



## **NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Aviation Safety  
Washington, D.C. 20594

September 24, 2021

### **Specialist's Factual Report**

# **METEOROLOGY**

CEN21FA238

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## **A. ACCIDENT**

Location: McDermott, Ohio  
Date: May 28, 2021  
Time: 1048 eastern daylight time  
1448 Coordinated Universal Time (UTC)  
Airplane: Lancair Evolution; Registration: N515DL

## **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 and also from the National Centers for Environmental Information (NCEI). This Specialist 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 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 latitude 38.8209° N, Longitude 83.0592° W, with an approximate elevation of 690 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 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.<sup>1</sup>

#### **1.1 Surface Analysis Chart**

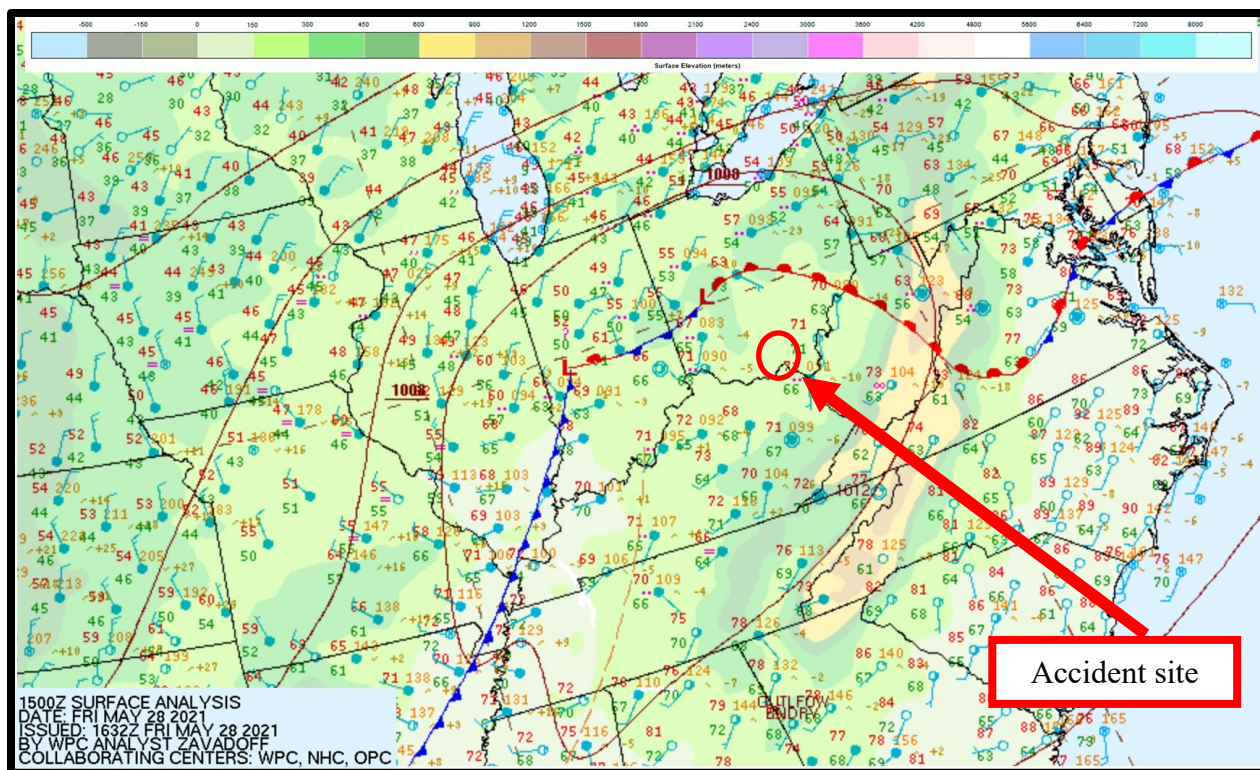
The NWS Surface Analysis Chart centered over the Ohio Valley for 1100 EDT is provided as figure 1 with the location of the accident site within the red circle. The chart depicted a stationary to warm frontal boundary from central Indiana eastward into central Ohio and southeastward into central Virginia. Low-pressure centers were located in western Indiana and western Ohio with pressures of 1008-hectopascals (hPa). An outflow boundary was depicted ahead of the cold front and extended from southern Indiana southward into central Kentucky, Tennessee, into Mississippi. The accident site was located in the warm air sector south of the warm front, and to the east of the outflow boundary.

The station models around the accident site depicted air temperatures in the low 70’s degrees Fahrenheit (°F), dew point temperatures in the mid 60’s °F with temperature-dew point spreads of 5°F or less, a south wind of 5 knots, and cloudy skies with light rain.

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<sup>1</sup>

[https://www.faa.gov/regulations\\_policies/advisory\\_circulars/index.cfm/go/document.information/documentID/1030235](https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235)



**Figure 1 – NWS Surface Analysis Chart for 1100 EDT.**

## 1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0800 EDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. The accident site was located east of a low-pressure system and its associated low- and mid-level trough<sup>2</sup>. Low-pressure systems and troughs are indication of the front aloft and can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a southwest wind at 15 knots at 925-hPa with the wind remaining from the southwest at 700-hPa, however, the wind speed increased to 40 knots (figure 4). The southwesterly wind continued through 300-hPa with a wind speed of 60 knots at 300-hPa (figure 6).

<sup>2</sup> Trough – An elongated area of relatively low atmospheric pressure or heights.

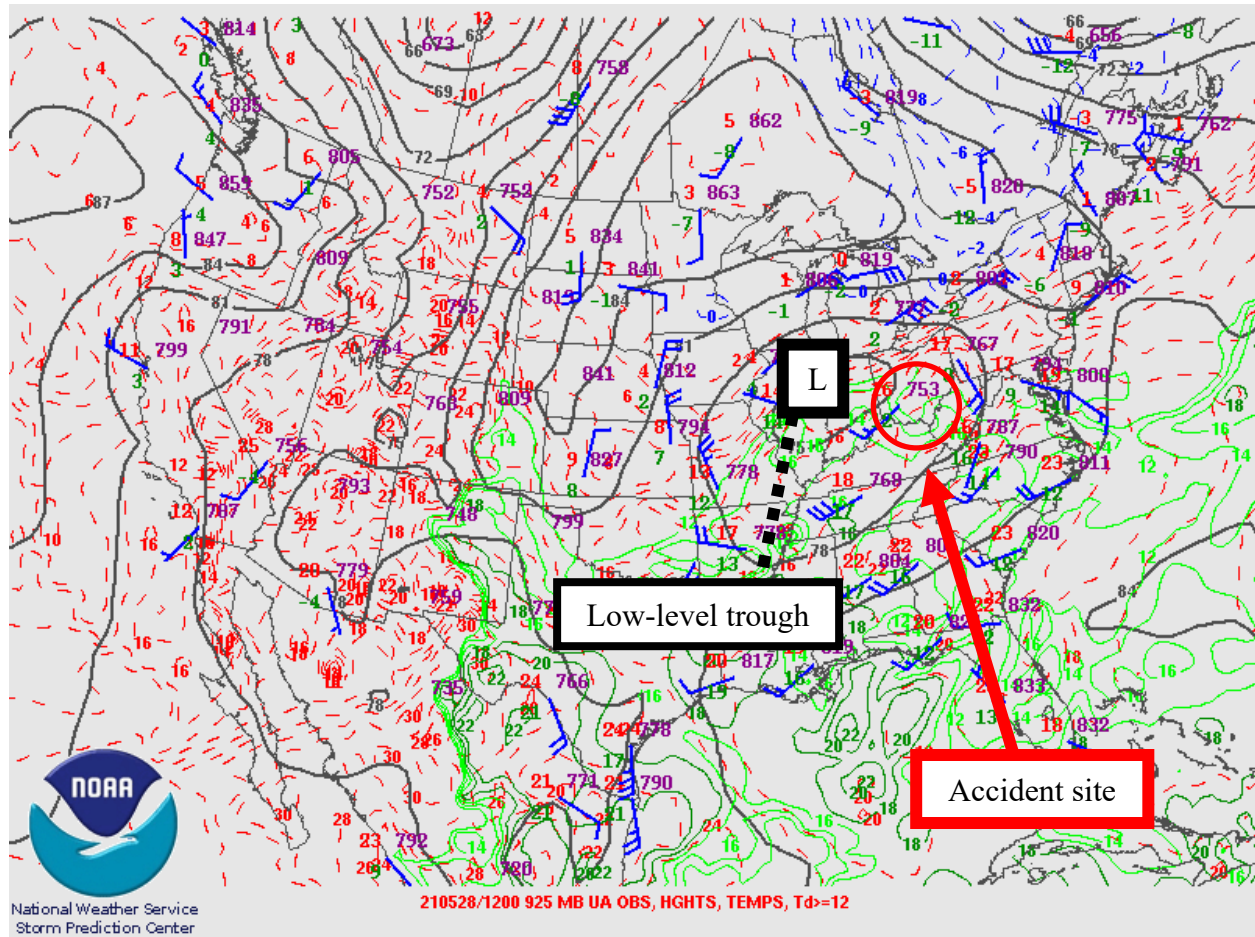


Figure 2 – 925-hPa Constant Pressure Chart for 0800 EDT.

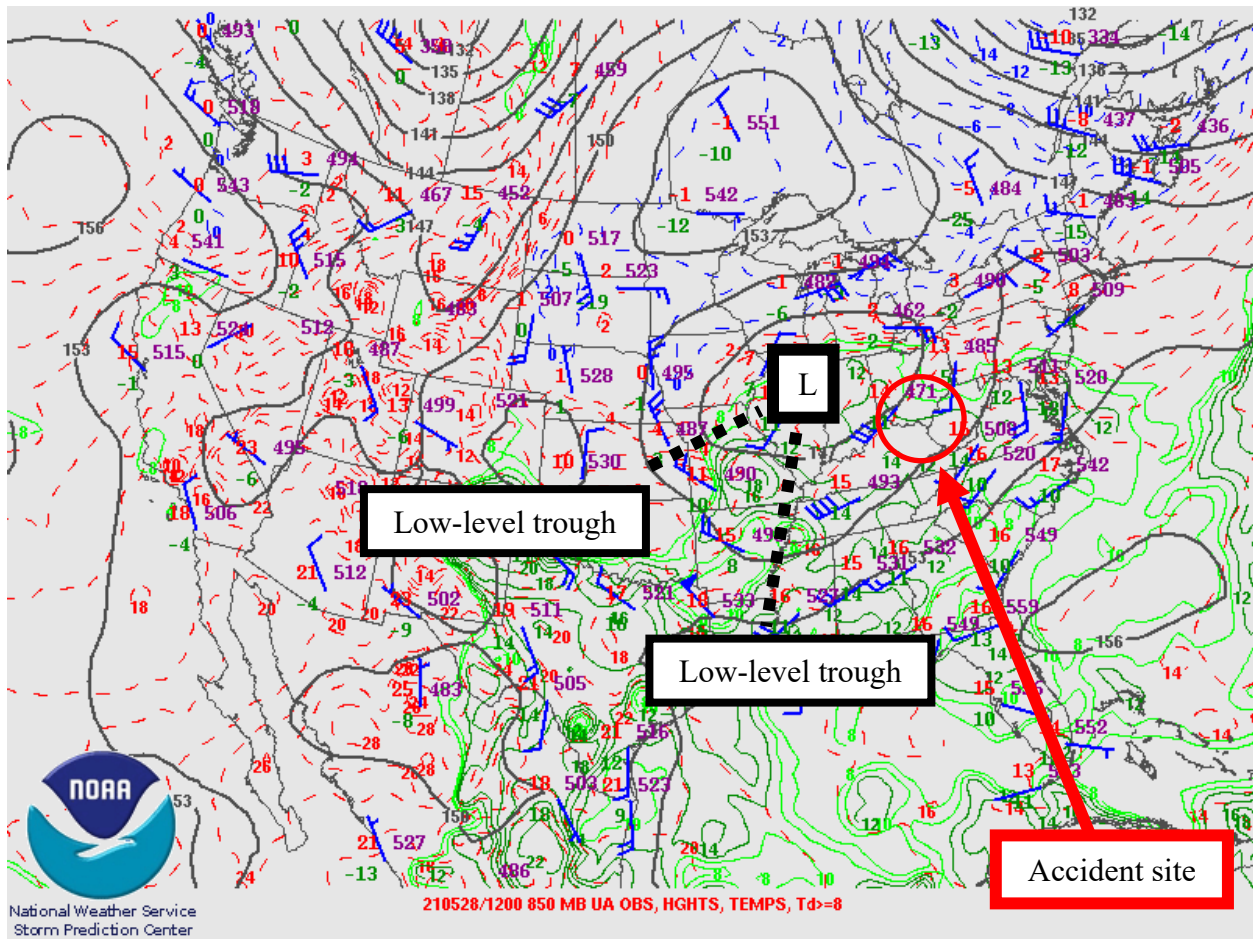


Figure 3 – 850-hPa Constant Pressure Chart for 0800 EDT.

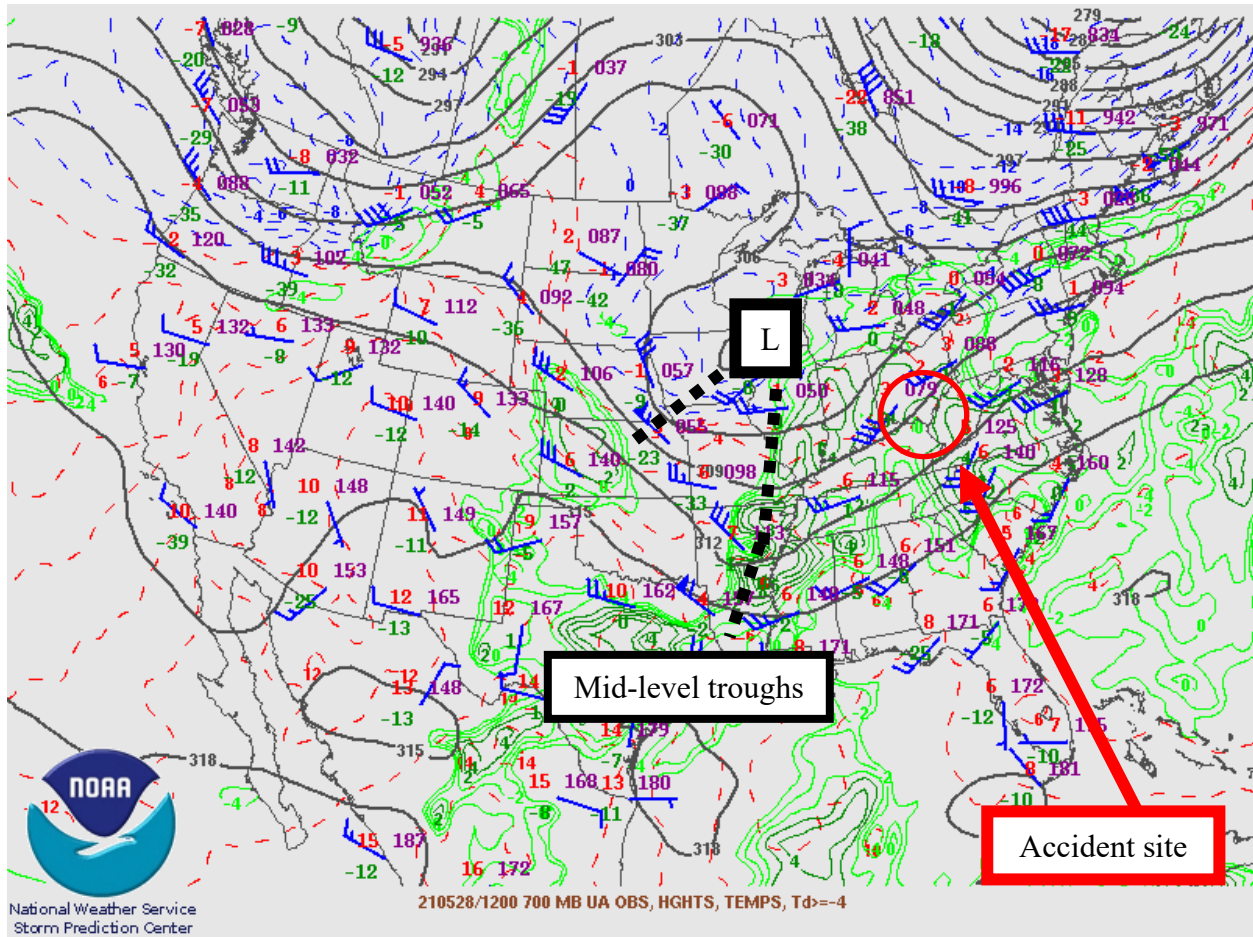
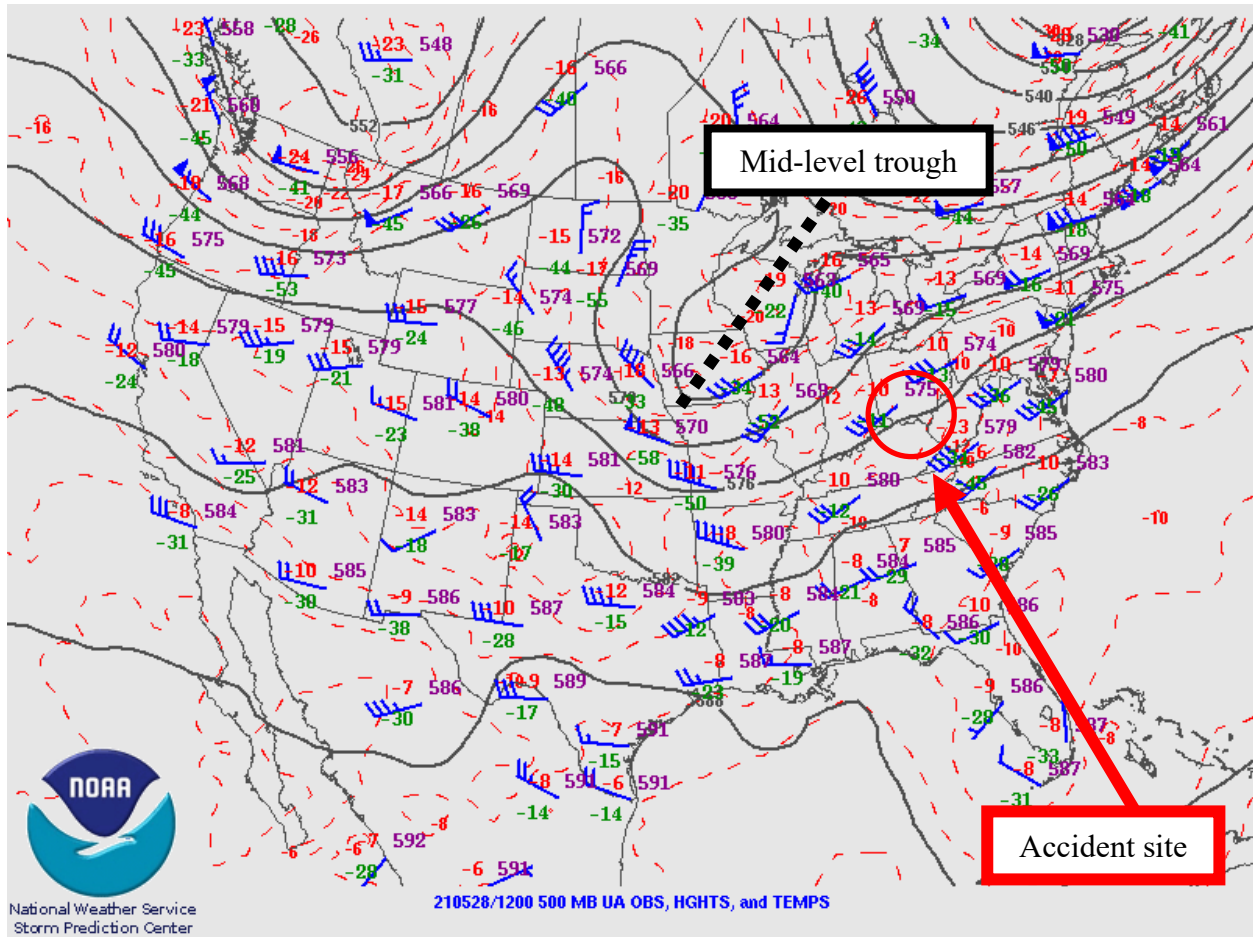
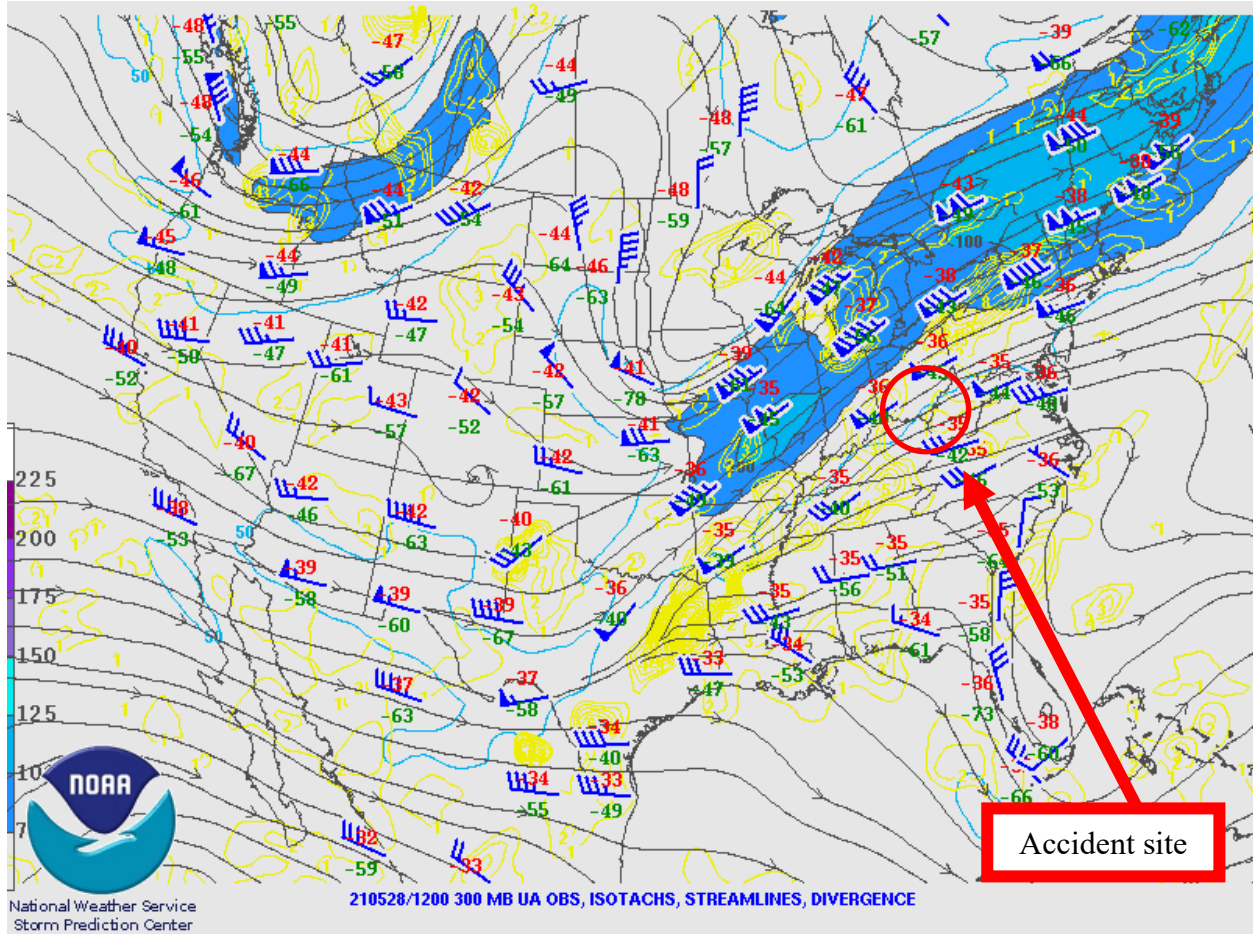


Figure 4 – 700-hPa Constant Pressure Chart for 0800 EDT.



**Figure 5 – 500-hPa Constant Pressure Chart for 0800 EDT.**

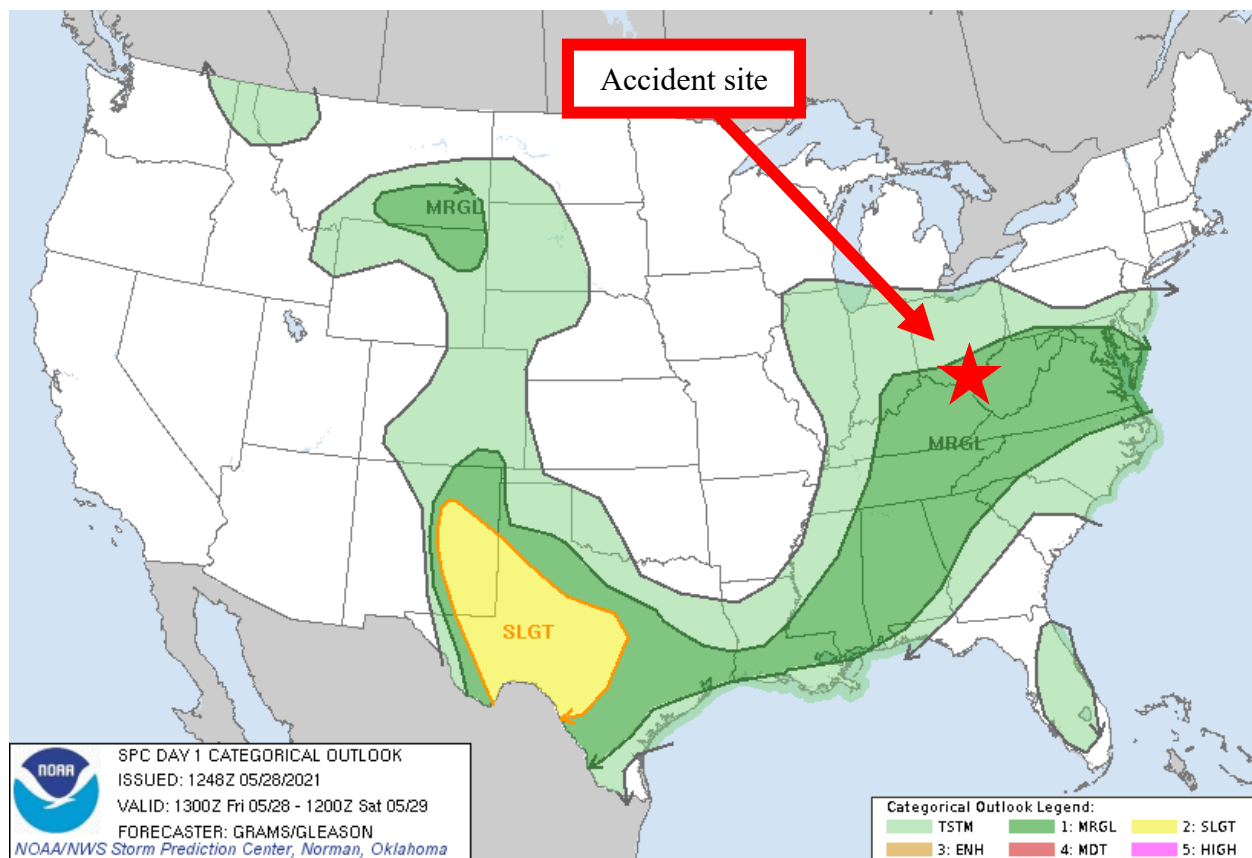


**Figure 6 – 300-hPa Constant Pressure Chart for 0800 EDT.**

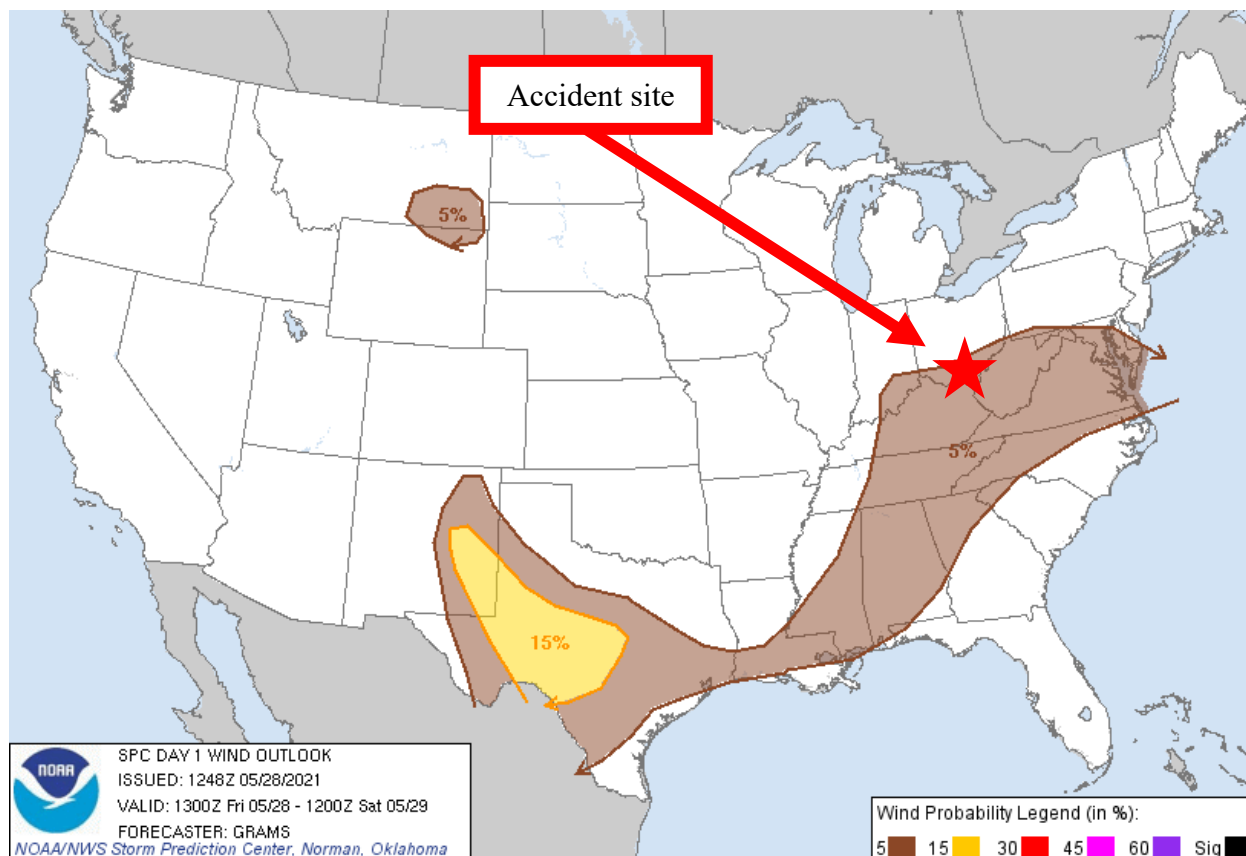
## 2.0 Storm Prediction Center Convective Outlook

SPC issued the following Day 1 Convective Outlook at 0848 EDT (figure 7) with a marginal risk for severe thunderstorms forecast for the area during the period. A marginal risk of severe thunderstorms is a normal risk compared to climatology of thunderstorms activity during the May timeframe for the accident location<sup>3</sup>. The accident site was located in an area where SPC forecasted a 5 percent chance of damaging thunderstorm winds or wind gusts 50 knots or greater within 25 miles of a point (figure 8). The SPC Day 1 Convective Outlook text follows figure 8.

<sup>3</sup> [NOAA/NWS Storm Prediction Center](https://www.noaa.gov/storm-prediction-center)



**Figure 7 – SPC day 1 Convective Outlook valid at the time of the accident.**



**Figure 8 – SPC day 1 Wind Outlook valid at the time of the accident.**

SPC AC 281248

Day 1 Convective Outlook  
 NWS Storm Prediction Center Norman OK  
 0748 AM CDT Fri May 28 2021

Valid 281300Z - 291200Z

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS WEST TO CENTRAL TX  
 AND EASTERN NM...

...SUMMARY...

Scattered severe thunderstorms with very large hail, damaging winds,  
 and a couple tornadoes are possible across parts of west and central  
 Texas into eastern New Mexico, mainly this afternoon and evening.

...TX and eastern NM...

Elevated convection rooted along the low-level baroclinic zone in  
 northwest TX may pose a risk for isolated severe hail and strong  
 wind gusts this morning. To the southeast of this activity, a  
 separate area of thunderstorm development is expected towards midday  
 near the Big Country/Concho Valley vicinity as convergence  
 strengthens along the remnant outflow boundary from decaying  
 convection over east TX. Scattered thunderstorms should also develop  
 across the higher terrain of eastern NM and the TX Trans-Pecos  
 during the afternoon.

A plume of moderate to large buoyancy is expected along and south of the composite front/outflow with peak MLCAPE of 3000-3500 J/kg in the Edwards Plateau to Permian Basin vicinity of west TX. With a belt of 30-40 kt 500-mb westerlies atop weak low-level easterlies, a nearly straight-line hodograph should foster left and right-splitting supercells capable of producing very large hail. Some guidance such as the HRRR indicates potential for numerous supercells across the region by late afternoon which should evolve into multiple east-southeast propagating clusters this evening, aiding in an increasing severe wind threat as well. For these reasons, have expanded the cat 2/SLGT risk. Greatest tornado potential will probably be maximized along a narrow portion of the baroclinic zone across the Permian Basin if a discrete supercell is able to be sustained off the Sacramento Mountains, with spatial extent likely limited by increasing MLCIN deeper into the post-frontal air mass.

...Deep South to OH Valley to the Lower Mid-Atlantic...

Ahead of convective outflow associated with decaying convection across the Deep South to TN Valley and within a broad low-level moist advection regime, weak surface-based buoyancy is expected this afternoon. The most deeply mixed boundary layer is expected farther east along the South Atlantic Coastal Plain where buoyancy should be lacking due to a hot but dry air mass.

Forcing for ascent should be greatest across a portion of the OH Valley towards the central Appalachians downstream of a shortwave trough moving east over the Midwest. But confidence is low that appreciable destabilization will occur here given pervasive morning cloud coverage. A separate corridor of ascent may be focused near a diurnally strengthening surface cyclone in south-central to southeast VA. Vast differences in the degree of destabilization among guidance amid poor mid-level lapse rates in regional 12Z soundings render low confidence in a greater damaging wind threat here relative to the rest of the lower-end severe risk. Still, a brief tornado and locally damaging winds are possible along the warm front from southeast VA into southern MD.

...Northeast WY/southeast MT...

Within a weakly buoyant but amply sheared environment, a couple discrete supercells may develop off the Big Horns during the late afternoon to early evening. Here, weak mid-level height falls downstream of a Northwest short wave trough will be favorably timed with peak diurnal heating. Isolated large hail and severe wind gusts are possible until convection weakens upon encountering a more stable air mass in the western Dakotas.

..Grams/Gleason.. 05/28/2021

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NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 1630Z

### 3.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METARs) and Specials Reports (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 9 is a local sectional chart with the accident site and the closest weather reporting location marked.



**Figure 9 – Sectional map of the accident area with the location of the accident site and surface observation site.**

Greater Portsmouth Regional Airport (KPMH) had the closest official weather station to the accident site. KPMH had an Automated Weather Observing System (AWOS<sup>4</sup>) whose longline<sup>5</sup> reports were not supplemented. The KPMH AWOS was located 9 miles east-northeast of the accident site, at an elevation of 663 ft, and had a 7° westerly magnetic variation<sup>6</sup> (figure 9). The following automated longline observations were disseminated during the times surrounding the accident:<sup>7</sup>

<sup>4</sup> AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting. AWOS are maintained by the FAA.

<sup>5</sup> “Longline” refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases (effectively, the whole world) and accessible to the general global public from many 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 general global public has access to surface weather observations, particularly outside of the aviation community.

<sup>6</sup> Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

<sup>7</sup> The bold sections in this NWS product and the rest of the products in this report are intended to highlight the text

[0559 EDT] KPMH 280959Z AUTO 00000KT 10SM CLR A2985 RMK AO2

[0659 EDT] KPMH 281059Z AUTO 00000KT 7SM BKN075 BKN080 OVC095 A2986 RMK AO2

[0759 EDT] KPMH 281159Z AUTO 16004KT 10SM SCT065 SCT080 BKN090 A2985 RMK AO2

[0859 EDT] KPMH 281259Z AUTO 15004KT 10SM SCT048 SCT060 BKN120 17/17 A2984 RMK AO2

***[0959 EDT] KPMH 281359Z AUTO 20004KT 10SM CLR 23/18 A2983 RMK AO2***

**ACCIDENT TIME 1048 EDT**

***[1059 EDT] KPMH 281459Z AUTO 22003KT 10SM SCT110 24/18 A2981 RMK AO2***

[1159 EDT] KPMH 281559Z AUTO 18005KT 10SM SCT034 BKN065 BKN080 24/19 A2980 RMK AO2

[1259 EDT] KPMH 281659Z AUTO 18005KT 5SM RA SCT013 BKN036 OVC075 21/21 A2979 RMK AO2

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

KPMH weather at 0959 EDT, automated, wind from 200° at 4 knots, visibility 10 miles or greater, clear skies below 12,000 ft above ground level (agl), temperature of 23° Celsius (C), dew point temperature of 18°C, and an altimeter setting of 29.83 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator.

KPMH weather at 1059 EDT, automated, wind from 220° at 3 knots, visibility 10 miles or greater, scattered clouds at 11,000 ft agl, temperature of 24° C, dew point temperature of 18°C, and an altimeter setting of 29.81 inHg. Remarks: automated station with a precipitation discriminator.

The observations from KPMH surrounding the accident time indicated VFR<sup>8</sup> conditions with moderate rain reported at 1259 EDT.

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that directly reference the weather conditions that affected the accident location around the accident time. The local times in this section next to the METARs are provided for quick reference between UTC and local times around the accident time.

<sup>8</sup> As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR\*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR\*\*) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.

## 4.0 Upper Air Sounding

Wilmington, Ohio (KILN) was the closest site with an upper air sounding, was 52 miles northwest of the accident site with a site elevation of 1,007 ft and had a station ID of 72426. The 0800 EDT KILN sounding was plotted on a standard Skew-T Log P diagram<sup>9</sup> with the derived stability parameters included in figure 10 with data from the surface to 300-hPa (or approximately 31,000 ft msl). These data were analyzed using the RAOB<sup>10</sup> software package. The sounding depicted the lifted condensation level (LCL)<sup>11</sup> at 2,100 ft msl, the convective condensation level (CCL)<sup>12</sup> at 6,531 ft msl, and the level of free convection (LFC)<sup>13</sup> at 9,517 ft msl. The freezing level was located at 11,418 ft msl. The precipitable water value was 1.50 inches.

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- 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.

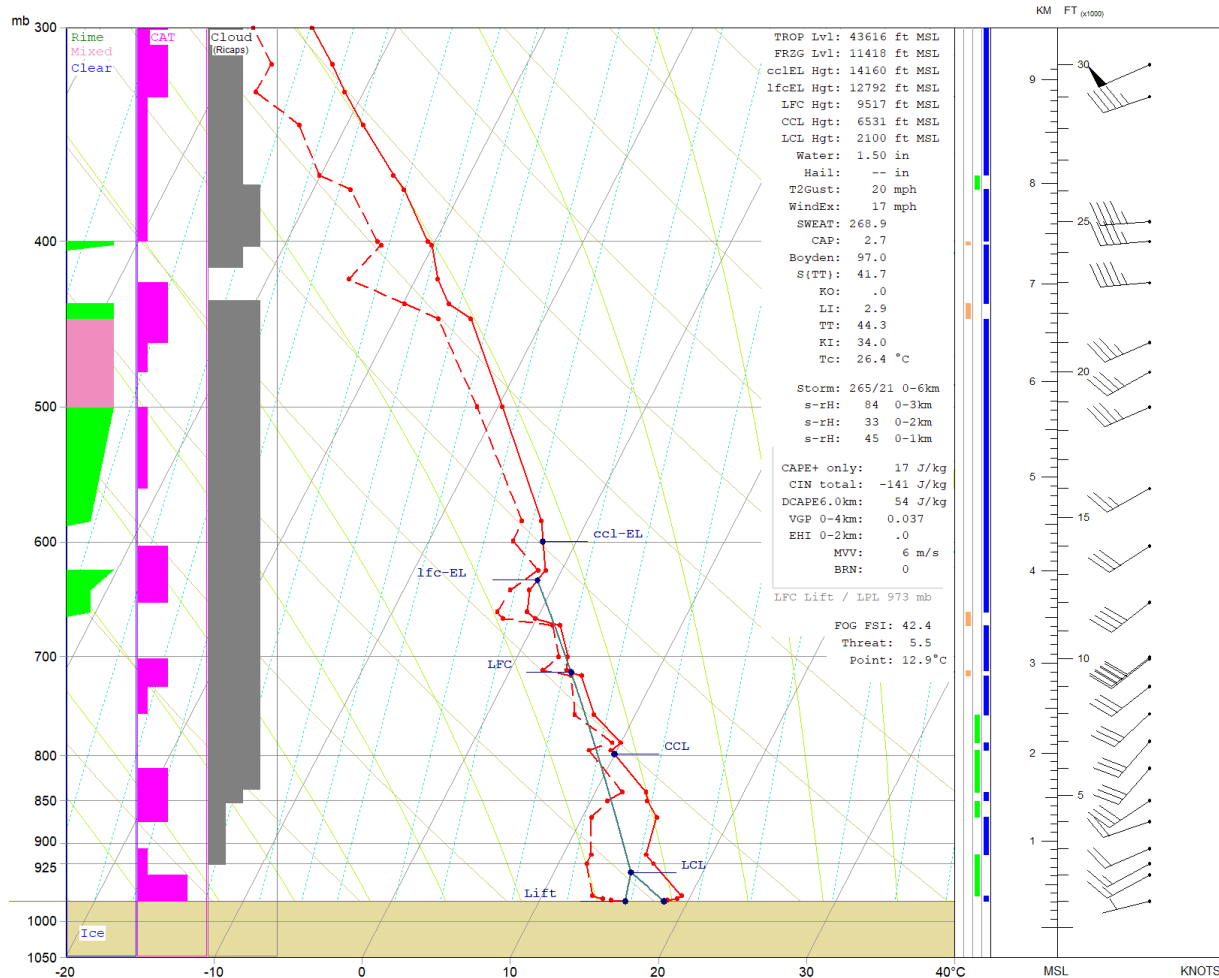
<sup>9</sup> Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

<sup>10</sup> RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Eosonde Research Services, The Villages, Florida.

<sup>11</sup> LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

<sup>12</sup> 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.

<sup>13</sup> 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.



**Figure 10 – 0800 EDT KILN sounding.**

The 0800 EDT KILN sounding for the accident site indicated a mainly stable environment from 8,000 ft msl through 30,000 ft msl. Clouds were indicated by RAOB from 2,500 ft msl through 22,000 ft msl with another cloud layer from 23,000 ft msl through 30,000 ft msl. RAOB indicated moderate rime and mixed icing from near 11,000 ft to 24,500 ft msl.

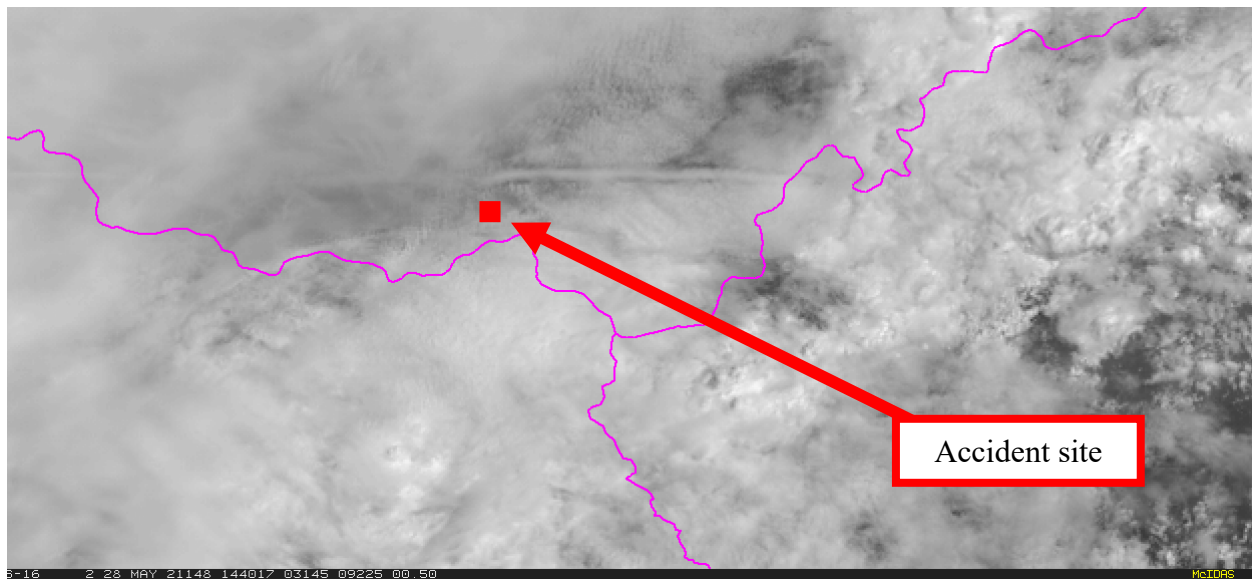
The 0800 EDT KILN sounding wind profile indicated a near surface wind from 255° at 4 knots with little directional variation with height through 23,000 ft msl. The wind speed increased to 30 knots by 5,000 ft msl with the wind speed to 50 knots by 30,000 ft msl. RAOB indicated the possibility of light to moderate clear-air turbulence in several layers between the surface and 30,000 ft msl. At the aircraft's altitude<sup>14</sup> near 25,000 ft msl around 1048 EDT, the wind was from 265° at 47 knots, temperature of -23.9°C and a dew point temperature of -27.5°C.

<sup>14</sup> For more information, please see air traffic control (ATC) data located in the docket of this accident.

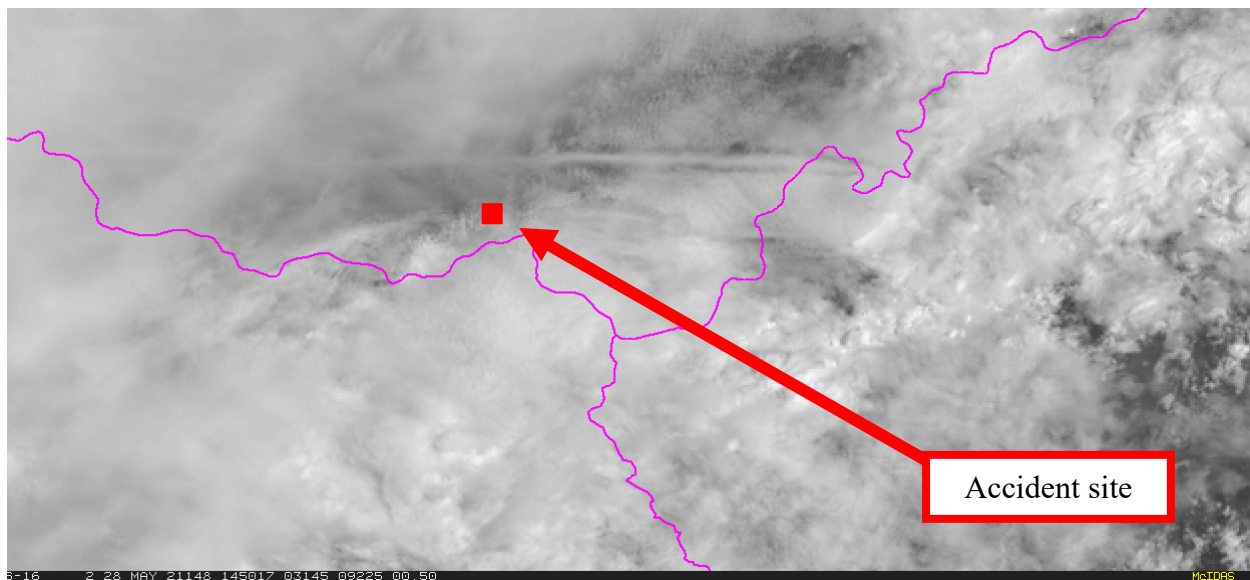
## 5.0 Satellite Data

The 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) at wavelengths of 0.64 microns ( $\mu\text{m}$ ) and 10.3  $\mu\text{m}$ , respectively, were retrieved for the period from 0800 EDT through 1500 EDT and reviewed, and the closest images to the time of the accident were documented.

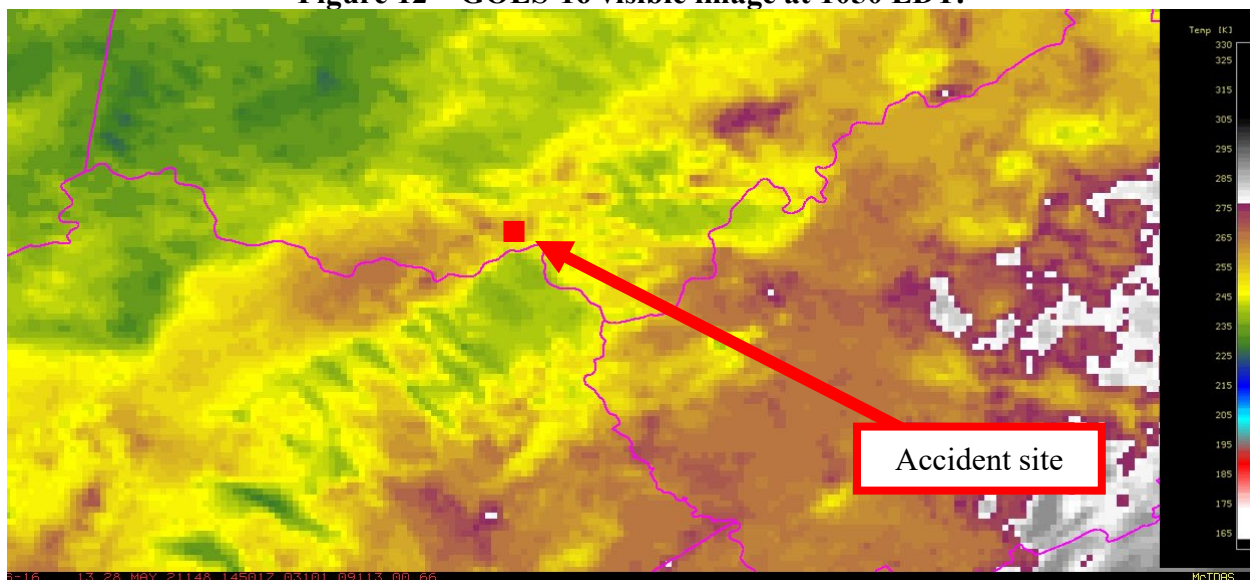
Figures 11 and 12 present the GOES-16 visible imagery from 1040 and 1050 EDT at 2X magnification with the accident site highlighted with a red square. The cloud cover was moving from southwest to northeast with cloud cover above the accident site (attachment 1). Figure 13 presents the GOES-16 infrared imagery from 1050 EDT at 6X magnification with the accident site highlighted with a red square. The lower brightness temperatures (green colors; higher cloud tops) were located to the northwest and south of the accident site. The brightness temperature of about 255 Kelvin above the accident site would have been near 23,000 ft msl based on the vertical temperature profile provided by the 0800 EDT KILN sounding. It should be noted these figures have not been corrected for any parallax error.



**Figure 11 – GOES-16 visible image at 1040 EDT.**



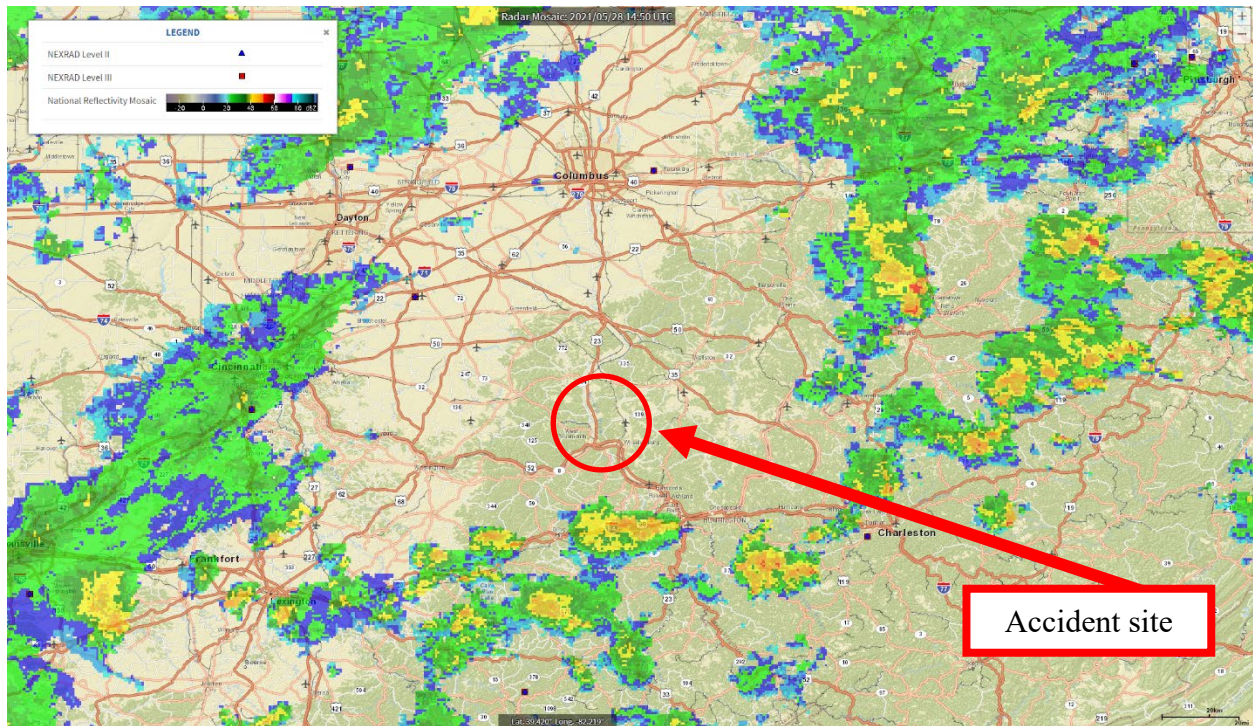
**Figure 12 – GOES-16 visible image at 1050 EDT.**



**Figure 13 – GOES-16 infrared image at 1050 EDT.**

## 6.0 Regional Radar Imagery Information

A regional view of the NWS National Composite Radar Mosaic from NCEI is included as figure 14 for 1050 EDT with the approximate location of the accident site marked within a red circle. The image depicted no echoes above the accident site at 1050 EDT.



**Figure 14 – Regional Composite Reflectivity image for 1050 EDT.**

## **7.0 Radar Imagery Information**

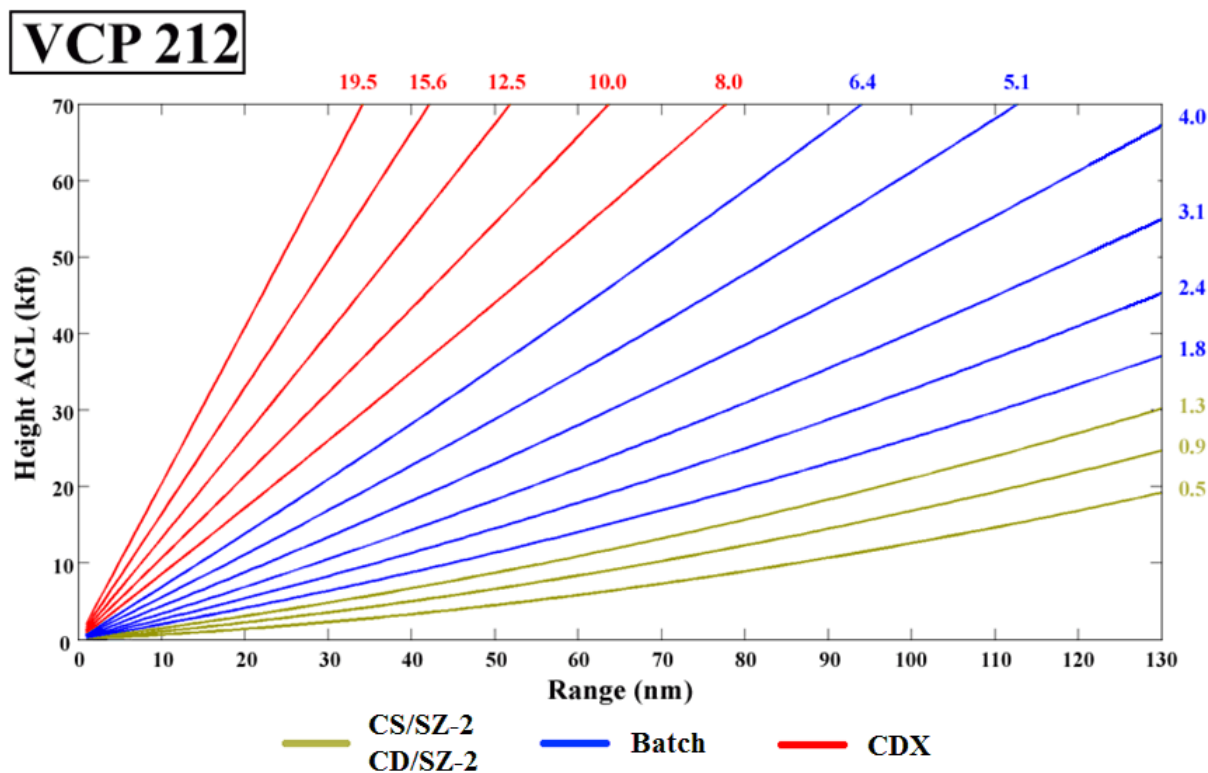
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)<sup>15</sup> to the accident site was KILN. Level II archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA’s Weather and Climate Toolkit software.

### **7.1 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. Products that require data from multiple elevation scans are not available until the end of the four-to-ten-minute volume scan.

<sup>15</sup> 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.

The WSR-88D operates in two main scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has several scanning strategies<sup>16</sup>. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This scanning strategy is documented as volume coverage pattern 212 (VCP-212). Mode B is the clear-air mode, where the radar makes 9 elevation scans during a ten-minute period. During the period surrounding the accident, the KILN WSR-88D radar was operating in the precipitation mode VCP-212. 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.



**VCP-212 Precipitation Mode Scan Strategy.**

<sup>16</sup> 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 refraction<sup>17</sup> of the KILN WSR-88D radar beam with the antenna elevation at 1,170 ft, and considering a beamwidth<sup>18</sup> of 0.95°, the following table shows the approximate heights for the radar beam center, base, and top for an antenna elevation over the accident site and for the approximate altitudes of the accident flight<sup>19</sup>. These heights have been rounded to the nearest 10 ft.

| ANTENNA<br>ELEVATION    | BEAM CENTER | BEAM BASE | BEAM TOP  |
|-------------------------|-------------|-----------|-----------|
| KILN 0.5°               | 7,680 ft    | 4,470 ft  | 10,890 ft |
| KILN 1.3°               | 9,860 ft    | 7,400 ft  | 12,320 ft |
| KILN 5.1°               | 17,980 ft   | 16,510 ft | 19,450 ft |
| KILN 6.4°               | 22,080 ft   | 20,610 ft | 23,550 ft |
| KILN 5.1°<br>(1041 EDT) | 24,470 ft   | 22,460 ft | 26,480 ft |
| KILN 3.1°               | 22,610 ft   | 19,750 ft | 25,470 ft |

Based on the radar height calculations, the elevation scan from KILN listed in the above table depicted the conditions between 4,470 ft and 26,480 ft msl and these scans “saw” the closest altitudes to the aircraft’s altitude at the KILN WSR-88D display times (section 7.4).

---

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

<sup>18</sup> Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

<sup>19</sup> For more altitude information please see the ATC track data located in the docket of this accident.

### 7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors<sup>20</sup> 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 (dBZ<sup>21</sup>) and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C<sup>22</sup>, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels (figure 15). 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.”

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

Figure 15 - Reflectivity values and precipitation intensity terminology.

### 7.4 Base Reflectivity and Lightning Data

Figures 16 through 21 present the KILN WSR-88D base reflectivity images for the 0.5°, 1.3°, 3.1°, 5.1°, and the 6.4° elevation scans initiated at 1014:05, 1020:03, 1026:42, 1036:33, 1041:20, and 1045:58 EDT, respectively, with a resolution of 0.5° X 250 m. Reflectivity values between 0 and 30 dBZ were located at the accident aircraft’s position during those periods.

There were no lightning flashes<sup>23</sup> near the accident site during the period.<sup>24</sup>

<sup>20</sup> 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.

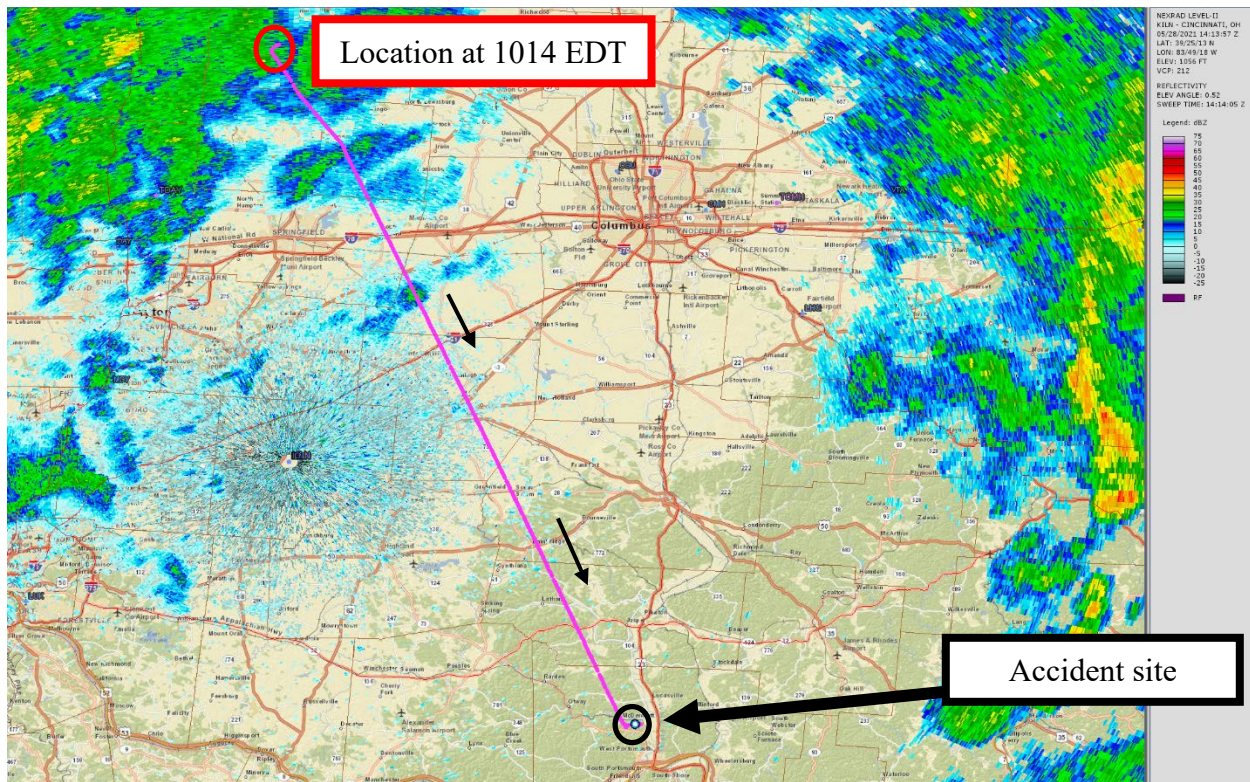
<sup>21</sup> dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

<sup>22</sup>

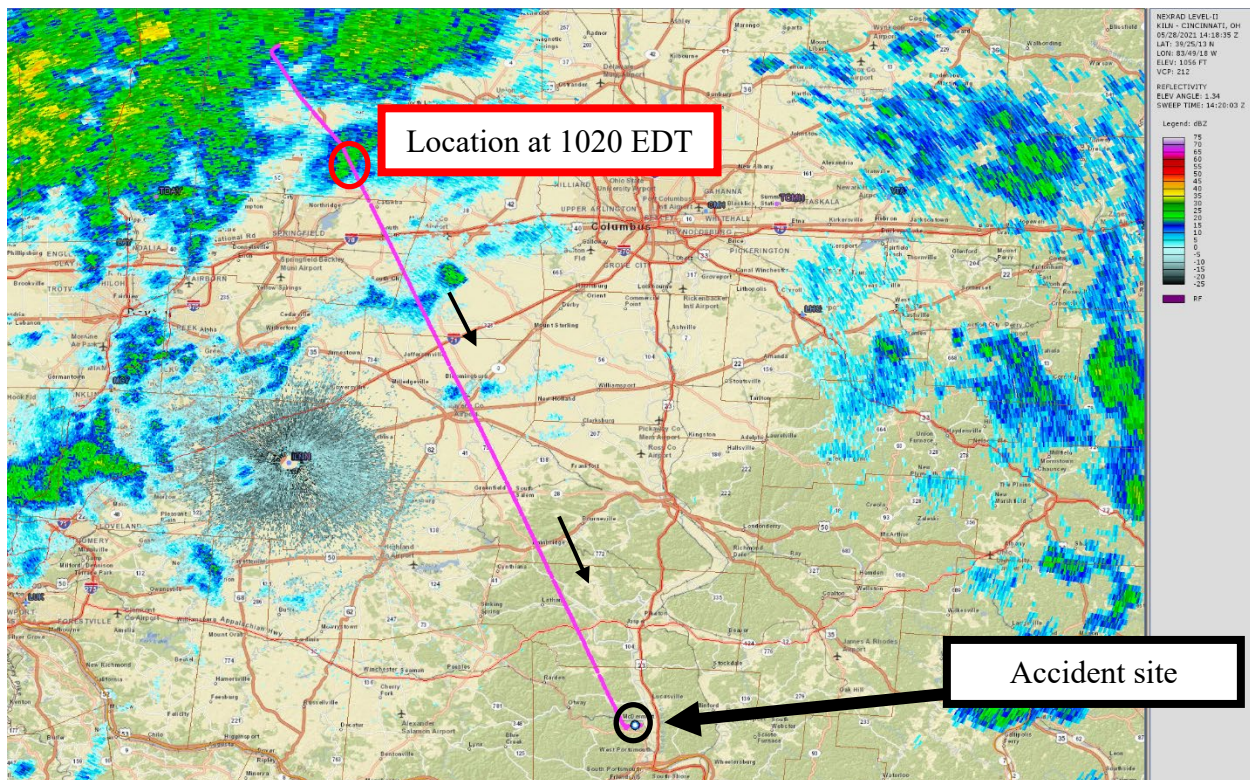
[https://www.faa.gov/regulations\\_policies/advisory\\_circulars/index.cfm/go/document.information/documentID/1020774](https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774)

<sup>23</sup> 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. A review of Earth Networks Total Lightning network was done.

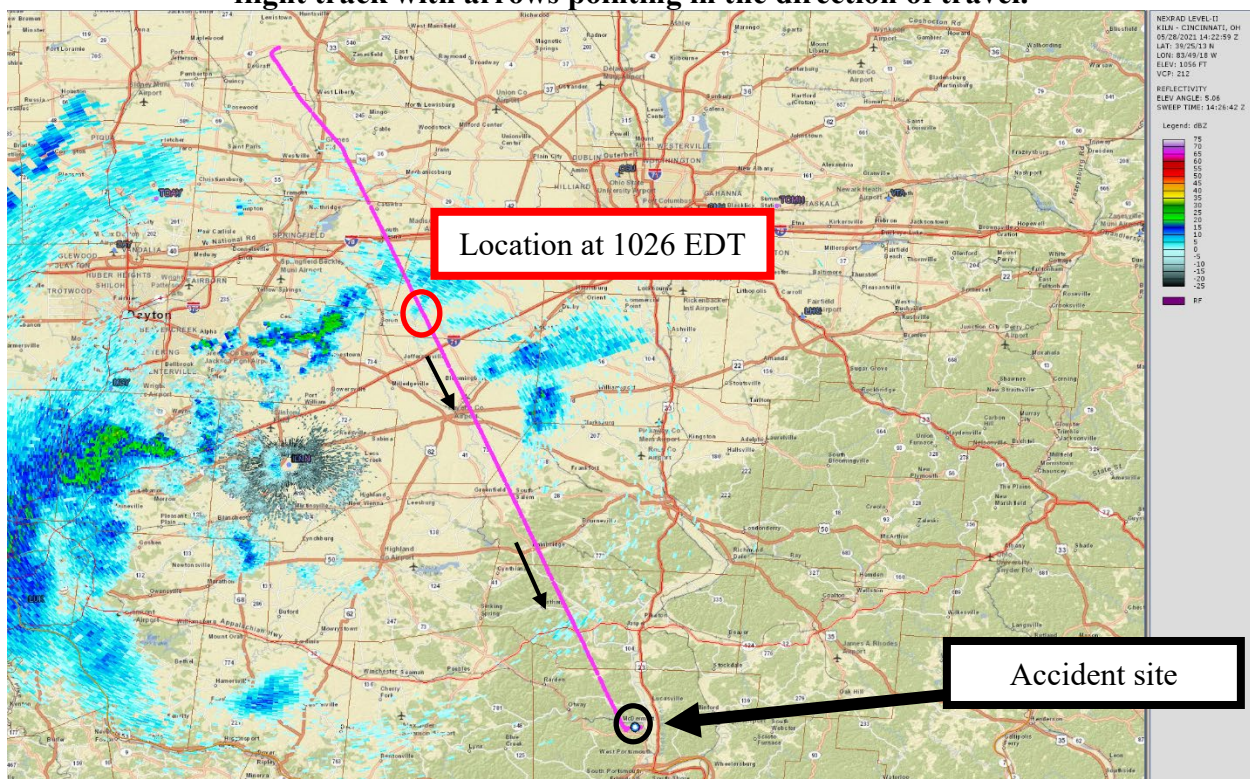
<sup>24</sup> A review of Earth Networks Total Lightning network was done.



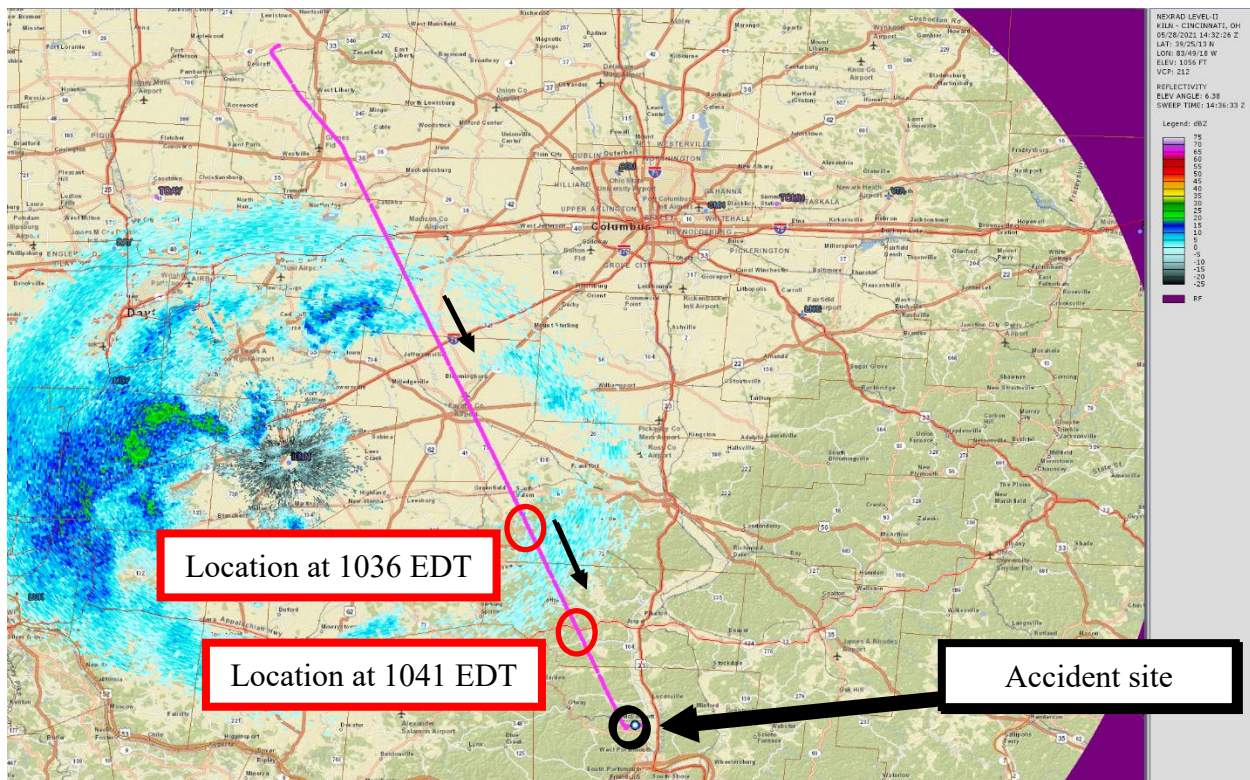
**Figure 16 – KILN WSR-88D 0.5° base reflectivity image for 1014:05 EDT with the total flight track with arrows pointing in the direction of travel.**



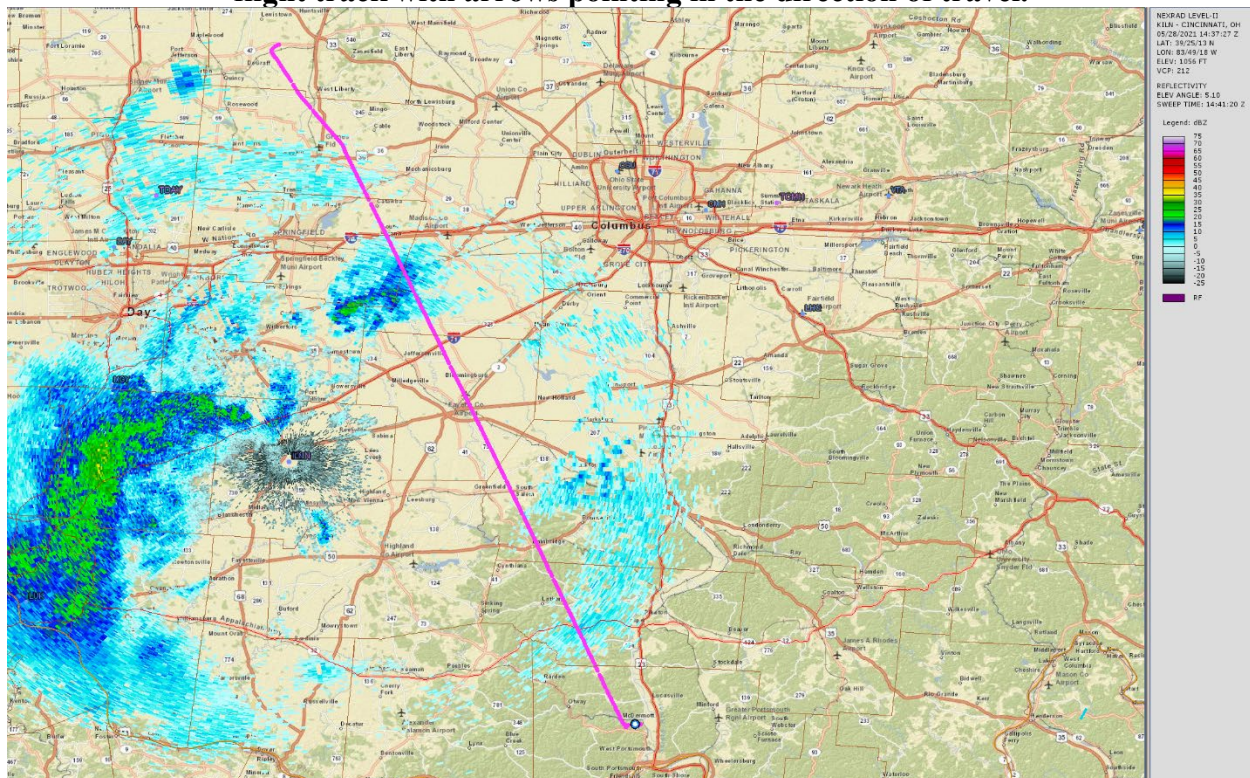
**Figure 17 – KILN WSR-88D 1.3° base reflectivity image for 1020:03 EDT with the total flight track with arrows pointing in the direction of travel.**



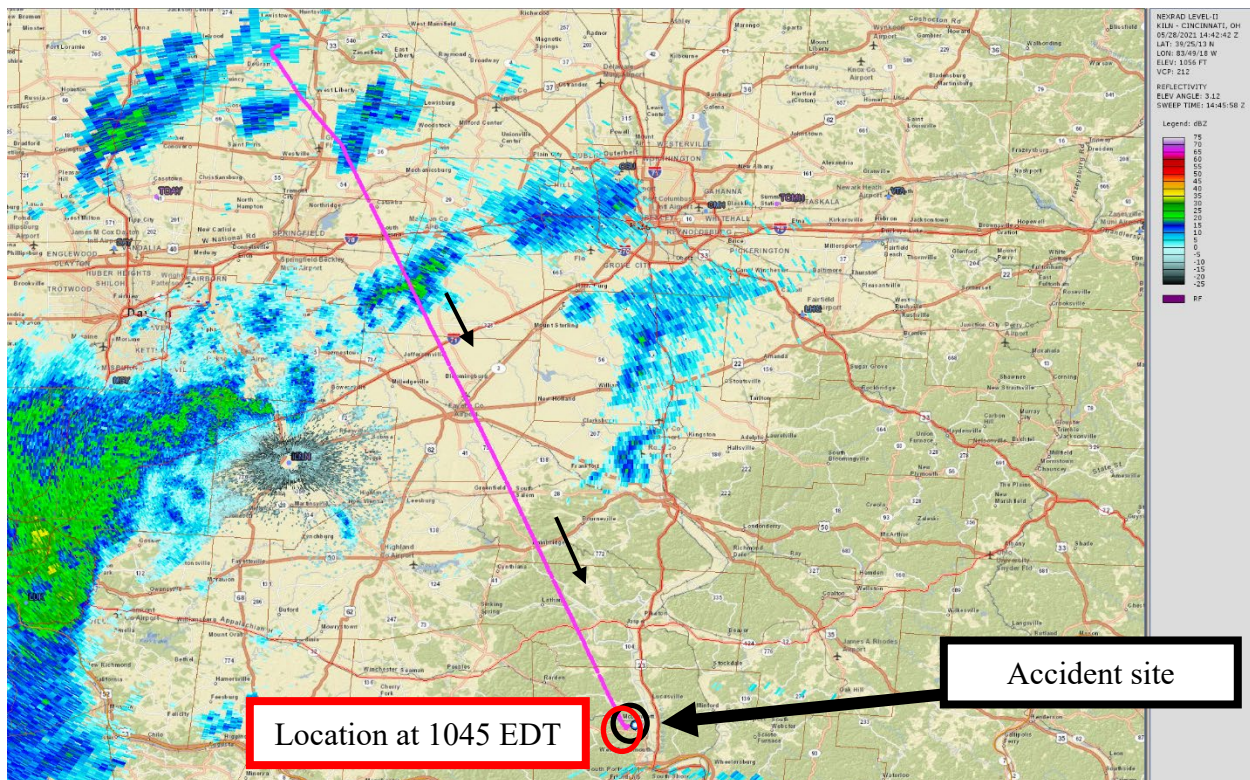
**Figure 18 – KILN WSR-88D 5.1° base reflectivity image for 1026:42 EDT with the total flight track with arrows pointing in the direction of travel.**



**Figure 19 – KILN WSR-88D 6.4° base reflectivity image for 1036:33 EDT with the total flight track with arrows pointing in the direction of travel.**



**Figure 20 –KILN WSR-88D 5.1° base reflectivity image for 1041:20 EDT with the total flight track with arrows pointing in the direction of travel.**



**Figure 21 – KILN WSR-88D 3.1° base reflectivity image for 1045:58 EDT with the total flight track with arrows pointing in the direction of travel.**

## 8.0 Pilot Reports

The longline-disseminated pilot reports<sup>25</sup> (PIREPs) distributed into the national airspace (NAS) were reviewed from about three hours prior to the accident time to two hours after the accident time and only the PIREPs around 100 miles of the accident site below FL300<sup>26</sup> are shown below. In addition, PIREPs obtained by Indianapolis (ZID) Air Route Traffic Control Center (ARTCC) for the accident day are contained in attachment 2.

CMH UA /OV APE180050/TM 1158/FL215/TP C25B/SK TOP210

HTS UA /OV HTS120010/TM 1218/FL030/TP A320/WX -RA/TB NEG

HTS UA /OV 312150015/TM 1338/FL080/TP C77R/SK BKN070 SCT080/TA 09

HTS UA /OV DWU/TM 1410/FL080/TP RV10/SK TOP080/TB NEG

HTS UA /OV ECB070010/TM 1430/FL090/TP C82T/SK SCT-BKN-TOPUNKN

<sup>25</sup> Only pilot reports with the World Meteorological Organization headers UBOH\*\*, UBKY\*\*, UBWV\*\*, UBIN\*\*, and UBVA\*\* were considered. These do not include pilot reports only broadcast via radio.

<sup>26</sup> 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.

## 9.0 Significant Meteorological Information

There were no non-convective or convective Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time.

## 10.0 Center Weather Service Unit Advisories

The ZID Center Weather Service Unit (CWSU) was responsible for the accident region. There were no Center Weather Advisories (CWA) valid at the accident time. ZID CWSU did produce pre-duty weather briefing information for ZID ATC with the pre-duty weather briefing valid at the accident time released at 0535 EDT (attachment 3) with icing conditions forecast to FL280. Weather products dissemination timeline for the various ATC sectors at ZID is contained in attachment 4.

## 11.0 Airmen's Meteorological Information

Airmen's Meteorological Information (AIRMET) advisories, issued by the NWS Aviation Weather Center (AWC), Sierra, Tango, and Zulu were valid for the accident site at the accident time, or for the departure airport at the time of departure, or both locations (issued around 0445, 0926, and 1045 EDT, respectively). The AIRMETs warned of IFR conditions due to ceilings below 1,000 ft agl and visibilities below 3 miles in precipitation and mist, moderate turbulence between FL250 and FL420, and moderate icing between the freezing level<sup>27</sup> and FL220:

WAUS41 KKCI 281326 AAC  
WA1S  
-BOSS WA 281326 AMD  
AIRMET SIERRA UPDT 5 FOR IFR AND MTN OBSCN VALID UNTIL 281500  
.  
AIRMET IFR...MA RI CSTL WTRS  
FROM 150ESE ACK TO 200SE ACK TO 210SSE HTO TO 90SSW ACK TO  
150ESE ACK  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 15Z THRU 21Z.  
.  
**AIRMET IFR...NY LO PA OH LE...UPDT**  
**FROM BUF TO 40SSE ERI TO CVG TO FWA TO 30SE ECK TO 50ESE DXO TO**  
**BUF**  
**CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 15Z THRU 21Z.**  
.  
OTLK VALID 1500-2100Z  
AREA 1...IFR MA RI NY NJ MD DE VA AND CSTL WTRS  
BOUNDED BY 150E ACK-200SE ACK-160SE SIE-SIE-150E ACK  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 21Z.  
.  
AREA 2...IFR NY LO PA OH LE WV MD VA  
BOUNDED BY 40NNE YYZ-70NW SYR-50NE SYR-30NNW ALB-20SE HNK-20SE  
PSB-60SSE JST-30SSE EKN-40W BKW-HNN-CVG-FWA-30SE ECK-40NNE YYZ  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 21Z.

---

<sup>27</sup> Freezing level between 3,000 and 13,000 ft msl.

.  
AREA 3...MTN OBSCN VT MA NY PA WV MD VA  
BOUNDED BY 30SW MPV-40SE ALB-20ENE HAR-60SW CSN-20ENE HMV-HNN-  
AIR-JHW-SYR-30SW MPV  
MTNS OBSC BY CLDS/PCPN/BR. CONDS DVLPG AFT 15Z. CONDS CONTG THRU  
21Z.

....

WAUS41 KPCI 281445  
WA1S  
-BOSS WA 281445  
AIRMET SIERRA UPDT 6 FOR IFR AND MTN OBSCN VALID UNTIL 282100

.  
AIRMET IFR...NJ CSTL WTRS  
FROM 140ESE ACK TO 200SE ACK TO 160SE SIE TO 110SE SIE TO 70ESE  
SIE TO 90SSW ACK TO 140ESE ACK  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS ENDG 18-21Z.

.  
**AIRMET IFR...NY LO PA OH LE WV MD VA**  
**FROM 50NE SYR TO 20NE ALB TO 40SSE HNK TO 50SSE EKN TO 40WSW BKW**  
**TO HNN TO CVG TO FWA TO 30SE ECK TO 40ESE DXO TO 30E YYZ TO 50NE**  
**SYR**  
**CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.**

.  
AIRMET MTN OBSCN...NH VT MA NY PA WV MD VA NC GA  
FROM 30WNW MPV TO 20WSW CON TO 20SE HNK TO 20NE HAR TO 20SW LYH  
TO 20S PSK TO 30NNW ATL TO GQO TO HMV TO HNN TO JHW TO SYR TO  
40SSW MSS TO 30WNW MPV  
MTNS OBSC BY CLDS/PCPN/BR. CONDS DVLPG AFT 15Z. CONDS CONTG BYD  
21Z THRU 03Z.

.  
OTLK VALID 2100-0300Z  
AREA 1...IFR ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA  
AND CSTL WTRS  
BOUNDED BY 20ESE YYZ-40ESE ENE-130SSE HTO-90ESE SBY-40SSW BKW-  
HNN-CVG-FWA-30SE ECK-30SE DXO-20ESE YYZ  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 03Z.

.  
AREA 2...MTN OBSCN NH VT MA NY PA WV MD VA NC SC GA  
BOUNDED BY 30WNW MPV-40S MPV-20SE CON-20E CLT-ATL-40SSW GQO-GQO-  
HNV-HNN-AIR-20WSW JHW-40N SYR-50SW MSS-30WNW MPV  
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG THRU 03Z.

....

WAUS41 KPCI 280845  
WA1T  
-BOST WA 280845  
AIRMET TANGO UPDT 1 FOR TURB AND STG SFC WNDZ VALID UNTIL 281500

.  
AIRMET TURB...ME NH MA AND CSTL WTRS  
FROM 70S BGR TO 110SSW YSJ TO 160ESE ACK TO 140S ACK TO 40SW ACK  
TO 70S BGR  
MOD TURB BTN FL250 AND FL420. CONDS ENDG 09-12Z.

.  
AIRMET TURB...ME NH VT NY LO AND CSTL WTRS  
FROM 70NW PQI TO 20NNE PQI TO 50WSW YSJ TO 110SSW YSJ TO 70S BGR

TO 40ESE MPV TO 30SE SYR TO 50NNW SYR TO 30N MSS TO YSC TO 70NW  
PQI  
MOD TURB BTN FL250 AND FL400. CONDS CONTG BYD 15Z THRU 21Z.

.  
**AIRMET TURB...NY LO PA OH LE WV**  
**FROM 40NNW SYR TO 30SE SYR TO 20W HNK TO 30SE SLT TO 30E EWC TO**  
**20SSE AIR TO 30NNW HNN TO CVG TO FWA TO 30SE ECK TO 30NW CLE TO**  
**20WSW BUF TO 30ESE YYZ TO 40NNW SYR**  
**MOD TURB BTN FL250 AND FL420. CONDS CONTG BYD 15Z THRU 21Z.**

.  
AIRMET TURB...ME NH VT MA NY AND CSTL WTRS  
FROM 70NW PQI TO 30NNE PQI TO 40W YSJ TO 140E ACK TO BOS TO ALB  
TO 50NNE SYR TO 30ESE YOW TO YSC TO 70NW PQI  
MOD TURB BTN 020 AND 100. CONDS ENDG 12-15Z.

.  
AIRMET STG SFC WND...NY PA OH LE  
FROM 20NNW BUF TO 20S BUF TO 30ESE CLE TO 40WSW CLE TO 20SSE DXO  
TO 20NNW BUF  
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 12-15Z.  
CONDS CONTG BYD 15Z THRU 21Z.

.  
OTLK VALID 1500-2100Z...TURB NY PA OH LE WV MD  
BOUNDED BY 20WNW BUF-50ENE SLT-20N HAR-60S JST-20SW AIR-30NW CLE-  
20WNW BUF  
MOD TURB BLW 080. CONDS DVLPG 18-21Z. CONDS CONTG THRU 21Z.

....

WAUS41 KPCI 281445  
WAIT  
-BOST WA 281445  
AIRMET TANGO UPDT 2 FOR TURB AND STG SFC WND...VALID UNTIL 282100

.  
**AIRMET TURB...NY LO PA OH LE WV**  
**FROM YOW TO 70S MSS TO 20NNE SLT TO HNN TO CVG TO FWA TO 30SE**  
**ECK TO YOW**  
**MOD TURB BTN FL250 AND FL420. CONDS CONTG BYD 21Z THRU 03Z.**

.  
AIRMET TURB...ME NH VT NY LO AND CSTL WTRS  
FROM 70NW PQI TO 60NE PQI TO 100SSW YSJ TO 70S MSS TO YOW TO YSC  
TO 70NW PQI  
MOD TURB BTN FL210 AND FL400. CONDS CONTG BYD 21Z THRU 03Z.

.  
AIRMET TURB...NY LO PA OH LE  
FROM 30SE ECK TO 40ESE BUF TO 30SE ERI TO FWA TO 30SE ECK  
MOD TURB BLW 070. CONDS CONTG BYD 21Z THRU 03Z.

.  
AIRMET STG SFC WND...NY PA OH LE  
FROM BUF TO 20ESE JHW TO 30WSW CLE TO 30SE DXO TO BUF  
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG BYD 21Z  
THRU 03Z.

.  
OTLK VALID 2100-0300Z  
AREA 1...TURB ME NH VT MA NY LO PA OH LE WV MD  
BOUNDED BY YSC-70WSW BGR-30SE ALB-HNN-CVG-FWA-30SE ECK-YOW-YSC  
MOD TURB BTN FL210 AND FL420. CONDS CONTG THRU 03Z.

.

AREA 2...TURB NJ PA WV MD DC DE VA AND CSTL WTRS  
BOUNDED BY 30WNW ETX-70ESE CYN-20WSW ORF-30NNW CSN-30WNW ETX  
MOD TURB BLW 080. CONDS DVLPG 00-03Z. CONDS CONTG THRU 03Z.

....

WAUS41 KPCI 280845

WA1Z

-BOSZ WA 280845

AIRMET ZULU UPDT 1 FOR ICE AND FRZLVL VALID UNTIL 281500

.

**AIRMET ICE...ME NH VT MA NY LO PA OH LE WV AND CSTL WTRS  
FROM 80WSW YOW TO 20NE ENE TO 120SSE BGR TO 40ESE BOS TO 20SSW  
ALB TO 30E PSB TO 20ESE AIR TO 50SSW HNN TO HNN TO CVG TO FWA TO  
20ENE DXO TO 40WNW ERI TO 80WSW YOW  
MOD ICE BTN FRZLVL AND FL220. FRZLVL 030-130. CONDS CONTG BYD 15Z  
THRU 21Z.**

.

OTLK VALID 1500-2100Z...ICE ME NH VT MA RI CT NY LO NJ PA OH LE  
WV MD DC DE VA AND CSTL WTRS  
BOUNDED BY 50SSW YOW-60SSE BGR-130SSE BGR-50ESE BOS-30S BOS-40ESE  
SIE-40ESE EMI-HNN-30NE CVG-FWA-DXO-20NNW CLE-30WSW BUF-40E  
YYZ-50SSW YOW  
MOD ICE BTN FRZLVL AND FL220. FRZLVL 030-130. CONDS CONTG THRU  
21Z.

.

FRZLVL...RANGING FROM SFC-140 ACRS AREA  
040 ALG 40NE YYZ-30ESE MPV-70SW YSJ  
080 ALG 40ESE ECK-40SE BUF-40SSW CON-70ESE ENE-110SE BGR  
120 ALG 30S FWA-20NE APE-40E AIR-140E ACK

....

WAUS41 KPCI 281445

WA1Z

-BOSZ WA 281445

AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 282100

.

**AIRMET ICE...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA  
AND CSTL WTRS  
FROM HUL TO 140SSE BGR TO 20SSE BOS TO 40E SIE TO HNV TO HNN TO  
CVG TO FWA TO 30SE ECK TO YYZ TO YSC TO HUL  
MOD ICE BTN FRZLVL AND FL220. FRZLVL 030-130. CONDS CONTG BYD 21Z  
THRU 03Z.**

.

OTLK VALID 2100-0300Z...ICE OH LE  
BOUNDED BY 20ENE DXO-50SSE DXO-30E ROD-50SW ROD-CVG-FWA-20ENE DXO  
MOD ICE BTN FRZLVL AND 150. FRZLVL 050-110. CONDS DVLPG AFT 00Z.  
CONDS CONTG THRU 03Z.

.

FRZLVL...RANGING FROM 020-140 ACRS AREA  
MULT FRZLVL 050-090 BOUNDED BY 60SW MSS-30WSW ALB-60SW SYR-  
50NNW ERI-BUF-30WNW YYZ-60SW MSS  
040 ALG YYZ-MPV-60SW YSJ  
080 ALG 40NW JHW-HNK-130SSE BGR  
120 ALG 50SW ROD-ROD-30N APE-40WSW CYN-90ESE ACK-140E ACK

....

## 12.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products issued before the accident flight and valid at 1100 EDT are shown in attachment 5. The GFA surface forecast valid before departure for around the accident time indicated VFR surface visibilities with numerous (between 60 to 100 percent) thunderstorms and a surface wind from the southwest at 5 knots. The GFA cloud forecast valid before departure for around the accident time indicated few clouds at 2,300 ft msl, scattered clouds at 6,000 ft msl, an overcast ceiling between 12,000 and 14,000 ft msl with cloud tops at FL370 to FL390. The Graphical AIRMET<sup>28</sup> (G-AIRMET) Zulu for icing was overlaid on the GFA cloud forecast graphics. The only human-generated information reflected in the two GFA products are the G-AIRMETs and the GFA is “human-over-the-loop.” For more information, please see attachment 5.

## 13.0 Terminal Aerodrome Forecast

There were no NWS<sup>29</sup> Terminal Aerodrome Forecast (TAF) sites located within 30 miles of the accident site.

## 14.0 NWS Area Forecast Discussion

The NWS office in Wilmington, Ohio, (WFO ILN) issued the following Area Forecast Discussion (AFD) at 0914 EDT:

FXUS61 KILN 281314  
AFDILN

AREA FORECAST DISCUSSION  
National Weather Service Wilmington OH  
914 AM EDT Fri May 28 2021

.SYNOPSIS...

Scattered showers and some thunderstorms are expected today, with showers continuing on- and- off through the day on Saturday. Much cooler air filters into the region today into tonight, with much below normal temperatures tonight through Sunday morning. Temperatures moderate early next week with dry weather expected Sunday through Tuesday.

&&

.NEAR TERM /UNTIL 6 PM THIS EVENING/...

An area of low pressure and associated cold front will move across the region today. This will allow for showers and some thunderstorms. Cooler temperatures are expected across northwestern portions of the region northwest of Dayton. Temperatures in this area will be in the 50s to low 60s. South of Interstate 70 temperatures are expected to reach into the

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<sup>28</sup> <https://aviationweather.gov/gairmet>

<sup>29</sup> 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](http://www.nws.noaa.gov/directives/sym/pd01008013curr.pdf)

upper 60s to middle 70s. Winds will pick up after the frontal boundary with wind gusts up around 20 to 30 mph. In advance of the front expect some thunderstorm development. There will be the potential for isolated strong to severe storm development during the afternoon and early evening hours. Damaging winds are expected to be the primary threat. Extensive cloud cover is expected today, which may limit the severe threat.

&&

.SHORT TERM /6 PM THIS EVENING THROUGH 6 PM SATURDAY/...

Any lingering storm activity south of the Ohio River will push quickly to the ESE and out of the ILN FA toward 00z. Behind this activity, much cooler air will be filtering in rather quickly this evening, with temperatures by midnight already in the 40s in west-central OH and in the lower 60s in south-central OH and northern KY. The surface CAA, aided by 15-20 MPH winds out of the north, will continue through the night, with temps by daybreak ranging from the lower 40s (NW) to lower 50s (SE).

It has become increasingly likely that daily record low maximums (highs) will be challenged on Saturday as thick/low cloud cover hangs around as the mid/upper low cuts off and meanders right over the local area. This will ensure 1) that drier air will not be quick to move back in, and 2) isolated to scattered showers during the daytime period will help keep temps even cooler than originally forecast. Current daily (05/29) record cool maximums at KCVG, KCMH, and KDAY are 54F, 52F, and 51F, respectively, may all be in jeopardy of being tied, depending exactly what the 1 AM temps are at each of these spots, as this will likely be the highest temps during the 24-hr period. It will be close, but perhaps stands the best chance of being tied at KCVG since the standing record is the warmest of the three local climate sites. Current forecasts for KCVG, KCMH, and KDAY are for daily highs of 54F, 54F, and 53F, respectively. Either way you shake it, record or no record, it is going to be a gray, damp, breezy, and very un-May-like day locally on Saturday as daytime temps hover a few degrees either side of 50 degrees.

Have increased PoPs for Saturday afternoon, generally ranging from 40-60% across the area as the saturated profile and subtle forcing should be enough to re-initiate showers during the late morning and afternoon.

&&

.LONG TERM /SATURDAY NIGHT THROUGH THURSDAY/...

Wrap-around shower activity in the evening will be more prevalent northeast of Columbus and generally be on the decrease as the atmosphere will have been worked over and the proximity of the upper low beyond this time will generally result in more cloud cover versus showers. Overnight lows will be similar to Friday night's, a little cooler in the east as the region will generally be within a few degrees of 45.

Cloud cover in the east Sunday will be slow to recede with the upper

low pressure retreating, but the sun that does make an appearance as clouds break up in the afternoon will help warm the region uniformly from the middle 60s in most locations to the upper 60s southwest of metro Cincy. Another cool night in the upper 40s will be the end of the unseasonably cool temperatures as high pressure settles over the region.

Cloud cover will increase Monday from the northwest but warmer temperatures into the low and mid 70s (possibly some upper 70s in the southeast towards Portsmouth) will be found as sunshine and weak southerly flow take hold.

Heights will increase through about Wednesday with an associated increase in temperatures, more noted in overnight lows only dropping to near 60 by daybreak Thursday. Highs Tues and Wed in the mid to upper 70s will be slightly more muted in the north with increasing cloud cover on Wednesday in stronger southwest flow aloft.

Rain chances will increase through Wed night/Thurs as the southwest flow interacts with upper level shortwave energy and peaks the interaction between the two. Friday still has the threat of showers given significant residual moisture, but the best forcing and upward motion have already been played out so lower chance pops are in order with temps near normal.

&&

.AVIATION /13Z FRIDAY THROUGH TUESDAY/...

**Episodic SHRA is expected throughout the TAF period. Will see some blossoming of SHRA activity locally through 16z before a brief break/decreased coverage may evolve into early afternoon. Additional activity along the front itself is expected past 18z from northwest to southeast, ending around 00z for the local terminals with just a few spotty SHRA lingering well back to the west for late tonight into Saturday.**

**Will see conditions remain VFR for a few hours before the column begins to saturate more substantially by 15z west to east. Will see CIGs go MVFR and eventually even IFR, with a mix of borderline IFR/MVFR expected for the afternoon before trending once again more solidly IFR toward/beyond 00z. Could also see some MVFR VSBYs with the column saturation and in any of the heavier SHRA activity.**

Best chance for TS will be for southern sites of KCVG, KLUK, and KILN between about 19z-00z, so have included a SHRA VCTS for these sites to account for the potential. Some gusty winds cannot be ruled out with any TS activity during this time period, but will handle this with amendments as needed.

Although most of the SHRA/TS activity moves south/east of the terminals past 00z, spotty SHRA will linger well back to the west and will continue to impact the sites on-and-off again late tonight into the day Saturday. Tonight may be the driest stretch in terms of coverage locally, but not completely dry either, especially past about 09z as spotty SHRA moves back in

from the west.

Light easterly/southeasterly winds through 12z will go more southerly and eventually westerly and even northerly by 21z and beyond. Northerly winds of 15kts with gusts to 20kts are expected late afternoon into early this evening, staying up at about 12kts through the nighttime.

.OUTLOOK...MVFR to IFR conditions are expected through Saturday afternoon.

&&

.ILN WATCHES/WARNINGS/ADVISORIES...

OH...None.

KY...None.

IN...None.

&&

\$\$

## 15.0 Winds and Temperature Aloft Forecast

The NWS 0957 EDT Winds and Temperature Aloft forecast valid for the closest points to the accident site are included below:

FBUS31 KWNO 281357

FD1US1

DATA BASED ON 281200Z

VALID 281800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

|     |      |         |         |         |         |                |        |        |        |
|-----|------|---------|---------|---------|---------|----------------|--------|--------|--------|
| FT  | 3000 | 6000    | 9000    | 12000   | 18000   | 24000          | 30000  | 34000  | 39000  |
| CMH | 2516 | 2723+11 | 2629+06 | 2533+00 | 2441-11 | <b>2359-20</b> | 236935 | 248046 | 259659 |
| CRW | 2220 | 2525+12 | 2325+07 | 2328+02 | 2436-08 | <b>2443-18</b> | 245735 | 256846 | 267858 |
| CVG | 2713 | 2726+11 | 2822+06 | 2531+00 | 2348-10 | <b>2455-21</b> | 246334 | 237246 | 248758 |

The closest forecast points to the accident site were Columbus, Ohio (CMH), Charleston, West Virginia (CRW), and Covington, Kentucky (CVG). The 0957 EDT CMH, CRW, and CVG, forecasts for 24,000 ft use between 1000 EDT and 1700 EDT indicated a wind from 230° at 59 knots with a temperature of -20°C at CMH, a wind from 240° at 43 knots with a temperature of -18°C at CRW, and a wind from 240° at 55 knots with a temperature of -21°C at CVG.

## 16.0 Pilot Weather Briefing

The accident pilot did not request nor receive weather information<sup>30</sup> from Leidos Flight Service.

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<sup>30</sup> [https://www.faa.gov/documentLibrary/media/Advisory\\_Circular/AC\\_91-92.pdf](https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf)

A search of archived ForeFlight information indicated that the accident pilot did not request nor receive weather information from ForeFlight prior to the accident flight. For more information, please see attachment 6. It is therefore unknown what the pilot familiarized himself or knew about the reported and forecast conditions for the route of flight.

## **17.0 Icing Potential**

CIP and FIP<sup>31</sup> products are created by the NWS AWC and are intended to supplement other icing advisories (e.g., AIRMETs and SIGMETs). Figures 22 through 24 are the FIP icing probabilities and icing severity products and 1-hour forecast valid at 1100 EDT at 20,000, 22,000, and 25,000 ft msl, and indicated a 10 to 60% probability of icing at 20,000 to 25,000 ft over the area. The FIP also indicated that the icing intensity near the accident site would range from “moderate” to “heavy” categories.<sup>32</sup>

The CIP product indicated a 10 to 60% probability of icing at 20,000, 22,000 and 25,000 ft msl at 1100 EDT above the accident site (figures 25, 26, and 27). The CIP also indicated that the icing near the accident site would be in the “light to moderate” category above 20,000 ft msl. In addition, the CIP indicated a 10 to 40% probability of Supercooled Large Droplets (SLD) between 20,000 and 22,000 ft msl and unknown probability above 22,000 ft msl at the accident site at 1100 EDT (attachment 7). For more FIP and CIP data please see attachment 7. For additional icing information please see Federal Aviation Administration (FAA) Advisory Circular “Pilot Guide: Flight in Icing Conditions”, AC 91-74B.<sup>33</sup>

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<sup>31</sup> 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.

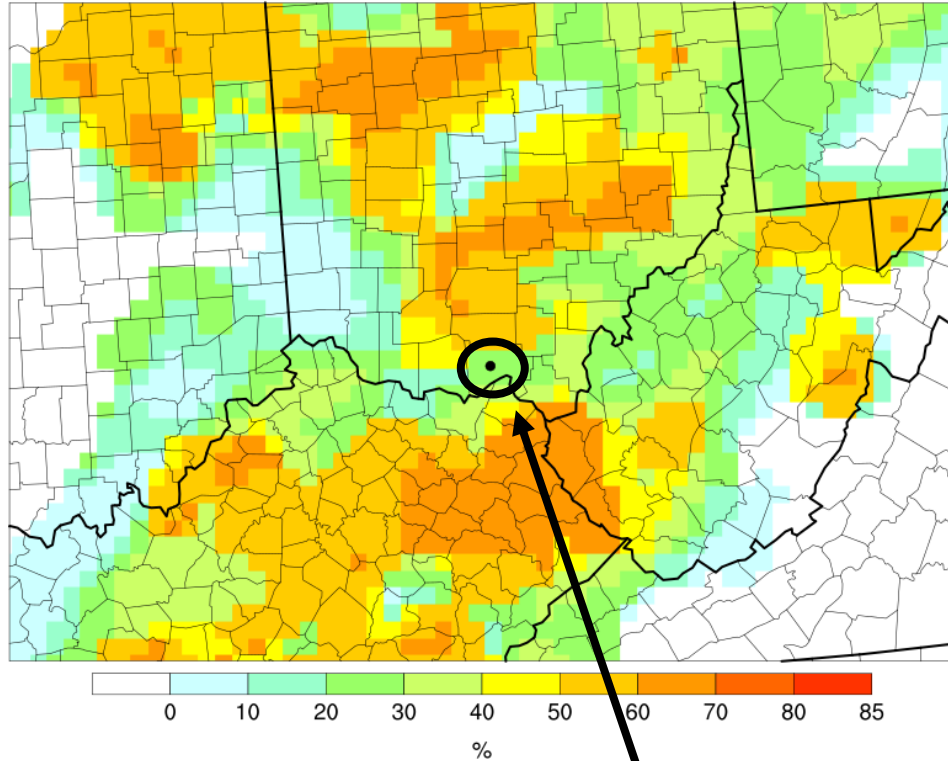
C.A. Wolff, F. McDonough, M. K. Politovich, B.C. Bernstein, and G. Cuning, FIP Severity Technical Document (Prepared for the Aviation Weather Technology Transfer Technical Review Board), pp. 1-44.

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

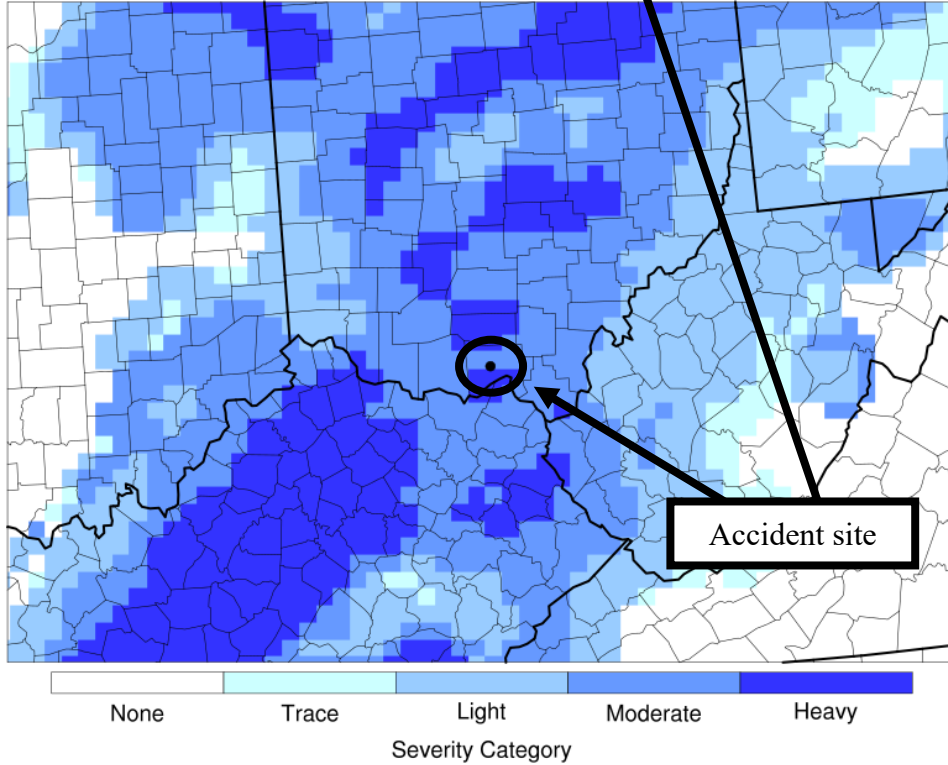
<sup>32</sup> <https://www.aviationweather.gov/icing/fip>

<sup>33</sup> [AC 91-74B - Pilot Guide: Flight In Icing Conditions – Document Information \(faa.gov\)](#)

ICING PROBABILITY at FL 200 01 Hour forecast valid at: 5/28/2021 1500 UTC



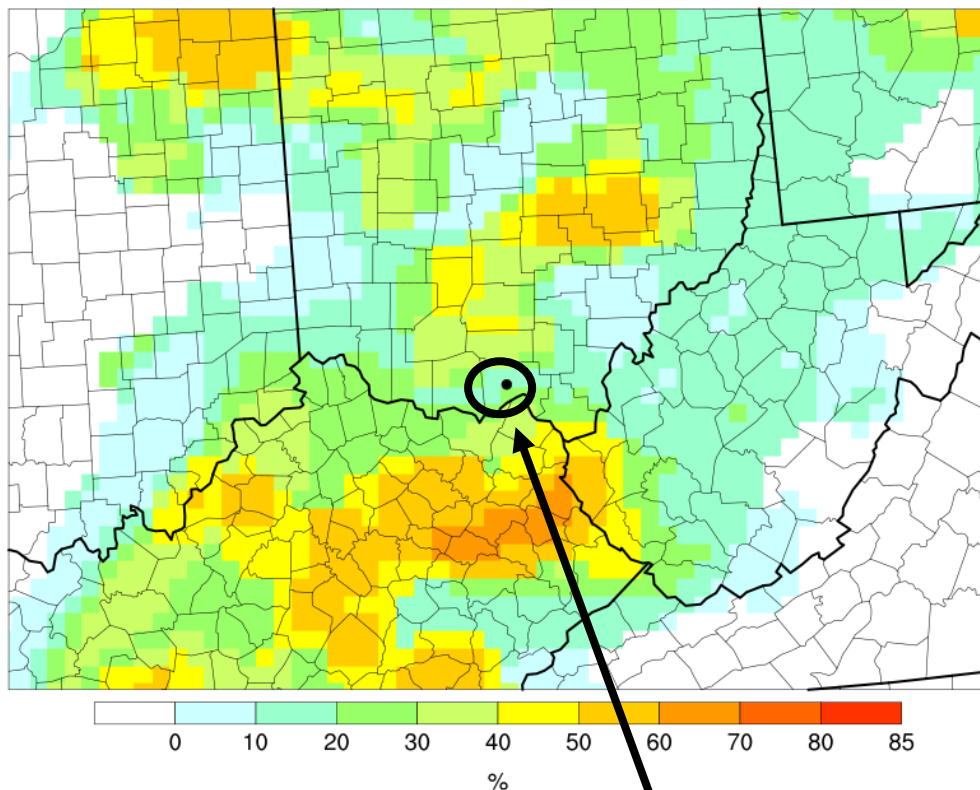
ICING SEVERITY CATEGORY at FL 200 01 Hour forecast valid at: 5/28/2021 1500 UTC



**Figure 22 – (top) FIP probability of icing at 20,000 ft above msl and (bottom) FIP severity of icing at 20,000 ft above msl 1-hour forecast valid for 1100 EDT.**

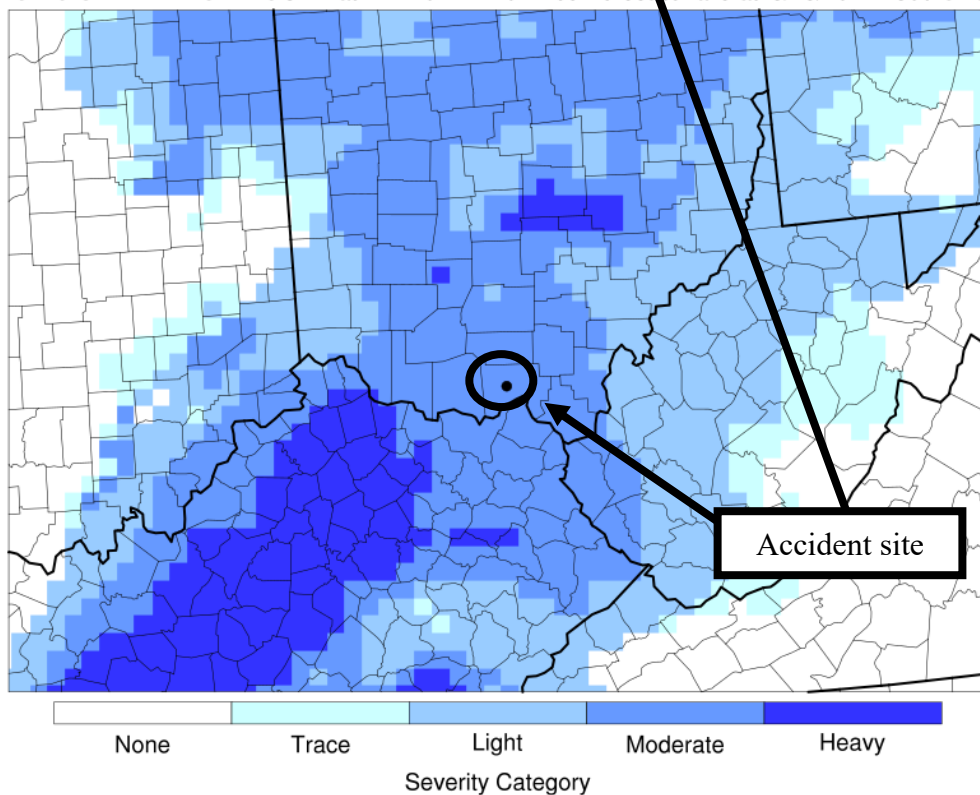
ICING PROBABILITY at FL 220

01 Hour forecast valid at: 5/28/2021 1500 UTC



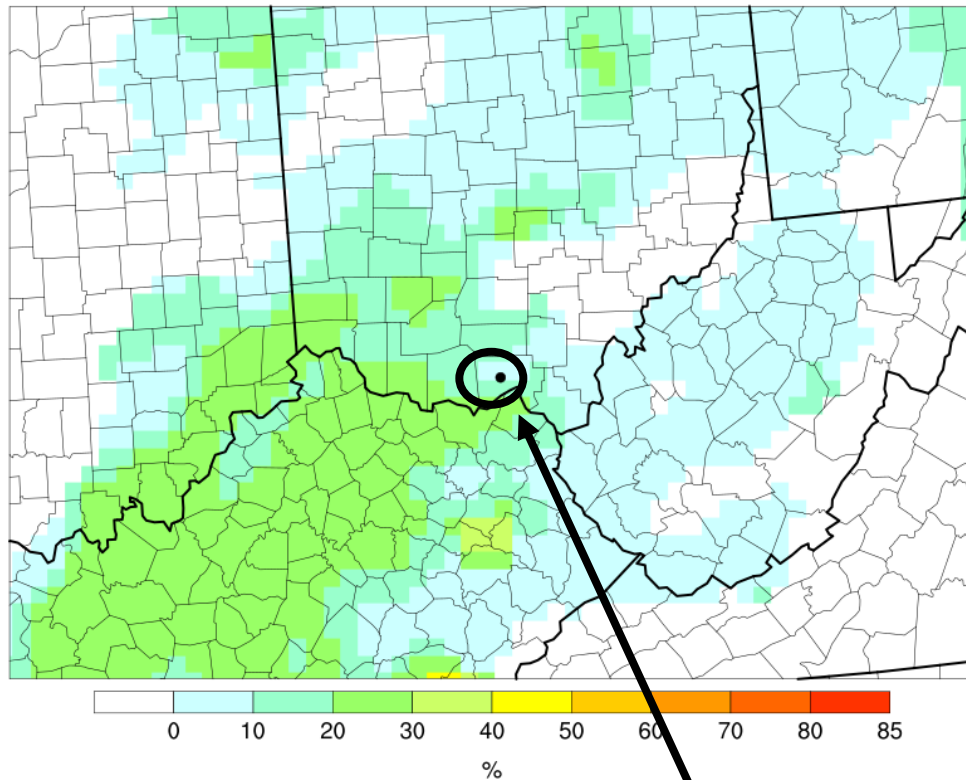
ICING SEVERITY CATEGORY at FL 220

01 Hour forecast valid at: 5/28/2021 1500 UTC

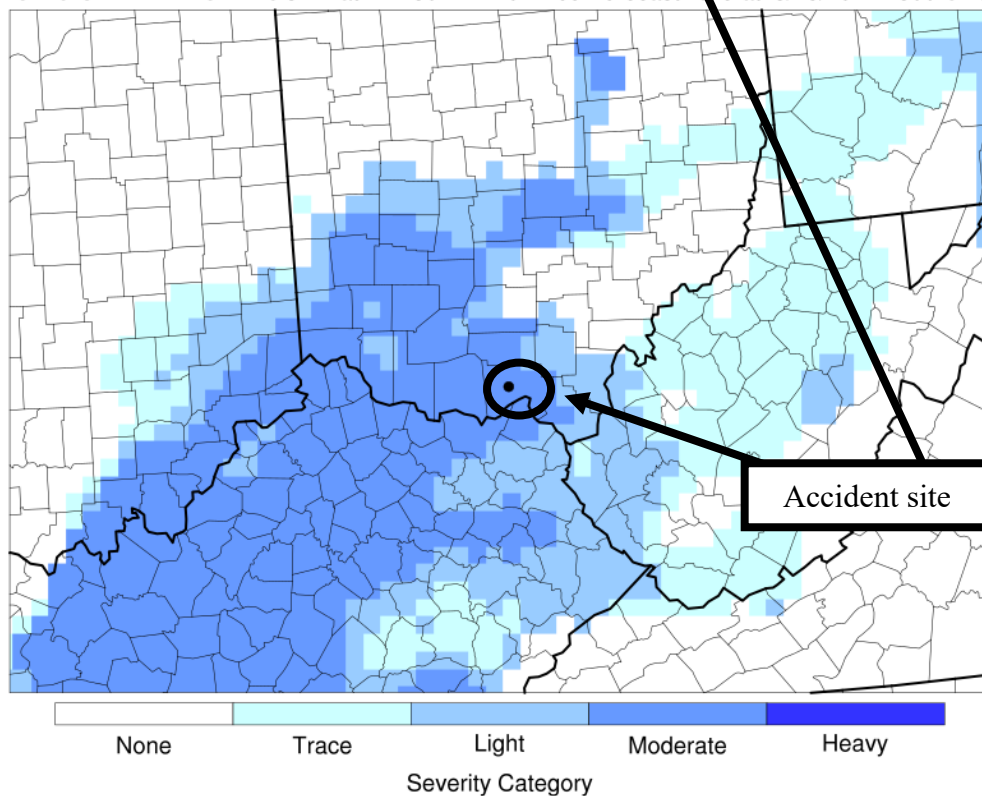


**Figure 23 – (top) FIP probability of icing at 22,000 ft above msl and (bottom) FIP severity of icing at 22,000 ft above msl 1-hour forecast valid for 1100 EDT.**

ICING PROBABILITY at FL 250 01 Hour forecast valid at: 5/28/2021 1500 UTC

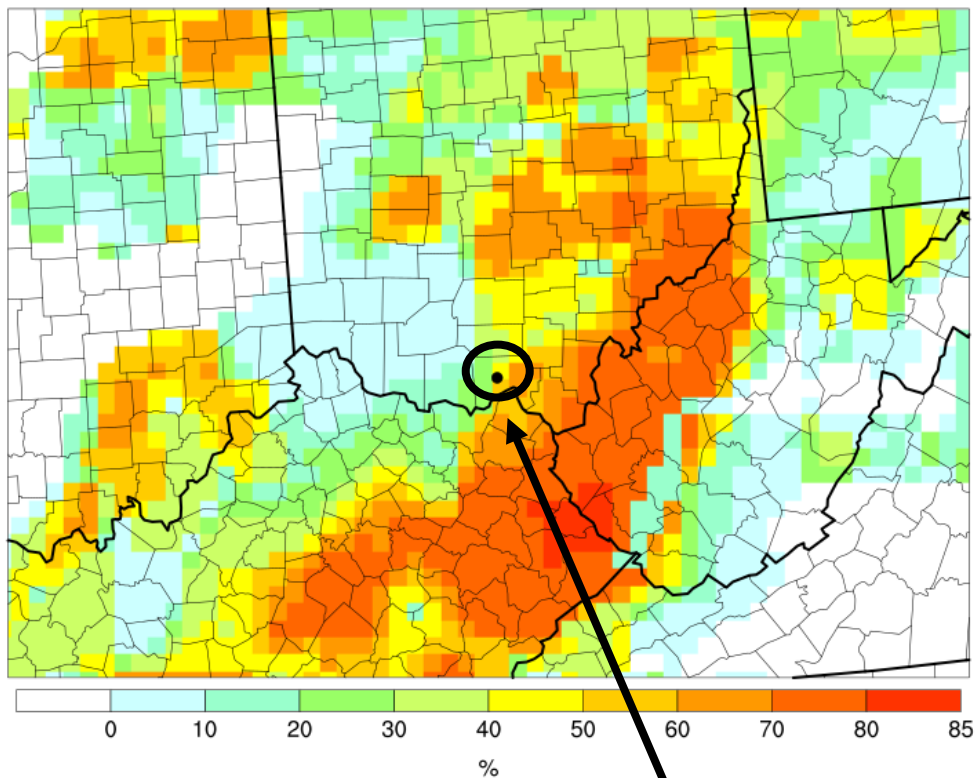


ICING SEVERITY CATEGORY at FL 250 01 Hour forecast valid at: 5/28/2021 1500 UTC

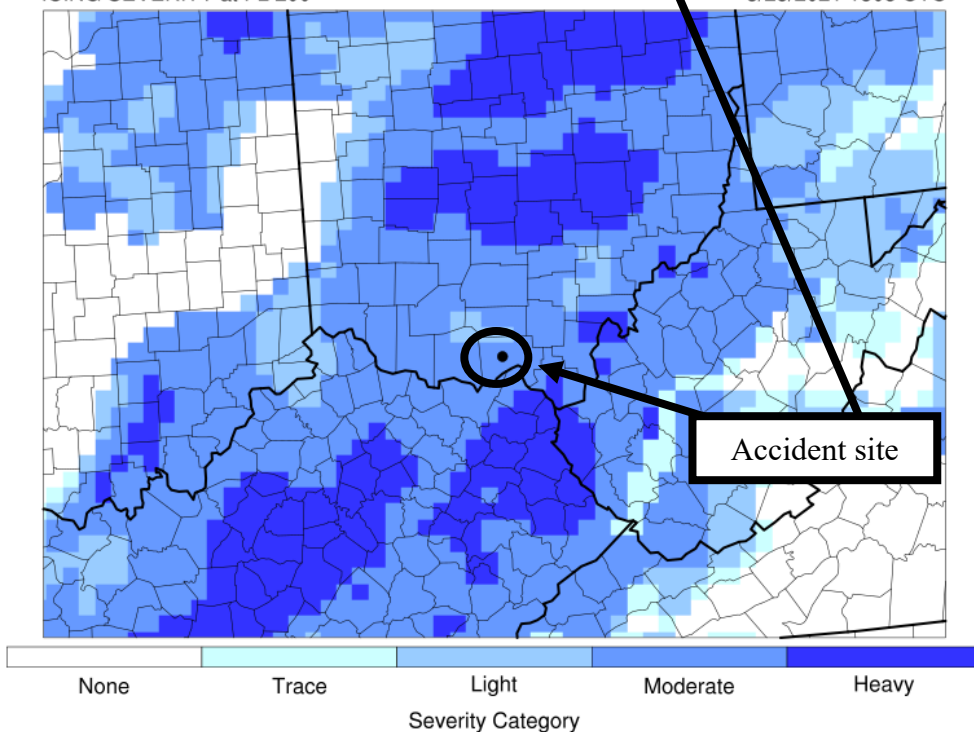


**Figure 24 – (top) FIP probability of icing at 25,000 ft above msl and (bottom) FIP severity of icing at 25,000 ft above msl 1-hour forecast valid for 1100 EDT.**

ICING PROBABILITY at FL 200 5/28/2021 1508 UTC



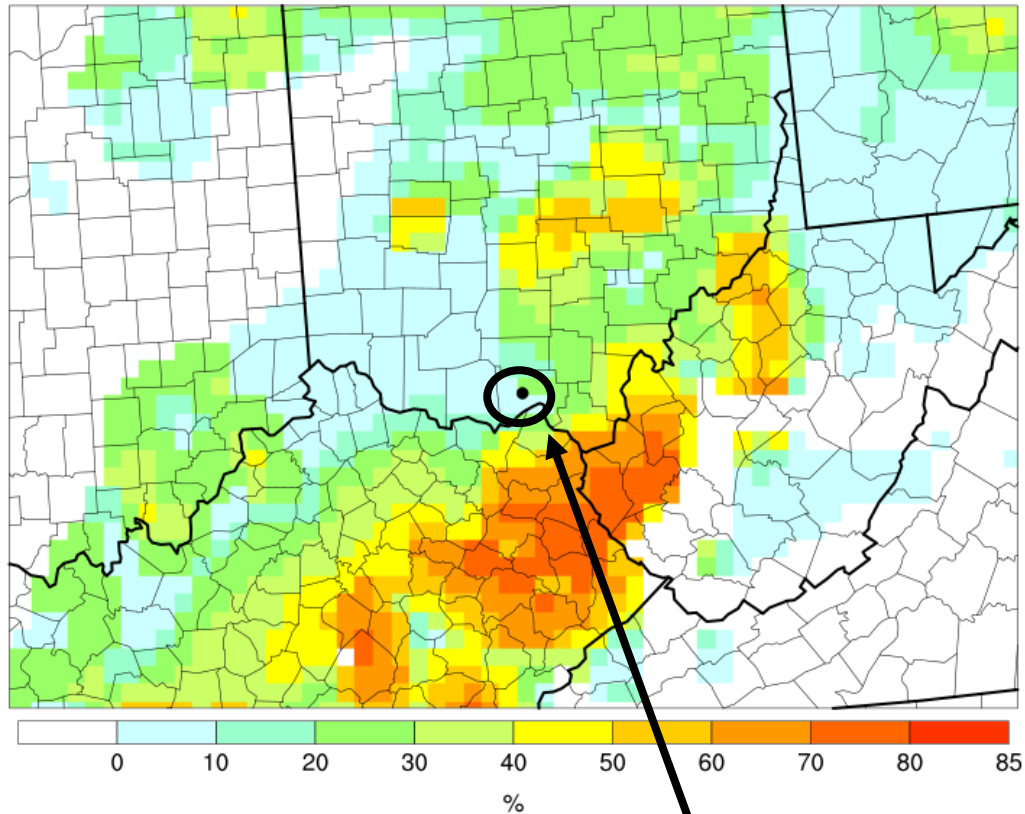
ICING SEVERITY at FL 200 5/28/2021 1508 UTC



**Figure 25 – (top) CIP probability of icing at 20,000 ft above msl and (bottom) CIP severity of icing at 20,000 ft above msl valid for around 1108 EDT.**

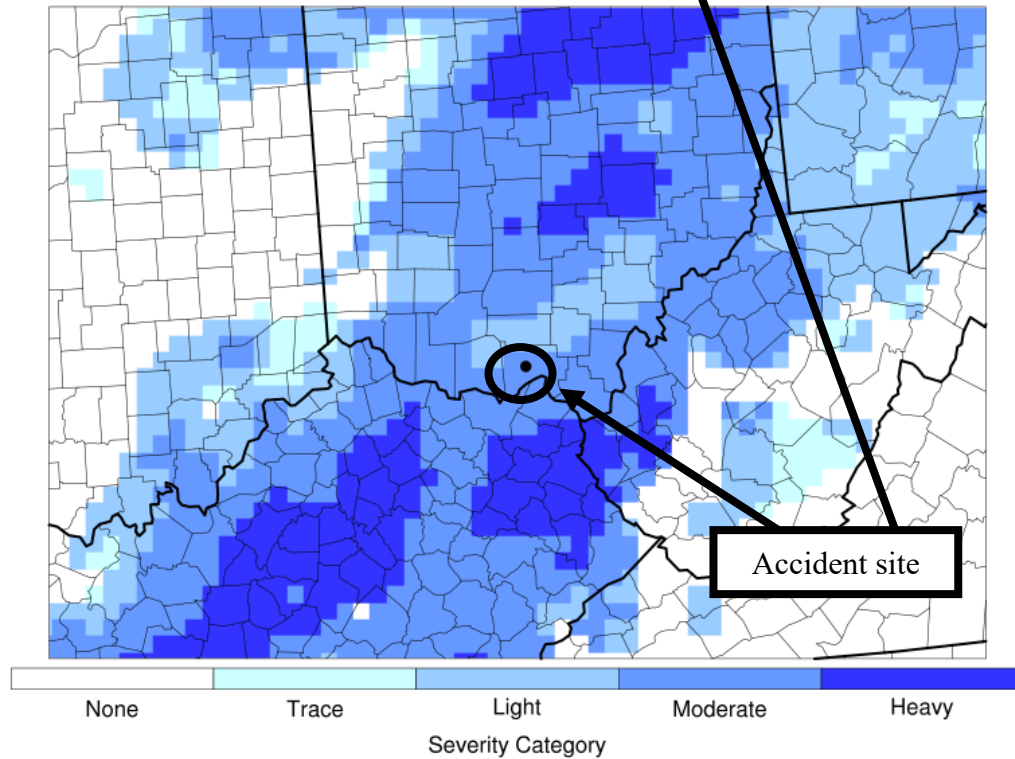
ICING PROBABILITY at FL 220

5/28/2021 1508 UTC



ICING SEVERITY at FL 220

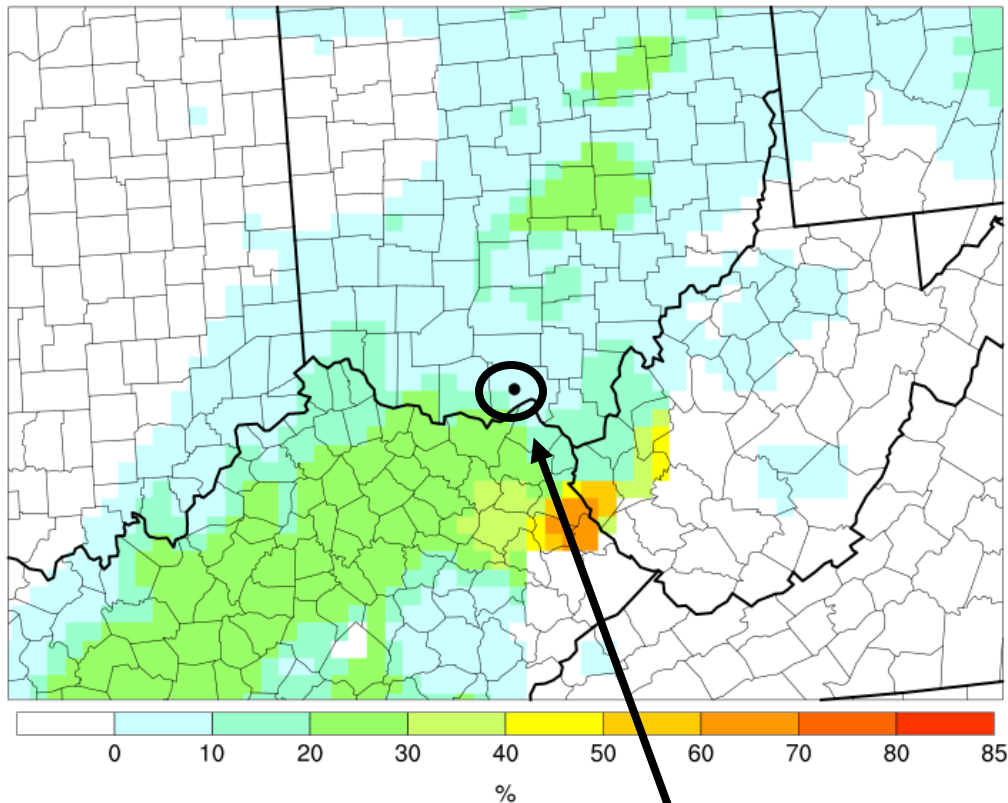
5/28/2021 1508 UTC



**Figure 26 – (top) CIP probability of icing at 22,000 ft above msl and (bottom) CIP severity of icing at 22,000 ft above msl valid for around 1108 EDT.**

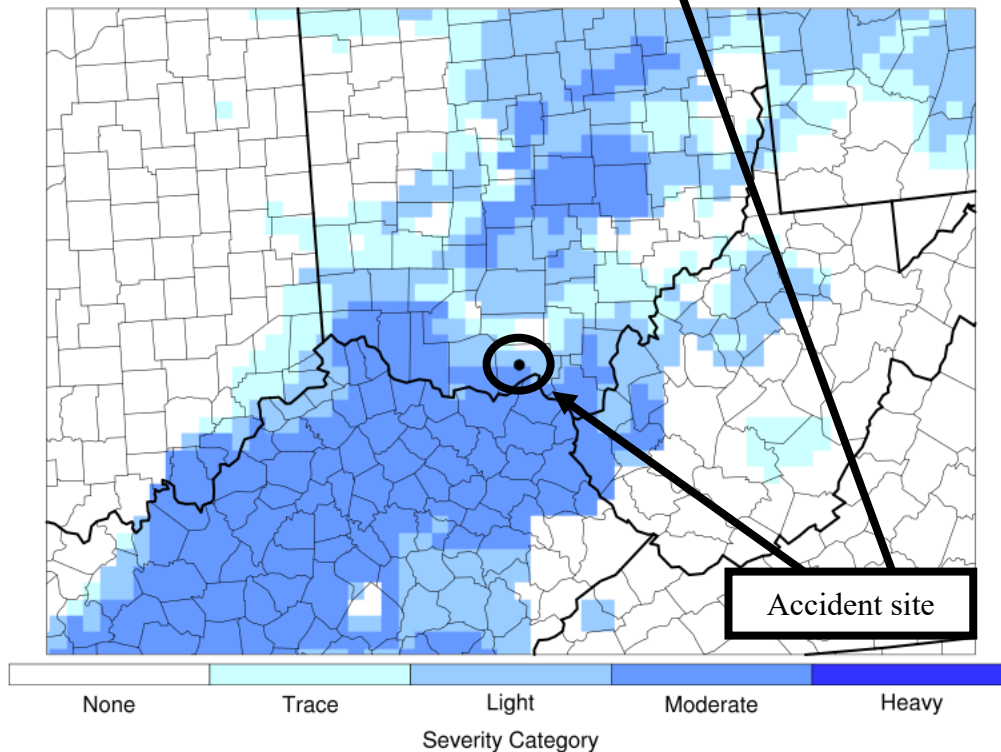
ICING PROBABILITY at FL 250

5/28/2021 1508 UTC



ICING SEVERITY at FL 250

5/28/2021 1508 UTC



**Figure 27 – (top) CIP probability of icing at 25,000 ft above msl and (bottom) CIP severity of icing at 25,000 ft above msl valid for around 1108 EDT.**

## 18.0 Astronomical Data

The astronomical data obtained for the accident site on May 28, 2021, indicated the following:

|                      |                              |
|----------------------|------------------------------|
| <b>SUN</b>           |                              |
| Begin civil twilight | 0539 EDT                     |
| Sunrise              | 0610 EDT                     |
| <b>Accident time</b> | <b>1048 EDT<sup>34</sup></b> |
| Sun transit          | 1329 EDT                     |
| Sunset               | 2049 EDT                     |
| End civil twilight   | 2120 EDT                     |

At the time of the accident the Sun was located at an altitude of 51.50° and azimuth of 104.69°.

## E. LIST OF ATTACHMENTS

Attachment 1 – GOES-16 visible satellite imagery animation from 1001 to 1101 EDT

Attachment 2 – ZID ARTCC PIREPs on the accident day

Attachment 3 – ZID CWSU pre-duty weather briefings valid on the accident day

Attachment 4 – ZID weather dissemination timeline at various ATC sectors around the accident time

Attachment 5 – GFA valid for the accident site at accident time

Attachment 6 – ForeFlight correspondence

Attachment 7 – FIP and CIP information valid for the accident site at the accident time

Submitted by:

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Paul Suffern  
Senior Meteorologist

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<sup>34</sup> Inserted accident time for reference and context.