



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

July 13, 2018

Weather Study

METEOROLOGY

ERA17FA180

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A. ACCIDENT

Location: Near Hopkinsville, Kentucky
Date: May 12, 2017
Time¹: 1152 central daylight time
1652 Coordinated Universal Time (UTC)
Airplane: Beech A36TC; registration: N1804E

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) meteorologist did not travel for this investigation and gathered the weather data for this investigation from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are central daylight time (CDT) on May 12, 2017, and are based upon the 24-hour clock, where local time is -5 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 36.926° N, longitude 87.609° W, at an approximate elevation of 605 feet (ft).

¹ Accident time based on best available information.

D. WEATHER 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 Weather Prediction Center, 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 joint NWS and Federal Aviation Administration (FAA) Advisory Circular “Aviation Weather Services”, AC 00-45H.²

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1300 CDT is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart depicted several frontal boundaries across the Mississippi and Tennessee river valleys and across the southeastern United States. The closest frontal boundary to the accident site was a stationary front which extended from a low-pressure system in West Virginia at 1008-hectopascals (hPa) southwestward into Kentucky and Tennessee then westward into central Arkansas to another low-pressure system at 1005-hPa, with a cold front extending southward from that low. The station models around the accident site depicted air temperatures in the mid 60’s degrees Fahrenheit (°F), with temperature-dew point spreads of 1° F or less, a north wind of 15 knots, overcast sky conditions, and visibility restricted in mist.

²

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

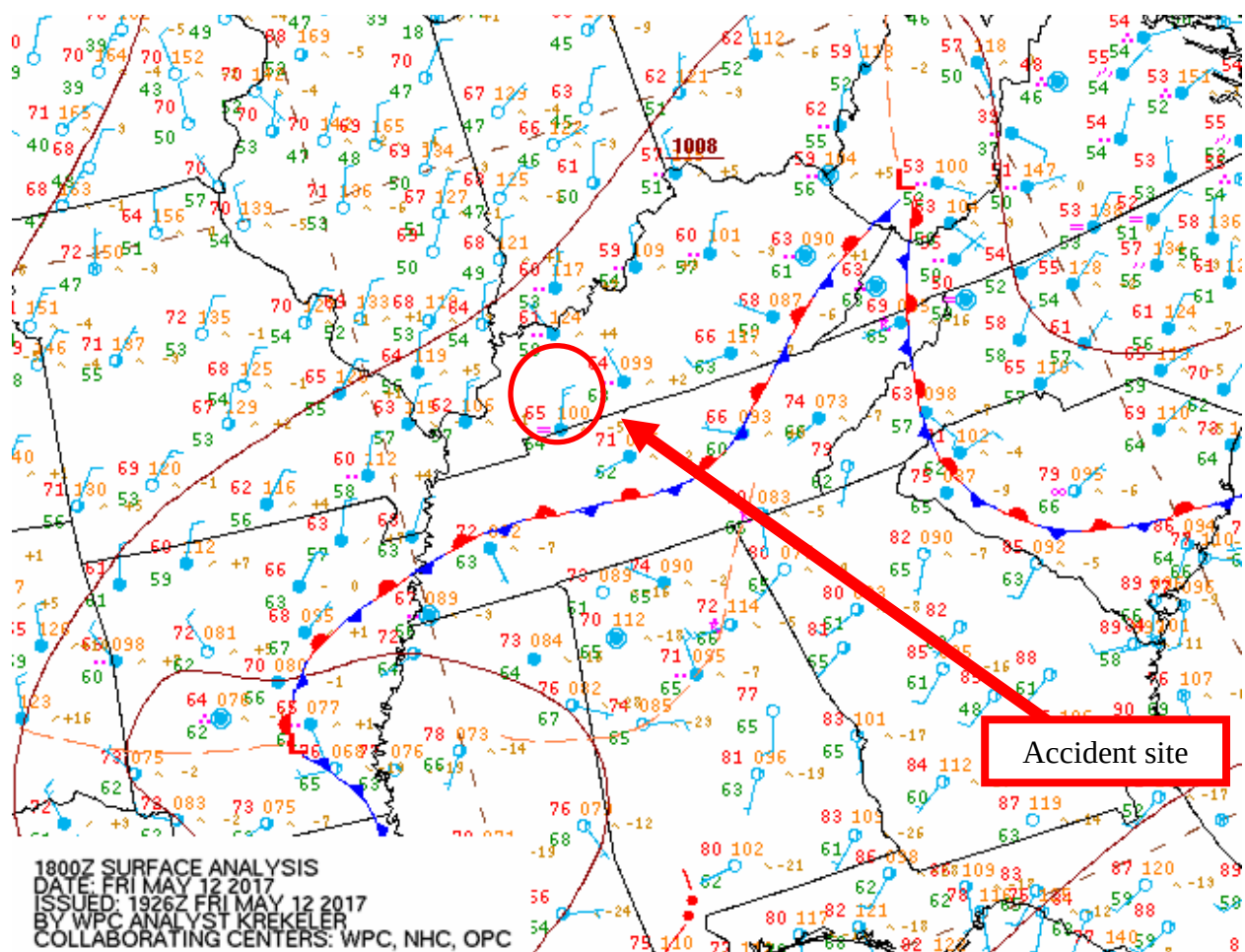


Figure 1 – NWS Surface Analysis Chart for 1300 CDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0700 CDT at 925-, 850-, 700-, 500-, and 300-hPa are included in figures 2 through 6. The 850-hPa chart depicted a low-pressure system over Arkansas with low-level trough³ just west of the accident site (figure 3). The 700- and 500-hPa charts continued to depict a closed contour low pressure system over Arkansas with a mid-level trough just west of the accident site (figures 4 and 5). Low-pressure systems and troughs typically act as lifting mechanisms where enhanced lift, gusty winds, fronts, clouds, and precipitation can occur. There was a southwest wind of about 10 knots at 850-hPa (figure 3) with the wind remaining southwesterly at 700-hPa with a wind speed of 30 knots (figure 4). The 30-knot southwesterly wind at 700-hPa became a 40-knot west-southwest wind by 300-hPa (figure 6).

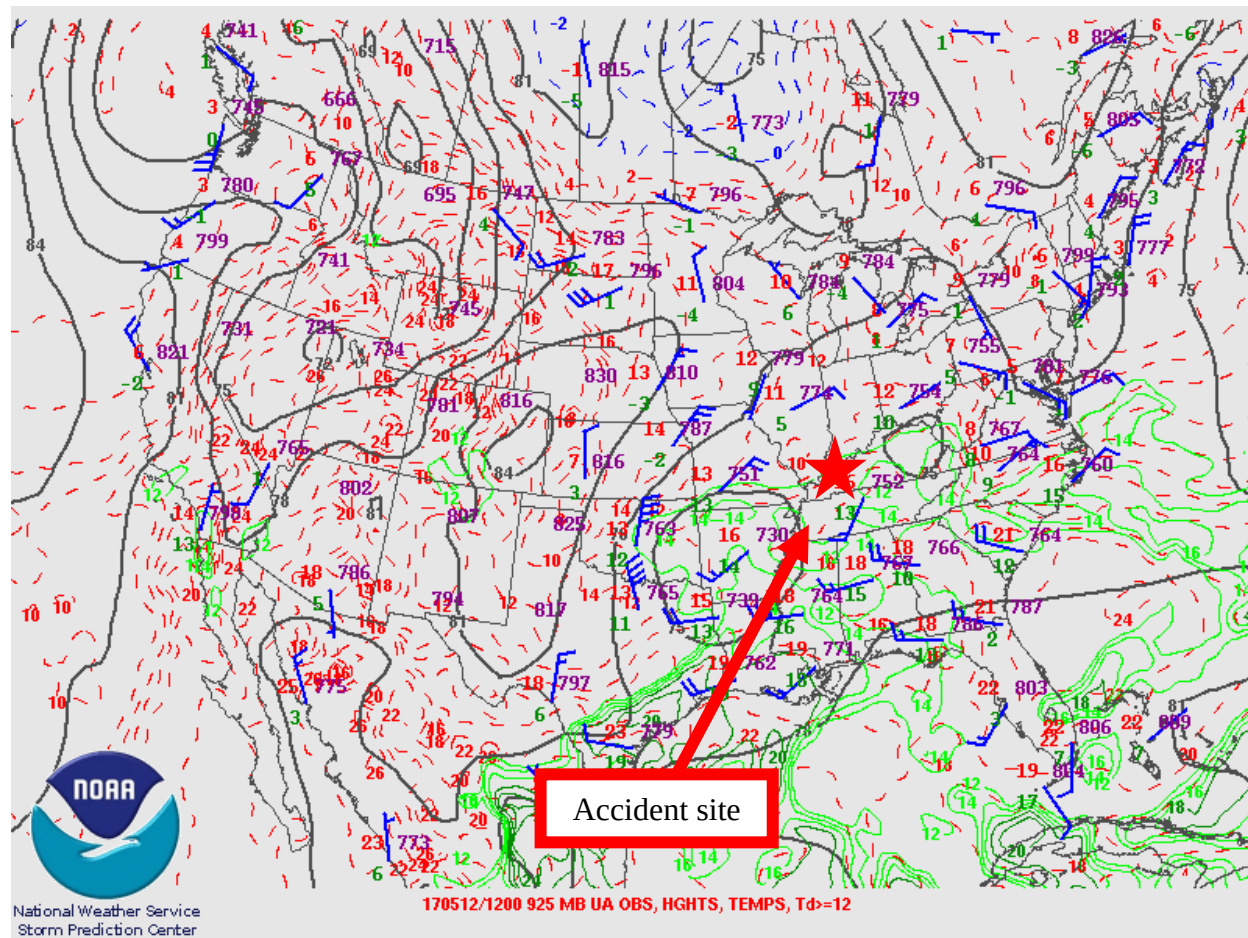


Figure 2 – 925-hPa Constant Pressure Chart for 0700 CDT

³ Trough – An elongated area of relatively low atmospheric pressure or heights.

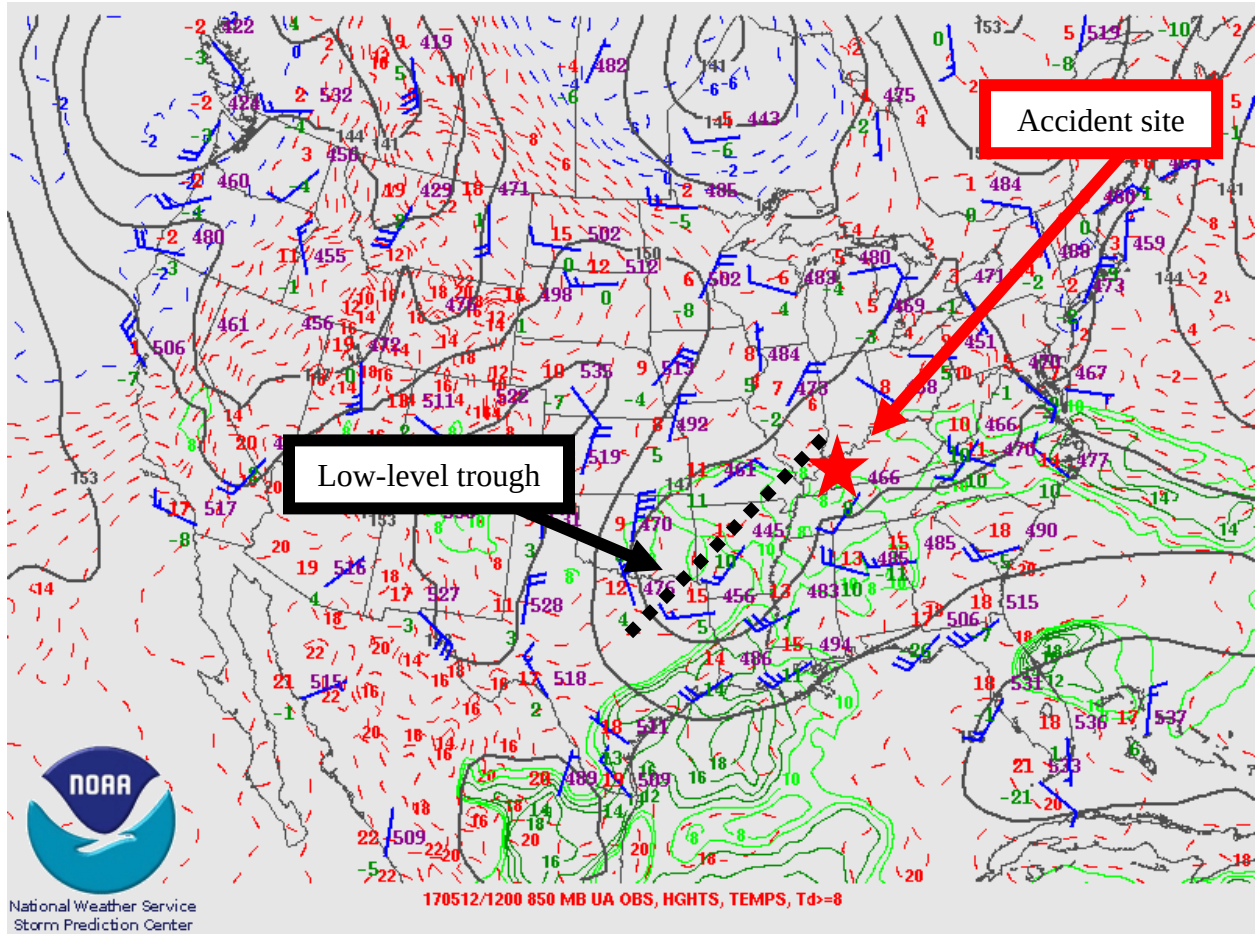


Figure 3 – 850-hPa Constant Pressure Chart for 0700 CDT

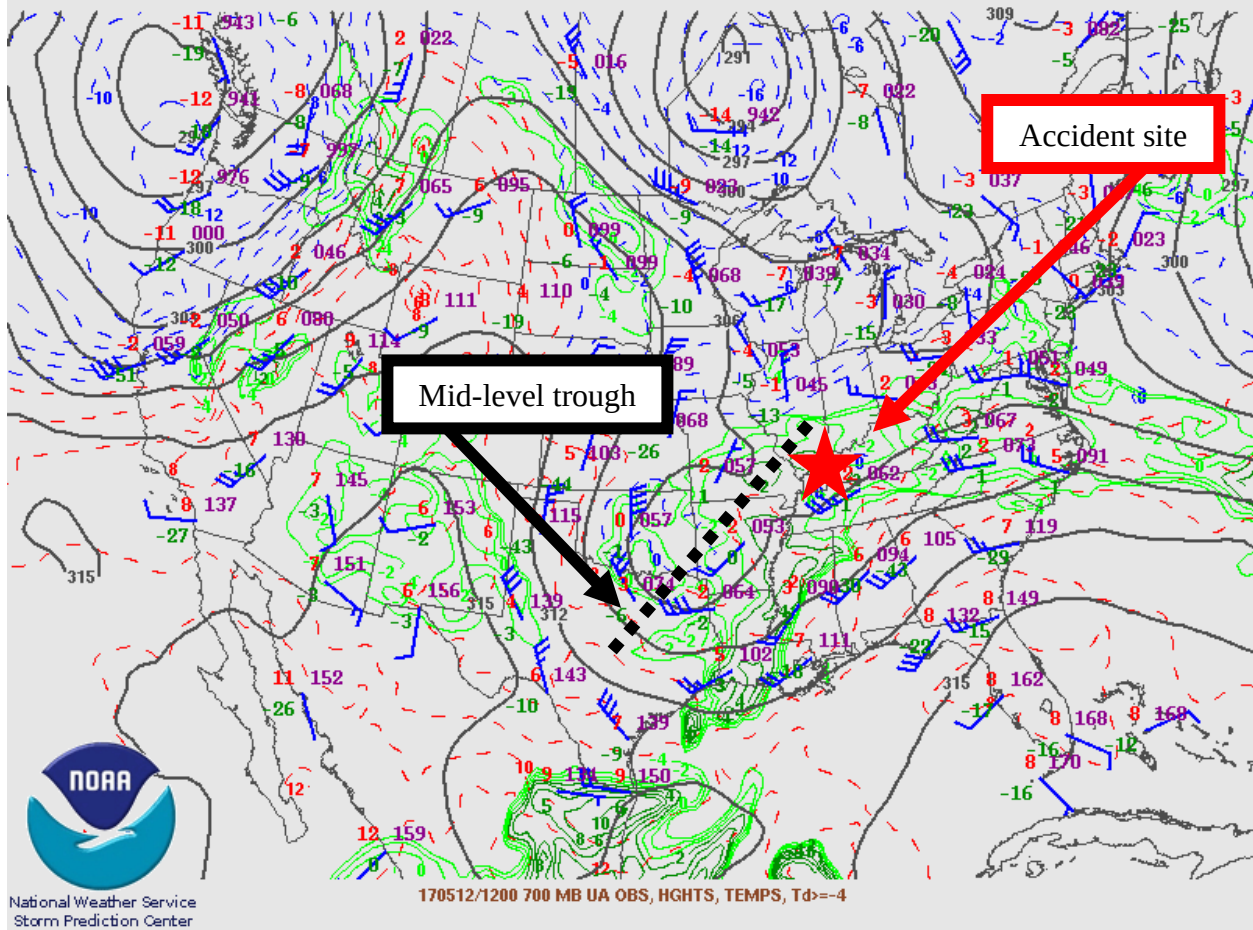


Figure 4 – 700-hPa Constant Pressure Chart for 0700 CDT

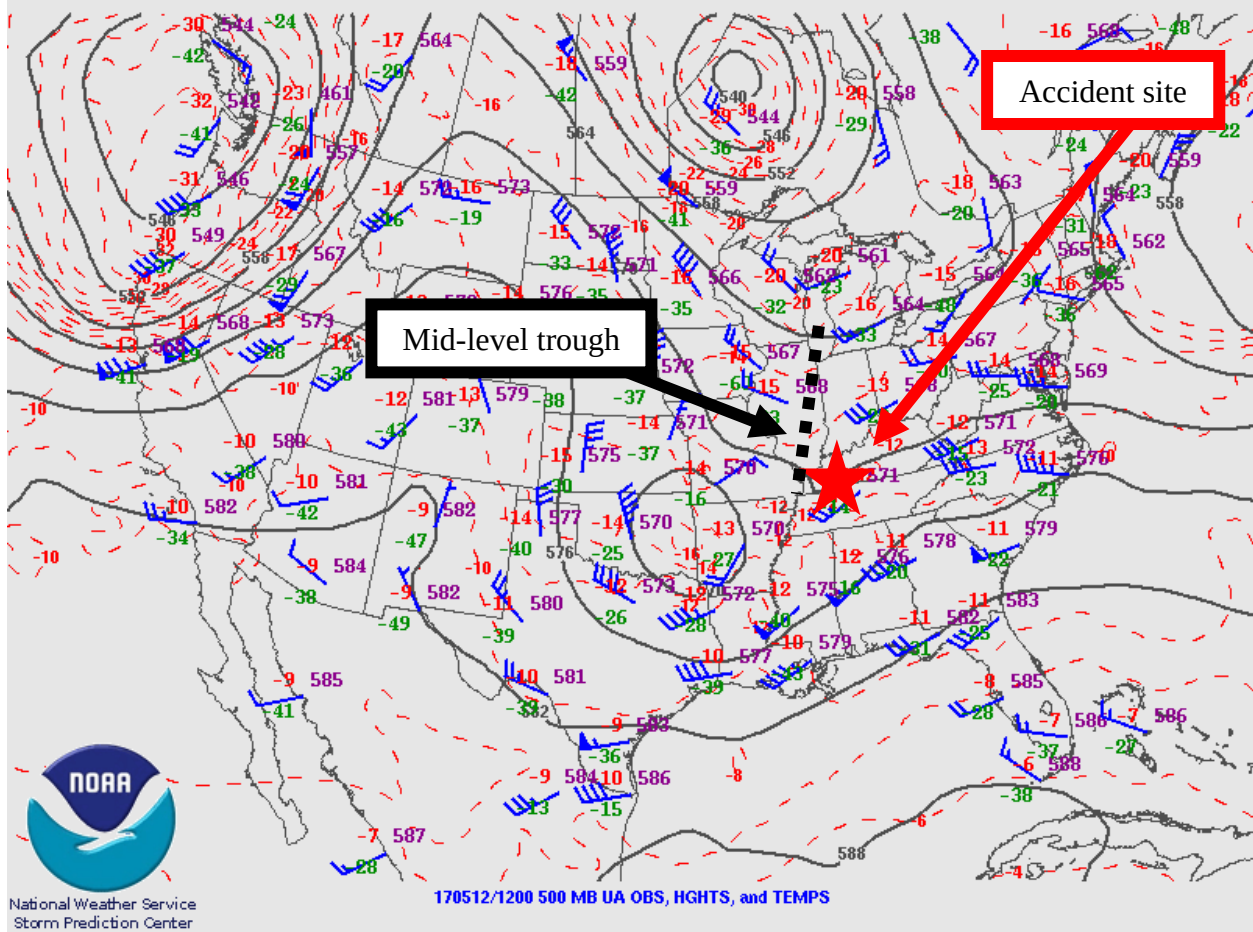


Figure 5 – 500-hPa Constant Pressure Chart for 0700 CDT

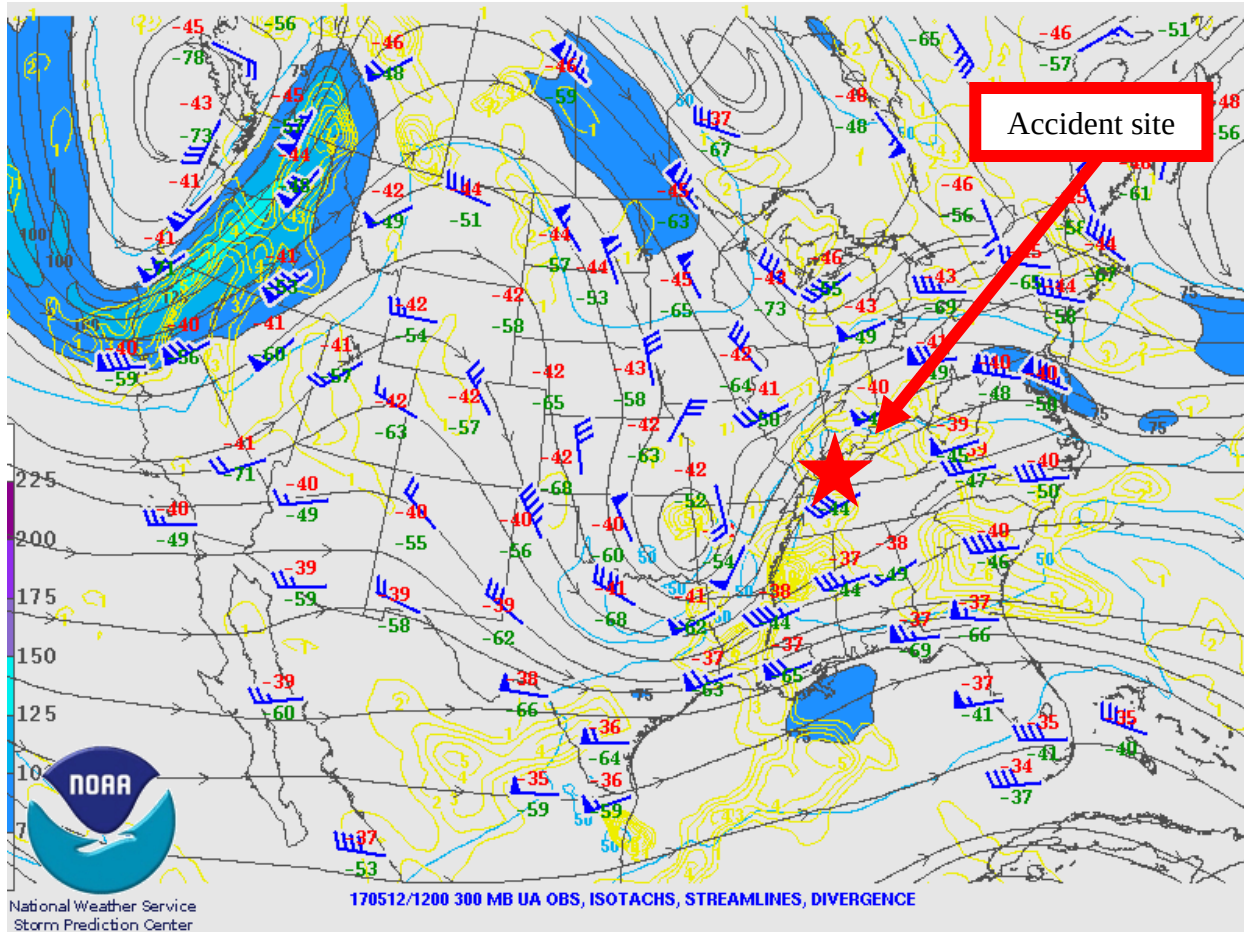


Figure 6 – 300-hPa Constant Pressure Chart for 0700 CDT

2.0 Storm Prediction Center Products

The NWS SPC issued the following Day 1 Convective Outlook at 1344 CDT (figure 7) with areas of general thunderstorms forecast for the accident site. The SPC Day 1 Convective Outlook valid before the time of takeoff had general thunderstorms forecast for a similar area, including the accident site:

SPC AC 121844

Day 1 Convective Outlook
NWS Storm Prediction Center Norman OK
0144 PM CDT Fri May 12 2017

Valid 121630Z - 131200Z

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS ACROSS PORTIONS OF CENTRAL AND SOUTHERN MS AND SOUTHEAST LA EAST ACROSS SOUTHWEST AL AND WESTERN PARTS OF THE FL PANHANDLE...

...THERE IS A MARGINAL RISK OF SEVERE THUNDERSTORMS ACROSS A LARGE PORTION OF THE SOUTHEAST U.S....

...THERE IS A MARGINAL RISK OF SEVERE THUNDERSTORMS ACROSS PARTS OF WESTERN AND CENTRAL MT...

...SUMMARY...

A few rounds of strong to severe storms are expected across portions of the Deep South. Damaging gusts and isolated severe hail are possible, and a tornado or two cannot be ruled out. Isolated severe storms also may occur across parts of west-central Montana later today and Georgia to parts of the Carolinas this evening, with isolated gusty winds and hail.

...Synopsis...

As a large upper low/trough continues shifting slowly east into the western U.S., a second/shorter-wavelength trough will continue crossing the southeast U.S. through the period.

At the surface, a cold front associated with the western trough will continue crossing the Intermountain West. Meanwhile, a wavy cold front will progress south/southeast across the Southeast/Gulf Coast states through the period.

...Parts of MS and southeast LA east to southwest AR/western FL...

A loosely organized band of thunderstorms -- with embedded stronger bowing clusters and occasional supercells -- continues moving east across the lower Mississippi Valley/central Gulf Coast region. The storms are ongoing within a very moist airmass, where roughly 1000 J/kg mixed-layer CAPE is indicated. With surface flow roughly southerly beneath low- to mid-level west-southwesterlies that increase with height through the mid levels, shear remains sufficient for a continuation of organized severe risk as convection tracks across the Gulf Coast region this afternoon. For additional short-term information, please refer to SWOMCD #704.

...Southeast AR/MS east to the SC vicinity...

Showers and isolated to scattered thunderstorms are forecast to continue evolving ahead of the advancing upper system, near and south of the slowly southeastward-moving cold front currently draped roughly west-to-east across the Tennessee vicinity. Continued/modest destabilization this afternoon combined with moderate flow aloft suggest mainly multicell organization, and thus some attendant risk for locally gusty/damaging winds and marginal hail across northern portions of the central Gulf Coast states and into parts of the Georgia and South Carolina vicinity. Greatest risk will likely reside over the Mississippi area this afternoon, nearest the colder air aloft associated with the southeastward-moving mid-level center of circulation now moving southeast into the Arklatex area. For additional short-term information, please refer to SWOMCD #705 and #706.

...Parts of western and central MT...

Continued/gradual eastward advance of the upper trough across the Pacific Northwest will continue to provide an area of ascent, supportive of an increase in thunderstorm development this afternoon near and ahead of the associated surface cold front. Weak/high-based CAPE (mixed-layer values generally 500 J/kg or less)

may be sufficient to support a few stronger storms -- aided by strong -- though southerly/meridional -- flow aloft. CAM runs remain consistent in depicting a few stronger storms/bands of storms that will move quickly north-northeast in/near the marginal risk area, where associated risk for locally gusty winds and possibly a hail event or two remain evident into the evening before weakening diurnally.

..Goss/Cohen.. 05/12/2017

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NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 2000Z

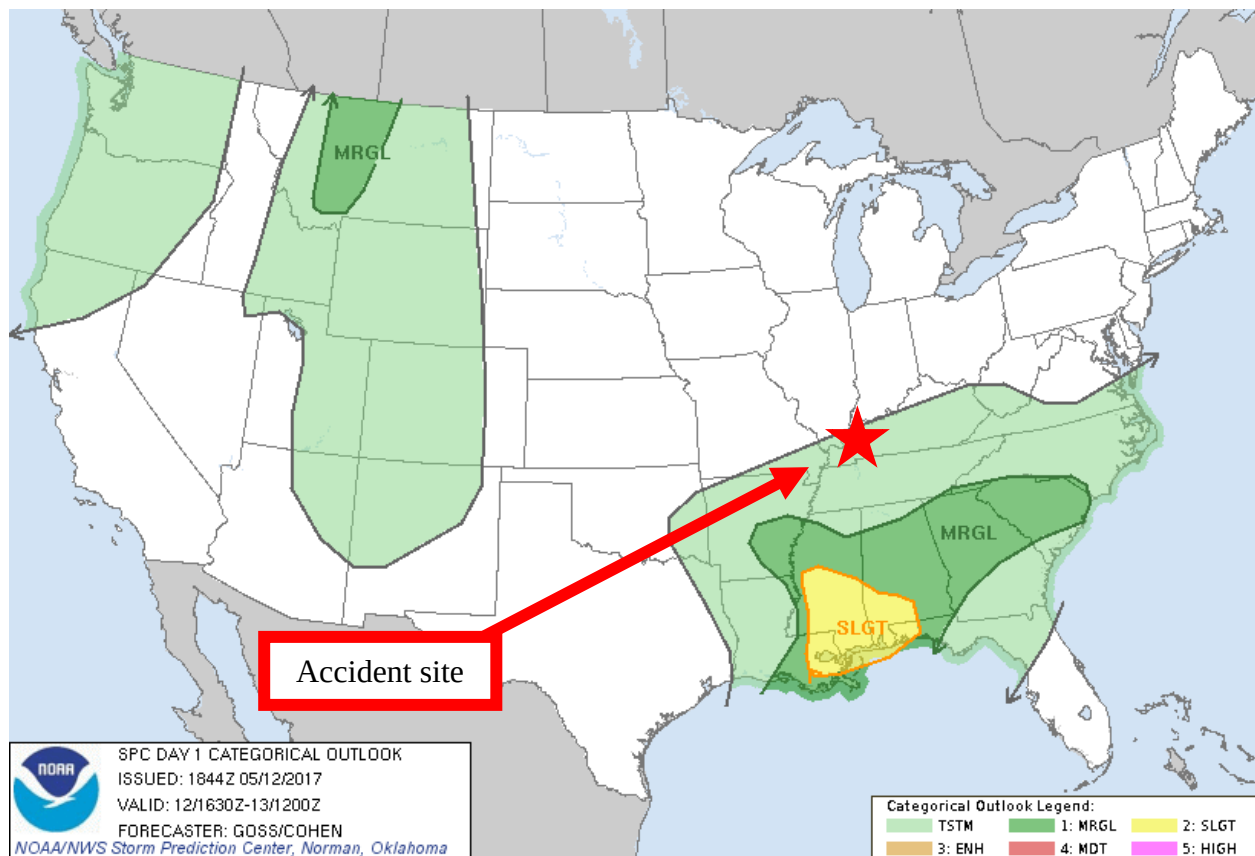


Figure 7 – SPC Day 1 Convective Outlook valid at the time of the accident

3.0 Surface Observations

The area surrounding the accident site was documented using official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 8 is a sectional map of the region with the accident site and the closest weather reporting location marked.

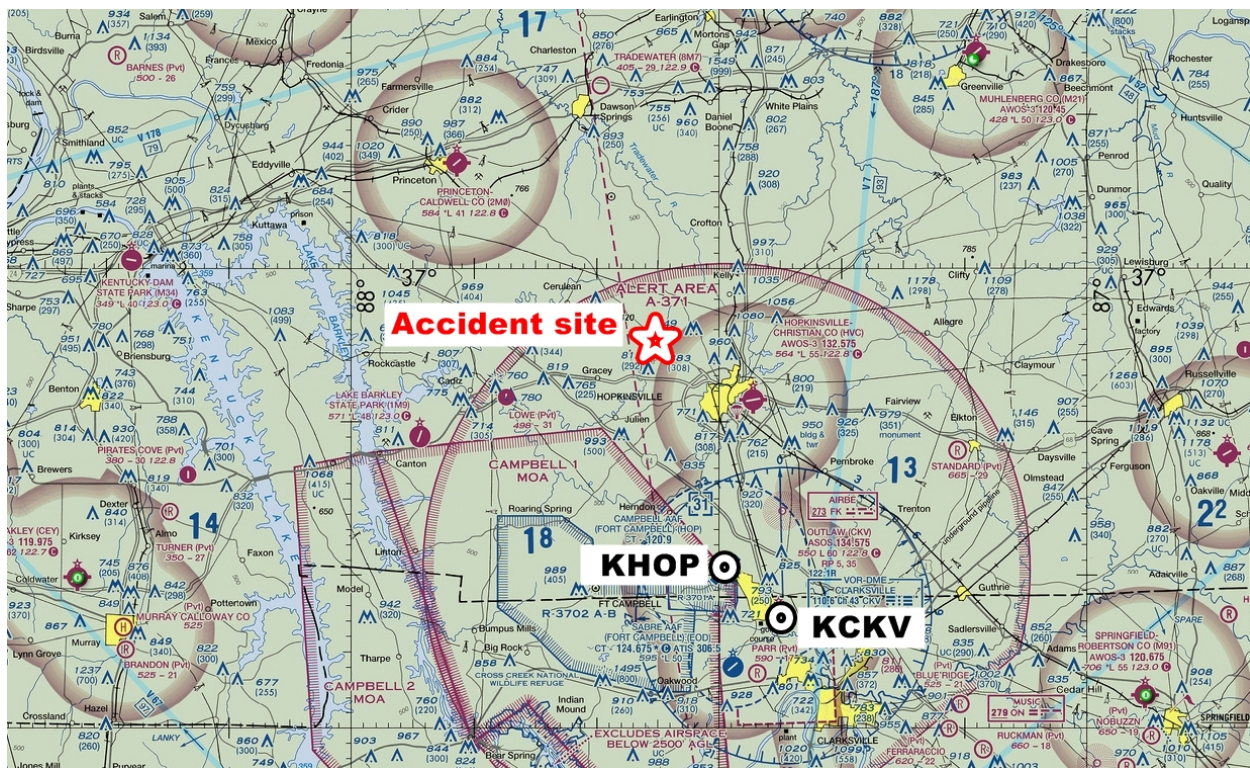


Figure 8 – Sectional Chart with the location of the accident site and surface observation sites

The closest weather reporting facility to the accident site was from Hopkinsville-Christian County Airport (KHVC) located about 8 miles east-southeast of the accident site in Hopkinsville, KY. The airport listed an Automatic Weather Observation System (AWOS) and broadcasts weather locally on VHF radio frequency with no METARs being transmitted by the FAA or NWS⁴.

The next closest weather reporting location was from Campbell Army Airfield (KHOP), Fort Campbell, Kentucky, located 16 miles south-southeast of the accident site, at an elevation of 571 ft, and had a 3° westerly magnetic variation⁵ (figure 8). The following observations were taken and disseminated during the times surrounding the accident:⁶

[1038 CDT] SPECI KHOP 121538Z AUTO 32004KT 7SM BKN014 BKN060 18/18 A2985
RMK AO2 CIG 014V060 BKN014 V SCT SLP106=

[1051 CDT] SPECI KHOP 121551Z AUTO 34006KT 7SM BKN007 BKN014 18/18 A2984
RMK AO2 CIG 007V014 BKN007 V SCT SLP103=

⁴ While KHVC had an AWOS and reported METAR locally, it does not have the communication equipment to be able to report the METAR observations nationally.

⁵ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1995, latest measurement taken from <http://www.airnav.com/airport/KHOP>

⁶ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1058 CDT] METAR KHOP 121558Z AUTO 33005KT 9SM BKN009 OVC014 18/18 A2984
RMK AO2 CIG 007V014 SLP103 T01810178=

[1113 CDT] SPECI KHOP 121613Z AUTO 36005KT 2 1/2SM BR BKN008 OVC013
18/18 A2984 RMK AO2 VIS 2 1/2V9 SLP103=

[1125 CDT] SPECI KHOP 121625Z AUTO 01006KT 3SM BR BKN008 OVC014 19/18
A2984 RMK AO2 SLP103=

[1126 CDT] SPECI KHOP 121626Z AUTO 02006KT 2 1/2SM BR BKN008 OVC014
19/18 A2984 RMK AO2 VIS 2V3 SLP103=

***[1130 CDT] SPECI KHOP 121630Z AUTO 02007KT 3SM BR BKN008 OVC014 19/18
A2984 RMK AO2 SLP103=***

***[1144 CDT] SPECI KHOP 121644Z AUTO 01006KT 10SM -DZ BKN009 OVC013 19/17
A2984 RMK AO2 DZB44 SLP103=***

ACCIDENT TIME 1152 CDT/1652 UTC⁷

***[1153 CDT] SPECI KHOP 121653Z AUTO 36006KT 10SM DZ OVC011 18/18 A2984
RMK AO2 DZB44 SLP103=***

***[1157 CDT] SPECI KHOP 121657Z AUTO 35004KT 9SM +DZ BKN009 OVC013 18/18
A2984 RMK AO2 DZB44 CIG 009V011 SLP103=***

[1158 CDT] METAR KHOP 121658Z AUTO 35005KT 9SM +DZ BKN009 OVC013 18/18
A2984 RMK AO2 DZB44 CIG 009V011 SLP103 P0000 T01840176=

[1200 CDT] SPECI KHOP 121700Z AUTO 34005KT 9SM DZ OVC011 18/18 A2984
RMK AO2 SLP103=

KHOP weather at 1130 CDT, automated, wind from 020° at 7 knots, 3 miles visibility, mist, broken ceiling 800 ft above ground level (agl), overcast skies at 1,400 ft agl, temperature of 19° Celsius (C), dew point temperature of 18° C, and an altimeter setting of 29.84 inches of mercury (Hg). Remarks: automated station with a precipitation discriminator, sea level pressure 1010.3 hPa.

KHOP weather at 1144 CDT, automated, wind from 010° at 6 knots, 10 miles visibility or greater, light drizzle, a broken ceiling at 900 ft agl, overcast skies at 1,300 ft agl, temperature of 19° C, dew point temperature of 17° C, and altimeter setting of 29.84 inches of Hg. Remarks: automated station with a precipitation discriminator, drizzle began at 1144 CDT, sea level pressure 1010.3 hPa.

⁷ Accident time based on best available information.

KHOP weather at 1153 CDT, automated, wind from 360° at 6 knots, 10 miles visibility or greater, moderate drizzle, an overcast ceiling at 1,100 ft agl, temperature of 18° C, dew point temperature of 18° C, and altimeter setting of 29.84 inches of Hg. Remarks: automated station with a precipitation discriminator, drizzle began at 1144 CDT, sea level pressure 1010.3 hPa.

KHOP weather at 1157 CDT, automated, wind from 350° at 4 knots, 9 miles visibility, heavy drizzle, a broken ceiling at 900 ft agl, overcast skies at 1,300 ft agl, temperature of 18° C, dew point temperature of 18° C, and altimeter setting of 29.84 inches of Hg. Remarks: automated station with a precipitation discriminator, drizzle began at 1144 CDT, ceiling varying between 900 and 1,100 ft agl, sea level pressure 1010.3 hPa.

Outlaw Field Airport (KCKV) was the next closest airport with official weather observations and was located 6 miles northwest of Clarksville, Tennessee. KCKV had Automated Surface Observing System (ASOS⁸) whose reports were not supplemented. KCKV was located 20 miles south-southeast of the accident site, at an elevation of 550 ft, and had a 3° westerly magnetic variation⁹ (figure 8). The following observations were taken and disseminated during the times surrounding the accident:

[0852 CDT] METAR KCKV 121352Z AUTO 01008KT 10SM SCT007 BKN012 OVC019
18/16 A2983 RMK AO2 SLP096 T01830161=

[0941 CDT] SPECI KCKV 121441Z AUTO 01004KT 10SM BKN007 OVC012 18/16
A2984 RMK AO2 T01830161=

[0952 CDT] METAR KCKV 121452Z AUTO 34005KT 9SM BKN006 OVC011 18/16 A2984
RMK AO2 SLP102 T01780161 53004=

[1010 CDT] SPECI KCKV 121510Z AUTO 35004KT 9SM SCT006 BKN043 OVC060
18/16 A2985 RMK AO2 T01780156=

[1024 CDT] SPECI KCKV 121524Z AUTO 02006KT 6SM BR BKN006 OVC060 18/16
A2985 RMK AO2 CIG 005V012 T01780161=

**[1052 CDT] METAR KCKV 121552Z AUTO 33005KT 7SM BKN006 OVC037 18/16 A2985
RMK AO2 CIG 005V009 SLP102 T01830161=**

**[1127 CDT] SPECI KCKV 121627Z AUTO 02009KT 8SM BKN011 OVC017 19/16 A2984
RMK AO2 T01940161=**

ACCIDENT TIME 1152 CDT/1652 UTC¹⁰

⁸ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁹ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1990, latest measurement taken from <http://www.airnav.com/airport/KCKV>

¹⁰ Accident time based on best available information.

[1152 CDT] METAR KCKV 121652Z AUTO 02007KT 8SM OVC011 19/16 A2984 RMK AO2 CIG 008V013 SLP100 T01890161=

[1252 CDT] METAR KCKV 121752Z AUTO 03006KT 10SM OVC016 19/16 A2983 RMK AO2 RAB1653E08 SLP098 P0000 60000 T01940161 10194 20178 56005=

[1313 CDT] SPECI KCKV 121813Z AUTO 02010KT 10SM OVC013 19/16 A2982 RMK AO2 T01890156=

[1329 CDT] SPECI KCKV 121829Z AUTO 36011KT 10SM SCT011 OVC020 18/16 A2983 RMK AO2 T01830156=

KCKV weather at 1052 CDT, automated, wind from 330° at 5 knots, 7 miles visibility, broken ceiling at 600 ft agl, overcast skies at 3,700 ft agl, temperature of 18° C, dew point temperature of 16° C, and an altimeter setting of 29.85 inches of Hg. Remarks: station with a precipitation discriminator, ceiling varying between 500 and 900 ft agl, sea level pressure 1010.2 hPa, temperature 18.3° C, dew point temperature 16.1° C.

KCKV weather at 1127 CDT, automated, wind from 020° at 9 knots, 8 miles visibility, broken ceiling at 1,100 ft agl, overcast skies at 1,700 ft agl, temperature of 19° C, dew point temperature of 16° C, and an altimeter setting of 29.84 inches of Hg. Remarks: station with a precipitation discriminator, temperature 19.4° C, dew point temperature 16.1° C.

KCKV weather at 1152 CDT, automated, wind from 020° at 7 knots, 8 miles visibility, overcast ceiling at 1,100 ft agl, temperature of 19° C, dew point temperature of 16° C, and an altimeter setting of 29.84 inches of Hg. Remarks: station with a precipitation discriminator, ceiling varying between 800 and 1,300 ft agl, sea level pressure 1010.0 hPa, temperature 18.9° C, dew point temperature 16.1° C.

KCKV weather at 1252 CDT, automated, wind from 030° at 6 knots, 10 miles visibility or greater, overcast ceiling at 1,600 ft agl, temperature of 19° C, dew point temperature of 16° C, and an altimeter setting of 29.83 inches of Hg. Remarks: station with a precipitation discriminator, rain began at 1153 CDT, rain ended at 1208 CDT, sea level pressure 1009.8 hPa, one-hourly precipitation of a trace, 6-hourly precipitation of a trace, temperature 19.4° C, dew point temperature 16.1° C, 6-hourly maximum temperature of 19.4 C, 6-hourly minimum temperature of 17.8 C, 3-hourly pressure decrease of 0.5 hPa.

The observations from KHOP and KCKV surrounding the accident time indicated MVFR¹¹ to IFR¹² conditions due to ceilings and visibilities with light to heavy drizzle. These surface conditions matched the weather radar imagery and the areas of drizzle and rain that the accident flight likely encountered (sections 6.4 and 6.5).

¹¹ Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 ft agl and/or 3 to 5 miles visibility.

¹² Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 ft agl and/or less than 3 miles visibility.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)¹³ model sounding was created for the accident site for 1200 CDT. The 1200 CDT sounding was plotted on a standard Skew-T log P diagram¹⁴ with the derived stability parameters included in figure 9 (with data from the surface to 600-hPa, or 14,000 ft msl.) This data was analyzed utilizing the RAOB¹⁵ software package. The sounding depicted the lifted condensation level (LCL)¹⁶ at 1,801 ft msl (1196 ft agl), a convective condensation level (CCL)¹⁷ of 1,961 ft, and a level of free convection (LFC)¹⁸ at 1,801 ft. The freezing level was located at 10,829 ft. The precipitable water value was 1.39 inches.

¹³ 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.

¹⁴ 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.

¹⁵ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹⁶ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁷ 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.

¹⁸ Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.



¹⁹ 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.

The 1200 CDT HRRR sounding wind profile indicated a surface wind from 360° at 9 knots with the wind remaining primarily northerly through 2,500 ft. The wind speed remained around 10 knots through 2,500 ft. Between 2,500 and 7,000 ft the wind became westerly and increased in speed to 20 knots. From 7,000 ft through 14,000 ft the wind remained westerly under 20 knots. The possibility of light low-level wind shear was indicated by RAOB between the surface and 100 ft agl. Several layers of possible clear-air turbulence were identified between the surface and 14,000 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) 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 NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-13 band 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 0900 CDT through 1400 CDT at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 10 and 11 present the GOES-13 visible imagery at 1145 and 1200 CDT at 2X magnification with the accident site highlighted with a red square. The visible imagery indicated abundant cloud cover above the accident site at the accident time with the cloud cover moving from west to east (attachment 1). Figure 12 presents the GOES-13 infrared imagery at 1145 CDT at 6X magnification with the accident site highlighted with a red square. The infrared imagery indicated cooler brightness temperatures and cloud tops (green and blue colors) located over the accident site at the accident time with the cooler brightness temperatures moving from southwest to northeast around the accident time (attachment 2). Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1200 CDT HRRR sounding, the approximate cloud-top heights over the accident site were 34,000 ft at 1145 CDT. It should be noted these figures have not been corrected for any parallax error. Based on the surface observations from KHOP (section 3.0) the cloud ceiling would have been 800 to 900 ft agl with a solid cloud layer from 800 to 900 ft agl through 14,000 ft msl (section 4.0). Layered clouds would have been likely from 14,000 ft msl (sections 4.0, 7.0, and 10.0) through 34,000 ft msl.

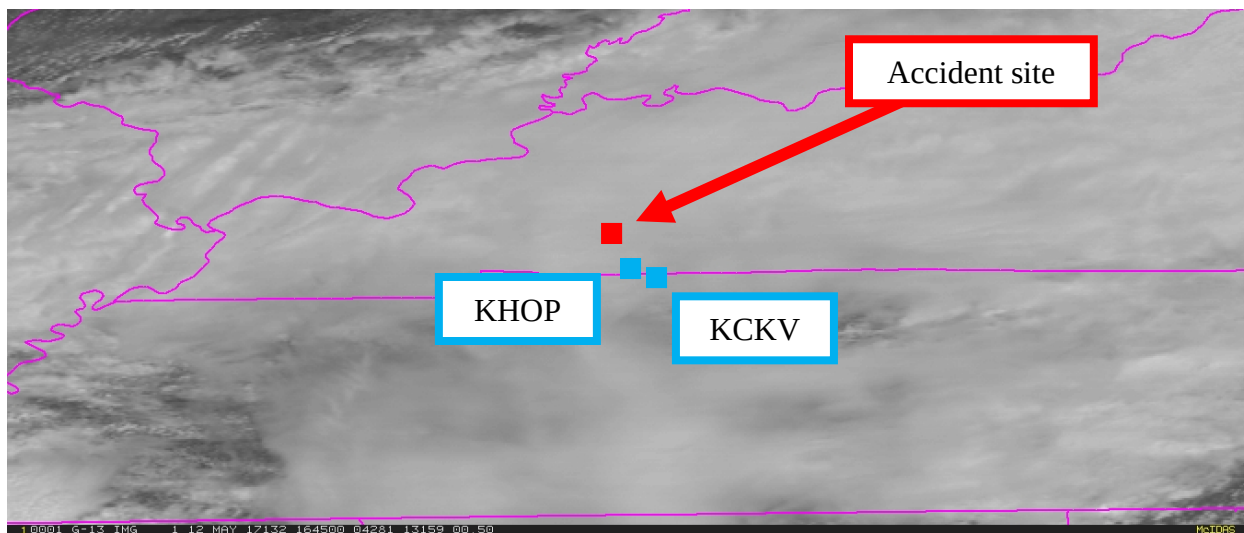


Figure 10 – GOES-13 visible image at 1145 CDT

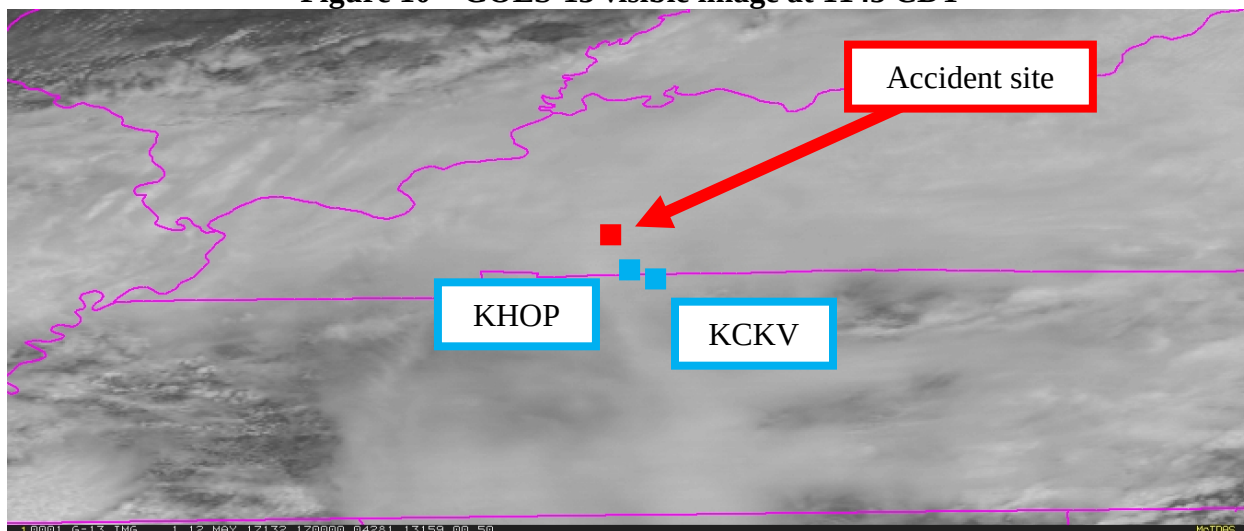


Figure 11 – GOES-13 visible image at 1200 CDT

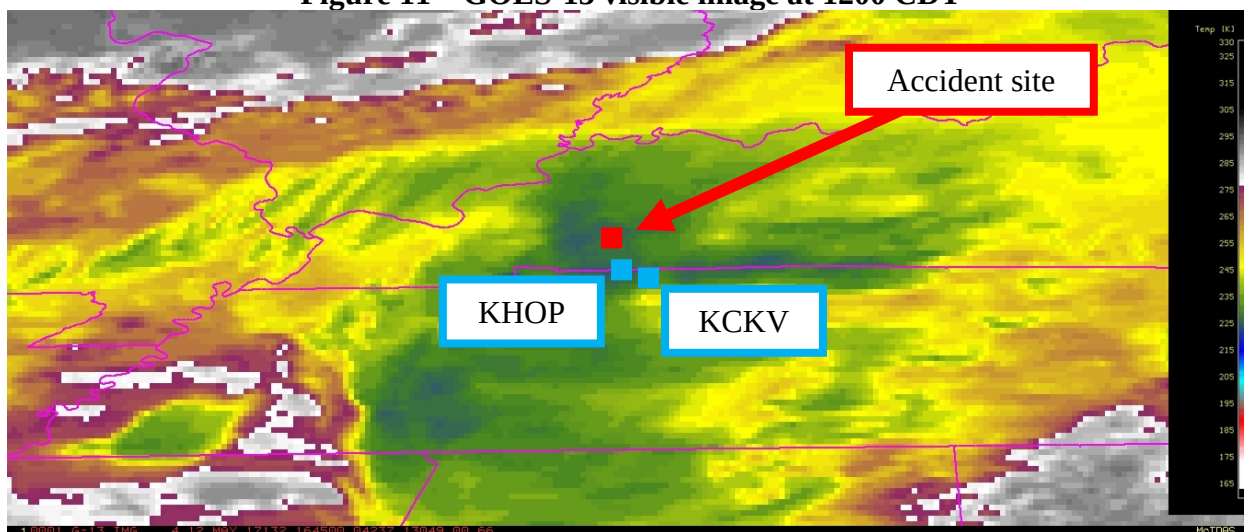


Figure 12 – GOES-13 infrared image at 1145 CDT

6.0 Radar Imagery Information

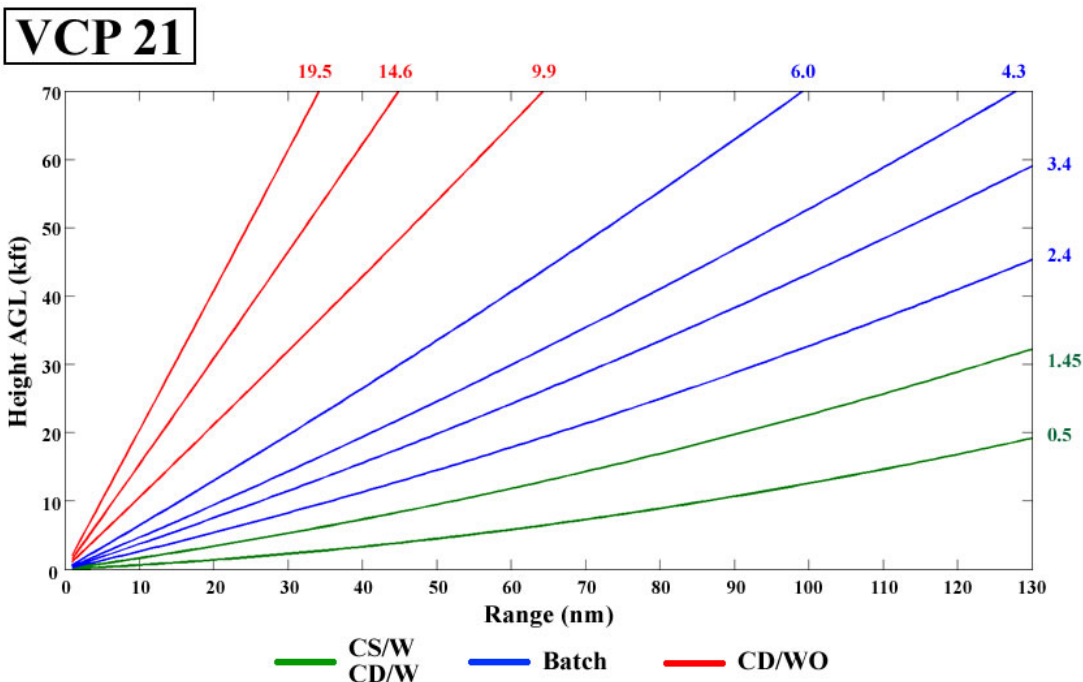
The closest Weather Surveillance Radar-1988, Doppler (WSR-88D)²⁰ to the accident site was the Fort Campbell, Kentucky, radar (KHPX), which was located 19 miles east-southeast of the accident site at an elevation of 576 ft. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. In addition, the NWS WSR-88D data from the Paducah, Kentucky, radar (KPAH), with an elevation of 392 ft, was retrieved and will be displayed below, as the accident flight turned eastward between 1106 and 1112 CDT.

6.1 Volume Scan Strategy

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

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten-minute period. During the period surrounding the accident, the KHPX WSR-88D radar was operating in the precipitation mode (Mode A, VCP-21). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

²⁰ 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.



VCP-21 Precipitation Mode Scan Strategy²¹

6.2 Beam Height Calculation

Assuming standard refraction²² of the WSR-88D radar beam, and considering a beamwidth²³ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for several antenna elevations over the accident site. These heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
0.5°	1,850 ft	910 ft	2,790 ft
1.5°	3,850 ft	2,910 ft	4,790 ft

²¹ 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)

²² Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²³ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

Based on the radar height calculations, the 0.5° and 1.5° elevation scans from KHPX depicted the conditions between 910 ft and 4,790 ft msl over the accident site.²⁴

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁵ 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 (dBZ²⁶), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “Thunderstorms,” dated February 19, 2013, 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 but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

²⁴ For more information, please see the air traffic control (ATC) data located in the docket for this accident.

²⁵ 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.

²⁶ 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.

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

6.4 Regional Weather Radar Summary

Figure 13 is a Radar Coded Message (RCM) radar summary image from 1145 CDT with reflectivity values over the midwestern United States. The accident site was located in an area of 20 to 30 dBZ values at 1145 CDT. These reflectivity values indicated light to moderate precipitation (section 6.3).

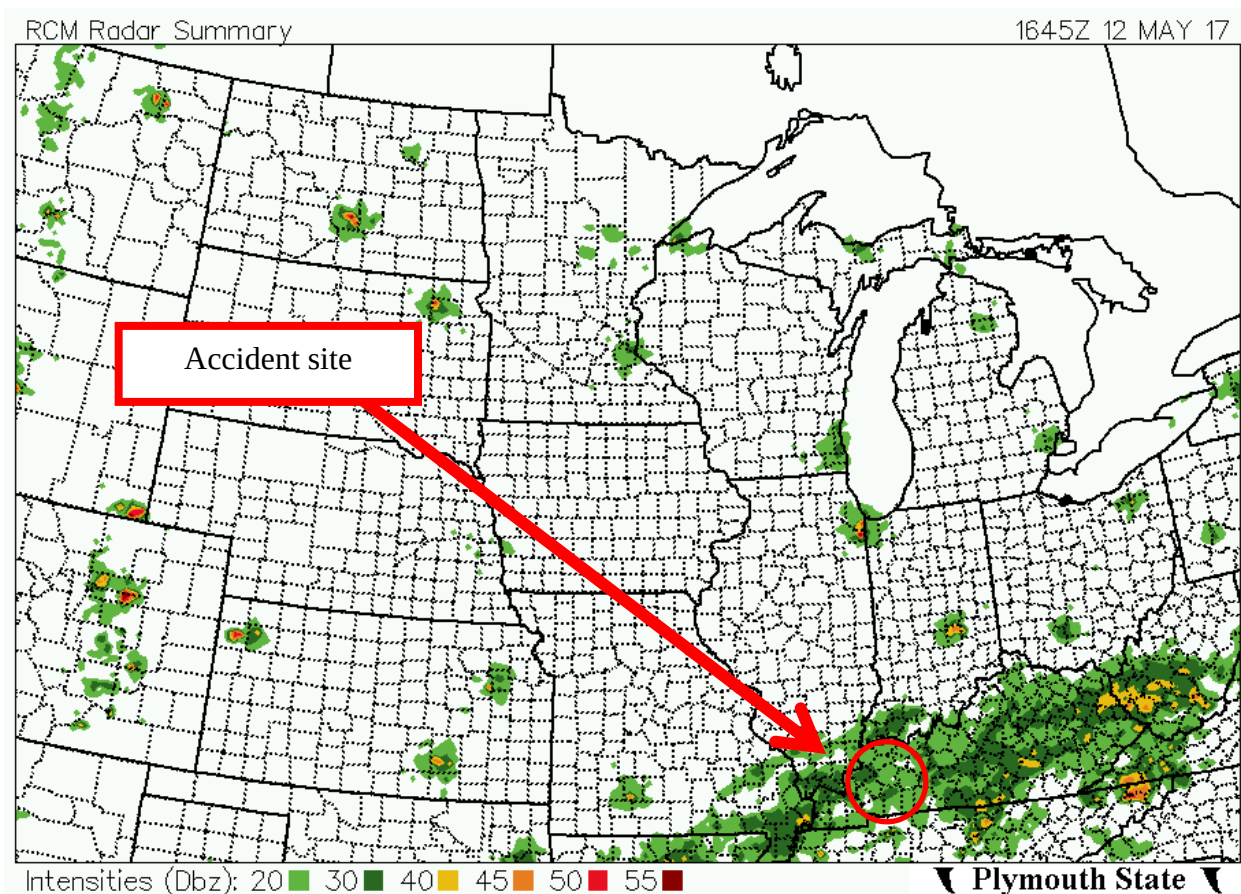


Figure 13 – Radar summary image for 1945 CDT with the accident site area circled

6.5 Base Reflectivity and Lightning Data

Figures 14 through 19 present the KHPX WSR-88D base reflectivity images for the 0.5° and 1.5° elevation scans initiated at 1141, 1142, 1147, 1148, 1153, and 1154 CDT with a resolution of 0.5° X 250 m. The ATC observed flight track is also included with the arrows pointing in the direction of travel. The accident flight track indicated that the accident flight was located in areas of 0 to 15 dBZ reflectivity values between 1141 and 1147 CDT (figures 14 through 16). At the accident time 10 to 25 dBZ reflectivity values were located above the accident site (figures 18 and 19). The coverage and intensity of the dBZ values expanded along the accident flight route and at the accident site between 1128 and 1205 CDT (attachments 3 and 4). The reflectivity values above the accident site at the accident time corresponded to light precipitation (section 6.3). An archived lightning database was reviewed and there were no lightning strikes near the accident site at the accident time.²⁷ For more information regarding the discussion between the accident pilot and ATC please see the NTSB Prepared Audio Review (attachment 5).²⁸ The KHPX WSR-88D elevation angles were located above the accident flight's altitude at 1145 and 1149 CDT, therefore the closest elevation angles to the accident flight's altitude are provided here in figures 14 through 19.

²⁷ A review of Earth Networks Total Lightning network was done.

²⁸ For more information, please see the ATC data located in the NTSB public docket for this investigation.

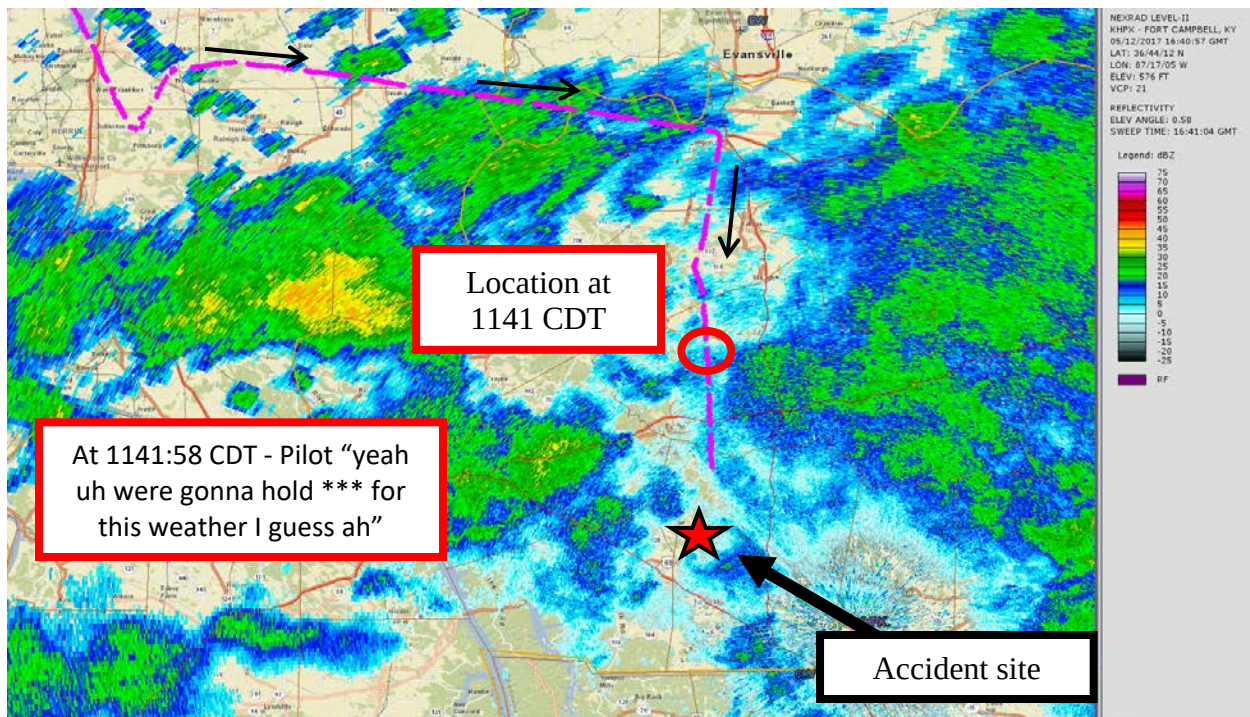


Figure 14 – KHPX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1141 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

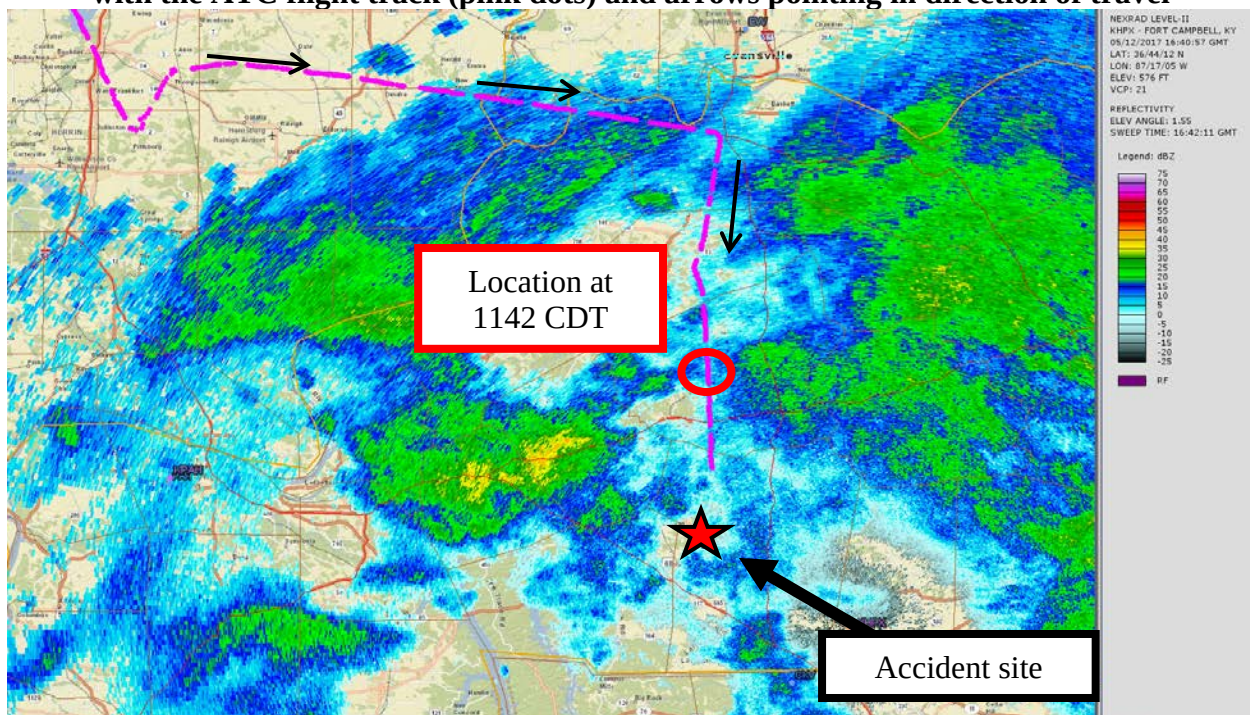


Figure 15 – KHPX WSR-88D reflectivity for the 1.5° elevation scan initiated at 1142 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

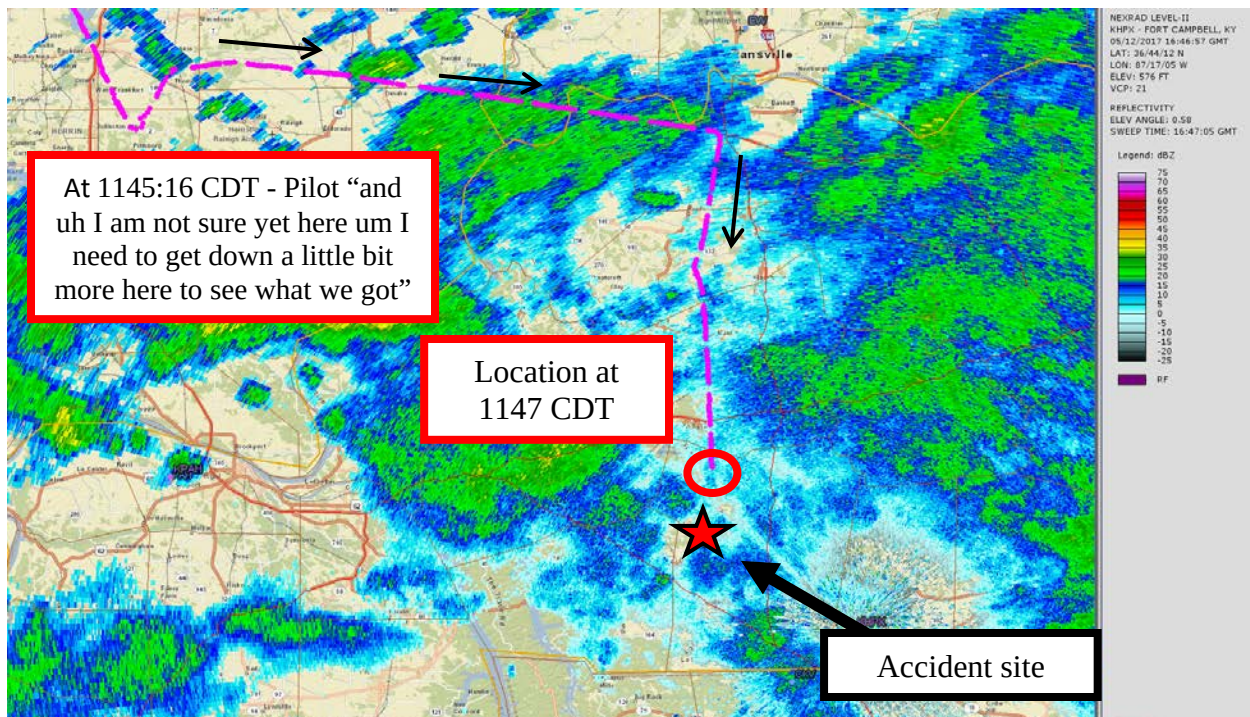


Figure 16 – KHPX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1147 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

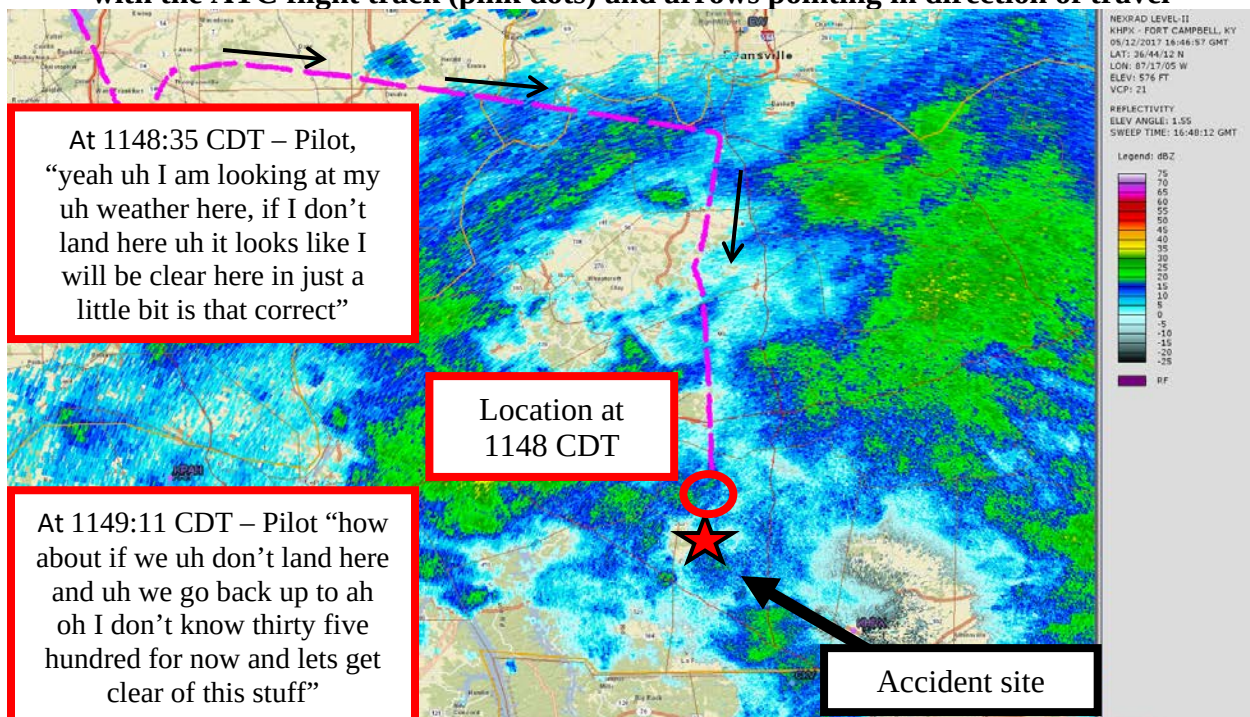


Figure 17 – KHPX WSR-88D reflectivity for the 1.5° elevation scan initiated at 1148 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

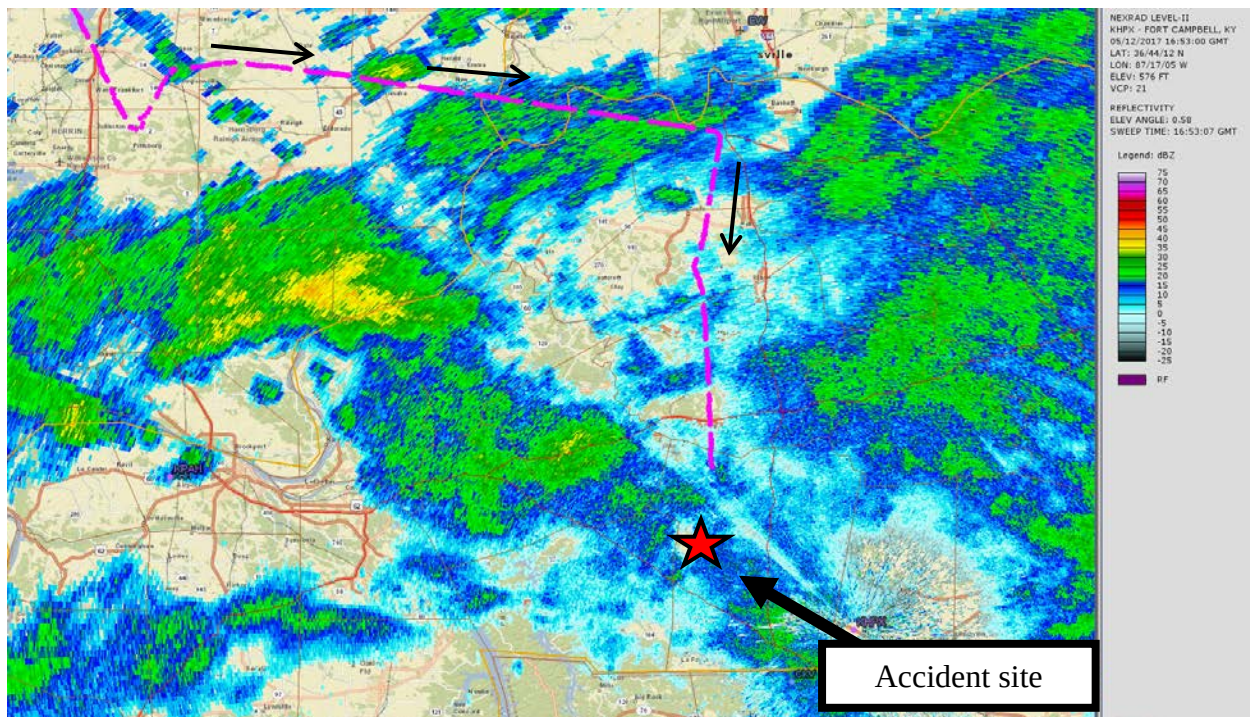


Figure 18 – KHPX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1153 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

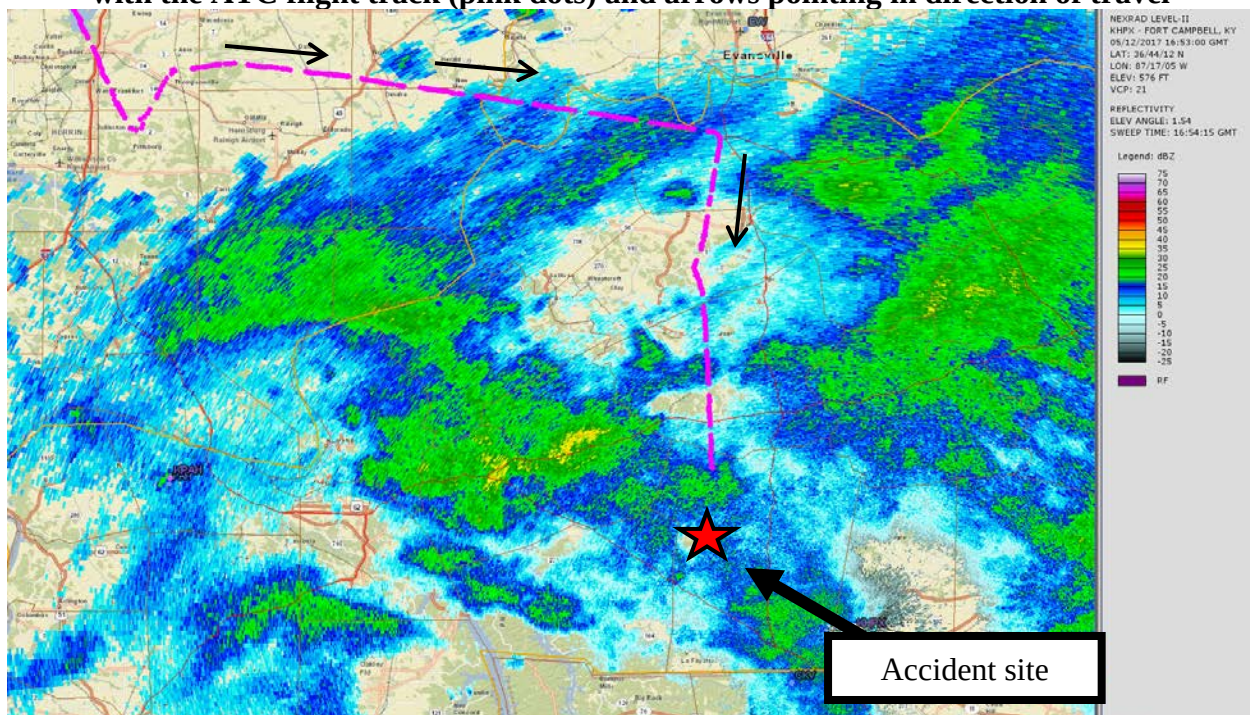


Figure 19 – KHPX WSR-88D reflectivity for the 1.5° elevation scan initiated at 1154 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

Figures 20 through 23 present the KPAH WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1057, 1103, 1108, and 1114 CDT with a resolution of 0.5° X 250 m. The ATC flight track is included with the arrows pointing in the direction of travel. While heading south-southeastward between 1057 and 1108 CDT the accident pilot and ATC at Kansas City Air Route Traffic Control Center (ZKC) discussed avoiding the weather in the direction of the destination airport (figures 20, 21, and 22). To avoid the weather conditions towards his destination, the accident pilot initiates a turn towards the NAVAID at Evansville, Indiana, (PXV) between 1108 and 1114 CDT (figures 22 and 23). The accident pilot and ZKC discuss that after reaching PXV, the accident flight will turn back towards his destination.²⁹

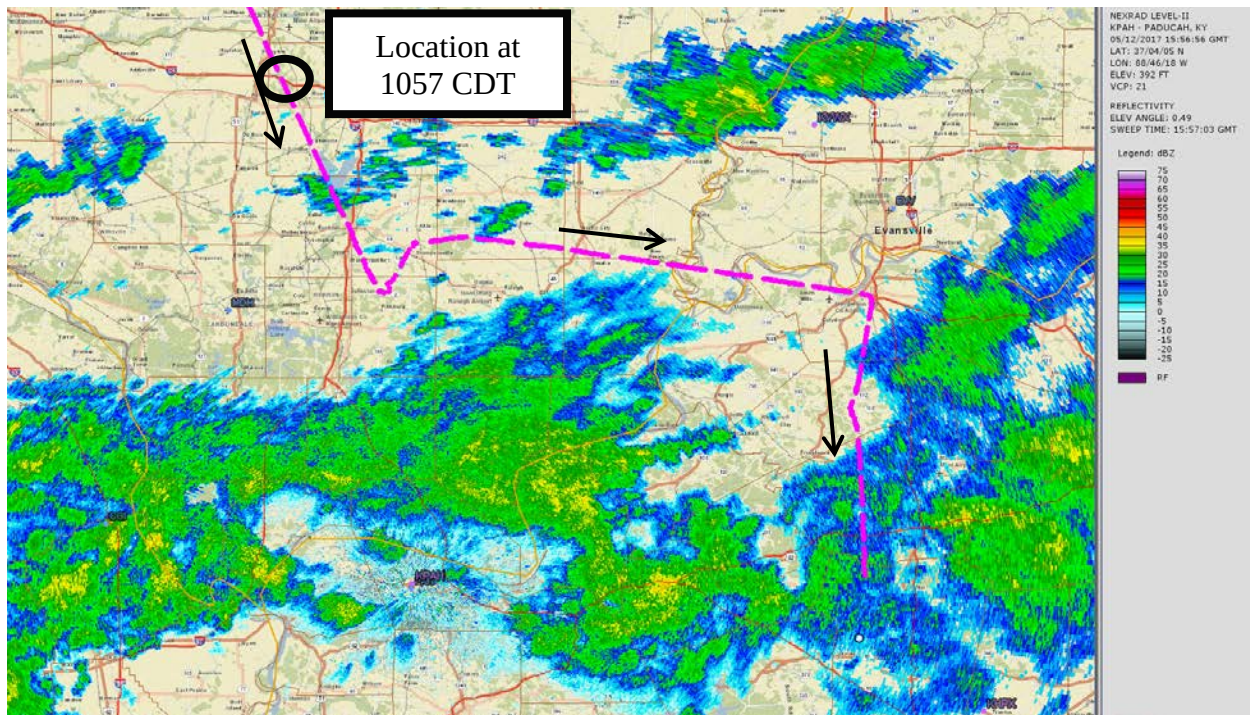


Figure 20 – KPAH WSR-88D reflectivity for the 0.5° elevation scan initiated at 1057 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

²⁹ For more information, please see the ATC data and NTSB Prepared Audio Review located in the NTSB public docket for this investigation.

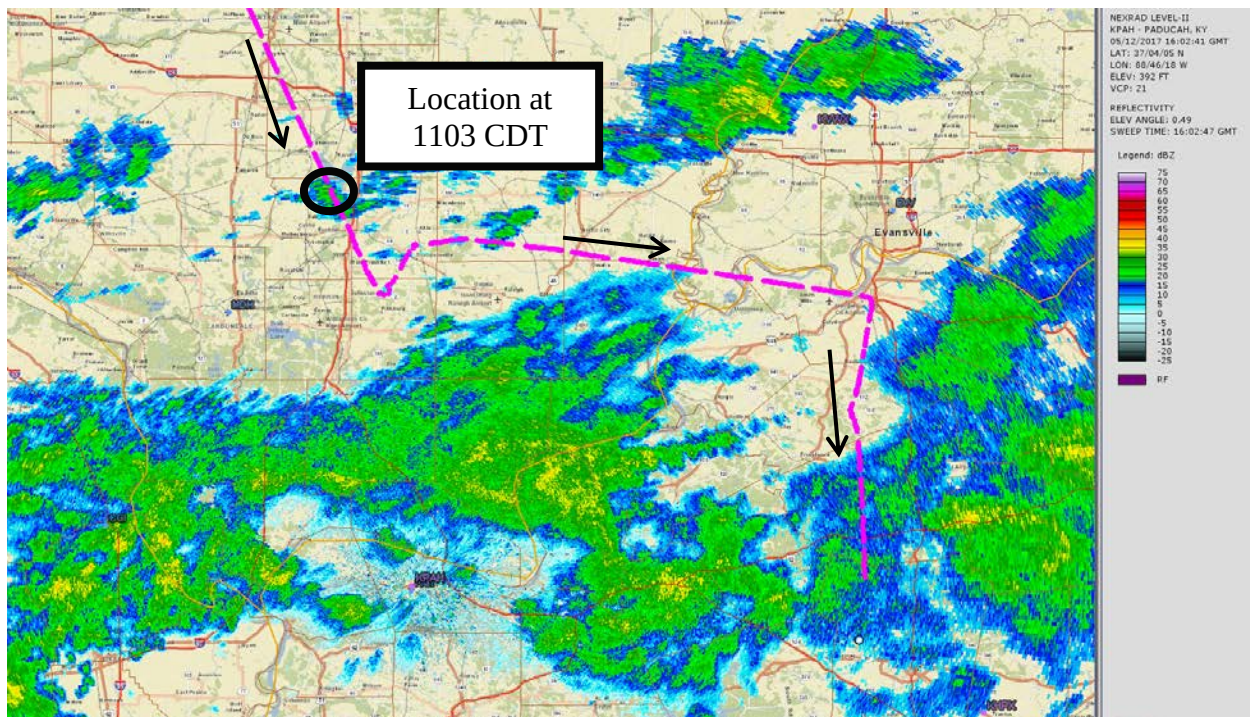


Figure 21 – KPAH WSR-88D reflectivity for the 0.5° elevation scan initiated at 1103 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

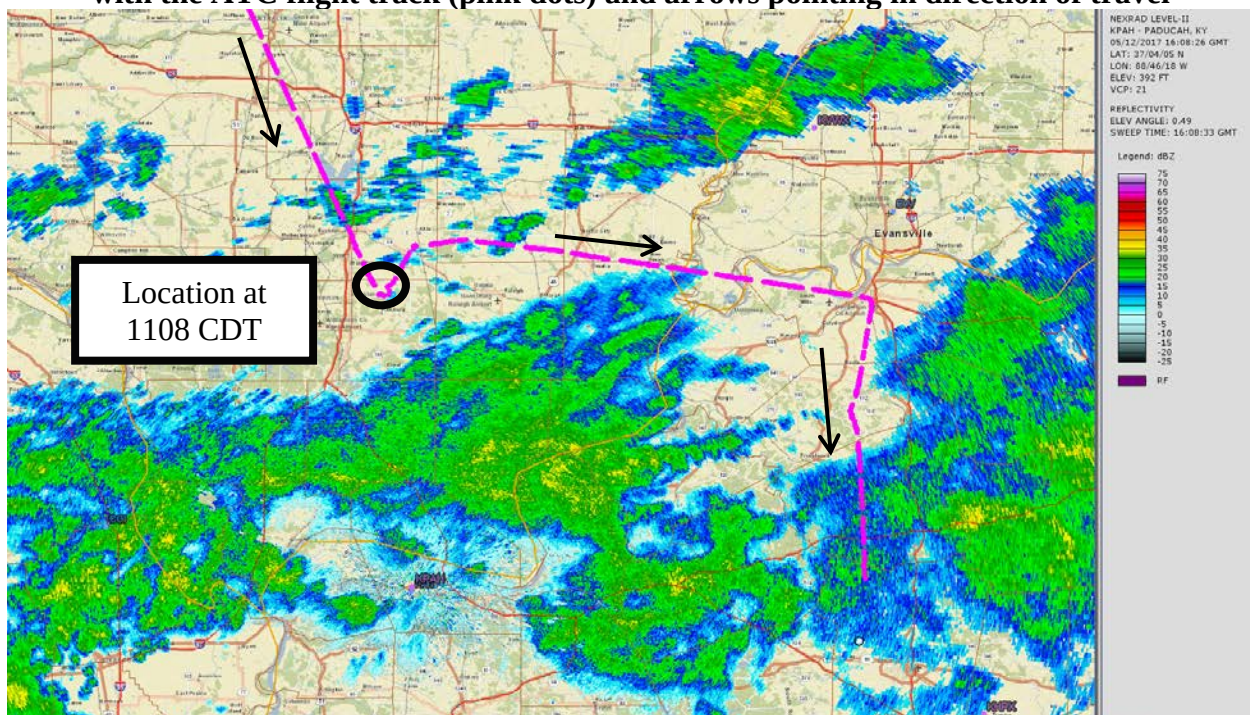


Figure 22 – KPAH WSR-88D reflectivity for the 0.5° elevation scan initiated at 1108 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

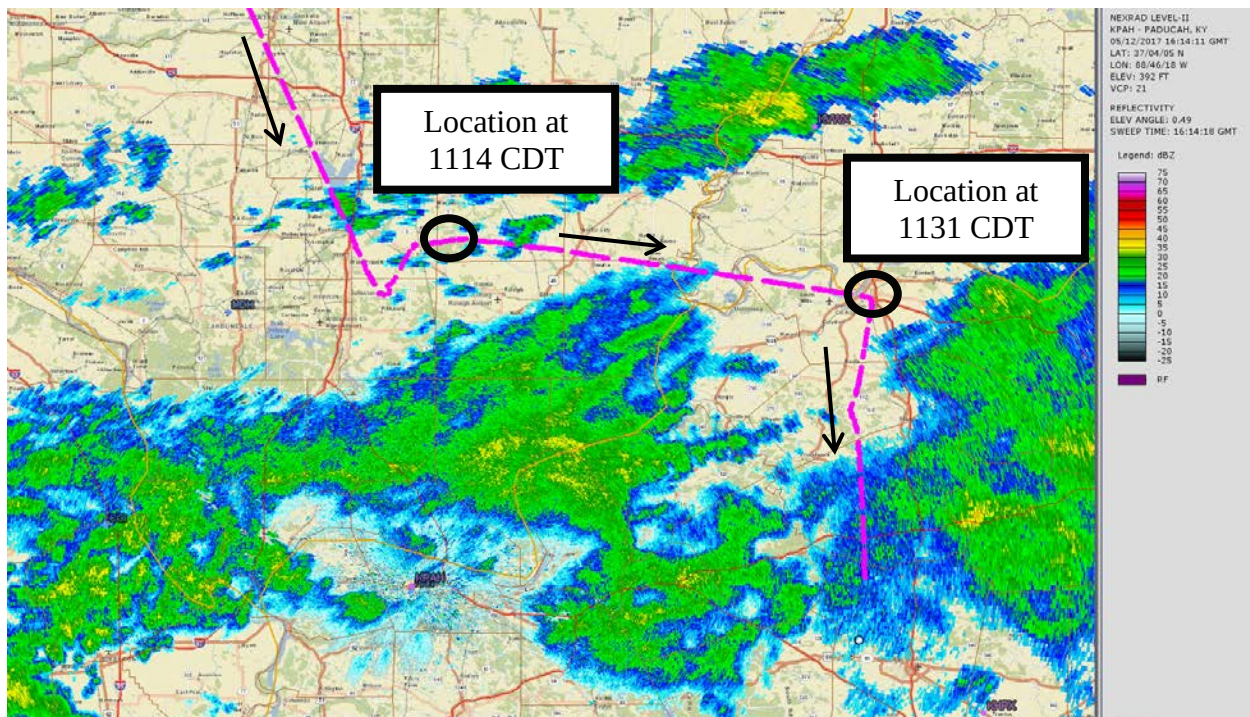


Figure 23 – KPAH WSR-88D reflectivity for the 0.5° elevation scan initiated at 1114 CDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

7.0 Pilot Reports³⁰

All pilot reports (PIREPs) within 150 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time for below 18,000 ft are provided below in raw and decoded form:

BNA UA /OV BNA/TM 1458/FLDURGC/TP A319/SK BKN012-TOP018/RM HIGH LYRS ABV

KMQY UA /OV MQY/TM 1501/FL012/TP C56X/SK BKN012 TOPS 023 OVC LAYER ABV/TB NEG/RM SMOOTH RIDE DURD

BNA UA /OV BNA360040/TM 1535/FL140/TP BE9L/TA M06/IC LGT RIME 160-140/RM ZME

BNA UA /OV BNA020010/TM 1550/FLDURGD/TP B737/SK SCT015 MULT SCT LYRS ABV

BWG UA /OV BWG/TM 1605/FL160/TP TBM7/TA M10/IC MOD RIME 210-160/RM ZME

GLW UA /OV BWG040017/TM 1640/FL070/TP A139/TA 09/TB NEG/IC NEG/RM IMC SMTH VISIBLE MOISTURE

BNA UA /OV BNA/TM 1655/FLDURGD/TP A319/SK BKN018-TOPUNKN

BNA UA /OV BNA090040/TM 1700/FL135/TP C340/TA 00/IC LGT CLR 135-155/RM ZME

BNA UA /OV BNA/TM 1720/FLDIRC/TP HS2B/SK SCT020-OVC071-TOP UNKN

³⁰ Only pilot reports with the WMO header UBKY**, UBTN**, UBIN**, UBIL**, and UBMO** identifier were considered.

The decoded PIREPs with time converted to CDT transcribes from standard abbreviations and code were as follows:

Routine pilot report (UA); Over - Nashville, TN (BNA); Time – 0958 CDT (1458Z); Altitude – During climb; Type aircraft – Airbus A319; Sky cover– Broken ceiling at 1,200 ft with tops at 1,800 ft; Remarks – High layers above.

Routine pilot report (UA); Over - Smyrna, TN (MQY); Time – 1001 CDT (1501Z); Altitude – 1,200 ft; Type aircraft – Cessna Citation Excel; Sky cover– Broken ceiling at 1,200 ft with tops at 2,300 ft and an overcast layer above; Turbulence – Negative; Remarks – Smooth ride during descent.

Routine pilot report (UA); Over - 40 miles from BNA VORTAC, on the 360° radial; Time – 1035 CDT (1535Z); Altitude – 14,000 ft; Type aircraft – Beechcraft King Air 90; Temperature – -6° C; Icing – Light rime ice between 16,000 and 14,000 ft.

Routine pilot report (UA); over - 10 miles from BNA VORTAC, on the 020° radial; Time – 1050 CDT (1550Z); Altitude – During climb; Type aircraft – Boeing B737-700; Sky cover – Scattered clouds at 1,500 ft with multiple scattered layers above.

Routine pilot report (UA); Over - Bowling Green, KY (BWG); Time – 1105 CDT (1605Z); Altitude – 16,000 ft msl; Type aircraft – Socata BM; Temperature – -10° C; Icing – Moderate rime between 21,000 and 16,000 ft.

Routine pilot report (UA); Over - 17 miles from BWG, on the 040° radial; Time – 1140 CDT (1640Z); Altitude – 7,000 ft; Type aircraft – AgustaWestland AW139; Temperature – 9° C; Turbulence – Negative; Icing – Negative; Remarks – In instrument meteorological conditions (IMC), smooth, with visible moisture.

Routine pilot report (UA); Over - BNA; Time – 1155 CDT (1655Z); Altitude – During climb; Type aircraft – Airbus A319; Sky cover – Broken ceiling at 1,800 ft with unknown tops.

Routine pilot report (UA); Over - 40 miles from BNA VORTAC, on the 090° radial; Time – 1200 CDT (1700Z); Altitude – 13,500 ft; Type aircraft – Cessna 340; Temperature – 0° C; Icing – Light clear ice between 13,500 and 15,500 ft.

Routine pilot report (UA); Over - BNA; Time – 1220 CDT (1720Z); Altitude – During climb; Type aircraft – Unknown; Sky cover– Scattered clouds at 2,000 ft with overcast ceiling at 7,100 ft and an unknown cloud top level.

8.0 SIGMET and CWSU Advisories

The NWS Aviation Weather Center (AWC) did not issue Significant Meteorological Information (SIGMET) or Convective SIGMET advisories valid for the region below 18,000 ft on the day of the accident.

There were no Center Weather Service Unit (CWSU) Meteorological Impact Statements (MIS)s or Center Weather Advisories (CWA)s were valid for the accident site at the accident time.

9.0 AIRMETS

The NWS AWC issued the following Airmen's Meteorological Information (AIRMET) advisories Tango and Sierra were issued at 0945 CDT and valid at the accident time for the accident site (figure 24). AIRMETs Tango and Sierra forecasted moderate turbulence between 5,000 ft and FL180 and forecast IFR conditions due to precipitation and mist. Another AIRMET Sierra for IFR conditions was issued for the accident site and along the intended flight path before the accident flight's departure time (figures 24 through 28):

WAUS43 KPCI 121445
WA3S
-CHIS WA 121445
AIRMET SIERRA UPDT 2 FOR IFR AND MTN OBSCN VALID UNTIL 122100
.
AIRMET IFR...MO IL IN KY OK AR TN LA MS
FROM HNN TO HNV TO 20S VXV TO GQO TO 50S BNA TO 20W BNA TO 30NW
MEM TO 40SW MEM TO 50SSE LIT TO 20ESE TXK TO 50SE TUL TO 40WSW
SGF TO 20SW FAM TO 30W IJU TO HNN
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
.
AIRMET MTN OBSCN...KY TN
FROM HNN TO HNV TO GQO TO 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 VALID UNTIL 122100
.
AIRMET TURB...KS MO MI IL IN KY OK TX AR TN LA MS AL AND CSTL
WTRS
FROM 30SSE ECK TO FWA TO CVG TO HNN TO HNV TO GQO TO 50SW PZD TO
40W CEW TO 130ESE LEV TO 120SSW LCH TO 40S TTT TO 40ESE OKC TO
BUM TO 30SSE ECK
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 21Z ENDG 00-03Z.
.
AIRMET TURB...IN KY TX TN LA MS AL AND CSTL WTRS
FROM CVG TO HNN TO HNV TO GQO TO 50SW PZD TO 40W CEW TO 130ESE
LEV TO 120SSW LCH TO 40SSE LSU TO 30SW MEI TO 50ESE MEM TO 60NNE
DYR TO CVG
MOD TURB BTN 050 AND FL180. CONDS CONTG BYD 21Z ENDG 21-00Z.
.
OTLK VALID 2100-0300Z...TURB MN IA MO WI LM LS MI IL IN
BOUNDED BY 70SE YWG-30N INL-YQT-40ESE GRB-FWA-30S IND-60SSE COU-
30SW IRK-40ESE DSM-70SE YWG
MOD TURB BTN FL250 AND FL370. CONDS DVLPG 21-00Z. CONDS CONTG

THRU 03Z.

....

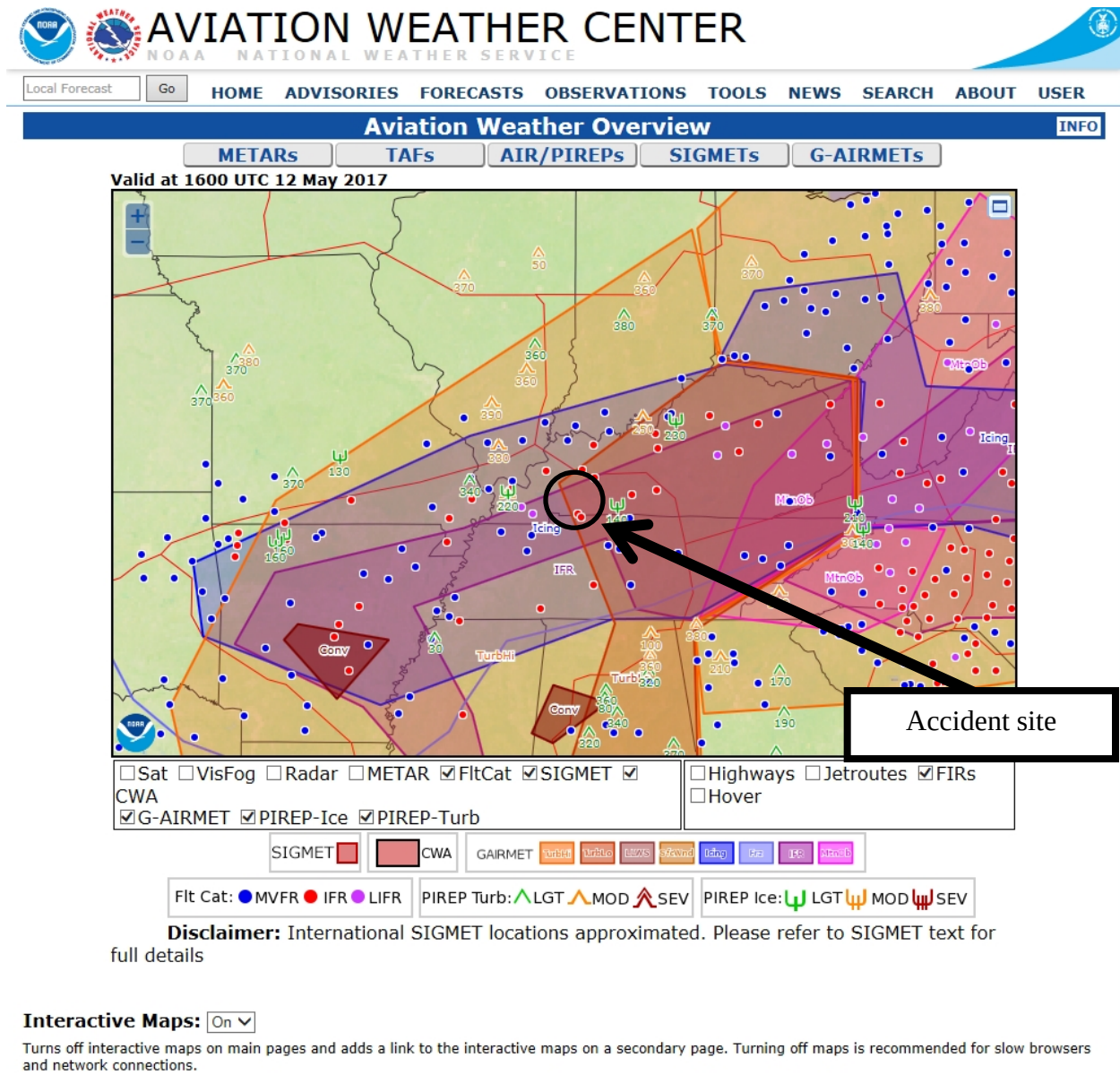


Figure 24 – AWC SIGMET, CWA, and AIRMET graphic valid for 1100 CDT

G-AIRMETS

Accident site

Figure 25 – AWC SIGMET, CWA, and AIRMET graphic valid for 1000 CDT



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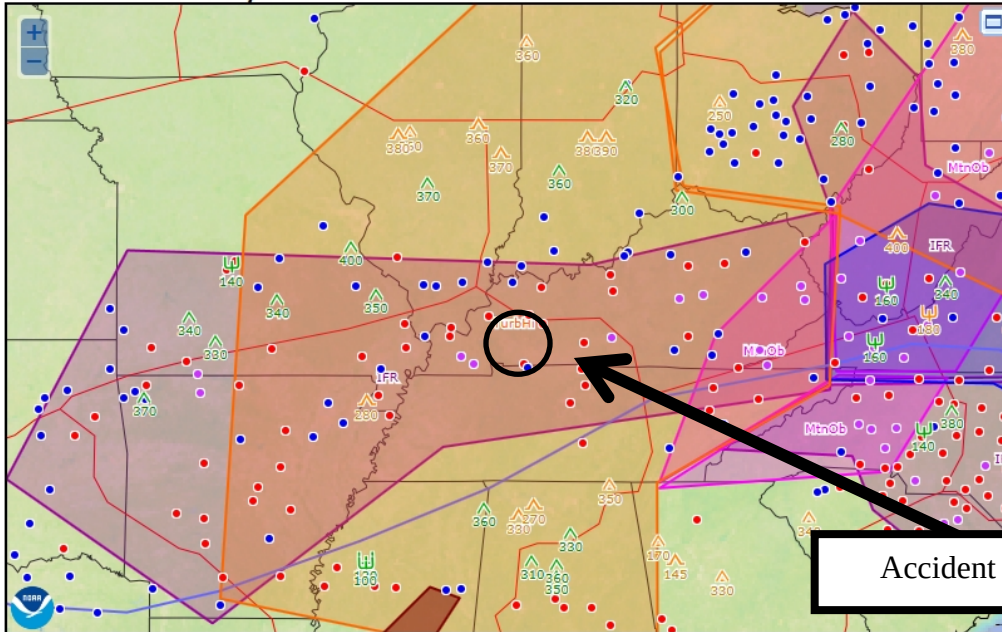
TAFs

AIR/PIREPs

SIGMETs

G-AIRMETs

Valid at 1400 UTC 12 May 2017



☐ Sat ☐ VisFog ☐ Radar ☐ METAR ☒ FltCat ☒ SIGMET ☒
CWA
☒ G-AIRMET ☒ PIREP-Ice ☒ PIREP-Turb

☐ Highways ☐ Jetroutes ☒ FIRs
☐ Hover

SIGMET ☒ CWA ☒ G-AIRMET ☒ PIREP-Ice ☒ PIREP-Turb

Flt Cat: ● MVFR ● IFR ● LIFR PIREP Turb: ▲ LGT ▲ MOD ▲ SEV PIREP Ice: ▲ LGT ▲ MOD ▲ SEV

Disclaimer: International SIGMET locations approximated. Please refer to SIGMET text for full details

Interactive Maps:

Turns off interactive maps on main pages and adds a link to the interactive maps on a secondary page. Turning off maps is recommended for slow browsers and network connections.

Figure 26 – AWC SIGMET, CWA, and AIRMET graphic valid for 0900 CDT

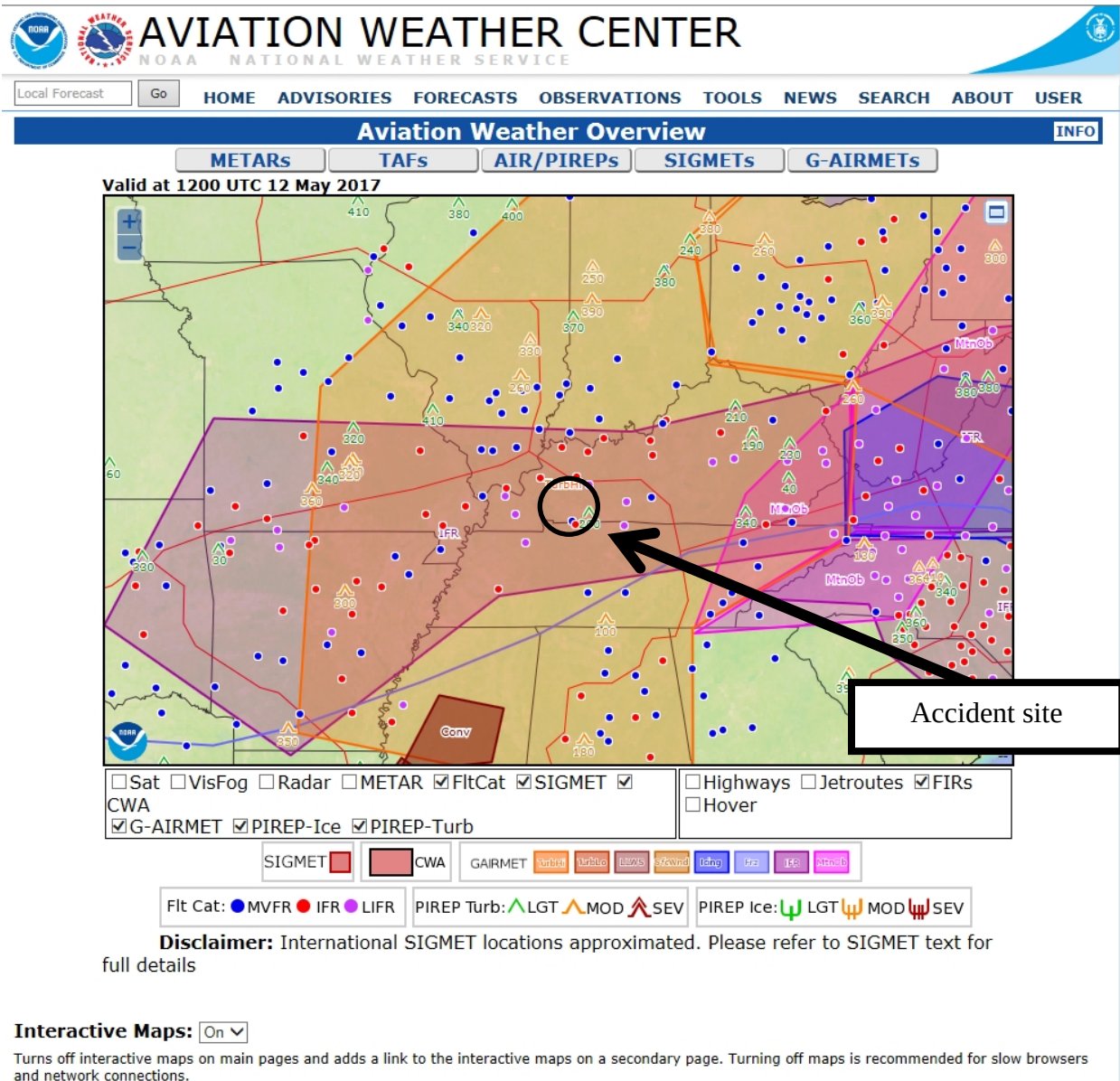


Figure 28 – AWC SIGMET, CWA, and AIRMET graphic valid for 0700 CDT

10.0 Area Forecast

The NWS AWC Area Forecast³¹ issued at 0445 CDT, valid at the time of departure and the accident time expected a broken ceiling at 2,000 ft msl with tops at 15,000 ft and overcast cirrus clouds above. Till 1400 CDT widely scattered thunderstorms and light rain were forecast with cumulonimbus tops to FL400:

FAUS43 KPCI 120945
FA3W

³¹ The Area Forecast is a general forecast for VFR flight conditions and must be used in conjunction with AIRMET Sierra for IFR and mountain obscuration conditions. Cloud heights are reported in msl heights.

-CHIC FA 120945
 SYNOPSIS AND VFR CLDS/WX
 SYNOPSIS VALID UNTIL 130400
 CLDS/WX VALID UNTIL 122200...OTLK VALID 122200-130400
 ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY

.

SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
 TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
 NON MSL HGTS DENOTED BY AGL OR CIG.

.

SYNOPSIS...10Z LOW INVOF FSM WITH STNR FNT ALG A FSM-BNA-20S HNV
 LN. STNR FNT ALG A GGW-ISN-FAR LN...CONTG AS A WRMFNT ALG A
 FAR-FOD LN. 04Z STNR FNT ALG A GGW-DIK-MSP LN.

.

ND
 WRN-S CNTRL...SKC. OCNL SCT CI. OTLK...VFR.
 ERN-N CNTRL...SCT-BKN100 TOPS 130. BECMG 1416 SCT150 SCT CI.
 OTLK...VFR.

.

SD
 SKC. 17Z OCNL SCT CI NRN SXNS. OTLK...VFR.

.

NE
 PNHDL...SKC. 19Z WND SE G25KT. OTLK...VFR WND.
 RMNDR...SKC. OTLK...VFR.

.

KS
 WRN-N CNTRL...SKC. OTLK...VFR.
 NERN...SCT050-060. OTLK...VFR.
 S CNTRL...SCT045 BKN060 TOPS 070. 15Z SKC. OTLK...VFR.
 SERN...BKN030 BKN050 TOPS 150. 14Z SCT040. OTLK...VFR.

.

MN
 NWRN...SCT-BKN080 TOPS 110. BECMG 1316 SCT100 SCT-BKN CI.
 OTLK...VFR.
 NERN...SKC. 15Z SCT-BKN100 TOPS 120. OTLK...VFR.
 CNTRL...BKN080 TOPS 120. ISOL -SHRA. BECMG 1720 SCT080 SCT150.
 OTLK...VFR.
 SRN...SKC. 13Z SCT080. OTLK...VFR.

.

IA
 ERN QTR...SCT-BKN060 TOPS 080. 14Z SKC. OTLK...VFR.
 RMNDR...SKC. OTLK...VFR.

.

MO
 N THIRD...SCT100 SCT CI. OTLK...VFR.
 CNTRL THIRD...SCT025 SCT-BKN060 TOPS 110. BECMG 1417 SCT070-080.
 OTLK...VFR.
 SWRN...OVC020 TOPS FL180. WDLY SCT -SHRA. BECMG 1619 SCT070.
 OTLK...VFR.
 SERN...BKN020 TOPS 150 BKN CI. WDLY SCT -SHRA. BECMG 1720 BKN040
 TOPS 060. OTLK...VFR.

.

WI
 NWRN-W CNTRL...SKC. 17Z SCT070 SCT150. OTLK...VFR.
 RMNDR...BKN050 TOPS 100. TIL 13Z ISOL -SHRA. 18Z SCT050 SCT100.

OTLK...VFR.

.

LS UPR MI
W HLF...SKC. TIL 15Z OCNL SCT070. OTLK...VFR.
E HLF...BKN060 TOPS 090. OTLK...VFR.

.

LM LWR MI LH
N HLF...SCT-BKN070 TOPS 120. OTLK...VFR.
SW QTR...SCT070 SCT CI. BECMG 1417 BKN050-060 TOPS 100.
OTLK...VFR.
SE QTR...SCT CI. BECMG 1518 BKN-SCT050 TOPS 090. OTLK...VFR.

.

IL
N THIRD...SCT-BKN050 TOPS 090. OTLK...VFR.
CNTRL THIRD...SCT100 BKN-SCT CI. 15Z SCT060 SCT100. OTLK...VFR.
S THIRD...BKN020 LYRD FL180. WDLY SCT -SHRA. BECMG 1619 BKN020
TOPS 060. OTLK...VFR.

.

IN
NRN...SCT-BKN070 TOPS 100. 16Z SCT100 SCT150. OTLK...VFR.
CNTRL...BKN-SCT045 TOPS 080. BECMG 1517 SCT110 SCT CI.
OTLK...VFR.
SRN...BKN020 TOPS 150 BKN CI. ISOL -SHRA. BECMG 1821 BKN040 TOPS
060. OTLK...VFR.

.

KY
**WRN...BKN020 TOPS 150 OVC CI. TIL 19Z WDLY SCT -TSRA. CB TOPS
FL400. OTLK...MVFR CIG 00Z VFR.**
CNTRL...BKN020 LYRD FL250. VIS 4SM IN SCT SHRA. WDLY SCT -TSRA
SRN SXNS. CB TOPS FL350. OTLK...MVFR CIG THRUT...SHRA ERN SXNS.
ERN...OVC020 LYRD FL300. WDLY SCT -SHRA. 14Z VIS 4SM IN SCT SHRA.
WDLY SCT -TSRA SRN SXNS. CB TOPS FL400. OTLK...IFR CIG SHRA.

....

11.0 Terminal Aerodrome Forecast

KHOP was the closest site to the accident site with a Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 1100 CDT and was valid for a 30-hour period beginning at 1100 CDT. The TAF for KHOP was as follows:

TAF KHOP 121600Z 1216/1322 **01009KT 8000 -SHRA OVC008 QNH2982INS**
BECMG 1222/1223 01006KT 9999 NSW SCT015 BKN060 QNH2983INS
BECMG 1304/1305 02006KT 9999 FEW060 510052 QNH2987INS
BECMG 1313/1314 03010G15KT 9999 FEW200 QNH2994INS
TX21/1316Z TN11/1311Z=

The KHOP forecast expected a wind from 010° at 9 knots, 8000 meters or 5 statute miles visibility, light rain showers, an overcast ceiling at 800 ft agl, and minimum altimeter setting of 29.82 inches Hg.

KCKV was the next closest site to the accident site with a NWS TAF. The NWS TAF valid at the time of the accident was an amended forecast issued at 0839 CDT and was valid for a 22-hour period beginning at 0900 CDT. The TAF for KCKV was as follows:

TAF AMD KCKV 121339Z 1214/1312 **35007KT P6SM BKN006 OVC060**
FM121700 01008KT 5SM -SHRA BR OVC008
FM122200 01009KT P6SM OVC010
FM131000 01007KT P6SM SCT010=

The forecast from 0900 through 1200 CDT expected a wind from 350° at 7 knots, greater than 6 statute miles visibility, broken ceiling at 600 ft agl, and overcast skies at 6,000 ft agl.

12.0 NWS Area Forecast Discussion

The NWS Office in Paducah, Kentucky, issued the following Area Forecast Discussion (AFD) at 0557 CDT (closest AFD to the accident time). The aviation section of the AFD discussed that MVFR to IFR conditions were expected to continue through 1100 to 1300 CDT with light rain showers and drizzle persisting. Conditions were expected to improve after 1300 CDT:

FXUS63 KPAH 121057
AFDPAH

Area Forecast Discussion
National Weather Service Paducah KY
557 AM CDT Fri May 12 2017

.UPDATE...
Issued at 557 AM CDT Fri May 12 2017

Aviation update.

&&

.SHORT TERM...(Today through Sunday night)
Issued at 252 AM CDT Fri May 12 2017

Upper low moving across east OK early this a.m. will, according to the models, track ESE today, ending up over the lower MS valley by 00z. This feature is cut off from a trof axis that will move across the Great Lakes and Ohio Valley regions today. Until both pass by, will continue with a chance of showers today, especially across the southern 2/3 of the area. Several models indicate limited elevated instability just north of the TN/AR state lines. Will keep a slight chance of TSRA as well SEMO, west KY, mainly through the morning. Drier air will work south and east this afternoon, with clearing to follow into the early to mid evening, quiet overnight.

Weak high pressure will move across the area over the weekend, resulting in dry weather, few clouds and seasonal temperatures. Used a HiRes model blend for PoPs today, with some NAM/CMC incorporation. After that, a general model consensus. Generally followed GFS/NAM MOS for temps.

.LONG TERM...(Monday through Thursday)
Issued at 252 AM CDT Fri May 12 2017

The extended forecast period begins with the dominant ridge still maintaining control across the WFO PAH forecast area, with dry conditions and temperatures 5 to 10 degrees above normal.

The closed low currently off the Washington/Oregon Coastline will be the genesis corridor for shortwaves rotating around the cyclonic circulation. A strong shortwave diving down the west side of the low will deepen the low into a sharp amplitude trough that will boldly move from the Pacific U.S. coastline to the western intermountain region on Tuesday, before becoming negatively tilted as it moves through the Plains early Wednesday.

The WFO PAH forecast area will be in a broad, unidirectional southwest flow on the western side of the ridge, receiving glancing blows from minor impulses (shortwaves) rotating around the Pacific coast low as it settles near the four corners region of the U.S. Southwest on Wednesday. The deterministic GFS takes this parent closed low and moves it northward into the High Plains by Friday, while ejecting shortwaves from Texas into Missouri and Illinois.

The net effect will be to bring somewhat disorganized convective activity across the WFO PAH forecast area starting Wednesday through Friday. At this point, have low forecast confidence (20-40%) on the timing and coverage of any precipitation during the aforementioned time period for the following reasons.

1. With the main closed low and trough still off the Pacific U.S. coast, there will be some more distinct sampling issues as we move from satellite (remote sensing) observations to more fine tuned balloon and surface observations. This will impact the overall orientation, placement, and timing of the shortwaves through the western half of the Nation by mid-week.
2. Given the forecast weak shear outside the dominant shortwave passages, most thunderstorm and shower activity will be strongly impacted by mesoscale or smaller features generating more out-flow and boundary focused convection. The timing of the shortwaves would impact the coverage and intensity of the convection. In addition, outside the shortwave passages, most of the convective activity would be strongly diurnal in nature.

Anticipate many variations in the precipitation forecast for the Wednesday to Friday time period between now and next week. This will also lead to a wide variation in storm type, including MCS's and pulse severe potential.

As for the remainder of the sensible weather elements, kept close to the regionally/nationally blended model suite. Forecast values were reasonable and generally accepted.

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.AVIATION...

Issued at 557 AM CDT Fri May 12 2017

Scattered light showers, rain and drizzle persist across the area with cigs ranging from MVFR to IFR, and vsbys occasionally MVFR. Expect these conditions through 16-18z. Conditions should improve after that, as drier air works in from the north. By tonight, skies should become clear, with NE winds 5-10 kts through the day becoming light overnight.

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.PAH WATCHES/WARNINGS/ADVISORIES...

IL...None.

MO...None.

IN...None.

KY...None.

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13.0 Winds and Temperature Aloft Forecast

The NWS 0902 CDT Winds and Temperature Aloft forecast valid for the accident flight are included below:

FBUS31 KWN0 121402

FD1US1

- DATA BASED ON 121200Z

VALID 121800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
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BNA	2909	2914+09	2610+03	2520-01	2428-13	2533-23	233939	234450	246857
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The closest forecast point was Nashville, Tennessee, (BNA). The forecast valid at 1300 CDT and for use between 0900 through 1600 CDT expected a wind at 3,000 ft from 290° at 9 knots, a wind at 6,000 ft from 290° at 14 knots with a temperature of 9° C, a wind at 9,000 ft from 260° at 10 knots with a temperature of 3° C, and a wind at 12,000 ft from 250° at 20 knots with a temperature of -1° C.

14.0 Pilot Weather Briefing and Information

A search of official weather briefing sources, such as LMFS, Leidos, and Direct User Access Terminal Service (DUATS), revealed that the accident pilot did not contact LMFS, Leidos, or DUATS.

The accident pilot did review weather information on ForeFlight prior to the accident flight. The accident pilot did not request a weather briefing, but the accident pilot did pull some weather imagery on May 11 and May 12 (attachment 6). The accident pilot pulled the Extended Convective Forecast Products (ECFP)³² several times between May 11 and May 12, with the last ECFP imagery checked at 0709 CDT on May 12 (attachment 6). The actual imagery that was reviewed by the accident pilot is unknown, but the pilot did check the ECFP. In addition, the accident pilot did enter a flight route on the ForeFlight app (attachment 7), with a proposed route from KDVN to KEKY to KECP at 160 knots with no altitude entered. It is unknown if the accident pilot checked or received additional weather information before or during the accident flight.

15.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on May 12, 2017, indicated the following:

SUN	
Begin civil twilight	0516 CDT
Sunrise	0545 CDT
Sun transit	1247 CDT
Sunset	1949 CDT
End civil twilight	2018 CDT

³² For more information on ECFP please see, <http://www.aviationweather.gov/ecfp/>

E. LIST OF ATTACHMENTS

Attachment 1 – GOES-13 visible satellite animation from 1100 to 1230 CDT

Attachment 2 – GOES-13 infrared satellite animation from 1100 to 1230 CDT

Attachment 3 – Animation of the KHPX WSR-88D base reflectivity images for the 0.5° elevation scans initiated between 1126 and 1205 CDT

Attachment 4 – Animation of the KHPX WSR-88D base reflectivity images for the 1.5° elevation scans initiated between 1126 and 1205 CDT

Attachment 5 – NTSB Prepared Audio Review

Attachment 6 – Correspondence with ForeFlight regarding ECFP

Attachment 7 – Correspondence with ForeFlight regarding flight plan

Submitted by:

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