130-065
 TRI UA /OV SOT050015/TM 2134/FL090/TP P28B/TA M15/IC LGT RIME 070-090
 OVG UA /OV OVG/TM 2127/FL100/TP BE35/TA M03/IC LGT RIME

³⁰ Only PIREPs with the World Meteorological Organization headers UBTN**, UBKY**, UBNC**, UBVA**, UBAL**, and UBGA** were considered. These do not include pilot reports only broadcast via radio.

CHA UUA /OV CHA360001/TM 2117/FL008/TP E145/SK BKN008/WX FV10SM/WW
29024G31/RM LLWS -30KT 008-SFC DURD RY 20 CHA
CHA UUA /OV CHA 1N/TM 2117/FL008/TP E145/SK BKN008/WX 10SM/WW
29024G31/RM LLWS -30KT 008-SFC DURD RY 20 CHA
RHP UA /OV HRS030115/TM 2116/FL100/TP BE33/TA M10/IC RIME/RM ZTL FD 18
CHA UUA /OV CHA 1S/TM 2113/FL008/TP E135/SK BKN085/WX 10SM/WW
30021KTG28/RM LLWS -20KT SFC 009 DURC RY20 CHA
CHA UUA /OV CHA180001/TM 2113/FL008/TP E135/SK BKN085/WX FV10SM/WW
30021KTG28/RM LLWS -20KT SFC 009 DURC RY20 CHA
TYS UA /OV TYS180035/TM 2112/FL130/TP E550/TA M10/IC LGT RIME/RM ZTL FD 18
TYS UA /OV ODF320015/TM 2054/FL072/TP C425/SK BASES 072/TB LGT CHOP/RM
ZTL FD 18
TYS UA /OV VXV010020/TM 2042/FL160/TP BE9L/TB LGT CHOP/RM ZTL FD 38
CHA UUA /OV CHA 1N/TM 2030/FL005/TP C550/SK BKN080/WX 10SM/WW
29017G22/RM LLWS +/-15KT 005-SFC DURD RY 20 CHA
CHA UUA /OV CHA360001/TM 2030/FL005/TP C550/SK BKN080/WX FV10SM/WW
29017G22/RM LLWS +/-15KT 005-SFC DURD RY 20 CHA
GSP UA /OV LQK270010/TM 1930/FL090/TP SF50/TA M10/IC RIME
CHA UUA /OV CHA360001/TM 1920/FL005/TP BE40/SK SCT070/WX FV10SM/WW
28020G30KT/TB MOD DURC 1S CHA SFC-040/RM LLWS +30KT 005-SFC DURD RY20
AND RY33 CHA
TYS UA /OV VXV/TM 1917/FL130/TP G150/TB MOD TURB/RM ZTL FD 41
1A5 UUA /OV 1A5/TM 1915/FL050/TP C425/RM LLWS 30KT LOSS
TYS UA /OV ODF010030/TM 1912/FL110/TP C310/IC LGT RIME/RM ZTL FD 49
AVL UA /OV SUG290015/TM 1901/FL100/TP E75S/TB MDT CHOP/RM ZTL FD 44
BNA UA /OV BNA135060/TM 1852/FL110/TP M20P/TA M10/IC TRACE RIME/RM
DURC. ZME
CHA UUA /OV CHA360001/TM 1832/FL002/TP B712/SK SCT070/WX FV10SM/WW
32029KT/RM LLWS +/-20KT 005-SFC DURD RY20 KCHA
AVL UA /OV AVL335030/TM 1832/FL100/TP BE55/TA -7/IC LGT RIME

9.0 Significant Meteorological Information

There were no non-convective Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time. There was a Convective SIGMET³¹ valid for the accident site at the accident time. SIGMET 68E issued at 1455 EDT, valid through 1655 EDT, forecast an area of embedded thunderstorms with tops to FL250³² with the SIGMET box area moving from 270° at 35 knots. The advisory was not updated or continued on the next hourly advisory update at 1555 EDT. The advisory issued at 1455 EDT was as follows:

WSUS31 KPCI 121855
SIGE
-MKCE WST 121855
CONVECTIVE SIGMET 68E
VALID UNTIL 2055Z
VA NC TN KY
FROM 20E LOZ-40ENE HMV-40NE ODF-50NNE GQO-20E LOZ
AREA EMBD TS MOV FROM 27035KT. TOPS TO FL250.

10.0 Center Weather Service Advisories

The Atlanta (ZTL) Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) was responsible for the accident region. There was no Center Weather Advisory (CWA) valid for the accident site at the accident time. The Pre-Duty Weather Briefings (PDWB) provided by ZTL CWSU for April 12 can be found in attachment 3.

³¹ US Convective SIGMETs - Convective SIGMETs are issued in the conterminous U.S. if these conditions are occurring or expected to occur:

- Line of thunderstorms at least 60 miles long with thunderstorms affecting 40% of its length
- Area of thunderstorms covering at least 40% of the area concerned and exhibiting a very strong radar reflectivity or a significant satellite or lightning signature
- Embedded or severe thunderstorms expected to occur for more than 30 minutes

Special issuance criteria occur with tornado, hail greater than 3/4 inch in diameter, and wind gusts greater than or equal to 50 knots. Any convective SIGMET implies severe or greater turbulence, severe icing, and low level wind shear. A convective SIGMET may be issued for any convective situation which the forecaster feels is hazardous to all categories of aircraft. Bulletins are issued hourly at Hour+55. The text of the bulletin consists of either an observation and a forecast or just a forecast. The forecast is valid for up to 2 hours or until superseded by the next hourly issuance.

³² Flight Level - A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the standard sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products issued by the NWS Aviation Weather Center (AWC) around 0900 EDT and valid at 1700 EDT are shown in figures 15 and 16 (additional GFA forecast products produced after 0900 EDT were not available due to AWC archiving constraints). The GFA surface forecast applicable at 1700 EDT for the accident site indicated VFR conditions with isolated (between 10 to 20 percent) thunderstorms and a west wind of 15 knots with gusts to 25 knots. The GFA cloud forecast applicable to the accident site for 1700 EDT indicated overcast cloud cover at the accident site with cloud bases around 3,500 ft and cloud tops to FL230 with cirrus clouds above. Graphical AIRMETs³³ (G-AIRMET) issued around 0900 EDT, included G-AIRMET Sierra were valid for 1700 EDT for the accident site (figure 16). The only human-generated information reflected in the two GFA products were the G-AIRMETs. G-AIRMETs Sierra, Tango, and Zulu issued at 1340 and 1045 EDT, respectively, and valid for 1700 EDT can be found in figures 17 through 19.

³³ Graphical AIRMETs (G-AIRMETs), found on the Aviation Weather Center webpage at <http://aviationweather.gov>, are graphical forecasts of en-route weather hazards valid at discrete times no more than 3 hours apart for a period of up to 12 hours into the future (for example, 00, 03, 06, 09, and 12 hours). G-AIRMETs are snap shots at discrete time intervals as defined above. The text AIRMET is the result of the production of the G-AIRMET but provided in a time smear for a 6hr valid period.

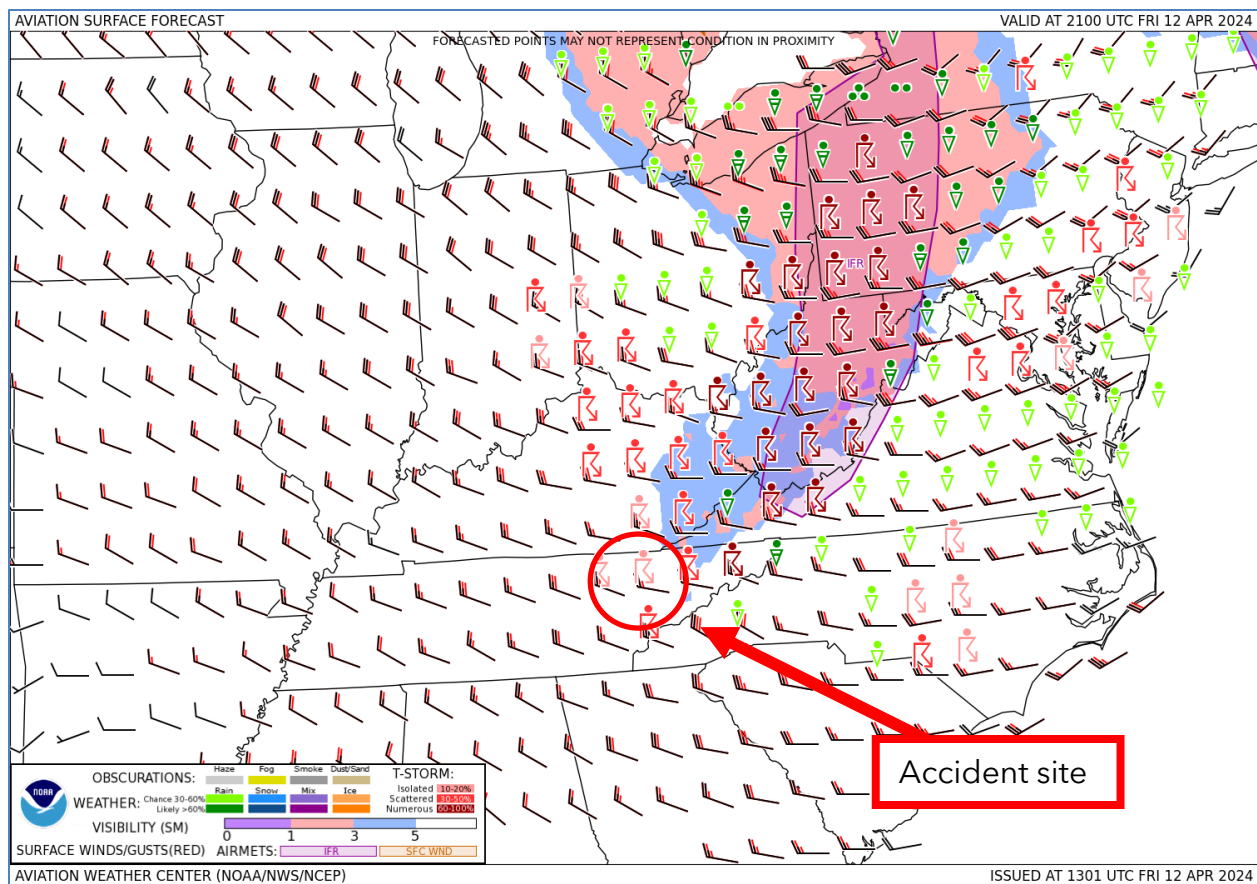


Figure 15. GFA Surface Forecast valid at 1700 EDT with forecast issued at 0901 EDT.

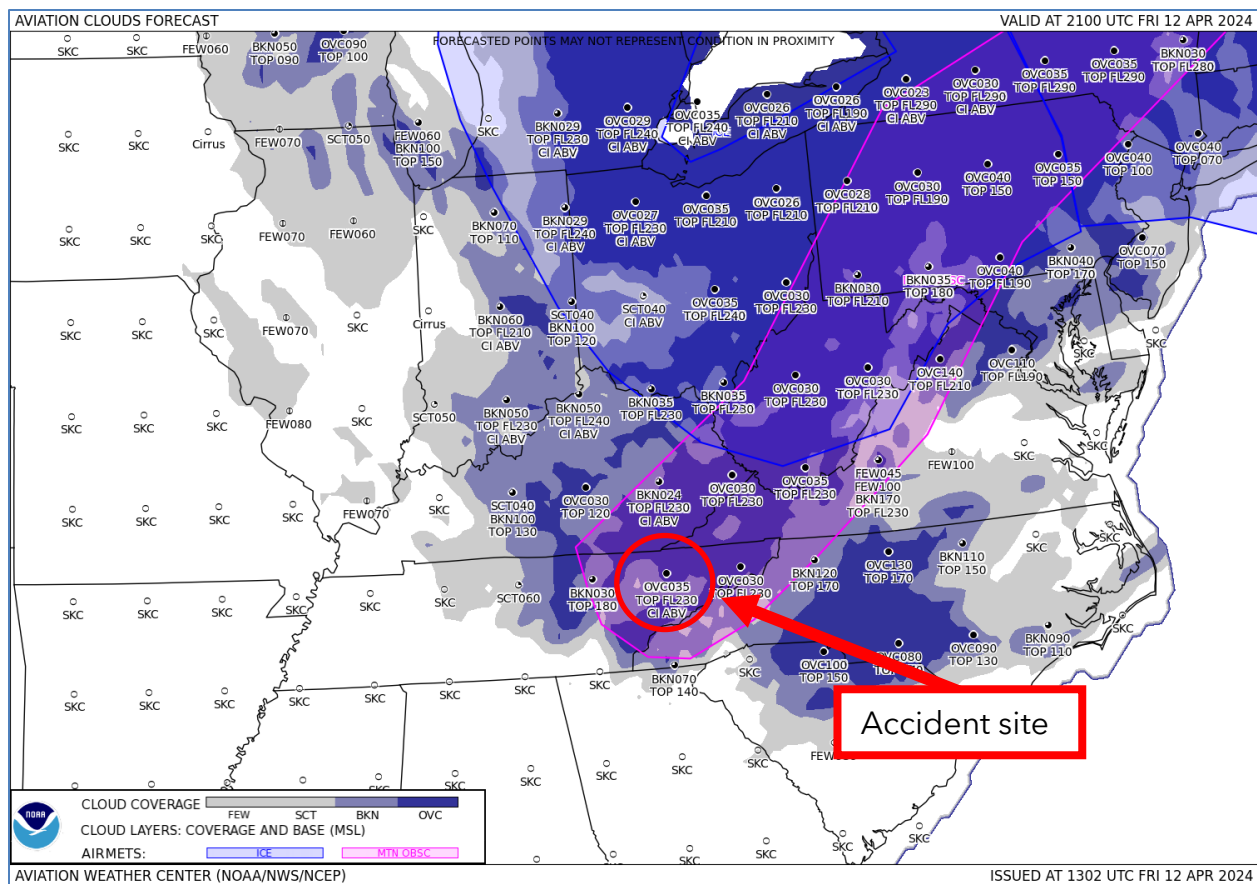


Figure 16. GFA Aviation Clouds Forecast valid at 1700 EDT with forecast issued at 0902 EDT.

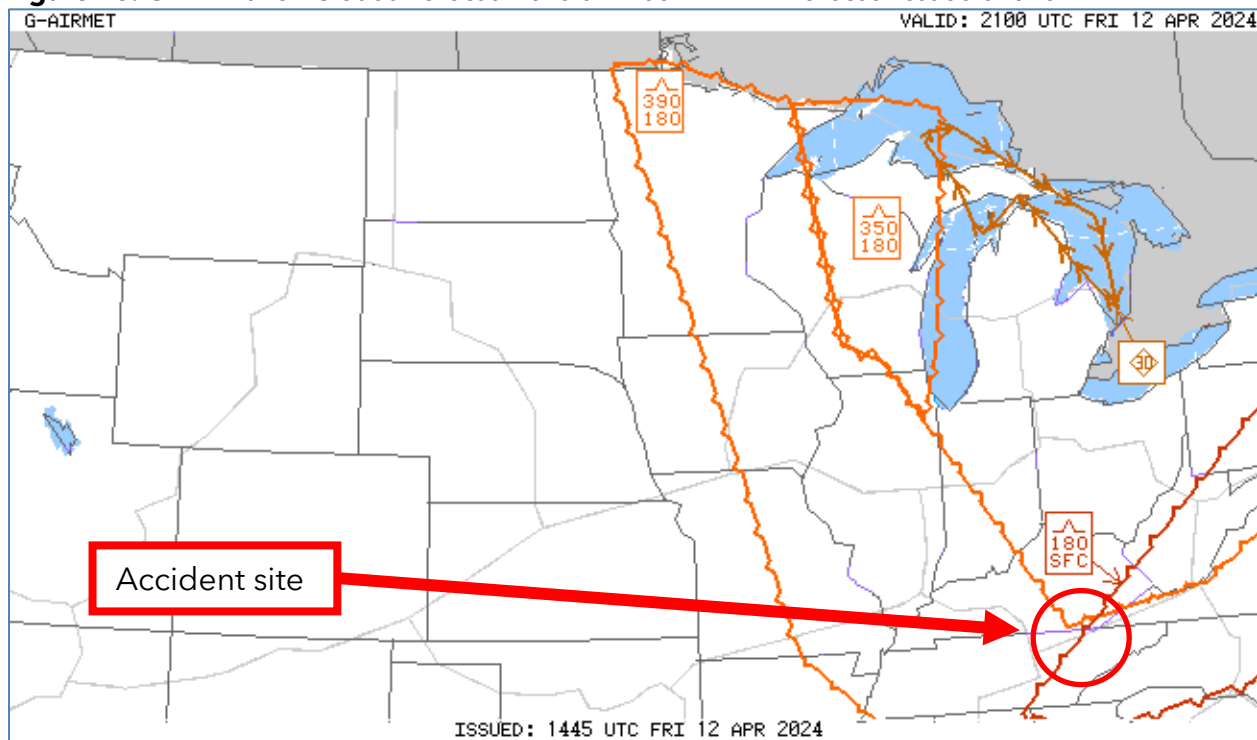


Figure 17. G-AIRMET Tango valid at 1700 EDT with forecast issued at 1045 EDT.

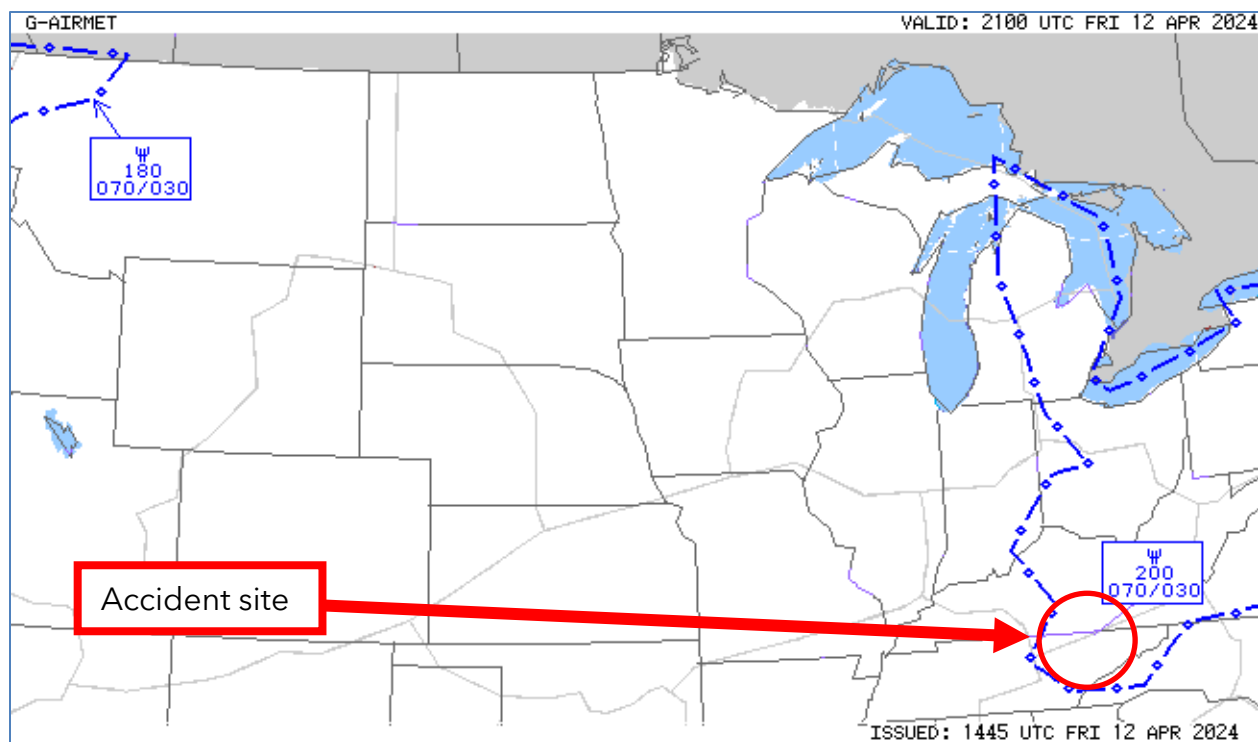


Figure 18. G-AIRMET Zulu valid at 1700 EDT with forecast issued at 1045 EDT.

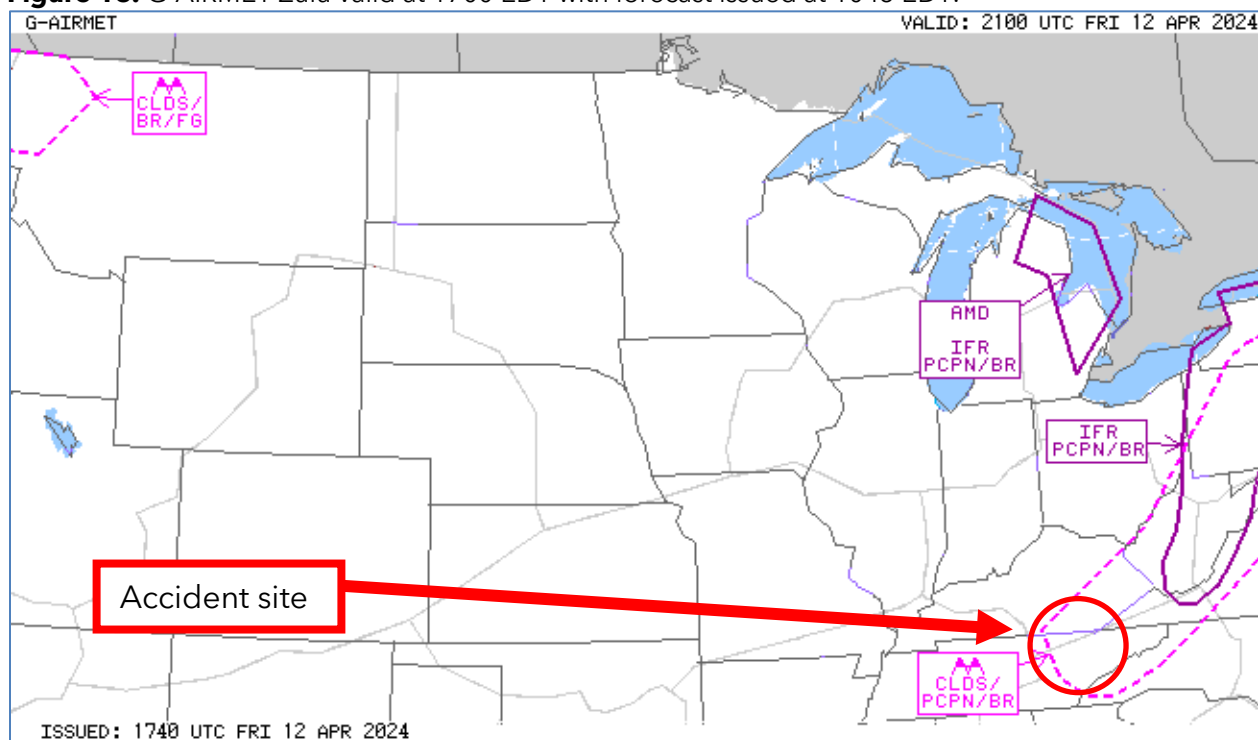


Figure 19. G-AIRMET Sierra valid at 1700 EDT with forecast issued at 1340 EDT.

12.0 Text Airmen's Meteorological Information

The AWC had text Airmen's Meteorological Information (AIRMET) advisory Sierra, Tango, and Zulu valid for the accident site at the accident time. The text AIRMETs were issued at 1045 and 1340 EDT forecast mountain obscuration conditions due to clouds, precipitation, and mist, moderate turbulence below 18,000 ft, and moderate icing between the freezing level³⁴ and FL200:

WAUS43 KPCI 121740 AAA
WA3S
-CHIS WA 121740 AMD
AIRMET SIERRA UPDT 5 FOR IFR AND MTN OBSCN VALID UNTIL 122100

.
AIRMET IFR...WI LM LS MI LH IN...UPDT
FROM 60WNW SSM TO 30SSE SSM TO 50WNW YVW TO 40ENE ECK TO 40S ECK
TO FWA TO 20NW CVG TO TTH TO 30SE PMM TO 40NW MKG TO 30NW SAW TO
60WNW SSM
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z ENDG 21-00Z.

.
AIRMET MTN OBSCN...KY TN
FROM HNN TO HNV TO 50WSW VXV TO 50WSW LOZ TO HNN
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.

....

WAUS43 KPCI 121445
WA3T
-CHIT WA 121445
AIRMET TANGO UPDT 2 FOR TURB STG WNDZ AND LLWS VALID UNTIL 122100

.
AIRMET TURB...MN WI LM LS MI LH IL IN
FROM 60W YQT TO 40ESE YQT TO 50WNW SSM TO FNT TO 20ENE DXO TO
FWA TO 40SSW FWA TO 20ESE JOT TO 40SW BAE TO 20SW DLL TO 60W YQT
MOD TURB BTN FL180 AND FL350. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET TURB...KY TN AL
FROM HNN TO HNV TO GGO TO 40S GGO TO 50W GGO TO HNN
MOD TURB BLW FL180. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET TURB...ND SD NE KS MN IA MO WI LS IL IN KY OK AR TN MS AL
FROM 70WNW INL TO 80W YQT TO 30SW DLL TO 40WSW BAE TO 20N IJU TO
50WNW HNN TO HNN TO HNV TO GGO TO 40S LGC TO 20SE FSM TO 60SE
ICT TO 30WNW FSD TO 40NNE MOT TO 70WNW INL
MOD TURB BTN FL180 AND FL390. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET STG SFC WNDZ...LM LS MI LH
FROM 100NNE SAW TO SSM TO 60NW YVW TO 30E ECK TO 20ENE MBS TO
50SSE SSM TO 30ENE SAW TO 80SE YQT TO 100NNE SAW
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG BYD 21Z

³⁴ Freezing level ranging from 3,000 to 9,000 ft.

THRU 03Z.

.
LLWS POTENTIAL...WI LM LS MI LH
BOUNDED BY 70WNW SSM-SSM-50NW YVW-30SSW YVW-40SSE ECK-20ESE MBS-
30SSW TVC-60WNW TVC-20N SAW-70WNW SSM
LLWS EXP. CONDS ENDG 15-18Z.

.
OTLK VALID 2100-0300Z...TURB MN IA MO WI LM LS MI LH IL IN KY AR
TN MS AL
BOUNDED BY 40SSE YWG-30N INL-YQT-SSM-YVW-30SE ECK-FWA-CVG-HNN-
HNV-GOO-LGC-50ESE MEM-40SSE YWG
MOD TURB BTN FL180 AND FL380. CONDS CONTG THRU 03Z.

....

WAUS43 KPCI 121445
WA3Z
-CHIZ WA 121445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 122100

.
AIRMET ICE...WI LM LS MI LH IL IN KY TN
FROM 70ESE YQT TO 20WNW YVW TO 30SE ECK TO FWA TO CVG TO HNN TO
HNV TO GOO TO 60SSW AXC TO 40SE BDF TO 30WSW GIJ TO 20NE GRB TO
70ESE YQT
MOD ICE BTN FRZLVL AND FL200. FRZLVL 030-090. CONDS CONTG BYD 21Z
THRU 03Z.

.
FRZLVL...RANGING FROM 020-120 ACRS AREA
MULT FRZLVL 020-040 BOUNDED BY 20E YQT-20NW SSM-60WNW YVW-
20ESE MBS-80SW YQT-20E YQT
040 ALG 60NE MOT-70WSW GFK-30NNE DLL-30SE GRB-DXO
080 ALG 20W ISN-20NE ANW-70SSE SGF

....

13.0 Terminal Aerodrome Forecast

Mc Ghee Tyson Airport (KTYN), located 15 miles southeast of the accident site, was the closest site with an NWS Terminal Aerodrome Forecast³⁵ (TAF) current at the time of the accident. The amended KTYN TAF valid at the accident time was issued at 1411 EDT and was valid for a 24-hour period beginning at 1400 EDT. The 1411 EDT TAF for KTYN was as follows:

³⁵ According to NWS Instruction 10-813: "An NWS TAF consists of the expected meteorological conditions significant to aviation at an airport for a specified time period. For the U.S., this is the area within five (5) statute miles (SM) of the center of an airport's runway complex."
www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

FTUS44 KMRX 121811 AAA
TAFTYS
TAF AMD
KTYS 121811Z 1218/1318 **25018G30KT P6SM VCTS SCT050CB BKN070**
TEMPO 1218/1220 2SM +TSRA BR OVC035CB
FM122300 26014G25KT P6SM BKN060
FM130100 25010G18KT P6SM SCT060
FM131000 24008KT P6SM SKC
FM131600 28010G18KT P6SM SKC=

Between 1400 and 1900 EST the KTYS forecast expected a wind from 250° at 18 knots with gusts to 30 knots, greater than 6 miles visibility, vicinity³⁶ thunderstorms, scattered cumulonimbus clouds at 5,000 ft agl, and a broken ceiling at 7,000 ft agl. Between 1400 and 1600 EST, temporary conditions were forecast to be 2 miles visibility, thunderstorms and heavy rain, mist, and overcast ceiling of cumulonimbus clouds at 3,500 ft agl.

14.0 National Weather Service Area Forecast Discussion

The NWS weather forecast office in Morristown, Tennessee, (WFO MRX) was responsible for the public forecast in the region of the accident site. WFO MRX issued the following Area Forecast Discussion (AFD) at 1528 EDT. This was the AFD issued closest to the accident time with an aviation section:

FXUS64 KMRX 121928
AFDMRX

Area Forecast Discussion
National Weather Service Morristown TN
328 PM EDT Fri Apr 12 2024

...New SHORT TERM, LONG TERM...

.SHORT TERM...
(This evening through Saturday)
Issued at 320 PM EDT Fri Apr 12 2024

Key Messages:

1. Numerous showers and a few thunderstorms this afternoon and early evening with small hail to about 0.50 inch already reported. Strong winds this afternoon with gusts up to 35 mph most locations and above 40 mph higher elevations.
2. Tonight clearing skies with winds only slowly diminishing.

³⁶ "In the vicinity" is defined as a weather phenomenon within 5-10 statute miles from the point of observation.

3. Sunny and much warmer Saturday with still breezy west winds.

Discussion:

Deep trough lies over the Eastern U.S. this afternoon. A shortwave is moving through the region now, bringing mostly cloudy to cloudy skies for all but the extreme south. Some thunderstorms have brought small hail across the northern half of east Tennessee and southwest Virginia. Gusty west to northwest winds up to 35 to 40 mph have been recorded area wide. Temperatures have been in the mid 60s at Chattanooga but mostly 50s elsewhere and in some places with the showers 40s and also higher elevations. Dew points are in the 30s to the lower 40s. The strong winds should decrease after 00Z tonight in the valley but should stay elevated most of the night in the mountains where the pressure gradient stays tighter.

As the moisture moves out and upper trough shifts east tonight expect clearing from southwest to northeast. High pressure will build in from the southwest overnight and Saturday. Lows tonight quite cool and in the 40s by morning. Saturday with high pressure still building in it will still be breezy with wind gusts as high as 40 mph in the northeast in the morning and with much lower relative humidities around 30 percent. Highs will be in the 60s to lower 70s.

&&

.LONG TERM...

(Saturday night through next Friday)

Issued at 320 PM EDT Fri Apr 12 2024

Key Messages:

1. Warming trend begins over the weekend, and warm weather continues next week.
2. Generally dry conditions expected for the first half of next week, with rain chances increasing mid to late next week.

Discussion:

At the start of this period, a large high pressure are will be centered near the Gulf Coast region, with a ridge axis extending northward to the Great Lakes. This ridge will shift east through Sunday, resulting in a SW flow pattern that will bring warm temperatures to the TN Valley region. On Sunday night, models indicate that a shortwave trough will cross the area, while a surface cold front will be moving SE across KY. Moisture will be limited but a few showers may be possible Sunday night and Monday in northern sections closer to the front, so some slight chance PoPs will be mentioned in SW VA/NE TN. The front will stall to our north and begin a northward retreat on Monday night as low pressure develops over the Plains.

A more unsettled pattern unfolds through the middle and end of next week. A closed low tracks from the central Plains to the Great Lakes, with its trailing cold front bringing a chance of showers and thunderstorms to our area on Wednesday. Instability looks limited due to weak amplification of the midlevel trough, and good dynamic forcing passes us to the north. The severe potential appears low, but we could get some breezy SW gradient winds up the Valley on Wednesday, with showers that produce locally higher gusts.

A better chance of showers and storms arrives on Thursday night and Friday as another closed low drops from the northern Plains to the Great Lakes/OH Valley. This system appears to have been northward moisture flux from the Gulf and a more sharply amplified trough and jet streak over the OH Valley, and a strong push of cold air behind the cold front. Still a long way out but this may be a system to watch over the next week.

&&

**.AVIATION...
(18Z TAFS)**

Issued at 147 PM EDT Fri Apr 12 2024

Some showers are currently moving across northeast and central east Tennessee. VFR conditions expected outside of showers and a possible thunderstorm affecting TYS and TRI. There is a possibility of thunder next few hours but kept showers as main weather. May need to amend if some storms develop near terminals. Conditions could go MVFR briefly in heavier showers. West winds will stay strong this afternoon with gusts up to 30 knots possible. Showers end by around 01-02Z with winds decreasing after sunset. Skies clear tonight with VFR conditions late tonight and Saturday.

&&

.PRELIMINARY POINT TEMPS/POPS...

Chattanooga Airport, TN	46	75	52	82	/	0	0	0	0
Knoxville McGhee Tyson Airport, TN	44	69	51	79	/	10	0	0	0
Oak Ridge, TN	45	71	49	80	/	0	0	0	10
Tri Cities Airport, TN	42	65	44	76	/	60	0	0	0

&&

.MRX WATCHES/WARNINGS/ADVISORIES...

NC...NONE.

TN...Wind Advisory until 9 PM EDT this evening for Blount Smoky Mountains-Cocke Smoky Mountains-Johnson-Sevier Smoky Mountains-Southeast Carter-Southeast Greene-Unicoi.

VA...NONE.

&&

\$\$

15.0 Winds and Temperature Aloft Forecast

The NWS 1457 EDT Winds and Temperature Aloft forecast, which was intended for use between 1600 and 2300 EDT and was valid for the closest point to the accident site, is included below:

FBUS31 KWN0 121957

FD1US1

DATA BASED ON 121800Z

VALID 130000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

TYS 2825 2938+00 3145-06 3240-12 3038-26 3166-37 318843 307944 297145

16.0 Icing Potential

The Current Icing Product (CIP) and Forecast Icing Product (FIP³⁷) imagery provided information on expected icing severity as five categories: none, trace, light, moderate, and heavy. The severity estimates are roughly based on the accretion rate of ice on an airplane, and the levels are determined by the time it would take for an airfoil to accrete 1/4 of an inch of ice: trace = 1 hour; light = 15 minutes to 1 hour; moderate = 5 to 15 minutes; severe = less than 5 minutes. Note that these are general values. Users should always consider the icing susceptibility of their airframe and availability of icing protection provided by their aircraft. Different aircraft and different flight configurations (airspeed, angle of attack, etc.) will experience variations in accretion rate.

³⁷ B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cuning, Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations (Journal of Applied Meteorology, 2005), pp. 969-986.

C.A. Wolff, F. McDonough, M. K. Politovich, B.C. Bernstein, and G. Cuning, FIP Severity Technical Document (Prepared for the Aviation Weather Technology Transfer Technical Review Board), pp. 1-44.

<https://arc.aiaa.org/doi/abs/10.2514/6.2009-3531>

Wolff, C. A., D. R. Adriaansen, and M. K. Politovich, 2014: Diagnosing and Forecasting In-Flight Icing Conditions in Alaska. Preprints, 6th AIAA Atmospheric and Space Environments Conference, Atlanta, GA, Amer. Inst. Aero. Astro., 2014-2070, available at: <http://arc.aiaa.org/doi/abs/10.2514/6.2014-2070>.

[Icing Product Alaska \(IPA\) - Experimental | NCAR Research Applications Laboratory | RAL \(ucar.edu\)](#)

The images presented in this report show data from National Center for Atmospheric Research (NCAR)'s prototype CIP and FIP algorithms, generated using NCAR's visualization software. These algorithms differ in various ways from the operational CIP and FIP³⁸ that provided data used to generate the publicly available images accessible through the AWC on the accident day. NCAR's prototype CIP and FIP represent the latest research and development conducted by their team of in-flight icing scientists, and have passed internal validation exercises using voice pilot reports (PIREPs) of icing conditions and scientific airborne research observations of in-flight icing (when available). Through coordination with the FAA and NOAA, NCAR provides the prototype CIP and FIP for an independent validation exercise to determine their suitability for operational use. Pending the outcome of that validation, the operational versions are replaced with the prototype versions. The frequency with which the operational versions are updated is dependent upon the research and development advancements in the prototype versions and available resources to support the operational upgrade.

The FIP icing probabilities and icing severity products for the 1-hour forecast valid at 1600 and 1700 EDT at 5,000 through 8,000 ft indicated a 30% to 85% probability of trace to heavy icing above the accident site (attachment 4) with the highest probability and intensities between 7,000 and 8,000 ft. The FIP indicated an 50 to 100% probability of Supercooled Large Droplets (SLD)³⁹ above the accident site at 6,000 through 8,000 ft at 1700 EDT. The CIP products indicated a 20 to 85% probability of trace to moderate icing from 6,000 ft through 8,000 ft at 1600 and 1700 EDT above the accident site (attachment 4). The highest CIP probability and intensities were at 7,000 and 8,000 ft. The CIP indicated a 10 to 40% probability of SLD above the accident site between 6,000 and 8,000 ft at 1600 and 1700 EDT. For more FIP and CIP data and imagery please see attachment 4.

17.0 Pilot Weather Information

Title 14 CFR 91.103 states that "Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight." FAA AC 91-92 "Pilot's Guide to a Preflight Planning" (dated March 15, 2021) provided pilot guidance on preflight self-briefings, including planning, weather interpretation, and risk identification/mitigation skills. The AC further stated in part:

Pilots adopting these guidelines will be better prepared to interpret and utilize real-time weather information before departure and en route, in the cockpit, via technology like Automatic Dependent Surveillance-Broadcast (ADS-B) and via third-party providers.⁴⁰

³⁸ <https://www.aviationweather.gov/icing/fip>

³⁹ [GFA Help \(aviationweather.gov\)](https://www.aviationweather.gov/gfa-help) and [Icing Hazards \(weather.gov\)](https://www.weather.gov/icing-hazards)

⁴⁰ https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf. The AC also listed multiple online FAA resources for aviation flight planning services for adverse weather.

A search of archived information indicated that the accident pilot did not request weather information from Leidos Flight Service. The accident pilot did have an account with ForeFlight and did file their flight plan through ForeFlight and received a weather briefing (attachments 5 and 6) around 1547 EDT. The ForeFlight weather briefing contained all the standard weather forecast information prior to 1547 EDT, including Convective SIGMET, G-AIRMETs, PIREPs, and METARs. The ForeFlight Vertical Cross Section Chart indicated moderate icing at 6,000 ft and above throughout the first half of the proposed flight route. For more information please see attachments 5 and 6.

18.0 Astronomical Data

The astronomical data obtained⁴¹ for the accident site on April 12, 2024, indicated the following:

SUN

Begin civil twilight	0640 EDT
Sunrise	0706 EDT
Sun transit	1337 EDT
Accident time	1633 EDT ⁴²
Sunset	2008 EDT
End civil twilight	2034 EDT

At the time of the accident the Sun was above the horizon at an altitude of 41.87° and an azimuth of 247.08°.

⁴¹ <https://www.suncalc.org/> and <https://www.mooncalc.org/>

⁴² Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 - GOES-16 visible animation from 1501 to 1701 EDT

Attachment 2 - KMRX WSR-88D base reflectivity animation from 1604 to 1645 EDT

Attachment 3 - ZTL CWSU PDWB for April 12

Attachment 4 - FIP and CIP information valid for the accident site

Attachment 5 - ForeFlight Information

Attachment 6 - ForeFlight correspondence

Submitted by:

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