



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

March 18, 2019

Factual Report

METEOROLOGY

ERA19FA039

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A. ACCIDENT

Location: Near Walton, New York
Date: November 9, 2018
Time: 1502 eastern standard time
2002 Coordinated Universal Time (UTC)
Aircraft: Cessna 310R, Registration: N5044J

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 eastern standard time (EST) on November 9, 2018, 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 approximate location of the accident site was at latitude 42.0769° N, longitude 75.2144° W, with an approximate elevation of 1,990 feet (ft).

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.¹

¹

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030

1.1 Surface Analysis Chart

The northeast section of the NWS Surface Analysis Chart for 1600 EST is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart identified a surface low pressure center located over eastern Lake Erie with a surface pressure of 1009-hectopascals (hPa). Other surface low pressure centers were located over northern Lake Michigan with a surface pressure of 1011-hPa and over eastern Virginia with a surface pressure of 1012-hPa. An occluded front stretched southward from the 1009-hPa low pressure center into western New York, Pennsylvania, West Virginia, and Virginia. Another frontal boundary stretched from the western Atlantic Ocean to the 1012-hPa low pressure center in eastern Virginia, then southward into North Carolina.

The station models around the accident site depicted air temperatures in the low 30's to low 40's degrees Fahrenheit (°F), dew point temperatures in the low 30's to upper 30's °F with temperature-dew point spreads of 6° F or less, a southeast to east wind of 5 to 15 knots, overcast sky cover, mist, light rain and snow to the west and north of the accident site, and light to heavy rain to the south and east of the accident site.

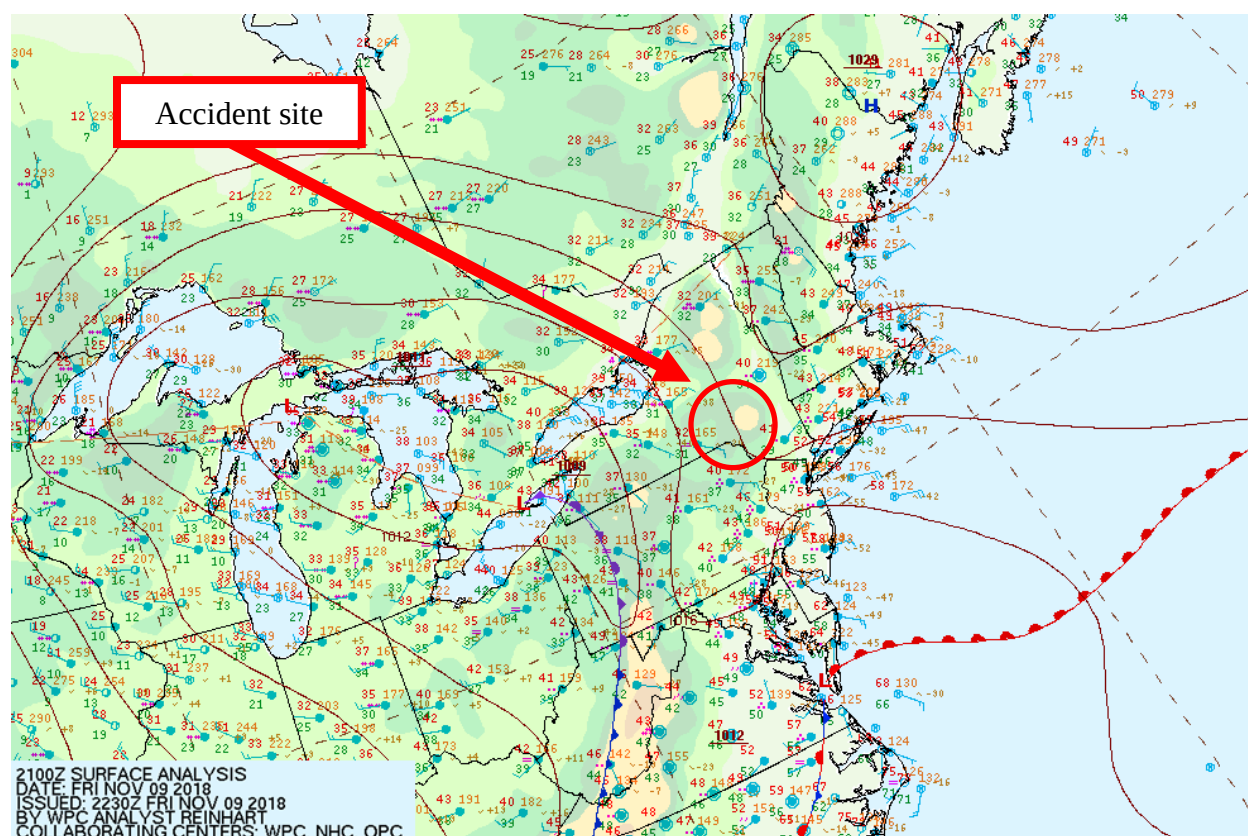


Figure 1 – NWS Surface Analysis Chart for 1600 EST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1900 EST at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There was a low-level trough² located southwest of the accident site (figures 2 and 3) at 925- and 850-hPa. Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was also a mid-level trough located south of the accident site at 700- and 500-hPa at 1900 EST (figures 4 and 5). There was a southeast wind of 40 knots at 925-hPa above the accident site with the wind becoming southwesterly by 700-hPa (figure 4) at 60 knots. By 300-hPa, the wind above the accident site was still from the southwest but increased to between 100 and 110 knots (figure 6).

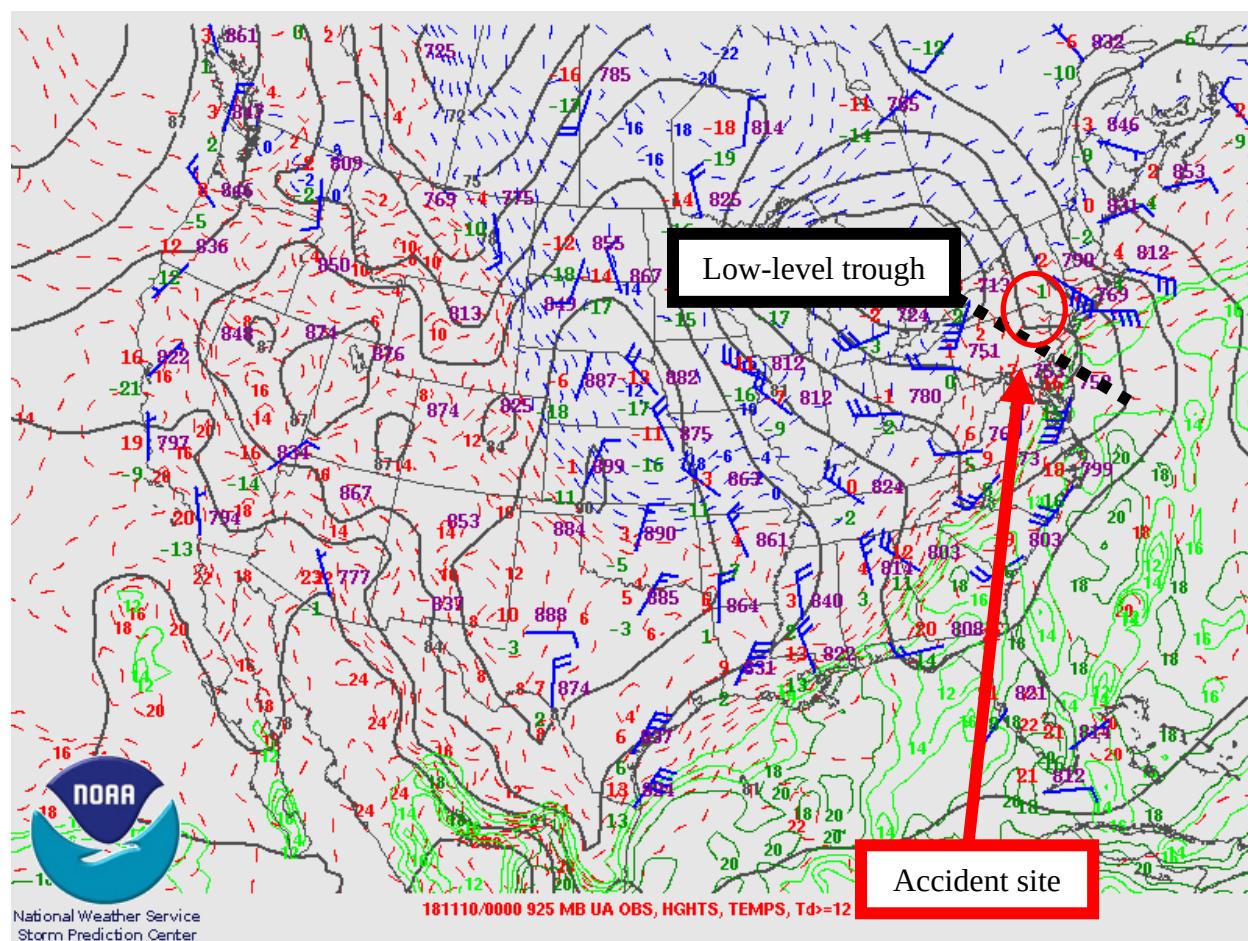


Figure 2 – 925-hPa Constant Pressure Chart for 1900 EST

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

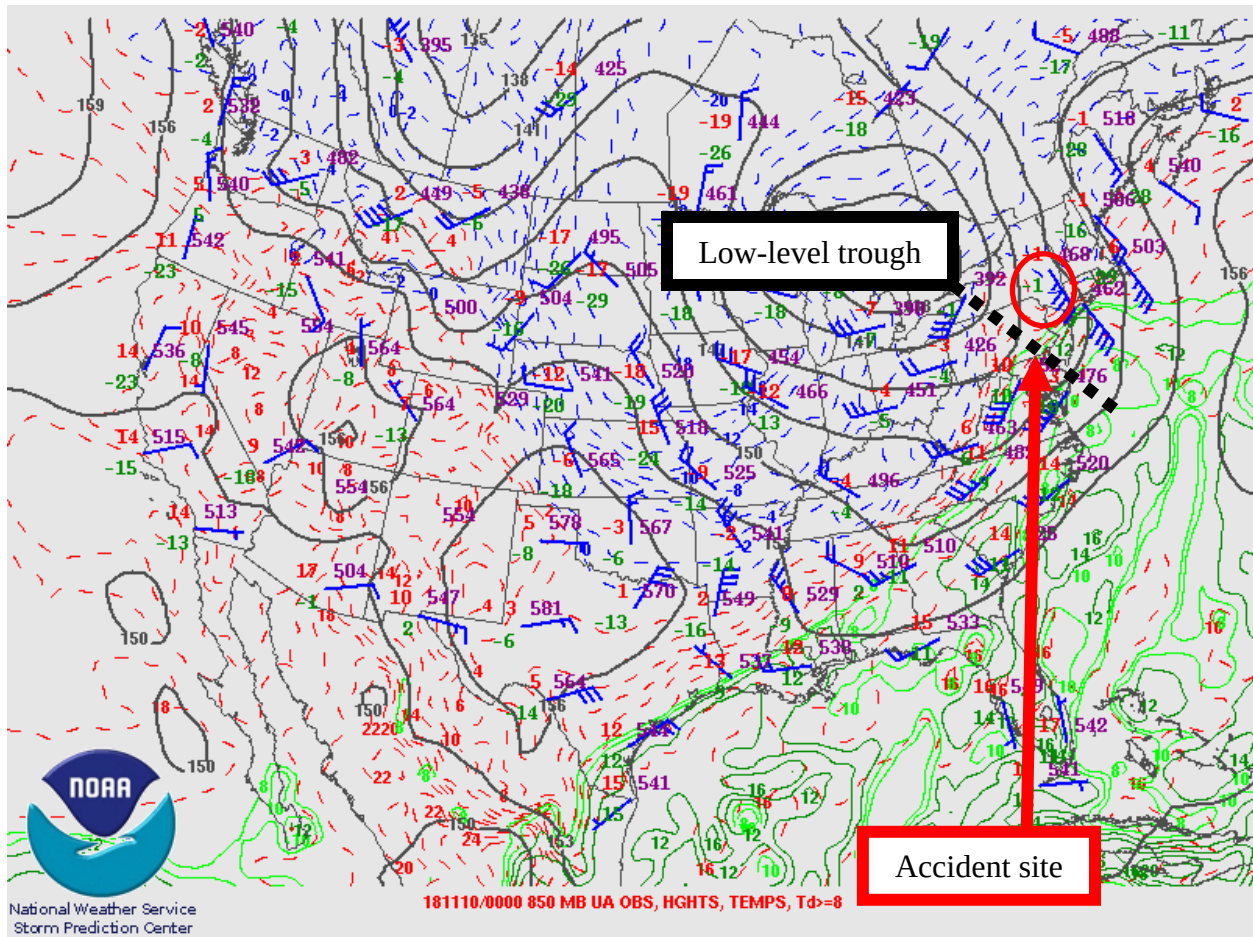


Figure 3 – 850-hPa Constant Pressure Chart for 1900 EST

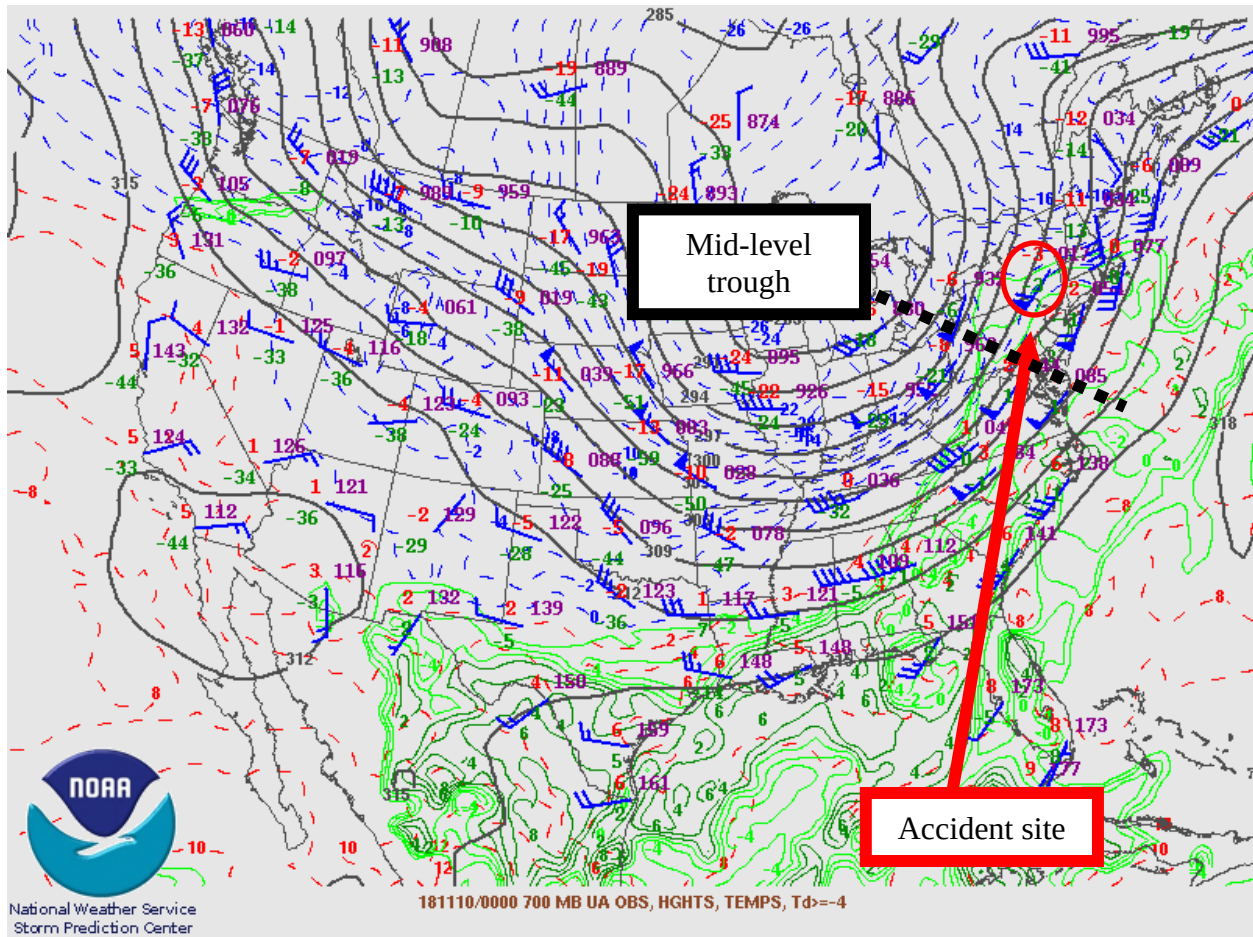


Figure 4 – 700-hPa Constant Pressure Chart for 1900 EST

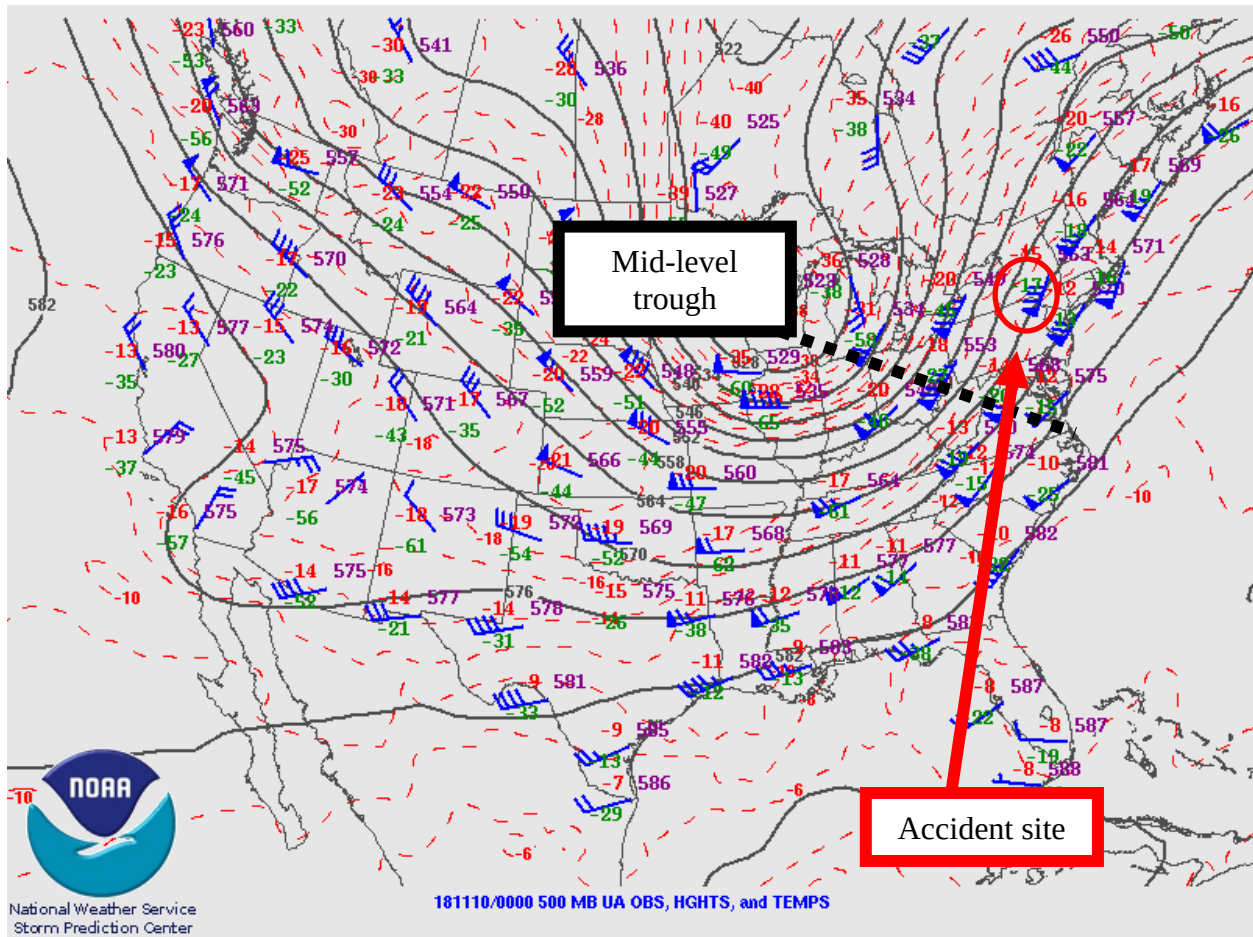


Figure 5 – 500-hPa Constant Pressure Chart for 1900 EST

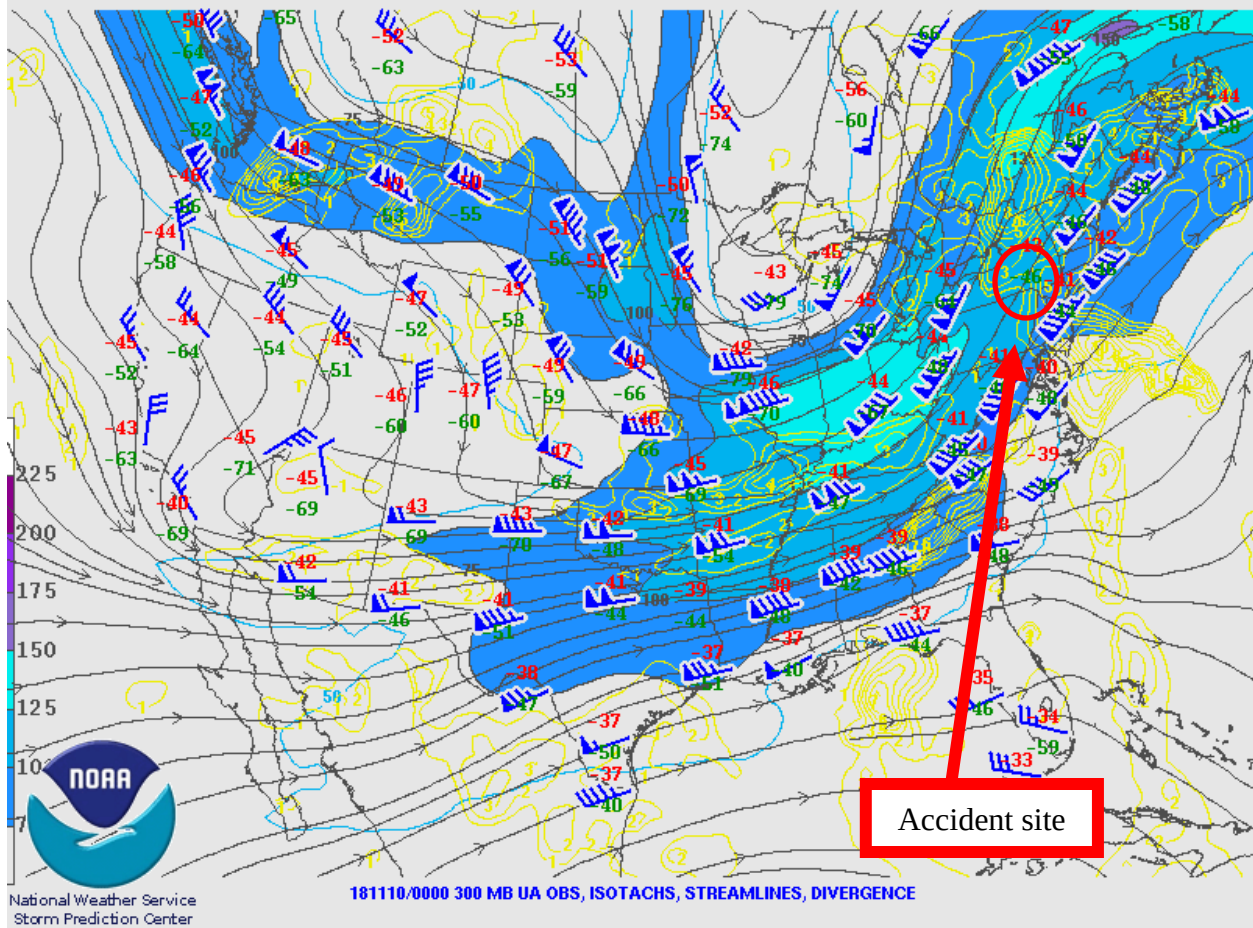


Figure 6 – 300-hPa Constant Pressure Chart for 1900 EST

2.0 SPC Products

The SPC Convective Outlook expected no organized thunderstorms over the region during the period.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 7 is a local sectional chart with the accident site and the closest weather reporting locations marked.

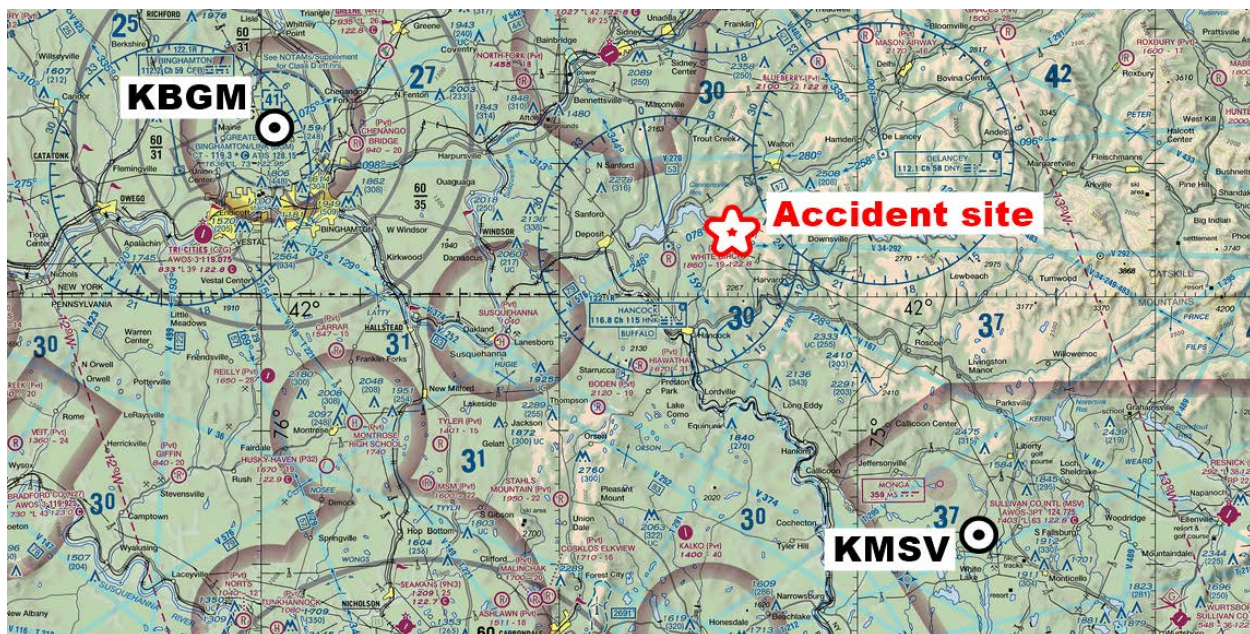


Figure 7 – Sectional map of the accident area with the location of the accident site and surface observation sites

Sullivan County International Airport (KMSV) had the closest official weather station to the accident site and was located 6 miles northwest of Monticello, New York. KMSV had an Automated Weather Observing System (AWOS³) whose reports were not supplemented. KMSV was located 29 miles southeast of the accident site, at an elevation of 1,403 ft, and had a 13° westerly magnetic variation⁴ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁵

- [1256 EST] METAR KMSV 091756Z AUTO 11010KT 10SM -RA OVC060 02/M01 A3014
RMK AO2 RAB26 SLP219 P0000 60000 T00221011 10028 21017
58038 FZRANO=
- [1313 EST] SPECI KMSV 091813Z AUTO 10007KT 10SM BKN024 OVC060 02/M01
A3013 RMK AO2 RAE12 P0000 FZRANO=
- [1349 EST] SPECI KMSV 091849Z AUTO 08005KT 1 1/2SM -SN OVC024 02/M01
A3013 RMK AO2 RAE12B31E49SNB49 P0000 FZRANO=

³ 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 twelve thousand feet, and altimeter setting.

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

⁵ The bold sections in this NWS product and the rest of the products in this report are intended to highlight the sections that directly reference the weather conditions that effected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1353 EST] SPECI KMSV 091853Z AUTO 09005KT 3/4SM -SN OVC024 02/M01 A3013
RMK AO2 RAE12B31E49SNB49 P0000 FZRANO RVRNO=

[1356 EST] METAR KMSV 091856Z AUTO 08004KT 3/4SM -SN BR OVC024 02/M01
A3013 RMK AO2 RAE12B31E49SNB49 SLP220 P0001 T00171006
FZRANO RVRNO=

[1401 EST] SPECI KMSV 091901Z AUTO 06005KT 1 1/4SM -SN BR OVC022 02/M01
A3013 RMK AO2 VIS 1/2V4 P0000 FZRANO=

**[1406 EST] SPECI KMSV 091906Z AUTO 05003KT 3SM -SN BR OVC022 02/00 A3013
RMK AO2 P0001 FZRANO=**

**[1456 EST] METAR KMSV 091956Z AUTO 35004KT 5SM -RA BR OVC020 01/00 A3013
RMK AO2 RAB48SNE48 PRESRR SLP221 P0010 T00060000 FZRANO=**

ACCIDENT TIME 1502 EST

**[1517 EST] SPECI KMSV 092017Z AUTO 07009KT 2 1/2SM -SN BR OVC020 01/00
A3010 RMK AO2 RAE1958UPB1958E02SNB02 PRESFR P0003 FZRANO=**

**[1540 EST] SPECI KMSV 092040Z AUTO 03008KT 5SM -RA BR OVC018 01/00 A3010
RMK AO2 RAE1958B38UPB1958E02SNB02E38 P0005 FZRANO=**

[1556 EST] METAR KMSV 092056Z AUTO 06009KT 2SM -SN BR BKN018 OVC027
01/01 A3010 RMK AO2 RAE1958B38E50UPB1958E02SNB02 SLP208
P0008 60019 T00110006 58013 FZRANO=

[1613 EST] SPECI KMSV 092113Z AUTO 05004KT 3SM -SN BR SCT020 OVC026
02/01 A3013 RMK AO2 PRESRR P0002 FZRANO=

KMSV weather at 1406 EST, automated, wind from 050° at 3 knots, 3 miles visibility, light snow and mist, overcast ceiling at 2,200 ft above ground level (agl), temperature of 2° Celsius (C), dew point temperature of 0° C, and an altimeter setting of 30.13 inches of mercury. Remarks: automated station with a precipitation discriminator, 0.01 inches of precipitation since 1353 EST, freezing rain information is not available.

KMSV weather at 1456 EST, automated, wind from 350° at 4 knots, 5 miles visibility, light rain and mist, overcast ceiling at 2,000 ft agl, temperature of 1° C, dew point temperature of 0° C, and an altimeter setting of 30.13 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1448 EST, snow ended at 1448 EST, pressure rising rapidly, 1022.1 hPa, 0.10 inches of precipitation since 1353 EST, temperature 0.6° C, dew point temperature 0.0° C, freezing rain information is not available.

KMSV weather at 1517 EST, automated, wind from 070° at 9 knots, 2 and a half miles visibility, light snow and mist, overcast ceiling at 2,000 ft agl, temperature of 1° C, dew point temperature of 0° C, and an altimeter setting of 30.10 inches of mercury. Remarks: automated station with a precipitation discriminator, rain ended at 1458 EST, unknown precipitation began at 1458 EST, unknown precipitation ended at 1502 EST, snow began at 1502 EST, pressure falling rapidly, 0.03 inches of precipitation since 1453 EST, freezing rain information is not available.

KMSV weather at 1540 EST, automated, wind from 030° at 8 knots, 5 miles visibility, light rain and mist, overcast ceiling at 1,800 ft agl, temperature of 1° C, dew point temperature of 0° C, and an altimeter setting of 30.10 inches of mercury. Remarks: automated station with a precipitation discriminator, rain ended at 1458 EST, rain began at 1538 EST, unknown precipitation began at 1458 EST, unknown precipitation ended at 1502 EST, snow began at 1502 EST, snow ended at 1538 EST, 0.05 inches of precipitation since 1453 EST, freezing rain information is not available.

Greater Binghamton Airport/Edwin A Link Field (KBGM) was the next closest airport and was located 7 miles north of Binghamton, New York. KBGM had an Automated Surface Observing System (ASOS⁶) whose reports were supplemented by air traffic control (ATC) when the tower was in operation.⁷ KBGM was located 35 miles west-northwest of the accident site at an elevation of 1,636 ft (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[1321 EST] SPECI KBGM 091821Z 14008KT 1SM -SN BR BKN004 BKN008 OVC020
00/M01 A3006 RMK AO2 TWR VIS 3 P0002 T00001006=

[1341 EST] SPECI KBGM 091841Z 12007KT 3/4SM -SN BR BKN004 OVC017 00/M01
A3004 RMK AO2 TWR VIS 3 P0004 T00001006=

[1351 EST] SPECI KBGM 091851Z 12009KT 1 1/4SM -SN BR BKN004 OVC008 00/M01
A3003 RMK AO2 TWR VIS 3 CIG 002V006 P0005=

[1353 EST] METAR KBGM 091853Z 12011KT 1 1/4SM -SN BR BKN004 OVC008 00/M01
A3003 RMK AO2 TWR VIS 3 CIG 002V006 SLP186 P0005 T00001006=

[1412 EST] SPECI KBGM 091912Z 13010KT 3SM -SN BR BKN004 OVC009 00/M01
A3003 RMK AO2 CIG 002V007 P0002 T00001006=

[1419 EST] SPECI KBGM 091919Z 13009KT 2 1/2SM -SN BR BKN004 OVC009 00/M01
A3003 RMK AO2 SFC VIS 4 CIG 002V007 P0003 T00001006=

**[1450 EST] SPECI KBGM 091950Z 14011KT 1 3/4SM -SN BR SCT004 BKN007 OVC027
00/M01 A3001 RMK AO2 TWR VIS 2 1/2 P0005=**

⁶ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁷ ATC hours 0600 to midnight local.

[1453 EST] METAR KBGM 091953Z 13010KT 1 3/4SM -SN BR BKN004 OVC013 00/M01 A3001 RMK AO2 TWR VIS 2 1/2 SLP179 P0005 T00001006=

ACCIDENT TIME 1502 EST

[1511 EST] SPECI KBGM 092011Z 13011KT 1 1/2SM -SN BR BKN005 BKN011 OVC016 00/M01 A2999 RMK AO2 TWR VIS 2 1/2 P0002 T00001006=

[1534 EST] SPECI KBGM 092034Z 13011KT 2 1/2SM -SN BR BKN005 BKN021 OVC040 00/M01 A2997 RMK AO2 SFC VIS 4 P0004 T00001006=

[1546 EST] SPECI KBGM 092046Z 13011KT 2 1/2SM UP BR BKN004 BKN011 OVC041 00/M01 A2997 RMK AO2 SFC VIS 6 UPB38SNE38 P0004 T00001006=

[1553 EST] METAR KBGM 092053Z 13010KT 2 1/2SM BR BKN004 BKN009 OVC020 00/M01 A2997 RMK AO2 SFC VIS 6 UPB38SNE38 SLP165 P0005 60015 T00001006 58020=

KBGM weather at 1450 EST, wind from 140° at 11 knots, 1 and three quarter miles visibility, light snow, mist, scattered clouds at 400 ft agl, broken ceiling at 700 ft agl, overcast skies 2,700 ft agl, temperature of 0° C, dew point temperature of -1° C, and an altimeter setting of 30.01 inches of mercury. Remarks: automated station with a precipitation discriminator, tower visibility 2 and a half miles, 0.05 inches of rain since 1353 EST.

KBGM weather at 1453 EST, wind from 130° at 10 knots, 1 and three quarters mile visibility, light snow, mist, broken ceiling at 400 ft agl, overcast skies 1,300 ft agl, temperature of 0° C, dew point temperature of -1° C, and an altimeter setting of 30.01 inches of mercury. Remarks: automated station with a precipitation discriminator, tower visibility 2 and a half miles, sea-level pressure 1017.9 hPa, 0.05 inches of rain since 1353 EST, temperature 0.0° C, dew point temperature -0.6° C.

KBGM weather at 1511 EST, wind from 130° at 11 knots, 1 and a half miles visibility, light snow, mist, broken ceiling at 500 ft agl, broken skies 1,100 ft agl, overcast skies 1,600 ft agl, temperature of 0° C, dew point temperature of -1° C, and an altimeter setting of 29.99 inches of mercury. Remarks: automated station with a precipitation discriminator, tower visibility 2 and a half miles, 0.02 inches of rain since 1453 EST, temperature 0.0° C, dew point temperature -0.6° C.

KBGM weather at 1534 EST, wind from 130° at 11 knots, 2 and a half miles visibility, light snow, mist, broken ceiling at 500 ft agl, broken skies 2,100 ft agl, overcast skies 4,000 ft agl, temperature of 0° C, dew point temperature of -1° C, and an altimeter setting of 29.97 inches of mercury. Remarks: automated station with a precipitation discriminator, surface visibility 4 miles, 0.04 inches of rain since 1453 EST, temperature 0.0° C, dew point temperature -0.6° C.

The observations from KBGM and KMSV surrounding the accident time indicated IFR⁸ to LIFR⁹ conditions with light snow at KBGM and a mix of light snow and light rain at KMSV. Ceilings were as low as 400 ft agl at KBGM at the accident time.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)¹⁰ model sounding was created for the accident site for 1500 EST with station elevation of 1,745 ft.¹¹ The 1500 EST HRRR sounding was plotted on a standard Skew-T Log P diagram¹² with the derived stability parameters included in figure 8 (with data from the surface to 600-hPa, or approximately 14,000 ft msl). This data was analyzed using the RAOB¹³ software package. The sounding depicted the lifted condensation level (LCL)¹⁴ at 288 ft agl (2,033 ft msl) and the convective condensation level (CCL)¹⁵ at 451 ft agl (2,196 ft msl). The sounding had a greater than 90% relative humidity from the surface through 14,000 ft msl. The freezing level was located at 111 ft agl (1,856 ft msl). The precipitable water value was 0.78 inches.

⁸ Instrument Flight Rules (IFR) – 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.

⁹ Low Instrument Flight Rules (LIFR) – Refers to the general weather conditions pilots can expect at the surface. LIFR criteria means a ceiling below 500 ft agl and/or less than 1-mile visibility.

¹⁰ 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.

¹¹ HRRR sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

¹² 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.

¹³ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹⁴ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁵ CCL – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

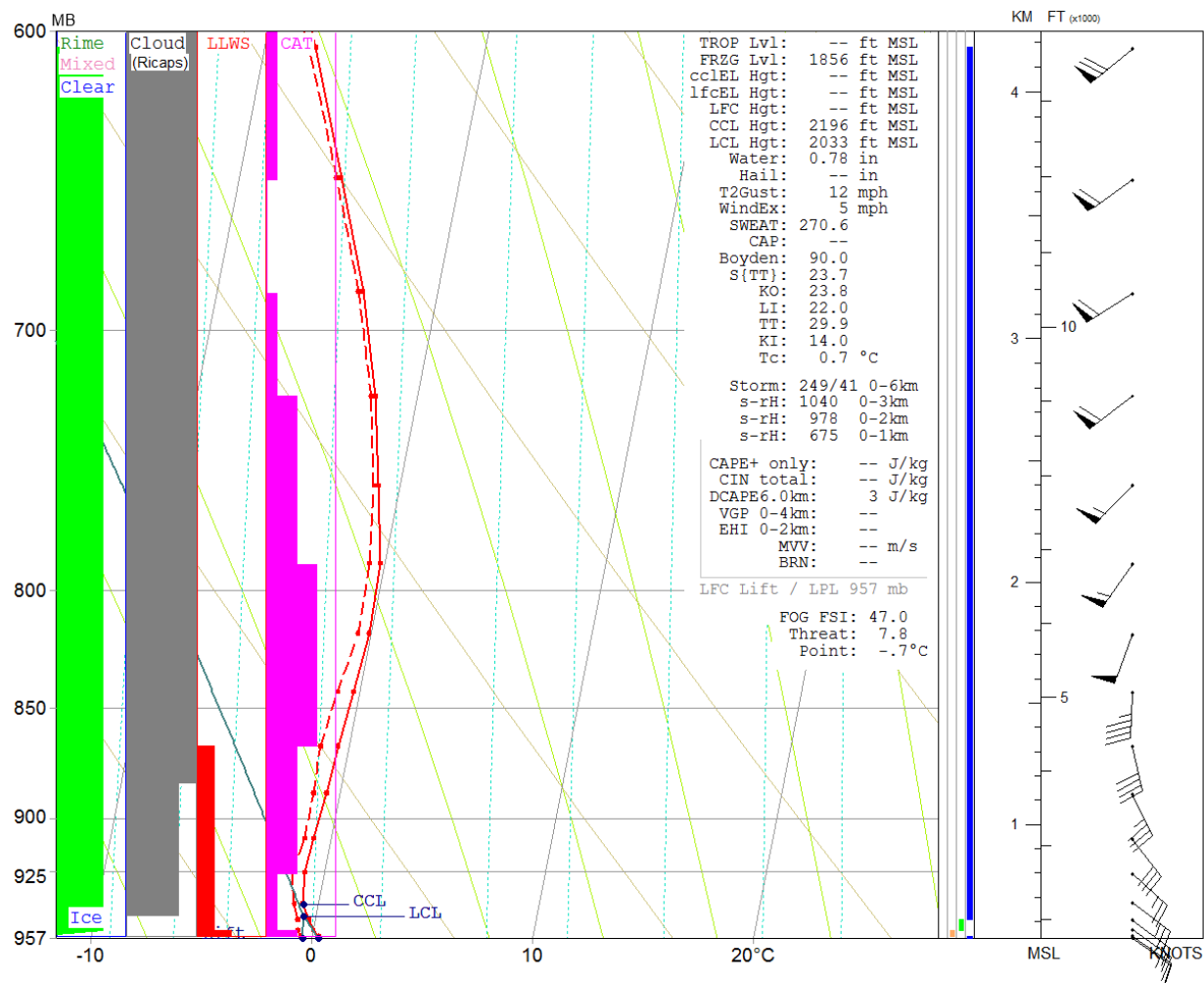


Figure 8 – 1500 EST HRRR sounding

The 1500 EST HRRR sounding indicated a conditionally stable environment from 255 ft agl (2,000 ft msl) through 14,000 ft. RAOB identified the possibility of clouds between 2,000 ft msl through 14,000 ft. Light to moderate rime icing was indicated by RAOB between the surface and 14,000 ft. Icing potential will be further discussed in section 17.0.¹⁶

¹⁶ S.G. Cober, G. A. Isaac, and J. W. Strapp, Characterizations of Aircraft Icing Environments that Include Supercooled Large Drops (Journal of Applied Meteorology, 2001), pp. 1984-2002.

B.C Bernstein, C.A. Wolff, and F. McDonough, An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part I: Canada and the Continental United States (Journal of Applied Meteorology and Climatology, 2007), pp. 1857-1878.

Williams, E.R., D.J. Smalley, M.F. Donovan, R.G. Hallowell, K.T. Hood, B.J. Bennett, R. Evaristo, A. Stepanek, T. Bals-Elsholz, J. Cobb, J. Ritzman, A. Korolev, M. Wolde, Measurements of Differential Reflectivity in Snowstorms in Warm Season Stratiform Systems (Journal of Applied Meteorology and Climatology, 2015), pp. 573-595.

The 1500 EST HRRR sounding wind profile indicated a surface wind from 127° at 10 knots with the wind remaining southeasterly through 4,000 ft msl. The wind increased in speed to 40 knots by 4,000 ft msl. The wind veered¹⁷ to the southwest above 4,000 ft with increasing wind speeds through 14,000 ft. The wind speed was as high as 70 knots by 13,500 ft msl. RAOB indicated the possibility of low-level wind shear (LLWS) between the surface and 4,000 ft. RAOB indicated a high probability of moderate or greater clear-air turbulence between the surface and 11,000 ft msl. At the accident airplane's cruising altitude¹⁸ around 6,900 ft, the sounding indicated a southwest wind at 53 knots with a temperature of -0.2° C, and with a relative humidity of 96%.

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 (μm) and 10.3 μm, respectively, were retrieved for the period from 1000 EST through 1800 EST and reviewed, and the closest images to the time of the accident are documented here.

Figures 9 and 10 present the GOES-16 visible imagery at 1500 and 1507 EST at 2X magnification with the accident site highlighted with a red square. The visible imagery indicated an extensive layer of cloud cover over the accident site moving from southwest to northeast (attachment 1).

Figure 11 presents the GOES-16 infrared imagery from 1502 EST at 4X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site. The lower brightness temperatures (blue and green colors; higher cloud tops) were located above and to the west of the accident site across Pennsylvania and New York. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1500 EST HRRR sounding, the approximate cloud-top heights over the accident site were 34,000 ft at 1502 EST (220° Kelvin). It should be noted these figures have not been corrected for any parallax error.

¹⁷ A change in wind direction with height in a clockwise sense in the Northern Hemisphere

¹⁸ For more information please see the NTSB ATC information in the docket for this accident.

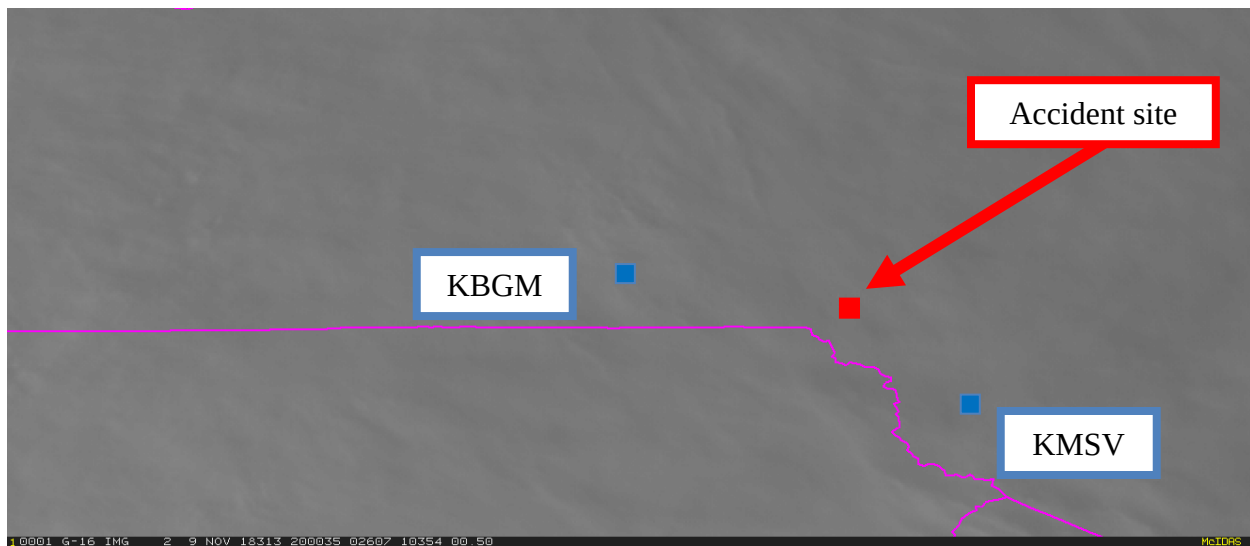


Figure 9 – GOES-16 visible image at 1500 EST

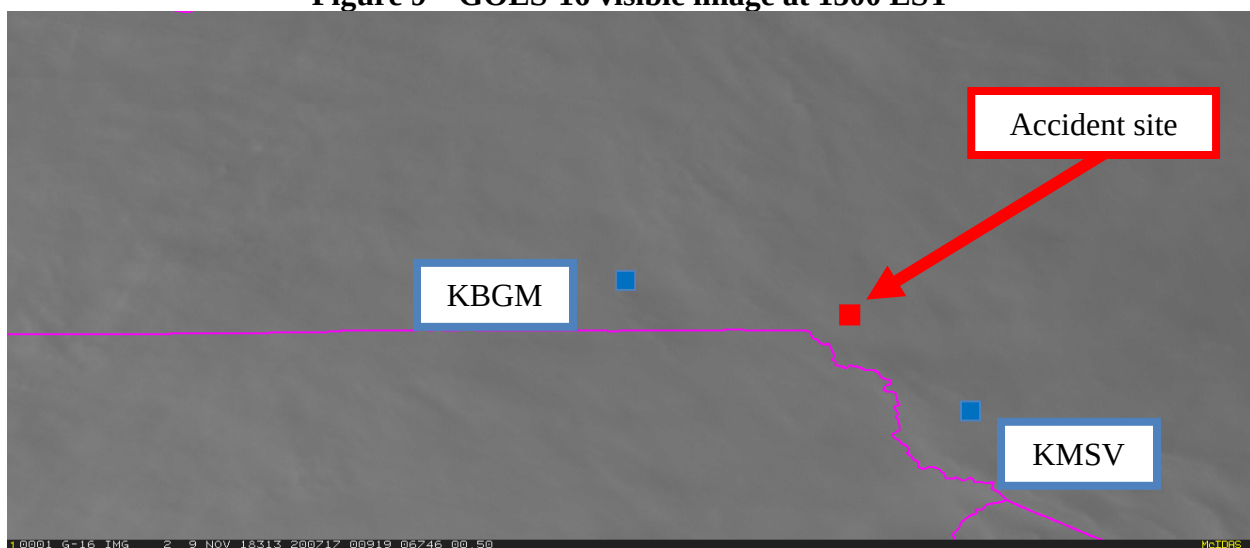


Figure 10 – GOES-16 visible image at 1507 EST

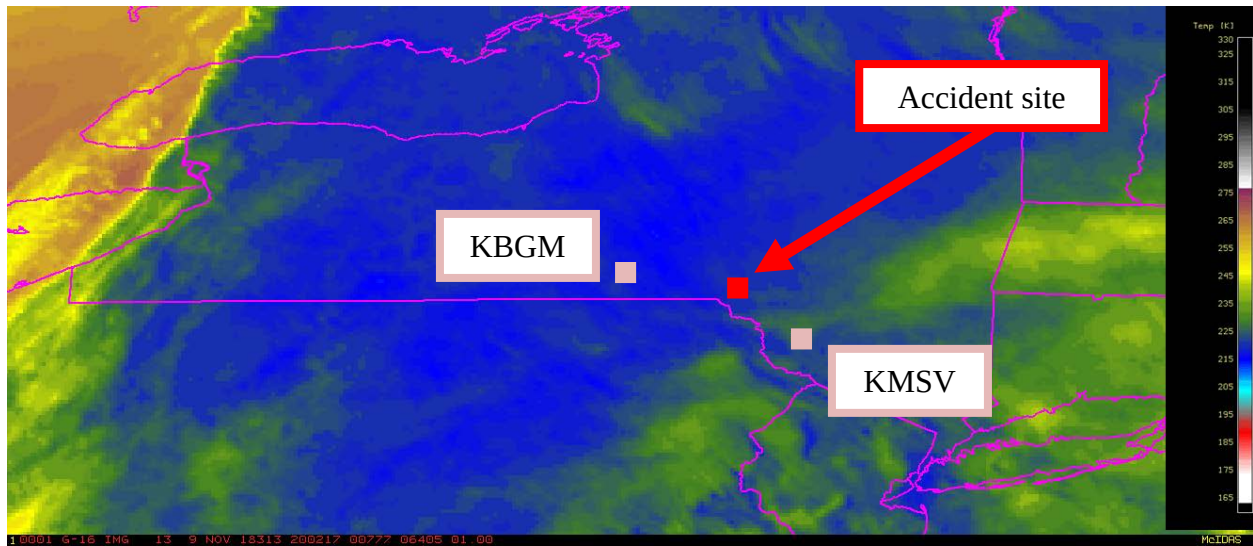


Figure 11 – GOES-16 infrared image at 1502 EST

Figures 12 and 13 are the GOES-16 Icing index analysis for 1445 and 1515 EST from the National Aeronautics and Space Administration (NASA) Langley Research Center Climate Science Branch (LARC-E302). The imagery from 1445 and 1515 EST for the accident area suggested likely moderate or greater icing to heavy icing.¹⁹

¹⁹ Smith, W. L., P. Minnis, C. Fleeger, D. Spangenberg, R. Palikonda, L. Nguyen, 2012: Determining the Flight Icing Threat to Aircraft with Single-Layer Cloud Parameters Derived from Operational Satellite Data (J. Appl. Meteor. Climatol., 51), pp. 1794–1810.

Smith, W. L., Jr, 2014: 4-D cloud properties from passive satellite data and applications to resolve the flight icing threat to aircraft. PhD Dissertation, University of Wisconsin-Madison, 165 pp.

https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?docid=22&lkdomain=Y&domain=ICNG_CONUS_GEW

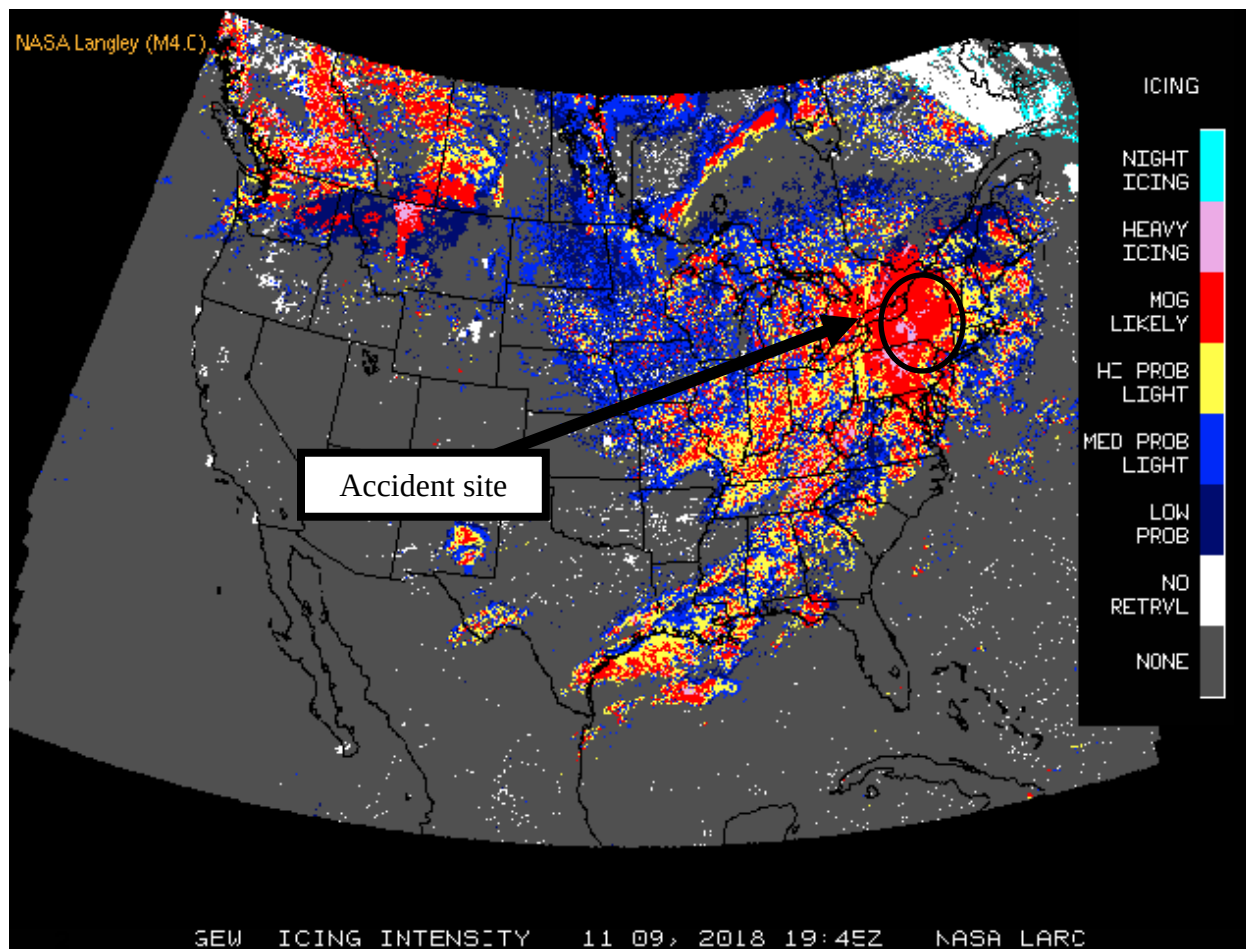


Figure 12 – NASA LARC-E302 GOES-16 icing index image at 1445 EST

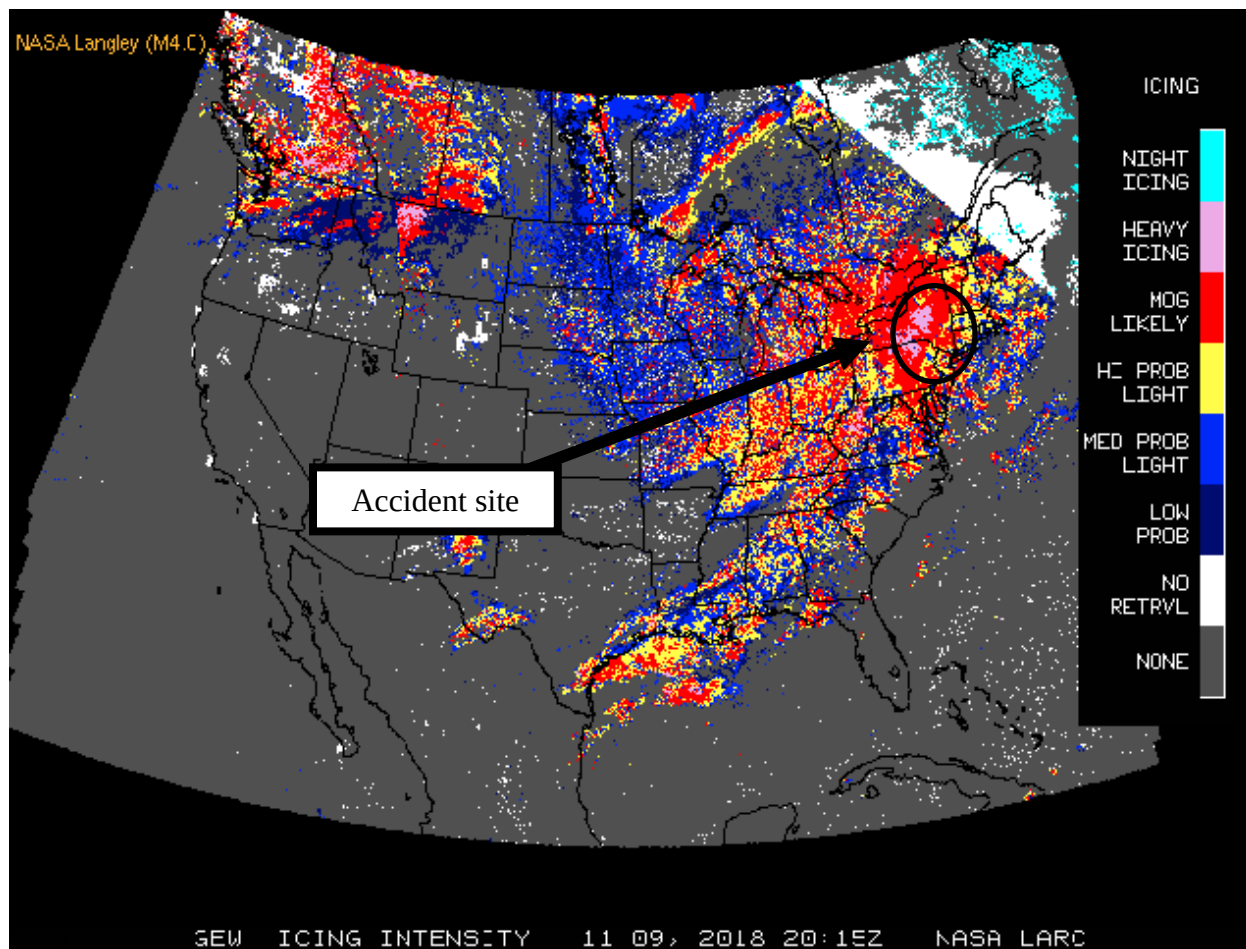


Figure 13 – NASA LARC-E302 GOES-16 icing index image at 1515 EST

6.0 Regional Radar Imagery Information

A regional view of the NWS national composite radar mosaic is included as figure 14 for 1500 EST with the approximate accident site marked by a red circle. The image depicted 20 to 45 decibels (dBZ²⁰) echoes above the accident site.

²⁰ 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.

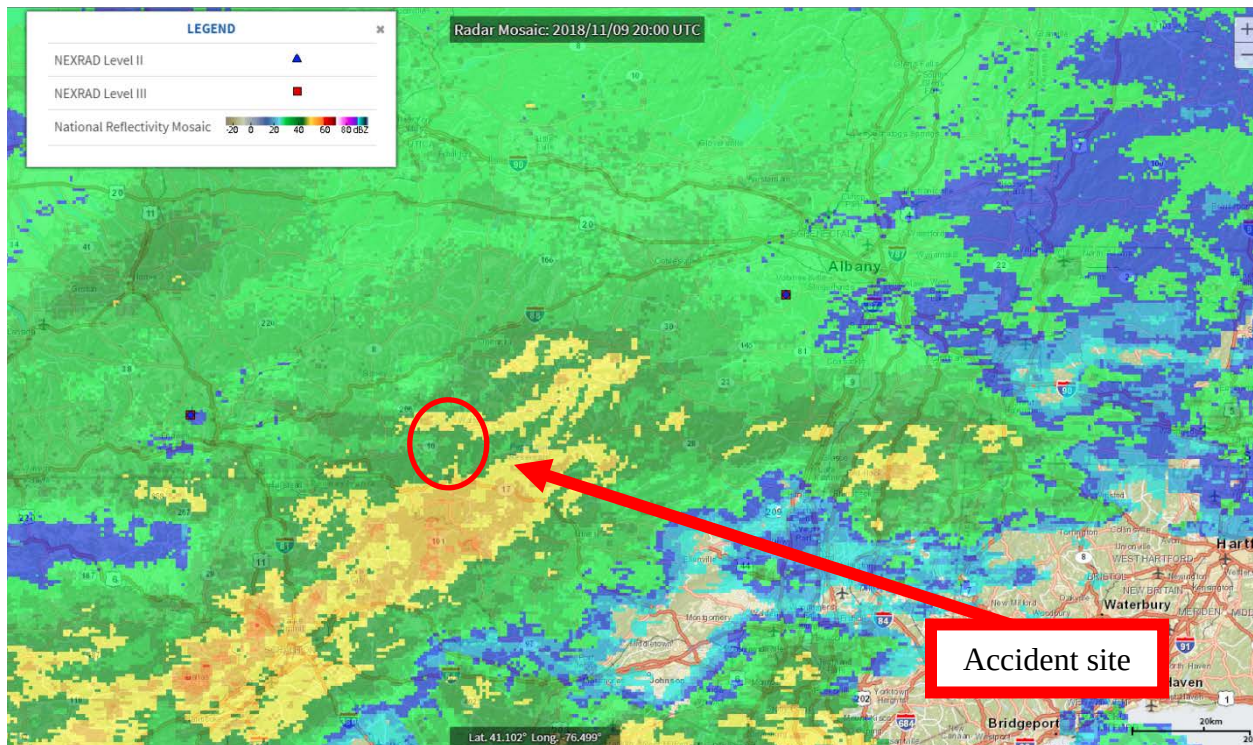


Figure 14 – Regional Composite Reflectivity image for 1500 EST

7.0 Radar Imagery Information

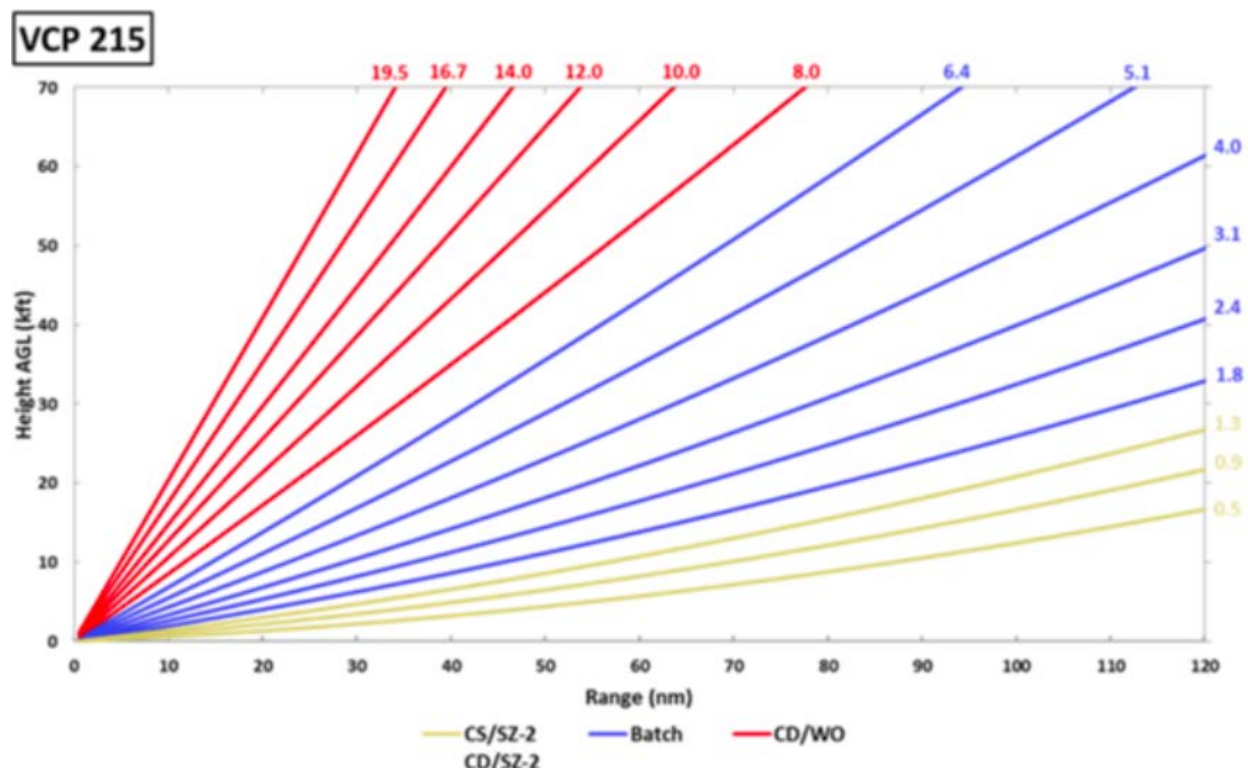
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)²¹ to the accident site was KBGM. Level II and level III archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

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 five to ten-minute volume scan.

²¹ 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 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 15 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 215 (VCP-215). 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 KBGM WSR-88D radar was operating in the precipitation mode VCP-215. 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-215 Precipitation Mode Scan Strategy

7.2 Beam Height Calculation

Assuming standard refraction²² of the WSR-88D radar beam with the antenna elevation at 1,703 ft, and considering a beamwidth²³ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
1.3°	7,400 ft	5,670 ft	9,130 ft

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 1.3° elevation scan depicted the conditions between 5,670 ft and 9,130 ft msl over the accident site and these scans “saw” the closest altitudes to the accident aircraft’s flight level²⁴ before the accident time.

7.3 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 dBZ, and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²⁶, “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:

- 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.

²⁴ For more information please see ATC data located in the docket of 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

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

7.4 Base Reflectivity and Lightning Data

Figures 15, 16, 17, and 18 present the KBGM WSR-88D base reflectivity images for the 1.3° elevation scans initiated at 1451:12, 1457:01, 1502:50, and 1508:39 EST, respectively, with a resolution of 0.5° X 250 m. Reflectivity values between 25 and 45 dBZ were located above the accident site at the accident time and along the accident aircraft's flight track (pink line). The reflectivity bands were moving from southwest to northeast (attachment 2).

There were no lightning strikes around the accident site at the accident time.²⁷

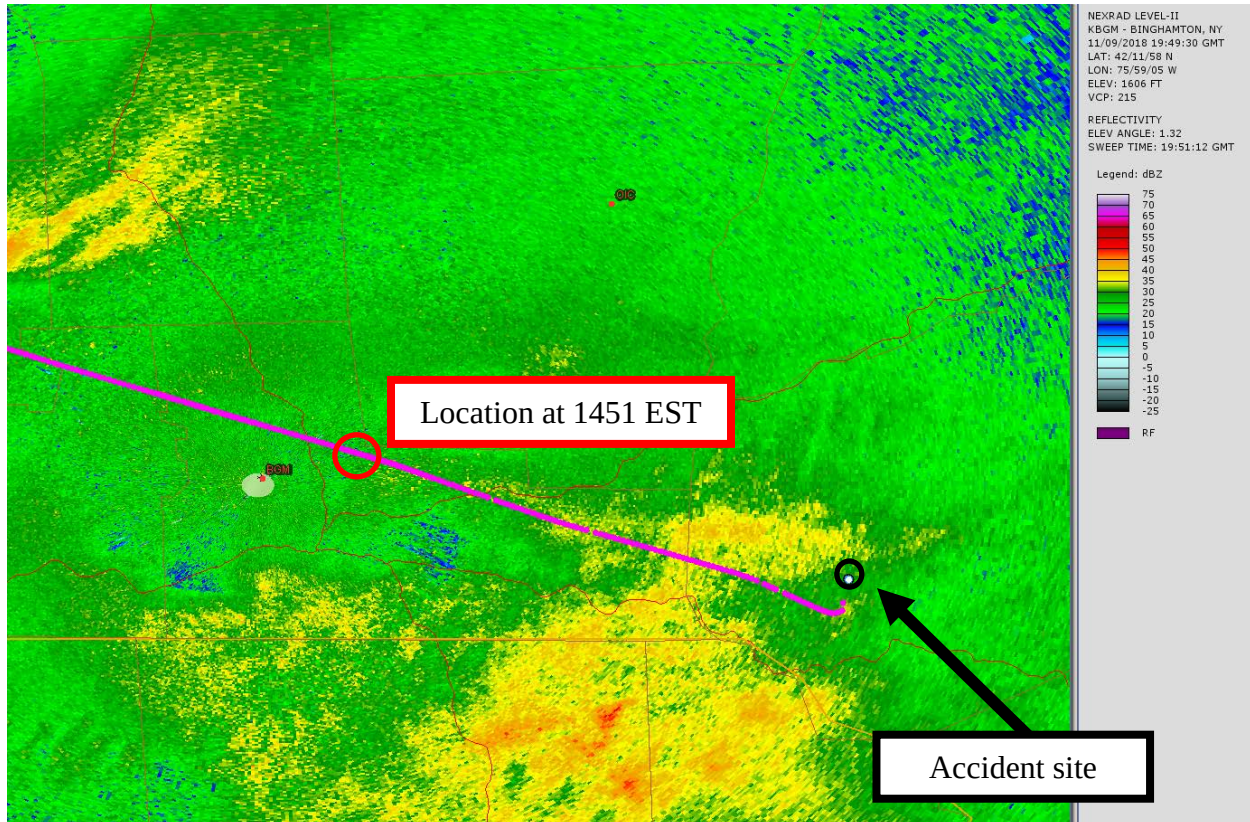


Figure 15 – KBGM WSR-88D reflectivity for the 1.3° elevation scan initiated at 1451:12 EST with the accident site marked with black circle, the accident flight track in pink

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

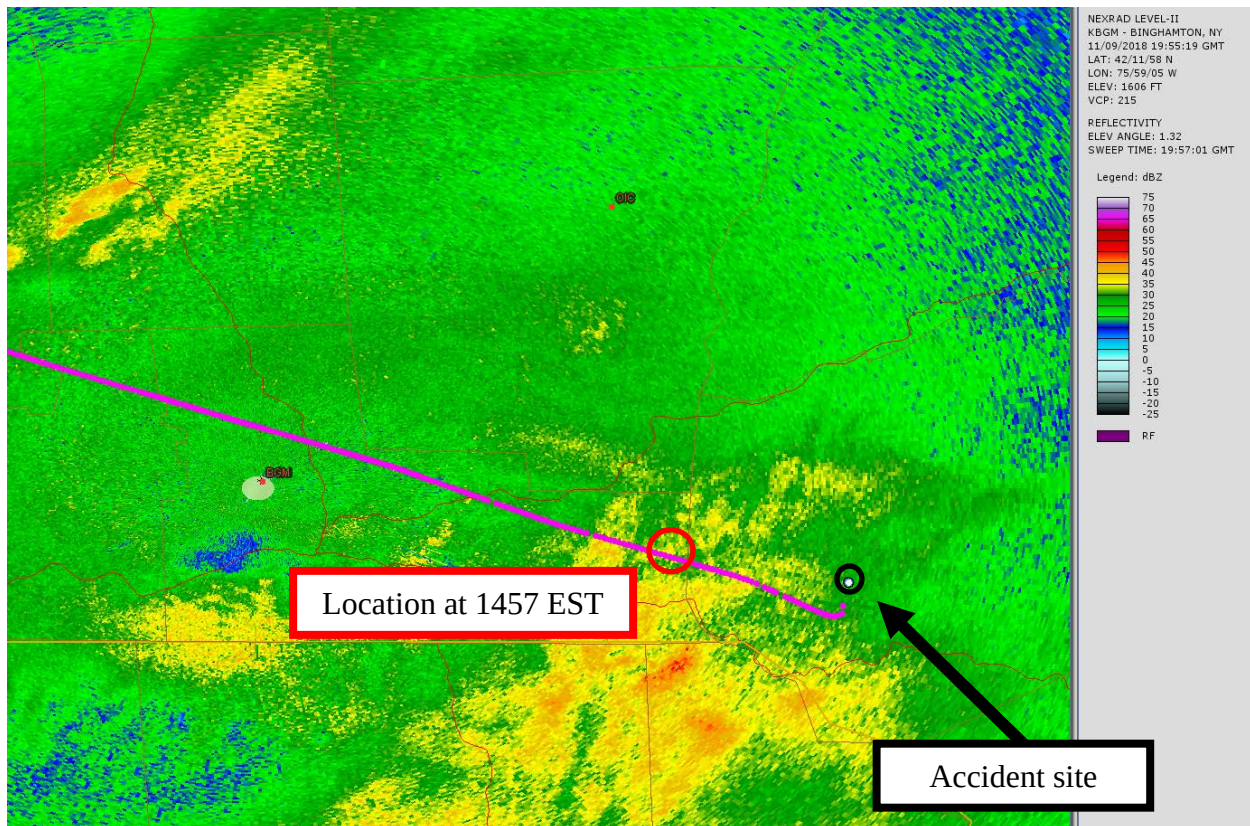


Figure 16 – KBGM WSR-88D reflectivity for the 1.3° elevation scan initiated at 1457:01 EST with the accident site marked with black circle, the accident flight track in pink

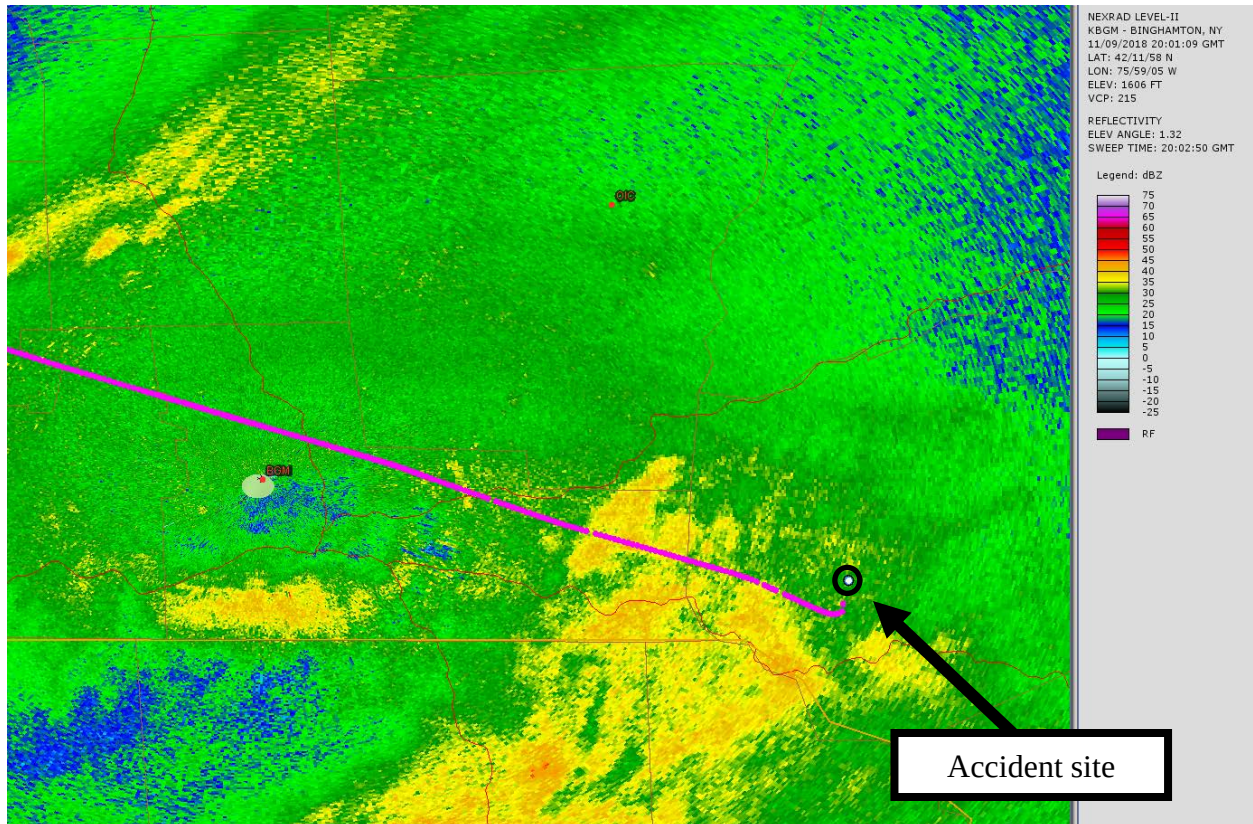


Figure 17 – KBGM WSR-88D reflectivity for the 1.3° elevation scan initiated at 1502:50 EST with the accident site marked with black circle, the accident flight track in pink

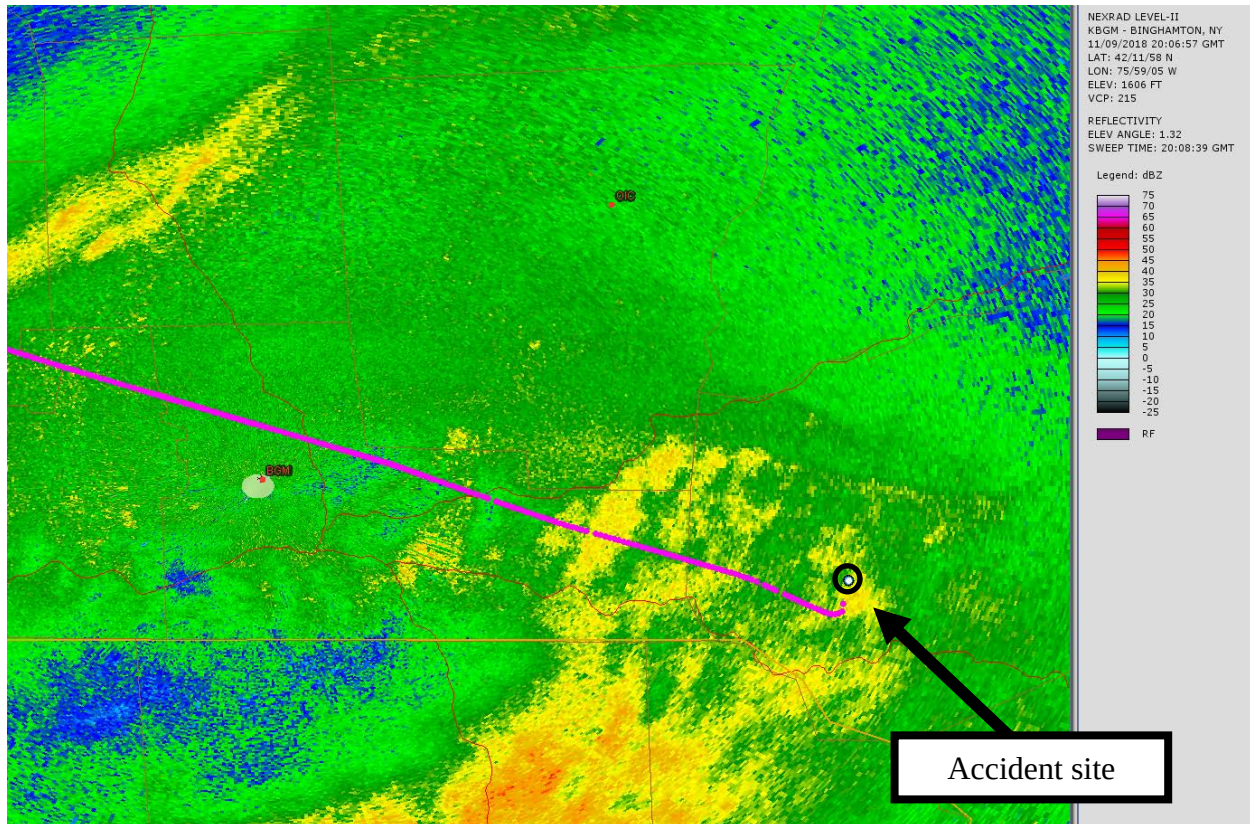


Figure 18 – KBGM WSR-88D reflectivity for the 1.3° elevation scan initiated at 1508:39 EST with the accident site marked with black circle, the accident flight track in pink

7.5 Dual-Pol Products²⁸

The following additional WSR-88D Dual-Polarization Products were utilized in this investigation.

Differential Reflectivity (Zdr) is the logarithm ratio of the horizontal power return to the vertical power return. Positive values of Zdr indicate that there is more horizontal power return than vertical power return.²⁹ A negative value of Zdr indicates that there is more vertical power return than horizontal power return indicating that the dominant hydrometeors are larger in the vertical than in the horizontal.³⁰ Near zero values of Zdr indicate that both the horizontal and vertical power return from within the volume scanned are of similar values, meaning the dominant hydrometeors are similar in size in both the vertical and horizontal.³¹

²⁸ Definitions for Zdr, CC, KDP, and HC adapted from training material from the NWS WDTD.

²⁹ A positive Zdr means that the dominant hydrometeors within the volume are larger in the horizontal than vertical (e.g., rain drops).

³⁰ A negative Zdr correlates to vertically oriented hydrometeors, e.g., vertically oriented crystals or conical graupel.

³¹ A near zero Zdr is often an indication of hail or spherical rain drops.

Correlation Coefficient (CC) is a measure of how similar the horizontal and vertical returned pulse characteristics are among all pulses in the sampled WSR-88D volume. CC provides information about the diversity of hydrometeors within the volume and the values range from 0 to 1.³² Meteorological echoes tend to have CC values greater than 0.80, with values greater than 0.96 indicating that the meteorological targets within the volume are all very similar in size, shape, type (liquid versus solid), and orientation. CC values between 0.96 and 0.80 indicate that the meteorological targets within the volume have a higher diversity of sizes, shapes, types, and orientations as the CC trends lower. If hail is located within the volume scanned the CC values are typically between 0.80 and 0.96. Non-meteorological echoes have CC values less than 0.80 and these non-meteorological echoes can include, but are not limited to, bugs, chaff, smoke and birds.

Specific Differential Phase (KDP) is a measure of the range derivative of the differential phase shift between the horizontal and vertical pulses phases. KDP has possible range values between -2 to 10 in degrees per kilometer. When a radar pulse is sent out and hits meteorological and non-meteorological targets alike, the radar pulse will have a phase shift between the horizontal and vertical pulses. Once we know the KDP value with meteorological targets, along with the other dual-pol parameters, one can tell areas of heavy rain, hail, and different characteristics in snow and ice crystals. KDP values that are large and positive often indicate areas of heavy rain. Areas with hail or snow often have KDP values much closer to 0. For non-meteorological targets, the KDP values are very noisy and difficult to interpret. In fact, for CC values less than 0.90 the KDP is not computed.

Hydrometeor Classification (HC) is a product produced by the hydrometeor classification algorithm and the HC attempts to discriminate between 10 classes of radar echoes at every 250 m range bin. HC ingests reflectivity, Zdr, CC, KDP, and velocity, along with radially averaged and smoothed fields of reflectivity and differential phase. HC then uses the height of the melting layer along with other WSR-88D data and assigns a radar class to each bin with a weighted value. The HC then applies a set of hard thresholds to reduce the number of clearly wrong class designations, and given the weight and likelihood of each of the 10 classes at each bin, the HC assigns the radar classification with the highest likelihood value to that particular bin.

7.6 Dual-Pol Imagery

Figures 19, 20, and 21 present the level III KBGM WSR-88D base reflectivity, Zdr, and CC values for the 1.3° elevation scans initiated at 1449, 1455, and 1501 EST with a resolution of 1° X 1 kilometer.

Figure 19 depicted light echoes in the base reflectivity at the aircraft location at 1449 EST with 25 to 30 dBZ values. The Zdr values were between -0.25 and 0.25 dB, and CC values ranged between 0.98 and 0.99. These values of dual-pol data at the aircraft location and along the flight path indicated small hydrometeor sizes, and/or a small amount of hydrometeors in the beam, hydrometeors that were more spherical shaped as they fell than horizontal, and the majority of the hydrometeors in the scan near the aircraft location 1449 EST had similar characteristics.

³² CC values greater than 1 indicate an untrustworthy signal due to low signal-to-noise ratio in areas of weak reflectivity.

Figure 20 depicted light echoes in the base reflectivity at the aircraft location at 1455 EST with 25 to 35 dBZ values. The Zdr values were between 0.25 and 0.75 dB, and CC values ranged between 0.97 and 0.99. These values of dual-pol data at the aircraft location and along the flight path indicated small hydrometeor sizes, and/or a small amount of hydrometeors in the beam, hydrometeors that were more horizontally shaped as they fell than spherical, and the majority of the hydrometeors in the scan near the aircraft location 1455 EST had similar characteristics

Figure 21 depicted light echoes in the base reflectivity above the accident site with 25 to 35 dBZ values. The Zdr values were between 0.0 and 0.5 dB, and CC values ranged between 0.97 and 0.99. These values of dual-pol data at the aircraft location and along the flight path indicated small hydrometeor sizes, and/or a small amount of hydrometeors in the beam, hydrometeors that were more horizontally shaped as they fell than spherical, and the majority of the hydrometeors in the scan near the aircraft location the accident time had similar characteristics

While the dBZ values remained light and CC values were consistently between 0.97 and 0.99 for the majority of the accident flight track, the Zdr values did range toward more horizontally shaped after 1449 EST. With the higher Zdr values, the accident aircraft would have encountered hydrometeors having a larger surface area in the horizontal dimension rather than the vertical dimension, meaning the hydrometeors were shaped more like pancakes, rather than spherical or tear dropped shaped as the hydrometeors fell.³³ For more information and animations please see attachments 3, 4, and 5.

³³ Ikeda, Kyoko, Roy M. Rasmussen, Edward Brandes, and Frank McDonough, 2009: Freezing Drizzle Detection with WSR-88D Radars (Journal of Applied Meteorology and Climatology, 48), pp. 41-60.

Ikeda, Alexander, Heather Reeves, Terry Schuur, Matthew Kumjian, and Dusan Zrnica, 2011: Investigation of Polarimetric Radar Signatures in Winter Storms and their Relation to Aircraft Icing and Freezing Rain. 35th Conference on Radar Meteorology. Pittsburg, PA, Amer. Meteor. Soc., P13.197.

Williams, E.R., D.J. Smalley, M.F. Donovan, R.G. Hallowell, K.T. Hood, B.J. Bennett, R. Evaristo, A. Stepanek, T. Bals-Elsholz, J. Cobb, J. Ritzman, A. Korolev, M. Wolde, Measurements of Differential Reflectivity in Snowstorms in Warm Season Stratiform Systems (Journal of Applied Meteorology and Climatology, 54), pp. 573-595.

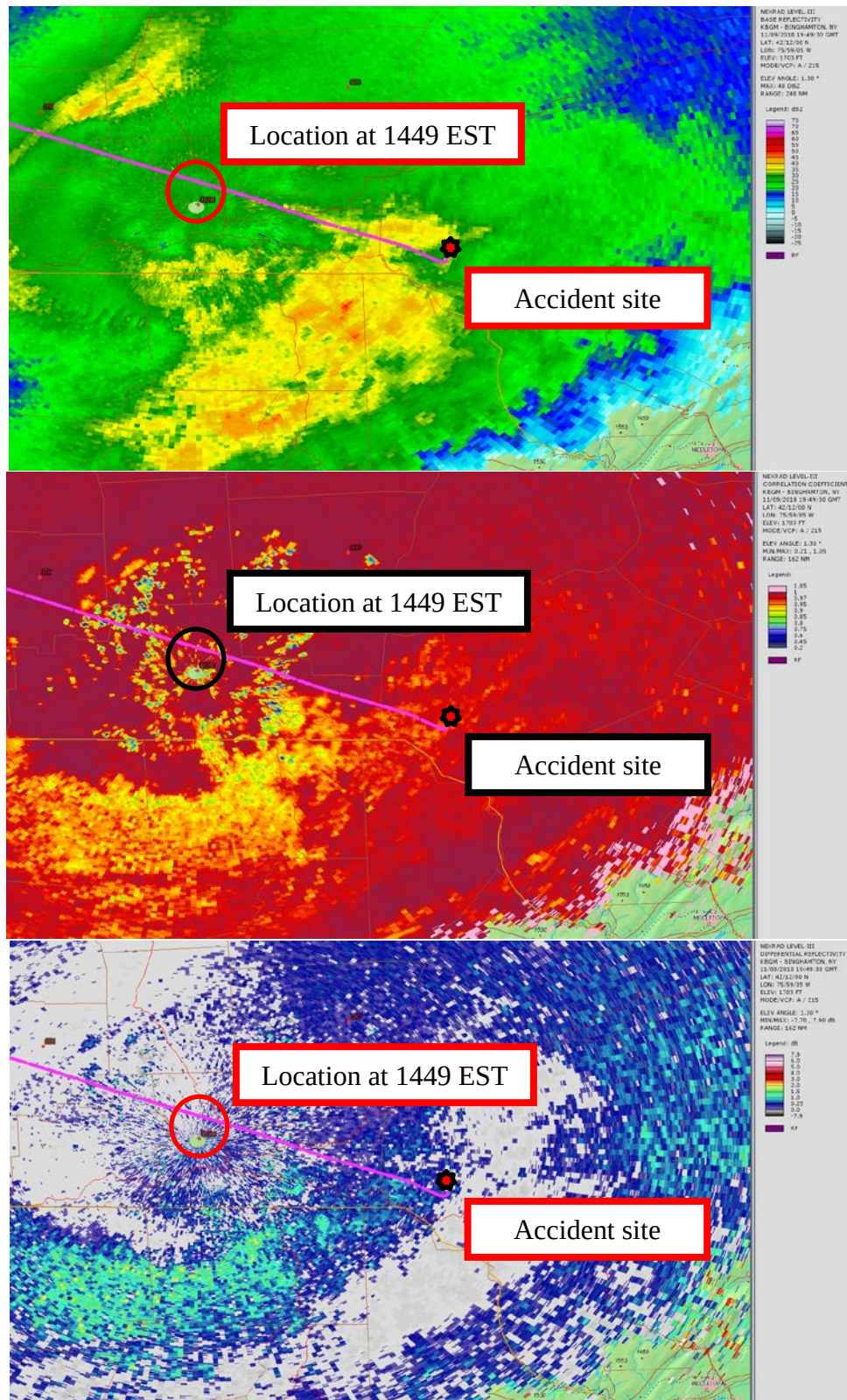


Figure 19 – KBBM WSR-88D 1.3° elevation scan for 1449 EST (a) base reflectivity, (b) CC, and (c) Zdr with the accident site marked with black circle, the accident flight track in pink

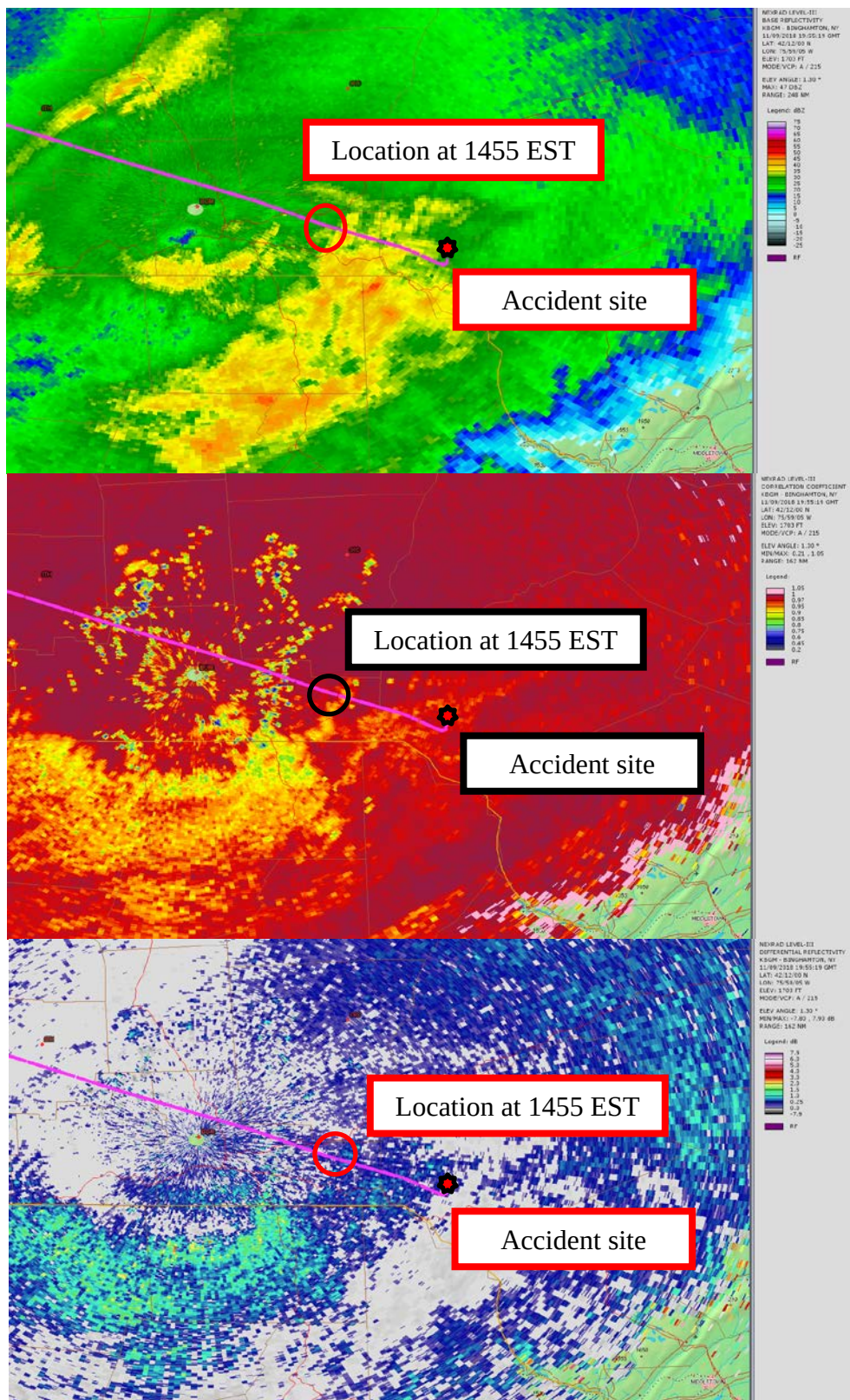


Figure 20 – KBGM WSR-88D 1.3° elevation scan for 1455 EST (a) base reflectivity, (b) CC, and (c) Zdr with the accident site marked with black circle, the accident flight track in pink

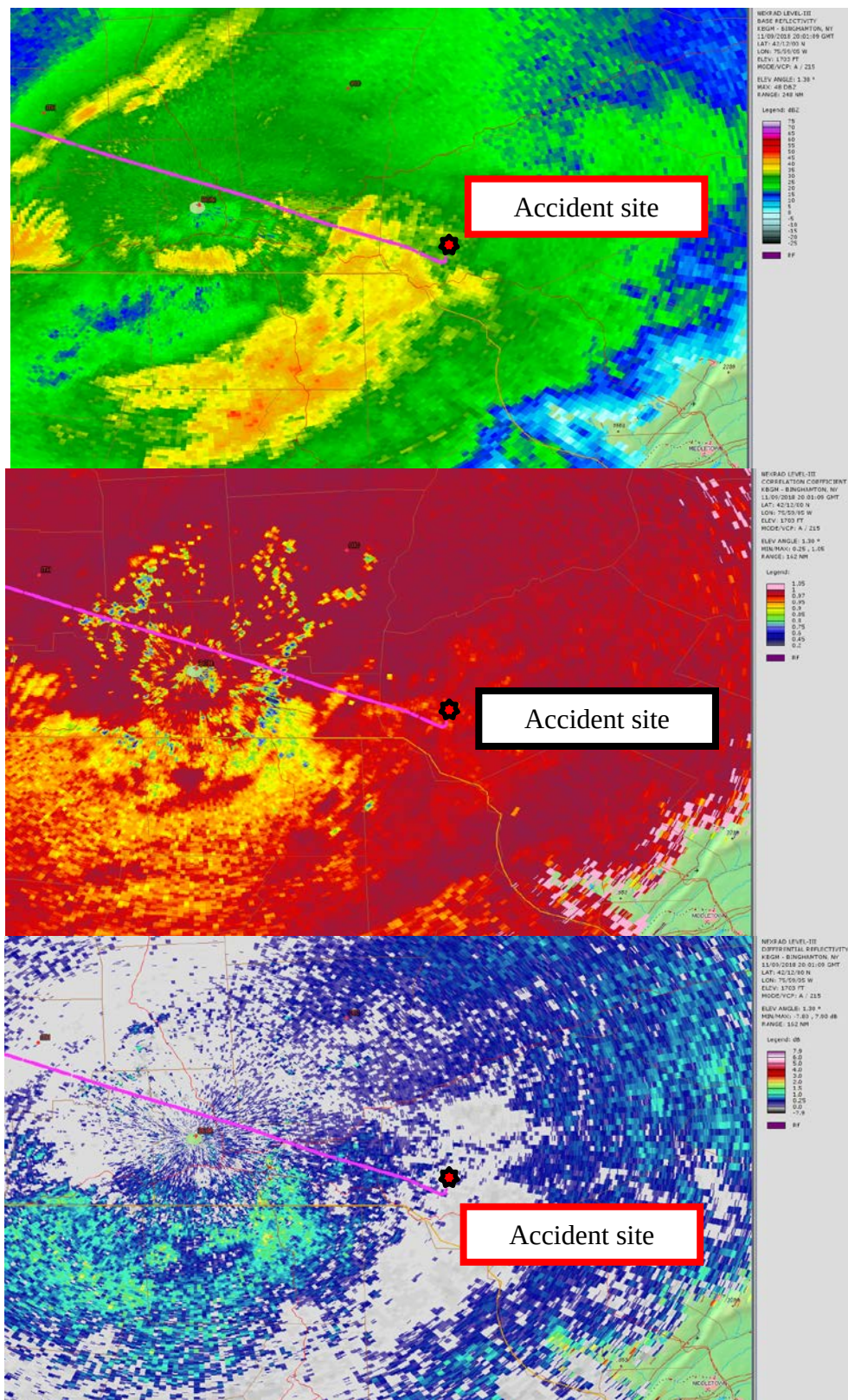


Figure 21 – KBGM WSR-88D 1.3° elevation scan for 1501 EST (a) base reflectivity, (b) CC, and (c) Zdr with the accident site marked with black circle, the accident flight track in pink

8.0 Pilot Reports³⁴

All pilot reports (PIREPs) within 80 miles of the accident site from about three hours prior to the accident time to about two hours after the accident time for below FL200³⁵ are provided below:

SYR UA /OV 5W/TM 1721/FL010/TP CL60/TA 0/IC LGT RIME/RM CL60 LGT RIME FINAL APPROACH BASES 010 TO 1721Z

SYR UA /OV GGT/TM 1739/FL170/TP PC12/TA M12/IC LGT RIME

AVP UA /OV LVZ360010/TM 1850/FL090/TP SR22/TA M01/IC TRACE-090

ALB UA /OV ALB185020/TM 1945/FL045/TP CRJ2/SK BASES045

ALB UA /OV ALB180012/TM 2007/FL030/TP C402/SK IMC/WX -SN

ABE UA /OV KABE300010/TM 2009/FL060/TP SR22/TB LGT-MOD 070/NEG 060/LGT 050

ALB UA /OV ALB191005/TM 2009/FL020/TP C402/RM SNSH

BGM UA /OV DNY/TM 2037/FL180/TP CRJ7/WX NEG RA/RM NEG RA FROM ITH TO DNY DURD FL330-180

SYR UA /OV 20 SW/TM 2049/FL85/TP E145/SK 100/85/TA M03/IC LITE CLR

SMQ UA /OV BWZ315015/TM 2056/FL090/TP E145/TB MOD

ALB UA /OV ALB186018/TM 2104/FL065/TP B737/SK IMC/WX -RA/TA 03/RM OCL LT CHOP

The reports in plain language taken from standard code and abbreviations, with time converted to local were as follows:

Routine pilot report (UA) Syracuse Hancock International Airport, New York (SYR); Over 5 miles west of SYR; Time – 1221 EST (1721Z); Altitude – 1,000 ft; Type aircraft – Bombardier Challenger 600; Temperature – 0° C; Icing – Light rime; Remarks – Bombardier Challenger 600 light rime on final approach with bases at 1,000 ft, temperature 0° C, at 1221 EST.

Routine pilot report (UA) SYR; Over Georgetown, New York (GGG); Time – 1239 EST (1739Z); Altitude – 17,000 ft; Type aircraft – Pilatus PC-12; Temperature – -12° C; Icing – Light rime.

Routine pilot report (UA) Scranton International Airport, Pennsylvania (AVP); Over 10 miles from Wilkes Barre Scranton, Pennsylvania, (LVZ) VORTAC on the 360° radial; Time – 1350 EST (1850Z); Altitude – 9,000 ft; Type aircraft – Cirrus SR22; Temperature – -1° C; Icing – Trace at 9,000 ft.

³⁴ Only pilot reports with the World Meteorological Organization headers UBPA**, UBNY**, UBNJ**, UBMA**, and UBCT** were considered.

³⁵ 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 average 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.

Routine pilot report (UA) Albany International Airport, New York (ALB); Over 20 miles from ALB on the 185° radial; Time – 1445 EST (1945Z); Altitude – 4,500 ft; Type aircraft – Bombardier CRJ-200; Sky – Bases at 4,500 ft.

Routine pilot report (UA) ALB; Over 12 miles from ALB on the 180° radial; Time – 1507 EST (2007Z); Altitude – 3,000 ft; Type aircraft – Cessna 402; Sky – Instrument meteorological conditions (IMCS); Weather – Light snow.

Routine pilot report (UA) Lehigh Valley International Airport, Pennsylvania (ABE); Over 10 miles from ABE on the 300° radial; Time – 1509 EST (2009Z); Altitude – 6,000 ft; Type aircraft – Cirrus SR22; Turbulence – Light to moderate at 7,000 ft, negative at 6,000 ft, light at 5,000 ft.

Routine pilot report (UA) ALB; Over 5 miles from ALB on the 191° radial; Time – 1509 EST (2009Z); Altitude – 2,000 ft; Type aircraft – Cessna 402; Remarks – Snow shower.

Routine pilot report (UA) BGM; Over Delancey, New York (DNY); Time – 1537 EST (2037Z); Altitude – 18,000 ft; Type aircraft – Bombardier CRJ700; Weather – Negative rain; Remarks – Negative rain from Ithaca, New York, (ITH) to DNY during descent from FL330 to 18,000 ft.

Routine pilot report (UA) SYR; Over 20 miles southwest of SYR; Time – 1549 EST (2049Z); Altitude – 8,500 ft; Type aircraft – Embraer ERJ-145; Sky – 10,000 ft; Temperature – -3° C; Icing – Light clear.

Routine pilot report (UA) Somerset Airport, New Jersey (SMQ); Over 15 miles from Schooley's Mountain, New Jersey (BWZ) on the 315° radial; Time – 1556 EST (2056Z); Altitude – 9,000 ft; Type aircraft – Embraer ERJ-145; Turbulence – Moderate.

Routine pilot report (UA) ALB; Over 18 miles from ALB on the 186° radial; Time – 1604 EST (2104Z); Altitude – 6,500 ft; Type aircraft – Boeing B737-700; Sky – IMC; Weather – Light rain; Temperature – 3° C; Remarks – Occasional light chop.

9.0 SIGMET

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

10.0 CWSU Products

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

11.0 AIRMETS

Airmen's Meteorological Information (AIRMET) advisories Sierra, Tango, and Zulu were valid for the accident site at the accident time for below FL200. The AIRMETS warned of IFR conditions due to precipitation, mist, and fog, mountain obscuration conditions due to clouds and precipitation, moderate icing between the freezing level³⁶ and FL200, and moderate turbulence below 10,000 ft:

WAUS41 KPCI 091726 AAA

WA1S

-BOSS WA 091726 AMD

AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 092100

.
**AIRMET IFR...NH VT MA CT NY LO NJ PA OH LE WV MD DC DE VA AND
CSTL WTRS...UPDT**

**FROM 20N MSS TO 30SW YSC TO 30ESE BDL TO 50SSE SBY TO 30E ECG TO
HNV TO HNN TO CVG TO FWA TO 30SE ECK TO 20NW CLE TO 20SSW BUF TO
20ESE YYZ TO 70SSW YOW TO 20N MSS**

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

.
**AIRMET MTN OBSCN...NH VT MA NY PA WV MD VA NC SC GA...UPDT
FROM 30SW YSC TO CON TO HAR TO CLT TO ATL TO GQO TO HNV TO HNN
TO EWC TO JHW TO SYR TO MSS TO 30SW YSC
MTNS OBSC BY CLDS/PCPN. 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
NC SC GA AND CSTL WTRS...UPDT

BOUNDED BY 70WNW PQI-60WSW BGR-140ESE ACK-70S ACK-80ESE CYN-60E
ILM-40SW ILM-40S CAE-30S IRQ-ATL-GQO-HNV-HNN-20WNW AIR-60SW DXO-
20ESE DXO-20NE CLE-30S BUF-20NNW BUF-MSS-YSC-70WNW PQI
CIG BLW 010/VIS BLW 3SM PCPN/BR/FG. CONDS CONTG THRU 03Z.

.
AREA 2...MTN OBSCN ME NH VT MA NY PA WV MD VA NC SC GA...UPDT
BOUNDED BY 70N PQI-MLT-20W ENE-20SE CLT-30SSW SPA-20S ATL-GQO-
HNV-HNN-60E CVG-30SSW BUF-20WSW MSS-50NE MSS-YSC-80NE YQB-70N PQI
MTNS OBSC BY CLDS/PCPN. CONDS CONTG THRU 03Z.

....

WAUS41 KPCI 091445

WA1T

-BOST WA 091445

AIRMET TANGO UPDT 2 FOR TURB AND LLWS VALID UNTIL 092100

.
**AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS**

**FROM 70NW PQI TO 60NE PQI TO 60SW YSJ TO 40E ACK TO 100ESE SIE
TO 30NE GSO TO HNV TO HNN TO 50SW ROD TO 40WNW ERI TO MSS TO YSC
TO 70NW PQI**

MOD TURB BTN FL240 AND FL420. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET TURB...OH LE

FROM 40WNW ERI TO 50SW ROD TO FWA TO DXO TO 40WNW ERI

³⁶ Freezing level between 2,000 and 10,000 ft.

MOD TURB BTN 150 AND FL340. CONDS CONTG BYD 21Z THRU 03Z.

.
**AIRMET TURB...VT MA CT NY LO NJ PA OH LE WV MD DC DE VA NC SC GA
AND CSTL WTRS
FROM 20SW MSS TO 60SE MSS TO 50WSW CON TO 30SSE CYN TO 20E SBY
TO 50SSE DCA TO RDU TO 30SE SPA TO 40SW ODF TO GQO TO HNV TO HNN
TO 40E CVG TO 30WSW BUF TO 20SW MSS
MOD TURB BLW 100. CONDS CONTG BYD 21Z THRU 03Z.**

.
LLWS POTENTIAL...NY PA OH LE WV MD DC VA NC SC GA
BOUNDED BY 20NW SYR-30W SBY-60ENE RDU-CAE-40SW ODF-GQO-HNV-HNN-
ERI-BUF-20NW SYR
LLWS EXP. CONDS CONTG BYD 21Z THRU 03Z.

.
OTLK VALID 2100-0300Z
AREA 1...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA FL AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-60SW YSJ-40E ACK-100ESE SIE-130SE
ILM-180ENE OMN-60NE OMN-50W PZD-GQO-HNV-HNN-60W HNN-30ESE JHW-
30NNE BUF-MSS-YSC-70NW PQI
MOD TURB BTN FL250 AND FL420. CONDS CONTG THRU 03Z.

.
AREA 2...TURB NY LO PA OH LE WV
BOUNDED BY 20NNE BUF-30ESE JHW-60W HNN-CVG-FWA-30SE ECK-40N CLE-
20NNE BUF
MOD TURB BTN 150 AND FL340. CONDS CONTG THRU 03Z.

.
AREA 3...TURB PA WV MD VA
BOUNDED BY 40ENE EWC-20SE PSB-20W DCA-40WSW RIC-30NNW CLT-HNV-
BKW-30SW EKN-40ENE EWC
MOD TURB BLW 060. CONDS DVLPG 21-00Z. CONDS CONTG THRU 03Z.

.
AREA 4...TURB ME NH VT MA RI CT NY LO NJ PA LE WV MD DC DE VA NC
AND CSTL WTRS
BOUNDED BY 20N MSS-BGR-80SE BGR-80ENE ACK-20WSW ORF-30E CLT-
30NNW CLT-40WSW RIC-20WNW DCA-20SE PSB-40ENE EWC-50S YYZ-20N MSS
MOD TURB BLW 100. CONDS CONTG THRU 03Z.

....

WAUS41 KPCI 091445
WA1Z
-BOSZ WA 091445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 092100

.
AIRMET ICE...NY LO PA OH LE WV
FROM 40ENE YYZ TO 30NNE ERI TO HNN TO CVG TO FWA TO 30SE ECK TO
40ENE YYZ
MOD ICE BTN FRZLVL AND 160. FRZLVL SFC-040. CONDS CONTG BYD 21Z
THRU 03Z.

.
**AIRMET ICE...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS
FROM 50ESE YQB TO 20SE MLT TO 110SE BGR TO 110SE ACK TO 90ESE SIE
TO 30W EMI TO 40NNE EKN TO HNN TO 20NNE ERI TO 40ENE YYZ TO 30SE
YOW TO YSC TO 50ESE YQB
MOD ICE BTN FRZLVL AND FL200. FRZLVL 020-100. CONDS CONTG BYD 21Z**

THRU 03Z.

.
AIRMET ICE...NY NJ PA OH WV MD DC DE VA NC SC GA AND CSTL WTRS
FROM 40NNE EKN TO 30W EMI TO 20SE SIE TO 90ESE SIE TO 40NE ORF TO
30NW IRQ TO 30S LGC TO GQO TO HNV TO HNN TO 50W HNN TO HNN TO
40NNE EKN
MOD ICE BTN FRZLVL AND FL240. FRZLVL 080-130. CONDS CONTG BYD 21Z
THRU 03Z.

.
OTLK VALID 2100-0300Z
AREA 1...ICE OH
BOUNDED BY 40SSE FWA-30SE APE-60W HNN-CVG-40SSE FWA
MOD ICE BTN FRZLVL AND 100. FRZLVL SFC-020. CONDS DVLPG AFT 00Z.
CONDS CONTG THRU 03Z.

.
AREA 2...ICE ME NH VT MA RI CT NY NJ PA OH WV MD DC DE VA NC SC
GA FL AND CSTL WTRS
BOUNDED BY 60SW ACK-40ENE ORF-30ENE GSO-50E ATL-30S PZD-80SSE
CEW-90SSW CEW-40W CEW-50SW PZD-GQO-50NW HNV-40NNE HNN-60SW ACK
MOD ICE BTN FRZLVL AND FL220. FRZLVL 050-130. CONDS CONTG THRU
03Z.

.
AREA 3...ICE NY LO PA OH LE WV MD VA
BOUNDED BY 50S YOW-50S SYR-20SW HAR-40NNE HNN-HNN-60W HNN-30SE
APE-20W ROD-FWA-30SE ECK-50ENE YYZ-50S YOW
MOD ICE BTN FRZLVL AND 120. FRZLVL SFC-060. CONDS CONTG THRU 03Z.

.
AREA 4...ICE ME NH VT MA RI CT NY LO NJ PA OH LE WV MD AND CSTL
WTRS
BOUNDED BY 70NW PQI-40ENE PQI-150ENE ACK-60SW ACK-20SW HAR-50S
SYR-50S YOW-YSC-70NW PQI
MOD ICE BTN FRZLVL AND FL200. FRZLVL 020-100. CONDS CONTG THRU
03Z.

.
FRZLVL...RANGING FROM 010-120 ACRS AREA
MULT FRZLVL 050-080 BOUNDED BY 70NW PQI-60NE PQI-40W YSJ-40E
YQB-70NW PQI
MULT FRZLVL 030-080 BOUNDED BY 30NW ALB-20WSW JFK-30SE HAR-
50SW JST-20SSW EWC-50SW APE-30N ROD-20N CLE-20WSW JHW-
50ENE SLT-30NW ALB
MULT FRZLVL 030-080 BOUNDED BY 50NNE ENE-110SSW YSJ-150ENE
ACK-20SSW PVD-20WSW JFK-30NW ALB-20SSE MPV-50NNE ENE
040 ALG 50E CVG-30SE CLE-40SSW ERI-50WSW SLT-110SSE BGR-110SE
BGR
080 ALG 30S HNN-40S AIR-20SSE HAR-20ENE JFK-140E ACK

....

12.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident flight are shown in attachment 6. The GFA surface forecast products indicated a mix of IFR and LIFR visibilities as there was likely (greater than 60 percent chance) light snow and a mix of rain and snow showers across southcentral New York at 1600 EST with VFR³⁷ conditions forecast for 1300 EST. The surface wind was indicated to be between 5 and 10 knots from the southeast. The GFA cloud forecast valid at 1600 EST indicated overcast skies at 2,500 ft west of KBGM with layered clouds through 9,000 ft and cirrus clouds above. East of KBGM the GFA forecast overcast skies at 8,000 ft with clouds tops at 10,000 ft and cirrus clouds above. For more information please see attachment 6.

The reason for the differences between the GFA surface forecast and the GFA cloud forecast is the two are computed automatically by two different weather models. The Rapid Refresh (RAP) weather model is used for the cloud forecast and the Localized Aviation MOS³⁸ Program (LAMP) weather model is used for the surface forecast charts, and both forecasts are issued with no human intervention. The only human-generated information reflected in the two GFA products are the AIRMETs and the GFA is “human-over-the-loop.”

13.0 Terminal Aerodrome Forecast

KBGM was the closest airport to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The KBGM TAF valid at the time of the accident was issued at 1245 EST and was valid for a 24-hour period beginning at 1300 EST. The TAF for KBGM was as follows:

TAF KBGM 091745Z 0918/1018 **14010G18KT 2SM -SN BR BKN008 OVC012**
TEMPO 0918/0921 3SM -SN BR SCT008 OVC012
FM092100 14010G18KT 3SM -RA BR OVC007
FM100400 22007KT P6SM OVC008
FM100600 26008KT P6SM OVC025
FM101200 27012G25KT P6SM BKN035=

Between 1300 and 1600 EST, the forecast expected a wind from 140° at 10 knots with gusts to 18 knots, 2 miles visibility, light snow and mist, a broken ceiling at 800 ft agl, and overcast skies at 1,200 ft agl. Temporary conditions between 1300 and 1600 EST of 3 miles visibility, light snow and mist, scattered clouds at 800 ft agl, and an overcast ceiling at 1,200 ft agl were expected.

14.0 NWS Area Forecast Discussion

The NWS office in Binghamton, New York, issued the following Area Forecast Discussion (AFD) at 1300 EST (closest AFD to the accident time). The aviation section of the AFD discussed a rain/snow mix across the region during the afternoon with occasional IFR conditions. Gusts to 18 knots were also discussed:

FXUS61 KBGM 091800

³⁷ Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 5 miles visibility.

³⁸ Model Output Statistics: https://www.weather.gov/mdl/mos_home

AFDBGM

Area Forecast Discussion
National Weather Service Binghamton NY
100 PM EST Fri Nov 9 2018

.SYNOPSIS...

A cool and wet low pressure system will bring rain to the region with some snow as well at higher elevations. This will be followed by a cold weekend, including strong west winds and scattered snow showers and flurries Saturday, and lake effect snow in parts of central New York Saturday night and Sunday.

&&

.NEAR TERM /THROUGH TONIGHT/...

1045 am update... As of late morning, precipitation is spreading across CNY/NEPA, about on schedule. Much of it has started as snow, or perhaps a rain/snow/sleet mix. We still anticipate at least a couple of hours of snow at the onset for the higher elevations, with a rain/snow mix in the valleys. Precipitation should trend towards rain by mid to late afternoon area-wide. The latest model soundings and meso-net profiles support this scenario. A coating-2" of snow on grassy surfaces is anticipated for many areas, particularly the higher terrain, with roadways staying just wet (road network temperatures in the 36-40 range). For the southern Tug Hill region, where the cold air is a bit deeper, 2-4" of snow is not out of the question.

As mentioned earlier, a period of steady rain is still in the cards from later this afternoon into the early evening, before a dry slot rotates in from the southwest and cuts off the steadier precipitation. Most model guidance still points to 0.75-1" of rain in our far southeastern zones (parts of NEPA and Sullivan County, NY). Although no significant hydro problems are foreseen, we'll still have to watch this area, as wet antecedent conditions and potential leaf clogging could lead to minor runoff issues.

By late afternoon, highs should range from the mid 30s-lower 40s.

Previous discussion... 300 AM Update... A chilly wet low pressure system will impact the area mostly with a solid dose of rain but also some wet snow, mainly at higher elevations.

Things are fairly quiet at this early hour, as the edge of departing high pressure still has some sway. Lake cloud leftovers can still be found along the NY Thruway as well as a band falling apart over the Central Twin Tiers. Elsewhere some clear sky can be found, but regardless, high clouds are starting to advance and will overspread and thicken across the region.

In response to an upper trough digging into the upper Midwest, a surface low now making its way towards the Ohio Valley will deepen while tracking into Southern Ontario. Meanwhile a

secondary low will make its way up the MidAtlantic Coast. Between the two lows, an inverted trough will swing through our region along with diffluent flow aloft, jet support, and deep moisture. We can thus expect steady precipitation to overspread the region midday through afternoon. It will persist this evening, but gradually pull out from southwest to northeast overnight tonight. Towards dawn Saturday, Lake Erie will try to throw the first of what will be more lake effect snow showers towards northwestern Steuben-Yates-Seneca counties.

Anticyclonic flow around the departing high will keep a cool air feed going via southeasterly low level flow, which will make precipitation type very tricky. Wetbulbing will also occur as the precipitation falls, dipping the temperature down closer to the dewpoint during what would ordinarily be peak heating hours. All told, mostly a cold rain but perhaps some wet snow during the onset, and for higher elevations it could actually persist for a time before becoming all rain. As the low pressure approaches and pressure gradient increases, the southeast wind could get fairly stiff especially higher elevations of Central New York, and flow-aligned drainages of the Finger Lakes region. Sustained 15-20 mph with gusts to 30 mph will be possible in those areas.

Precipitation amounts will range from about a half inch in the Finger Lakes to three quarters of an inch or so. However, higher elevations of Northeast PA, especially Poconos, and into the Catskills as well as northern Oneida County in NY will be closer to a full inch. Those same locations could actually have a decent burst of moderate rain between 4-8pm, during which leaf-clogged drains and other areas of poor drainage could easily have some ponding. As for snow, very touchy but 2 to 3 inches of wet snow accumulation may occur at highest elevations of western Steuben-Yates as well as the western Catskills and parts of the Southern Tug Plateau. Generally from the Twin Tiers northward, light slushy higher terrain accumulations will be possible especially above 1400 feet elevation.

&&

.SHORT TERM /SATURDAY THROUGH SUNDAY NIGHT/...

A cold west-northwest flow in the wake of a departing cyclone will pull lake effect snow showers into portions of Upstate NY on Saturday. The snow showers will be most persistent along the I-90 corridor near Syracuse and Utica, and are expected to extend into Northern Chenango and Otsego Counties.

The upper level trough associated with this storm system will push unseasonably cold air into our forecast area. Temperatures will peak in the middle-30s Saturday afternoon.

A few inches of snow will accumulate in persistent bands by Sunday morning.

Lake effect snow showers will diminish and lift north on Sunday as a high pressure system slides through the Ohio Valley. It

will remain quite cool, with temperatures in the middle or upper-30s.

&&

.LONG TERM /MONDAY THROUGH FRIDAY/...

A cold and wintry pattern is forecast for much of next week as a deep Canadian trough digs into the Great Lakes and pours cold air into NY and PA.

Light lake effect snow showers will come to an end over Northern NY on Monday when winds shift ahead of a developing cyclone ejecting out of the Southeastern U.S. A mix of rain and snow will spread across the forecast area Monday night, with snow expected to be most persistent over the high terrain east of I-81. A few inches of snow is forecast over our eastern forecast area.

The precipitation will change to rain diurnally on Tuesday before the cyclone moves to our east, opening the flood gates for much colder air to flow down from Canada. Lake effect snows will become more widespread Tuesday night, especially from Onondaga County into Madison and Oneida.

Very chilly air will persist into Wednesday and Thursday, with lake effect snow showers continuing downwind of Lake Ontario.

&&

.AVIATION /18Z FRIDAY THROUGH WEDNESDAY/...

Two low pressure systems one moving through the central Great Lakes and another along the coast will spread a rain/snow mix across the terminals this afternoon which will transition to rain by late afternoon then end late this evening. In general conditions will lower into the Alternate Required category this afternoon with KBGM/KELM occasionally IFR. This evening conditions will vary between Alternate Required and IFR in light rain then improve late tonight into the MVFR/low VFR category once the wind shifts to the southwest. On Saturday low VFR conditions are anticipated.

E/SE winds around 10 knots gusting to 15-18 knots becoming S/SW this evening around 7-10 knots then westerly on Saturday at 10-15 knots with gusts 25-30 knots.

Outlook...

Saturday night through Sunday...Lake effect snow restrictions expected for KSYR-KRME, especially Saturday night through early Sunday; perhaps briefly at KITH. Otherwise VFR.

Sunday night through Monday...Mainly VFR.

Monday night through Tuesday...Restrictions in rain or snow.

Tuesday night through Wednesday...Restrictions likely in snow

showers.

&&

.BGM WATCHES/WARNINGS/ADVISORIES...

PA...None.

NY...None.

&&

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15.0 Winds and Temperature Aloft Forecast

The NWS 0856 EST Winds and Temperature Aloft forecast valid for the closest points to the accident site are included below:

FBUS31 KWN0 091356

FD1US1

DATA BASED ON 091200Z

VALID 091800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
AVP	1333	1947+03	2247+02	2249-04	2360-15	2368-27	249243	751454	762464
ALB	1325	1723-01	1943-06	2257-04	2361-17	2578-29	751245	753355	762864

The accident site was between the AVP and ALB forecast point. The 0856 EST AVP forecast for use between 0900 EST and 1600 EST indicated a wind at 3,000 ft from 130° at 33 knots, a wind at 6,000 ft from 190° at 47 knots with a temperature of 3° C, and a wind at 9,000 ft from 220° at 47 knots with a temperature of 2° C. The ALB forecast indicated a wind at 3,000 ft from 130° at 25 knots, a wind at 6,000 ft from 170° at 23 knots with a temperature of -1° C, and a wind at 9,000 ft from 190° at 43 knots with a temperature of -6° C.

16.0 Pilot Weather Briefing and Witness Information

The accident pilot did not request a weather briefing from Leidos.

A search of archived ForeFlight information indicated that the accident pilot did not request weather information via ForeFlight. There is no record of the accident pilot receiving or retrieving any other weather information before or during the accident flight.

17.0 Icing Potential³⁹

Current Icing Potential (CIP) and Forecast Icing Potential (FIP) products are created by the NWS Aviation Weather Center (AWC) and are intended to be supplemental to other icing advisories (e.g. AIRMETs and SIGMETs). Figures 22 through 24 were the FIP icing probabilities and icing severity products, 1-hour forecast valid at 1500 EST at 6,000, 7,000, and 8,000 ft msl (similar FIP values are seen in the 2-hour forecast valid at both 1400 and 1500 EST, attachment 7). The FIP images indicated between a 30 to 70% probability of icing at 6,000 to 8,000 ft at 1500 EST above the accident site (figures 22, 23, and 24). The FIP also indicated that the icing near the accident site would likely be light to moderate (figures 22, 23, and 24). The FIP indicated an unknown probability of Supercooled Large Droplets (SLD) over the accident area around the accident time on the SLD composite imagery (attachment 7). FIP information was publicly available on the NWS AWC website before the accident flight departed.⁴⁰

The CIP product indicated between a 20 to 50% probability of icing at 6,000 to 8,000 ft at 1500 EST at the accident site (figures 25, 26, and 27). The CIP also indicated that the icing near the accident site would likely be trace to moderate intensity between 6,000 and 8,000 ft (figures 25, 26, and 27). The CIP also indicated an unknown probability of SLD near the accident site at 1500 EST between 6,000 and 8,000 ft (attachment 7). For more FIP and CIP data please see attachment 7.

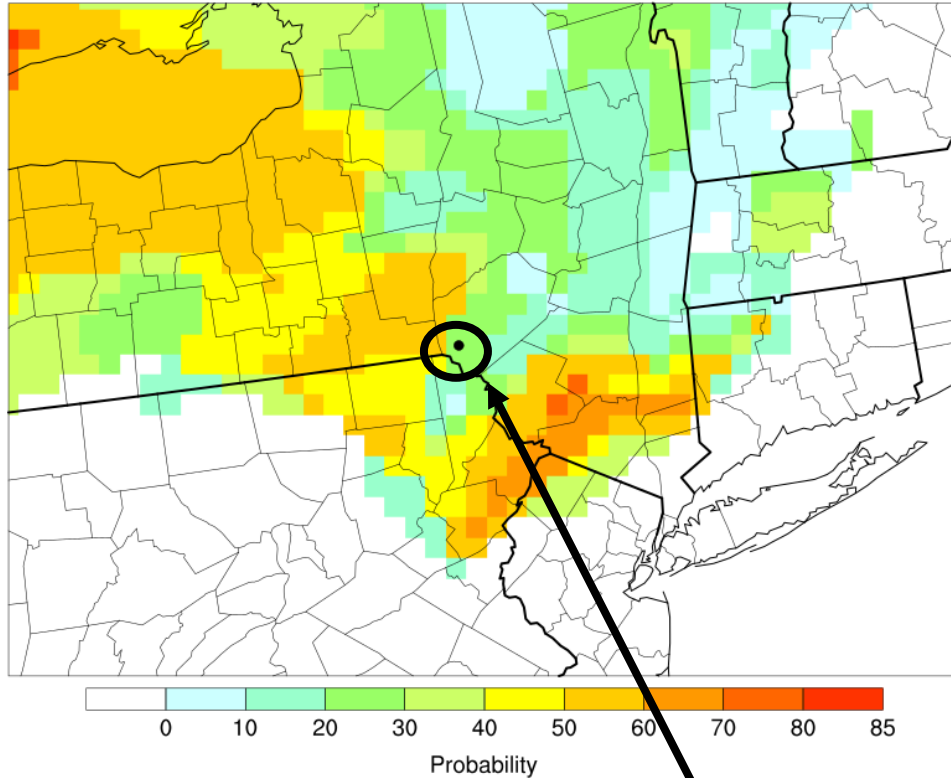
³⁹ B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cuning, Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations (Journal of Applied Meteorology, 2005), pp. 969-986.

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>

⁴⁰ <https://www.aviationweather.gov/icing/fip>

ICING PROBABILITY at FL 060 01 Hour forecast valid at: 11/9/2018 2000 UTC



ICING SEVERITY at FL 060 01 Hour forecast valid at: 11/9/2018 2000 UTC

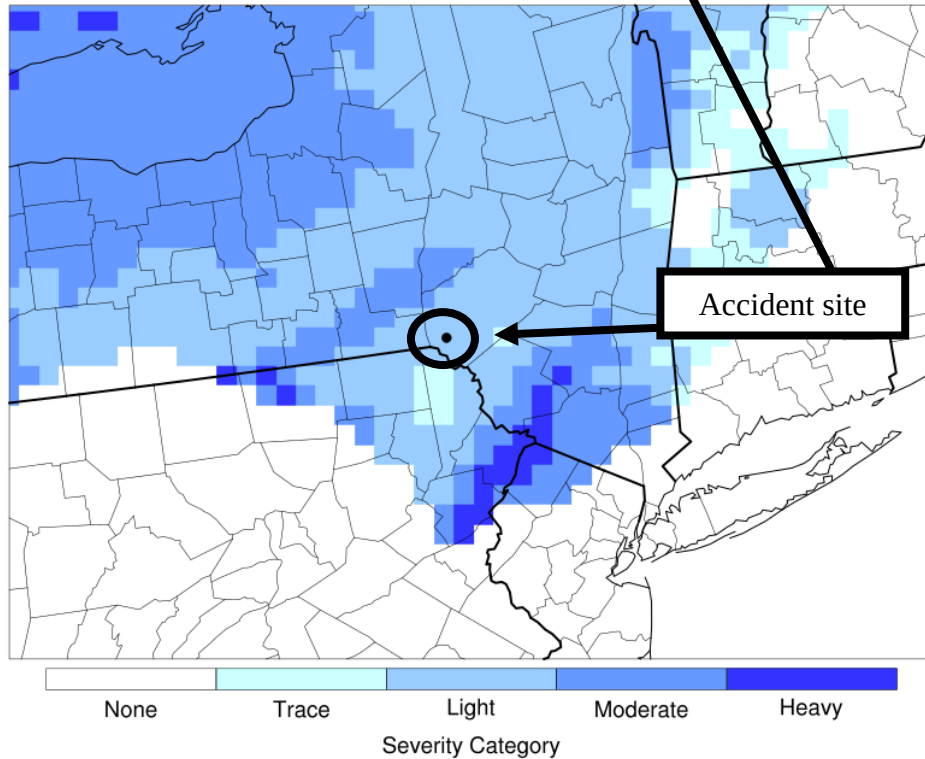
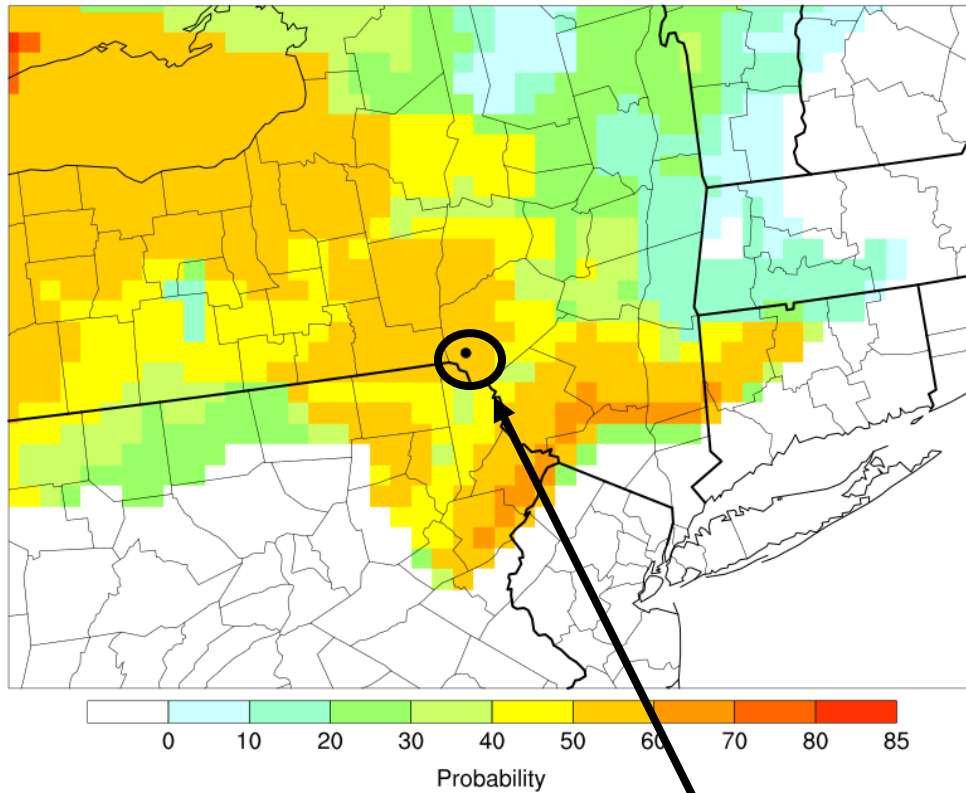


Figure 22 – (top) FIP probability of icing at 6,000 ft msl and (bottom) FIP severity of icing at 6,000 ft msl 1-hour forecast valid for 1500 EST

ICING PROBABILITY at FL 070 01 Hour forecast valid at: 11/9/2018 2000 UTC



ICING SEVERITY at FL 070 01 Hour forecast valid at: 11/9/2018 2000 UTC

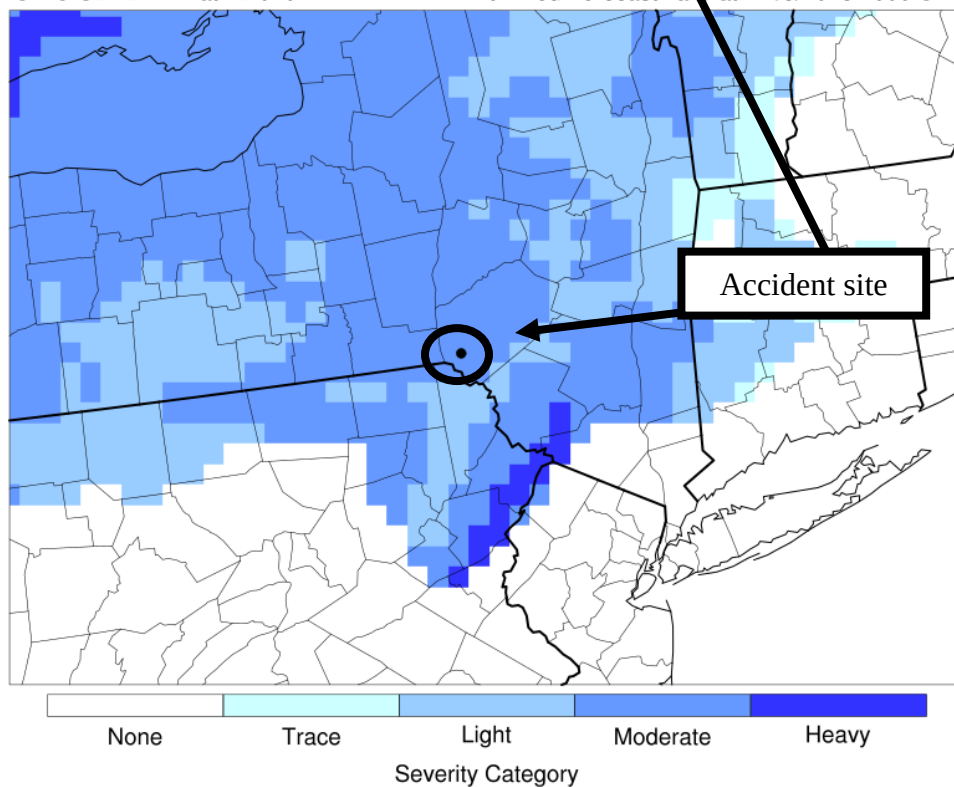
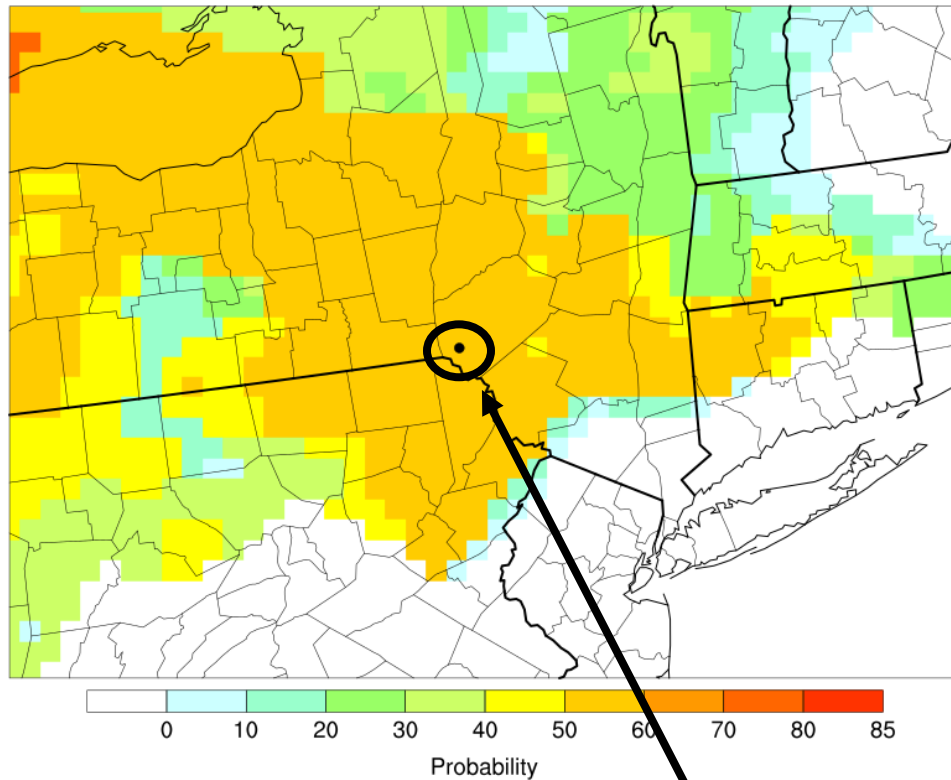


Figure 23 – (top) FIP probability of icing at 7,000 ft msl and (bottom) FIP severity of icing at 7,000 ft msl 1-hour forecast valid for 1500 EST

ICING PROBABILITY at FL 080

01 Hour forecast valid at: 11/9/2018 2000 UTC



ICING SEVERITY at FL 080

01 Hour forecast valid at: 11/9/2018 2000 UTC

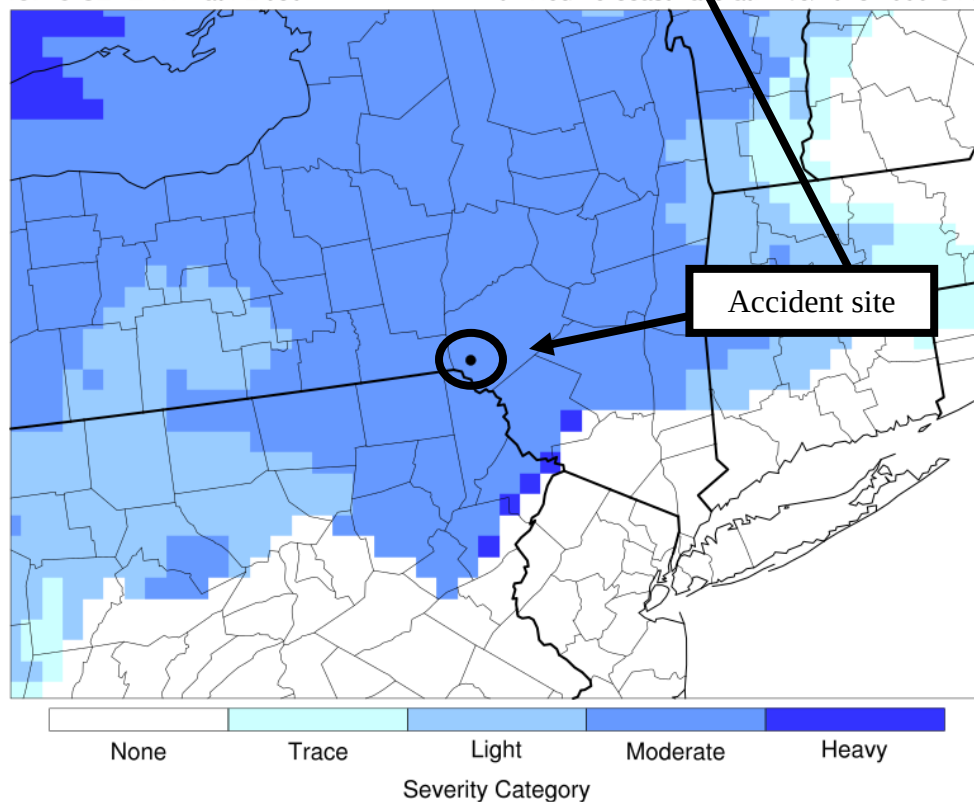


Figure 24 – (top) FIP probability of icing at 8,000 ft msl and (bottom) FIP severity of icing at 8,000 ft msl 1-hour forecast valid for 1500 EST

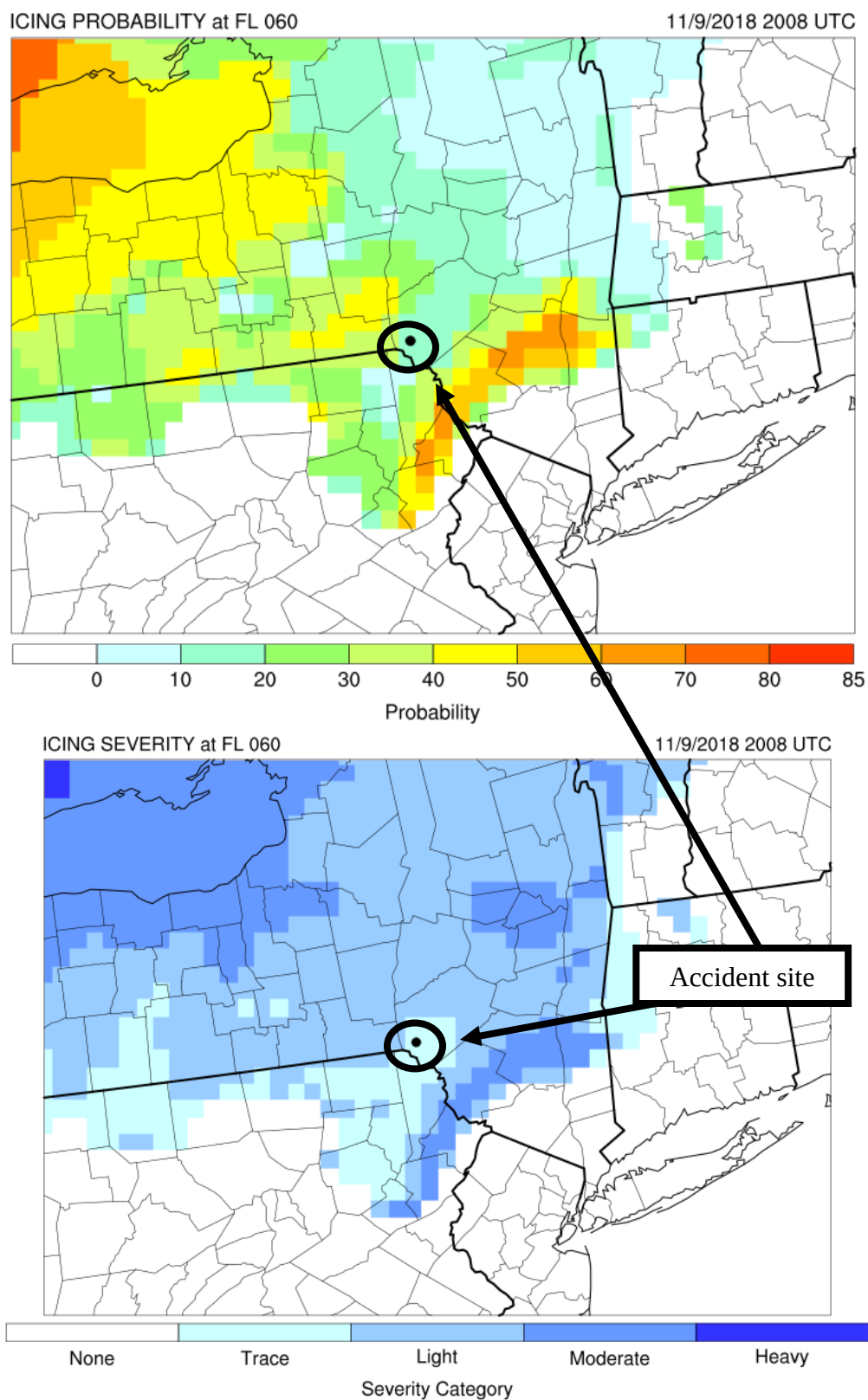


Figure 25 – (top) CIP probability of icing at 6,000 ft msl and (bottom) CIP severity of icing at 6,000 ft msl valid for 1500 EST

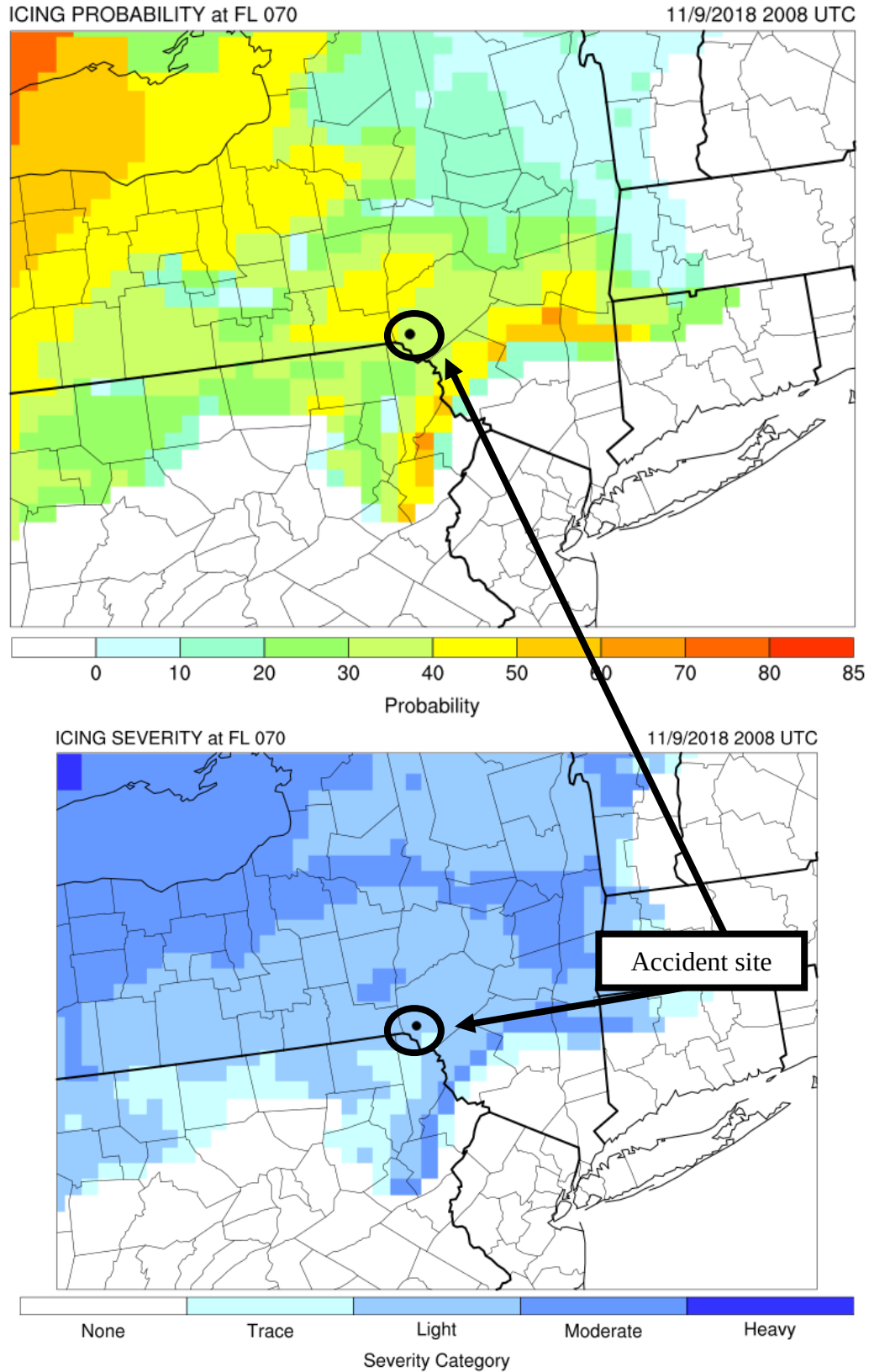
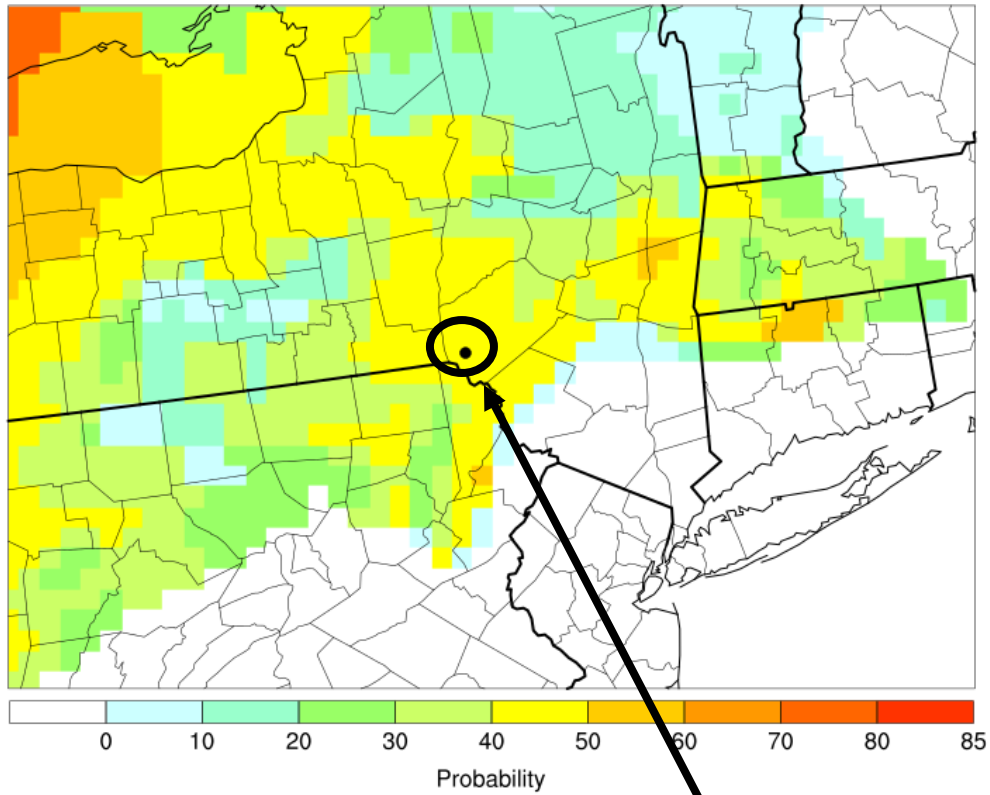


Figure 26 – (top) CIP probability of icing at 7,000 ft msl and (bottom) CIP severity of icing at 7,000 ft msl valid for 1500 EST

ICING PROBABILITY at FL 080

11/9/2018 2008 UTC



ICING SEVERITY at FL 080

11/9/2018 2008 UTC

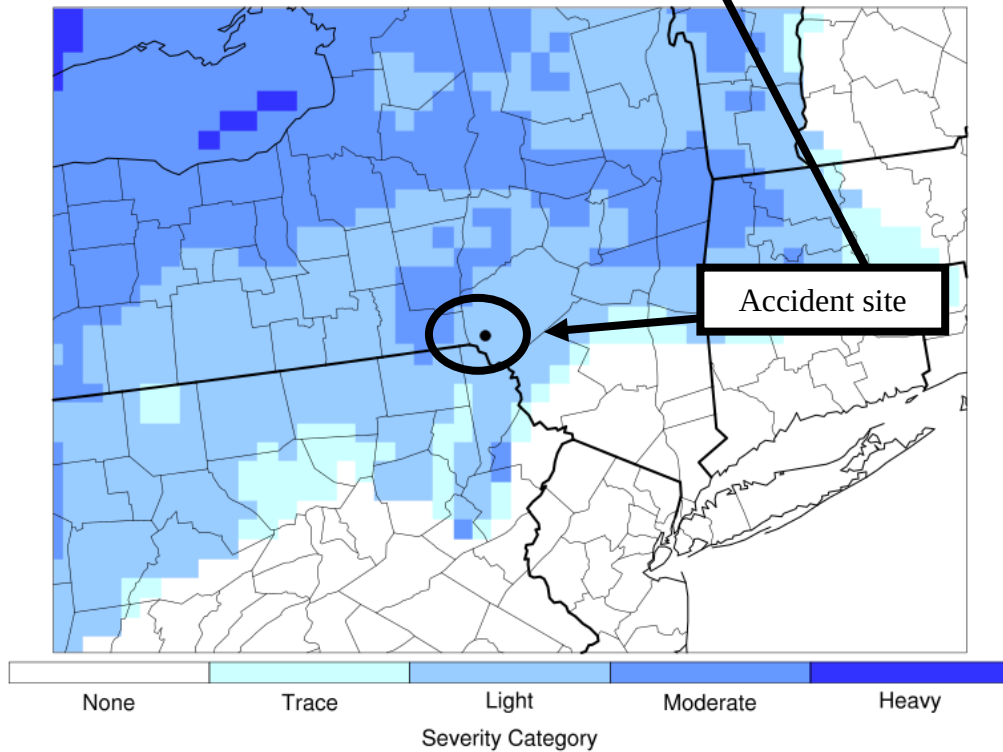


Figure 27 – (top) CIP probability of icing at 8,000 ft msl and (bottom) CIP severity of icing at 8,000 ft msl valid for 1500 EST

18.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on November 9, 2018, indicated the following:

SUN	
Begin civil twilight	0614 EST
Sunrise	0644 EST
Sun transit	1145 EST
Accident time	1502 EST⁴¹
Sunset	1645 EST
End civil twilight	1715 EST

E. LIST OF ATTACHMENTS

Attachment 1 – GOES-16 Visible animation from 1302 to 1602 EST

Attachment 2 – KBGM WSR-88D level 2 base reflectivity animation for the 1.3° elevation scans from 1420 to 1524 EST

Attachment 3 – KBGM WSR-88D level 3 base reflectivity animation for the 1.3° elevation scans from 1426 to 1524 EST

Attachment 4 – KBGM WSR-88D level 3 Zdr animation for the 1.3° elevation scans from 1426 to 1524 EST

Attachment 5 – KBGM WSR-88D level 3 CC animation for the 1.3° elevation scans from 1426 to 1524 EST

Attachment 6 – GFA products valid for the accident site around the accident time

Attachment 7 – CIP and FIP products valid at 1400 and 1500 EST for the accident flight

Submitted by:

Paul Suffern
Senior Meteorologist

⁴¹ Inserted accident time for reference and context.

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