



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

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Weather Study

METEOROLOGY

CEN18FA037

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A. ACCIDENT

Location: Near Pittsford, Vermont
Date: November 22, 2017
Time: 1700 eastern standard time
2200 Coordinated Universal Time (UTC)
Airplane: Cessna 172, Registration: N4676L

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 22, 2017, and are based upon the 24-hour clock, where local time is -5 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The final wreckage location was located at latitude 43.7556° N, longitude 73.0400° W, at an approximate elevation of 780 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.¹

¹

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 indicated a low-pressure system at 1003-hectopascals (hPa) just off the Massachusetts's coast with a stationary front extending along the coast of Massachusetts, New Hampshire, Maine, and into Canada, and with a cold front extending southward from the low into the Atlantic. Another surface low pressure center with a pressure of 1002-hPa was located directly to the southeast of the 1003-hPa low pressure center in the western Atlantic Ocean. Separate cold fronts stretched southward from each low-pressure center in the western Atlantic Ocean, respectively. The accident site was located west of the stationary front in the colder airmass.

The station models around the accident site depicted air temperatures in the low to mid 30's degrees Fahrenheit (°F), dew point temperatures in the low 30's °F with temperature-dew point spreads of 3° F or less, a west-northwest wind of 5 to 10 knots, overcast sky cover, and light rain.

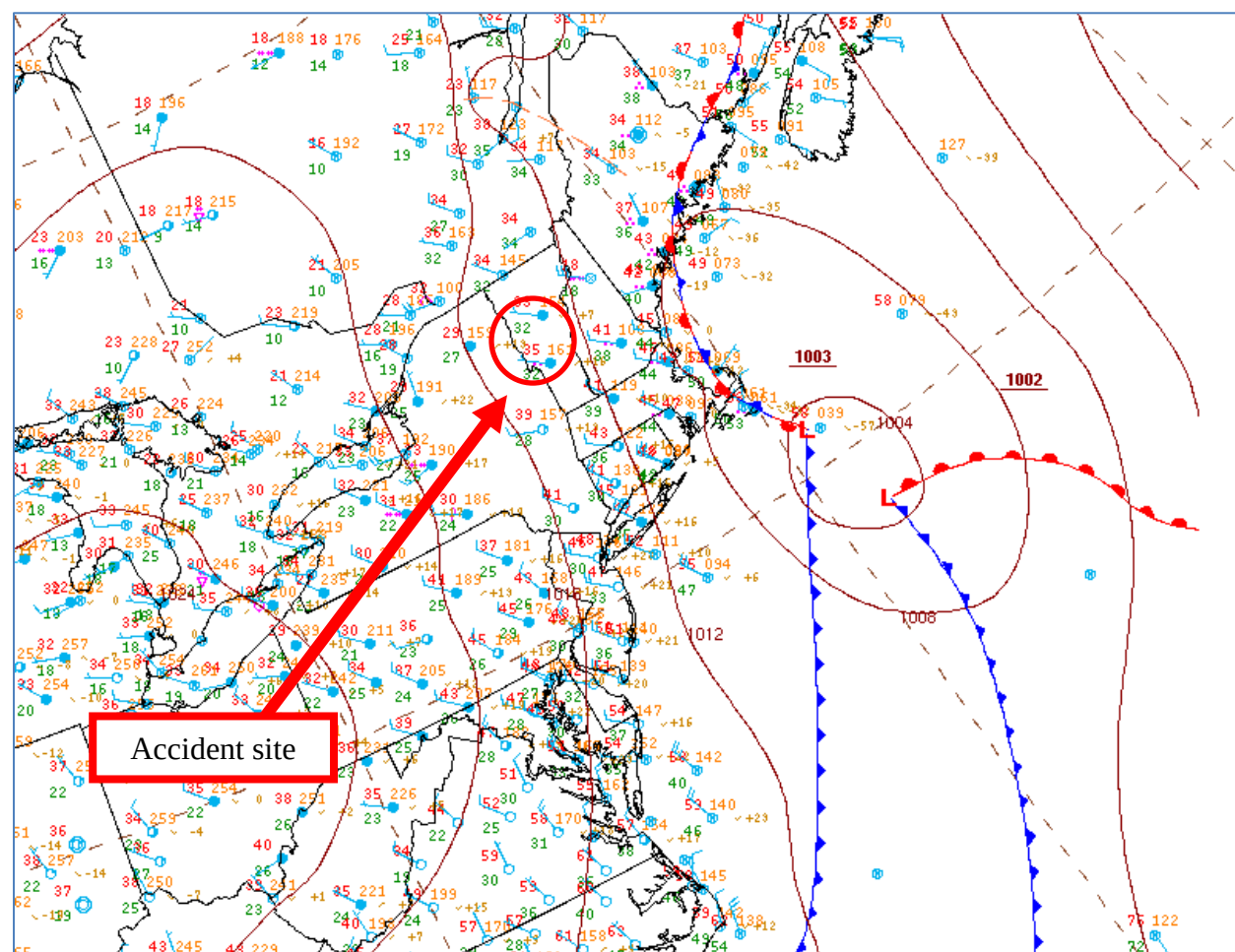


Figure 1 – NWS Surface Analysis Chart for 1600 EST

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

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 west of the accident site (figures 2 and 3) at 925- and 850-hPa. There was a mid- and upper-level trough located over the accident site at the accident time (figures 4, 5, and 6). Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a northwest wind of 30 to 35 knots at 925- and 850-hPa with the wind remaining around the same speed and direction through 500-hPa. By 300-hPa, the wind was from the west-southwest at 60 knots (figure 6).

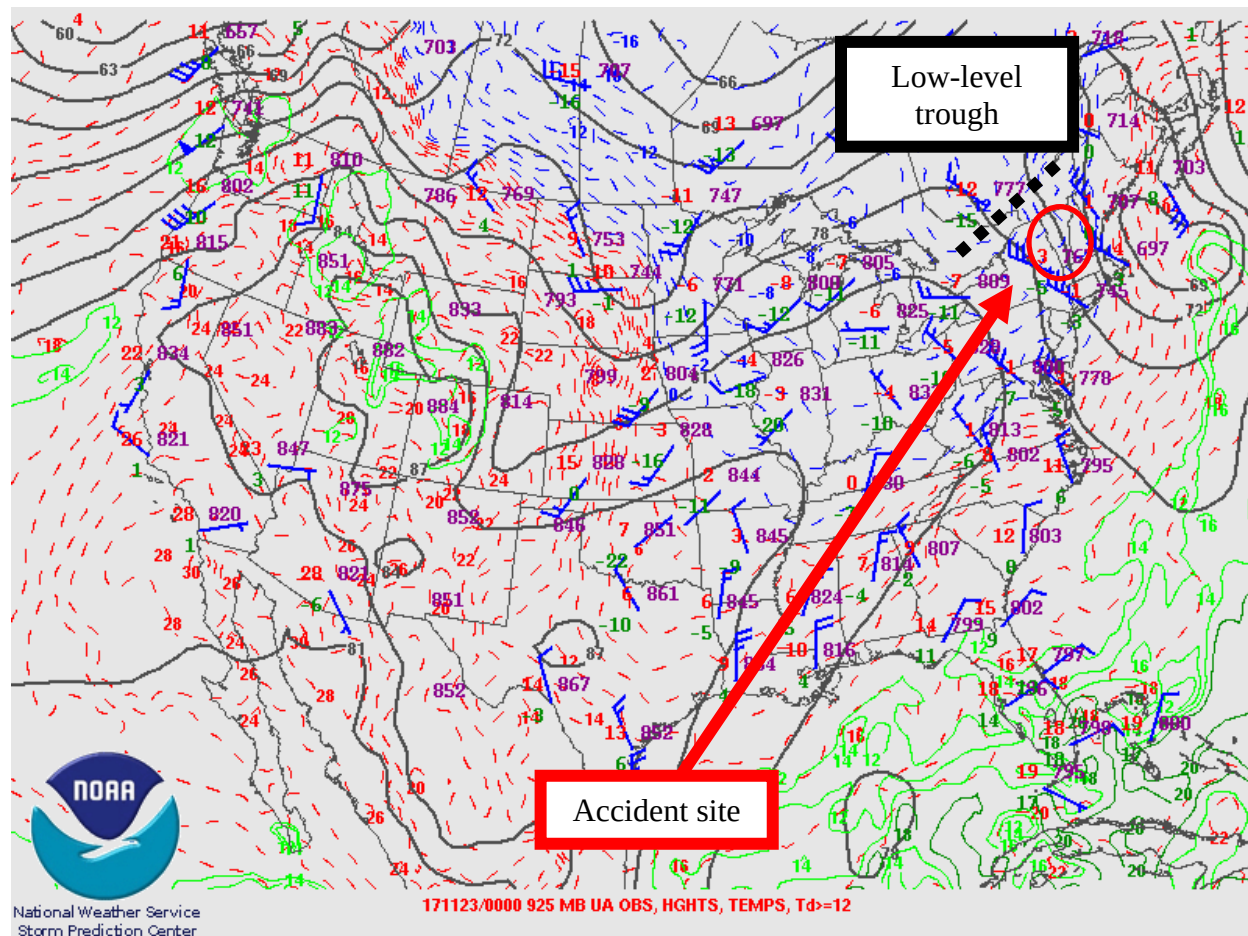


Figure 2 – 925-hPa Constant Pressure Chart for 1900 EST

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

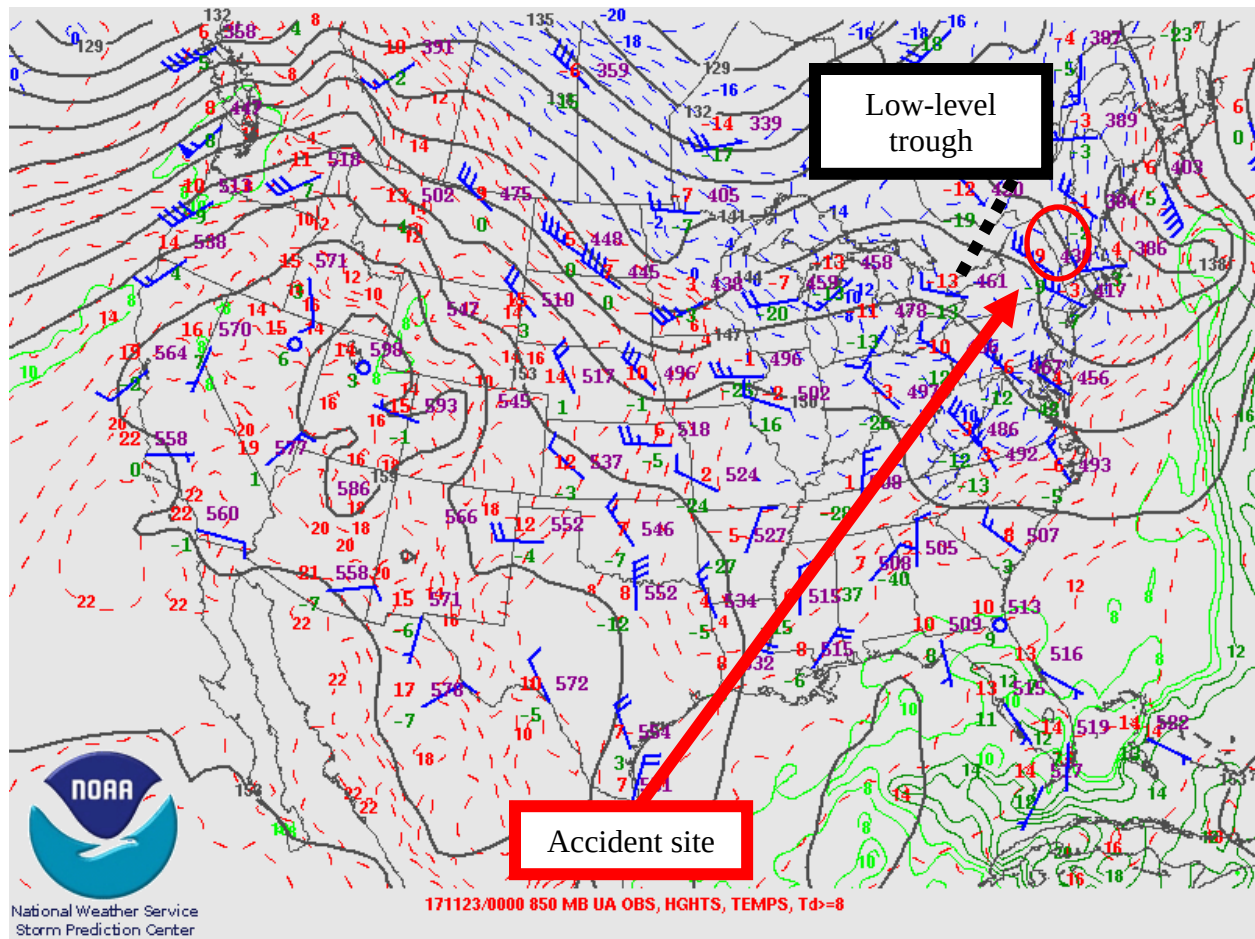


Figure 3 – 850-hPa Constant Pressure Chart for 1900 EST

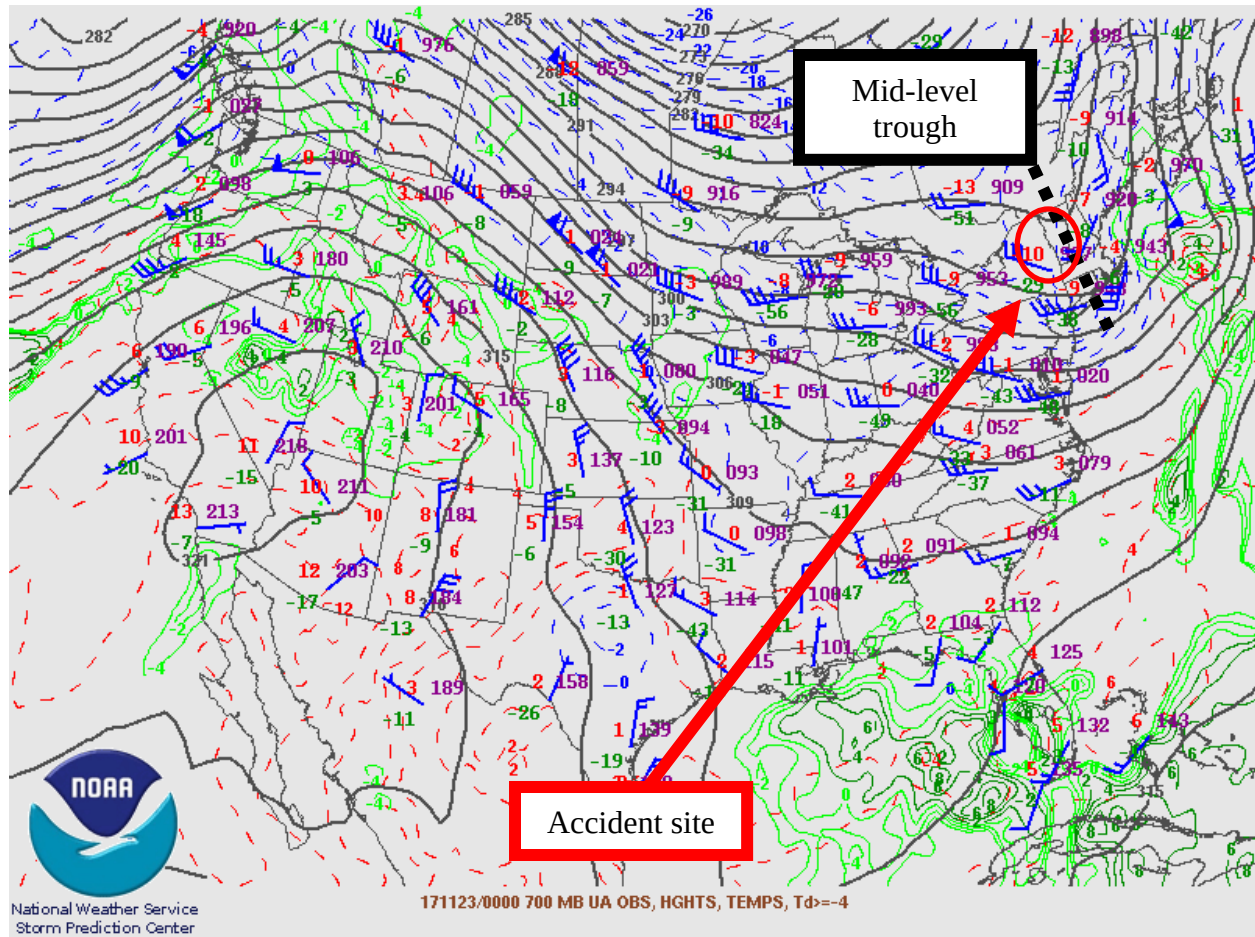


Figure 4 – 700-hPa Constant Pressure Chart for 1900 EST

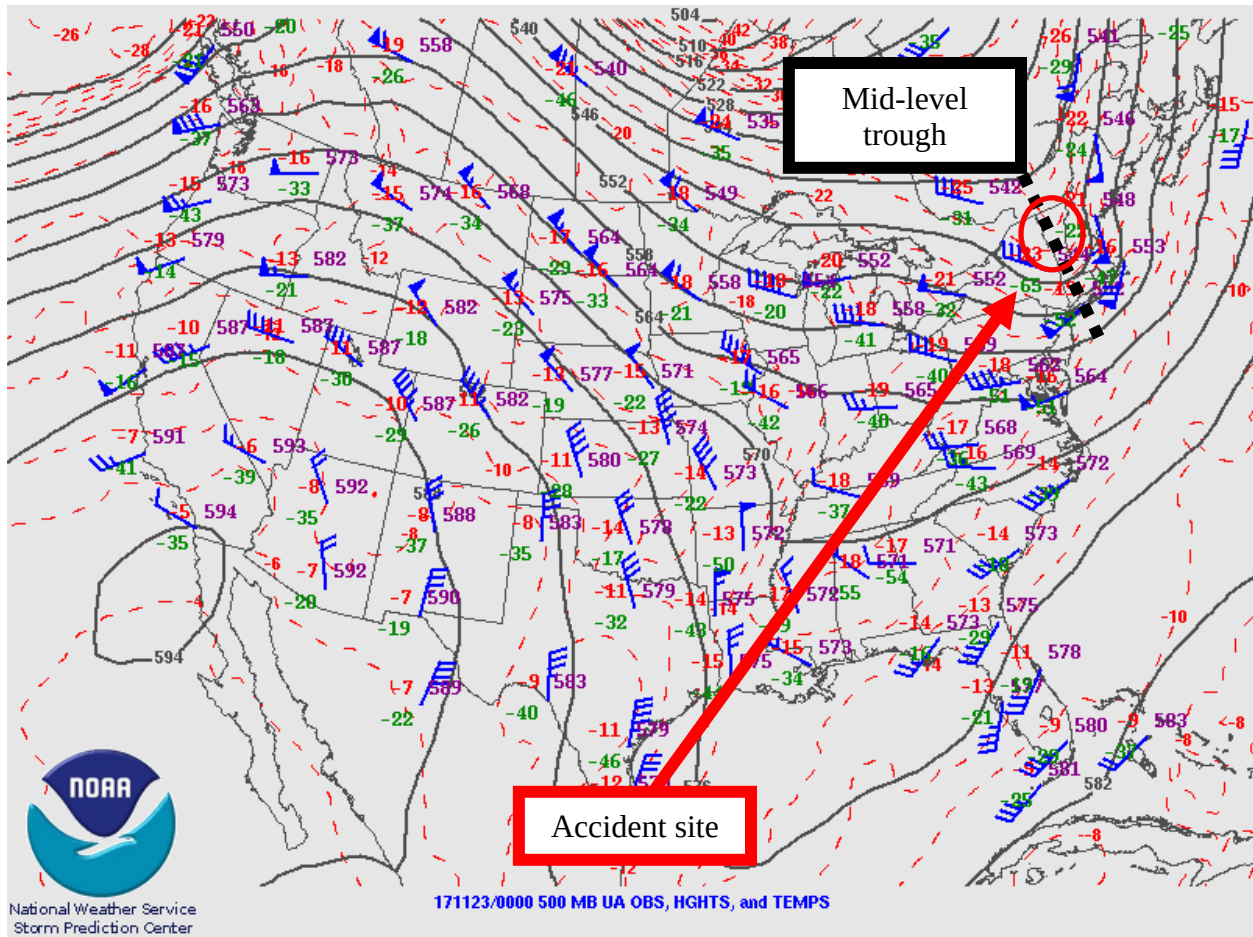


Figure 5 – 500-hPa Constant Pressure Chart for 1900 EST

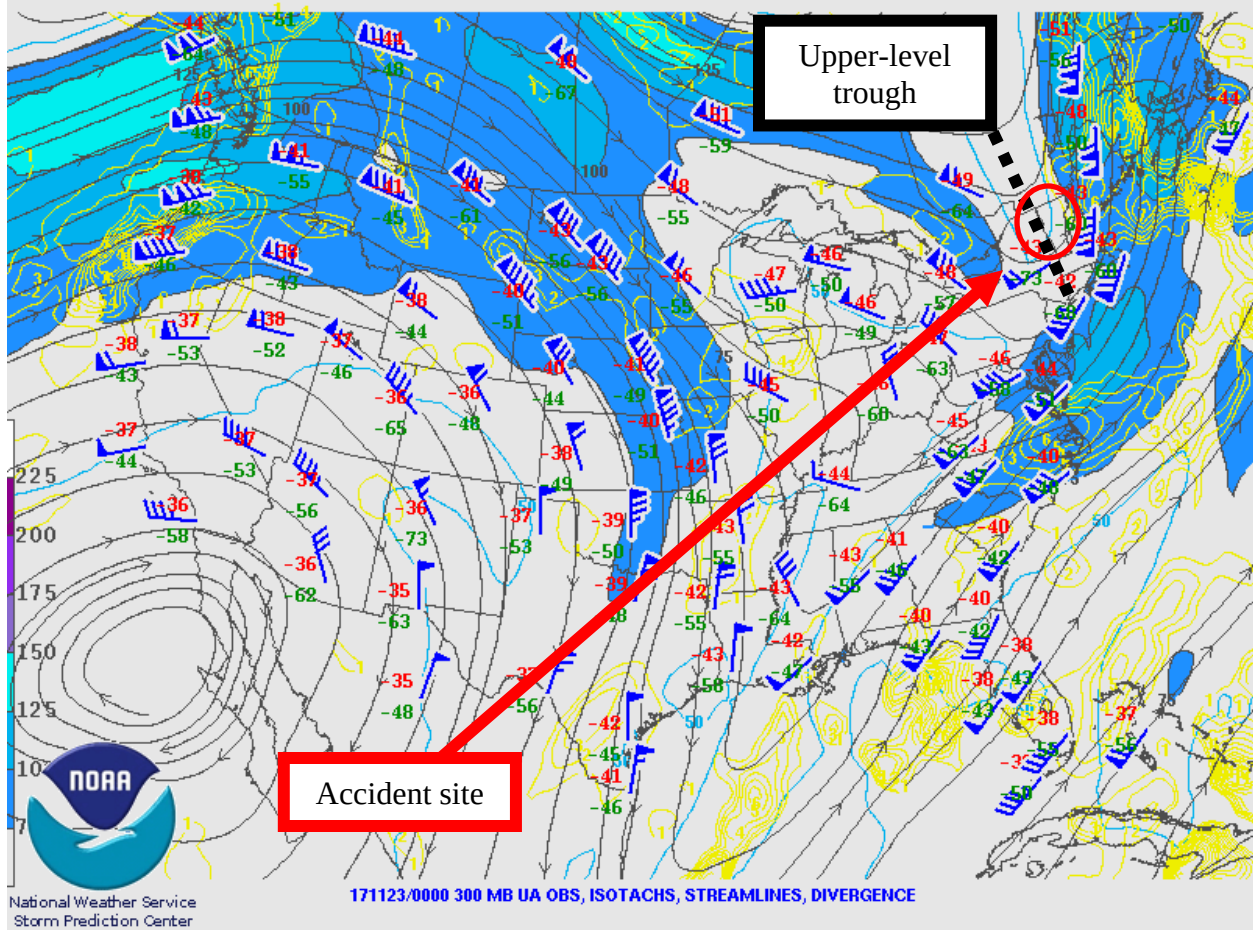


Figure 6 – 300-hPa Constant Pressure Chart for 1900 EST

2.0 SPC Products

No thunderstorms were forecast by SPC for the accident site on the accident day.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 7 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked.

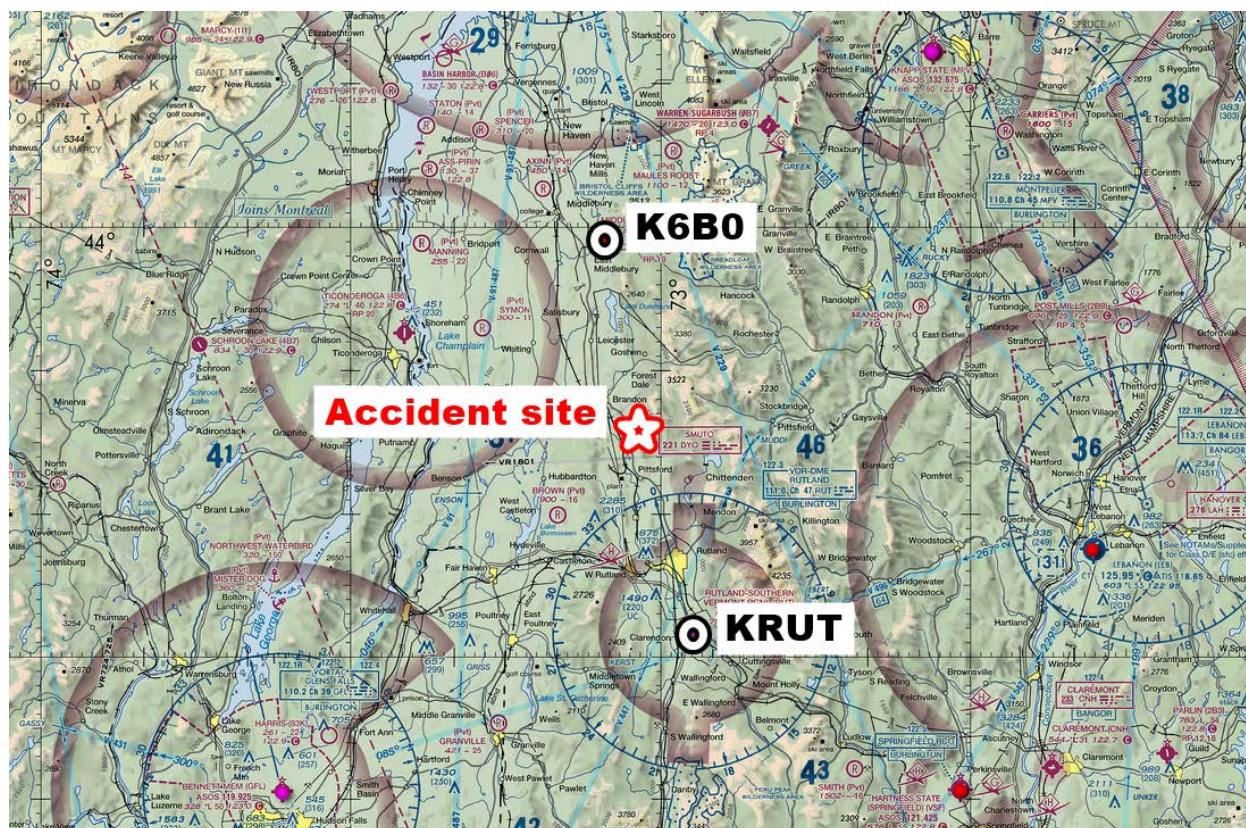


Figure 7 – Sectional chart of accident area with the location of the accident site and the closest surface observation sites

Rutland – Southern Vermont Regional Airport (KRUT) had the closest official weather observation point to the accident site, and was located 5 miles south of Rutland, Vermont. KRUT had an Automated Weather Observing System (AWOS³) whose reports were not supplemented. KRUT was located 14 miles south-southeast of the accident site, at an elevation of 787 ft, and had a 15° westerly magnetic variation⁴ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁵

[1353 EST] SPECI KRUT 221853Z AUTO 32011G14KT 10SM SCT010 BKN025 OVC030
02/01 A2991 RMK AO2 RAE53 P0001 FZANO \$=

[1356 EST] METAR KRUT 221856Z AUTO 32008G15KT 10SM BKN010 BKN022 OVC030
02/01 A2991 RMK AO2 RAE53 SLP150 P0001 T00220011 FZANO \$=

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. 1985, latest measurement taken from <http://airnav.com/airport/KRUT>

⁵ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1437 EST] SPECI KRUT 221937Z AUTO 31006KT 10SM -RA FEW014 OVC021 02/01 A2993 RMK AO2 RAB36 P0000 FZRANO \$=

[1456 EST] METAR KRUT 221956Z AUTO 31004KT 10SM -RA OVC021 02/01 A2993 RMK AO2 RAB36 SLP158 P0000 T00170006 FZRANO \$=

[1556 EST] METAR KRUT 222056Z AUTO 31004KT 10SM -RA OVC020 02/00 A2994 RMK AO2 SLP161 P0000 60001 T00170000 51016 FZRANO \$=

[1656 EST] METAR KRUT 222156Z AUTO 31006KT 10SM BKN020 OVC026 02/00 A2994 RMK AO2 RAE19B36E51 SLP162 P0000 T00170000 FZRANO \$=

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[1756 EST] METAR KRUT 222256Z AUTO 30007KT 6SM -SN BR BKN014 OVC022 01/00 A2995 RMK AO2 RAB32E41SNB41 SLP165 P0001 T00110000 FZRANO \$=

[1856 EST] METAR KRUT 222356Z AUTO 32007KT 5SM -RA BR OVC010 01/00 A2997 RMK AO2 RAB00SNE00 CIG 007V014 SLP173 P0001 60003 T00060000 10028 20006 53011 FZRANO \$=

[1956 EST] METAR KRUT 230056Z AUTO 31008KT 10SM SCT015 BKN021 OVC040 01/M02 A2999 RMK AO2 RAE22UPB22E37 SLP177 P0000 T00061017 FZRANO \$=

[2014 EST] SPECI KRUT 230114Z AUTO 33009KT 10SM FEW018 OVC040 01/M02 A2999 RMK AO2 FZRANO \$=

KRUT weather at 1556 EST, automated, wind from 310° at 4 knots, 10 miles visibility or greater, light rain, an overcast ceiling at 2,000 ft above ground level (agl), temperature of 2° Celsius (C), dew point temperature of 0° C, and an altimeter setting of 29.94 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1016.1 hPa, a trace of precipitation since 1456 EST, 6-hourly precipitation of 0.01 inches, temperature 1.7° C, dew point temperature 0.0° C, 3-hourly pressure increase of 1.6 hPa, freezing rain information not available, maintenance is needed on the system.

KRUT weather at 1656 EST, automated, wind from 310° at 6 knots, 10 miles visibility or greater, a broken ceiling at 2,000 ft agl, overcast skies at 2,600 ft agl, temperature of 2° C, dew point temperature of 0° C, and an altimeter setting of 29.94 inches of mercury. Remarks: automated station with a precipitation discriminator, rain ended at 1619 EST, rain began at 1636 EST, rain ended at 1651 EST, sea level pressure 1016.2 hPa, a trace of precipitation since 1556 EST, temperature 1.7° C, dew point temperature 0.0° C, freezing rain information not available, maintenance is needed on the system.

KRUT weather at 1756 EST, automated, wind from 300° at 7 knots, 6 miles visibility, light snow, a broken ceiling at 1,400 ft agl, overcast skies at 2,200 ft agl, temperature of 1° C, dew point temperature of 0° C, and an altimeter setting of 29.95 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1732 EST, rain ended at 1741 EST, snow began at 1741 EST, sea level pressure 1016.5 hPa, 0.01 inches of precipitation since 1656 EST, temperature 1.1° C, dew point temperature 0.0° C, freezing rain information not available, maintenance is needed on the system.

KRUT weather at 1856 EST, automated, wind from 320° at 7 knots, 5 miles visibility, light rain and mist, an overcast ceiling at 1,000 ft agl, temperature of 1° C, dew point temperature of 0° C, and an altimeter setting of 29.97 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1800 EST, snow ended at 1800 EST, ceiling varying between 700 and 1,400 ft agl, sea level pressure 1017.3 hPa, 0.01 inches of precipitation since 1756 EST, 6-hourly precipitation of 0.03 inches, temperature 0.6° C, dew point temperature 0.0° C, 3-hourly pressure increase of 1.6 hPa, 6-hourly maximum temperature of 2.8° C, 6-hourly minimum temperature 0.6° C, 3-hourly pressure increase of 1.1 hPa, freezing rain information not available, maintenance is needed on the system.

Middlebury State Airport (K6B0) was the next closest airport to the accident site with official weather information. K6B0 had an AWOS whose reports were not supplemented. K6B0 was located 14 miles north-northwest of the accident site, at an elevation of 490 ft, and had a 15° westerly magnetic variation⁶ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[1455 EST] METAR K6B0 221955Z AUTO 32004KT 10SM BKN032 OVC050 03/00
A2994 RMK AO2 T00250001=

[1515 EST] METAR K6B0 222015Z AUTO 34005KT 10SM OVC032 02/00 A2994 RMK
AO2 T00240000=

[1535 EST] METAR K6B0 222035Z AUTO 31004KT 10SM SCT030 BKN035 OVC044
02/00 A2995 RMK AO2 T00230000=

[1555 EST] METAR K6B0 222055Z AUTO 32004KT 10SM SCT022 BKN032 OVC042
02/00 A2995 RMK AO2 T00220000=

[1615 EST] METAR K6B0 222115Z AUTO 32004KT 10SM BKN022 OVC032 02/00
A2995 RMK AO2 T00200001=

**[1635 EST] METAR K6B0 222135Z AUTO 34004KT 10SM BKN022 OVC034 02/00
A2996 RMK AO2 T00200000=**

**[1655 EST] METAR K6B0 222155Z AUTO 35005KT 10SM SCT020 OVC036 02/00
A2996 RMK AO2 T00180000=**

⁶ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from <http://airnav.com/airport/6B0>

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[1715 EST] METAR K6B0 222215Z AUTO 35008KT 10SM SCT020 OVC038 02/00 A2996 RMK AO2 T00201001=

[1735 EST] METAR K6B0 222235Z AUTO 36006KT 10SM SCT016 SCT025 OVC038 02/00 A2997 RMK AO2 T00180000=

[1755 EST] METAR K6B0 222255Z AUTO 35006KT 10SM SCT016 BKN025 OVC038 02/00 A2998 RMK AO2 T00170000=

[1815 EST] METAR K6B0 222315Z AUTO 35009G14KT 10SM SCT016 SCT022 OVC046 02/00 A2999 RMK AO2 T00161005=

K6B0 weather at 1635 EST, automated, wind from 340° at 4 knots, 10 miles visibility or greater, a broken ceiling at 2,200 ft agl, overcast skies at 3,400 ft agl, temperature of 2° C, dew point temperature of 0° C, and an altimeter setting of 29.96 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 2.0° C, dew point temperature 0.0° C.

K6B0 weather at 1655 EST, automated, wind from 350° at 5 knots, 10 miles visibility or greater, scattered clouds at 2,000 ft agl, overcast ceiling at 3,600 ft agl, temperature of 2° C, dew point temperature of 0° C, and an altimeter setting of 29.96 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 1.8° C, dew point temperature 0.0° C.

K6B0 weather at 1715 EST, automated, wind from 350° at 8 knots, 10 miles visibility or greater, scattered clouds at 2,000 ft agl, overcast ceiling at 3,800 ft agl, temperature of 2° C, dew point temperature of 0° C, and an altimeter setting of 29.96 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 2.0° C, dew point temperature -0.1° C.

K6B0 weather at 1735 EST, automated, wind from 360° at 6 knots, 10 miles visibility or greater, scattered clouds at 1,600 ft agl, scattered clouds at 2,500 ft agl, overcast ceiling at 3,800 ft agl, temperature of 2° C, dew point temperature of 0° C, and an altimeter setting of 29.97 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 1.8° C, dew point temperature 0.0° C.

The observations from KRUT and K6B0 surrounding the accident time indicated mainly MVFR⁷ conditions with periods of VFR⁸ conditions at K6B0. Both light rain and light snow were reported at KRUT around the accident time with reduced visibility conditions.

⁷ Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 ft agl and/or 3 to 5 miles visibility.

⁸ 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.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)⁹ model sounding was created for the accident site for 1700 EST with station elevation of 951 ft. The 1700 EST HRRR sounding was plotted on a standard Skew-T Log P diagram¹⁰ with the derived stability parameters included in figure 8 (with data from the surface to 600-hPa, or 14,000 ft msl.) This data was analyzed using the RAOB¹¹ software package. The sounding depicted the level of free convection (LFC)¹² and the lifted condensation level (LCL)¹³ at 376 ft agl (1,156 ft msl), and the convective condensation level (CCL)¹⁴ at 1,660 ft agl (2,440 ft msl). The sounding had a greater than 90% relative humidity from the LFC to the equilibrium level at about 5,500 ft. The freezing level was 1,262 ft. The precipitable water value was 0.30 inches.

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

¹⁰ 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.

¹¹ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹² 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.

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

¹⁴ 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.

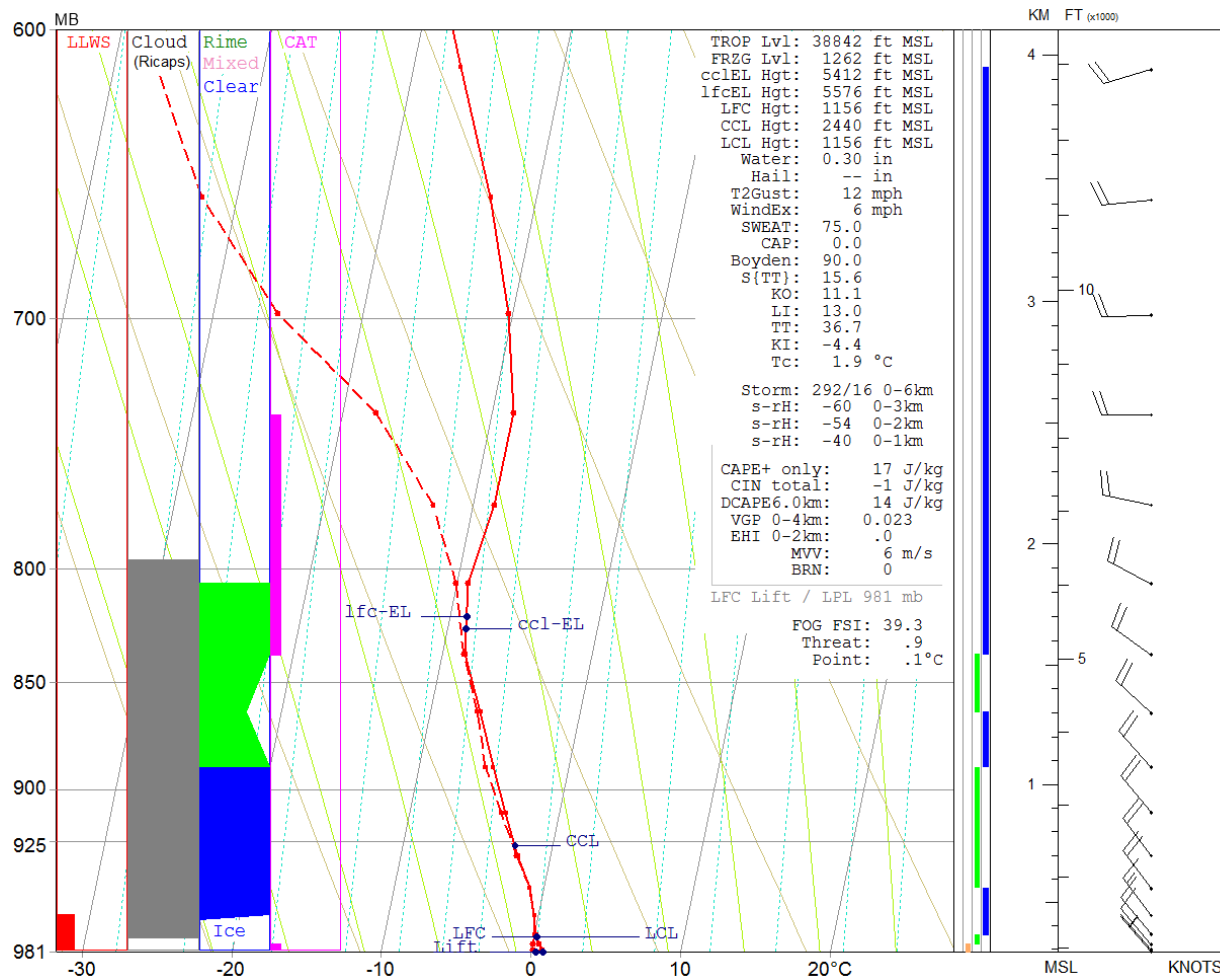


Figure 8 – 1700 EST HRRR sounding

The 1700 EST HRRR sounding indicated an alternating conditionally unstable and stable environment from the surface through 14,000 ft. RAOB identified the possibility of clouds between 1,200 ft through 7,000 ft. Moderate or greater clear and rime icing was indicated by RAOB between 1,500 and 6,000 ft. Supercooled liquid water would have likely been present in the cloud cover between the 1,500 ft and 6,000 feet.¹⁵ Icing potential will be further discussed in section 14.0.

¹⁵ 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, in press).

The 1700 EST HRRR sounding wind profile indicated a surface wind from 321° at 7 knots with the wind remaining northwesterly through 5,000 ft. Above 5,000 ft the wind became westerly through 14,000 ft. The wind speed remained around 20 knots from 2,000 ft through 14,000 ft. RAOB indicated the possibility of low-level wind shear between the surface and 1,500 ft. RAOB indicated a low probability of clear-air turbulence in a layer between 5,000 ft and 8,500 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System 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. Satellite imagery surrounding the time of the accident, from 1300 EST through 1900 EST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here. Due to the time of the accident and the low light conditions only the infrared imagery was documented below.

Figures 9 and 10 present the GOES-16 infrared imagery from 1645 and 1700 EST at 5X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site with the cloud cover moving from west-northwest to east-southeast (attachment 1). The lower brightness temperatures (green and yellow colors; higher cloud tops) were located east of the accident site at 1645 and 1700 EST and were located over Maine. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1700 EST HRRR sounding, the approximate cloud-top heights over the accident site were 10,000 ft at 1700 EST. It should be noted these figures have not been corrected for any parallax error.

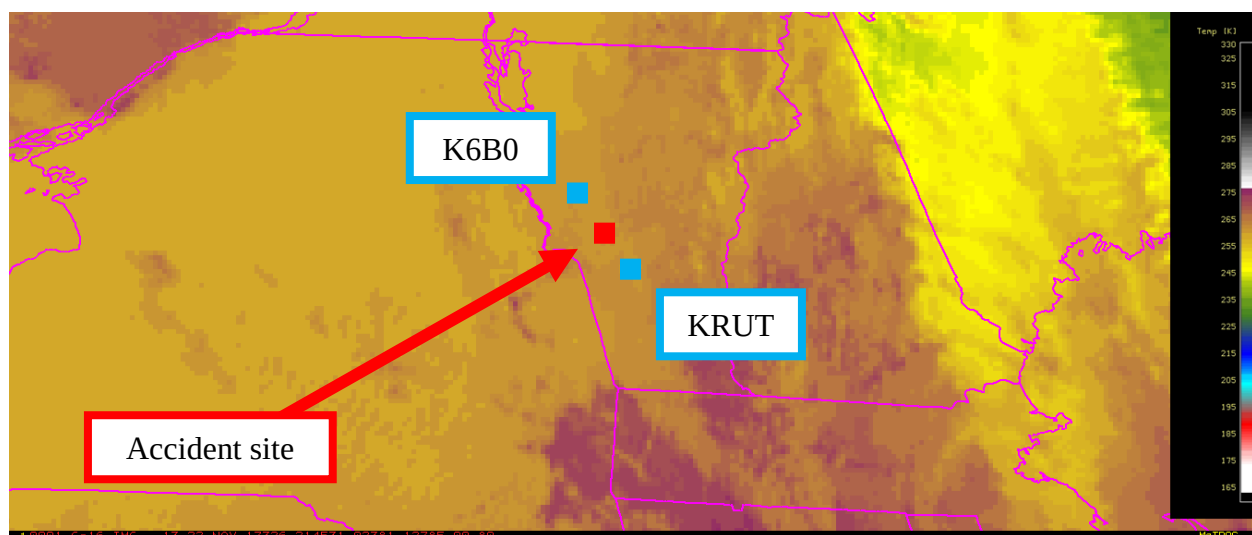


Figure 9 – GOES-16 infrared image at 1645 EST

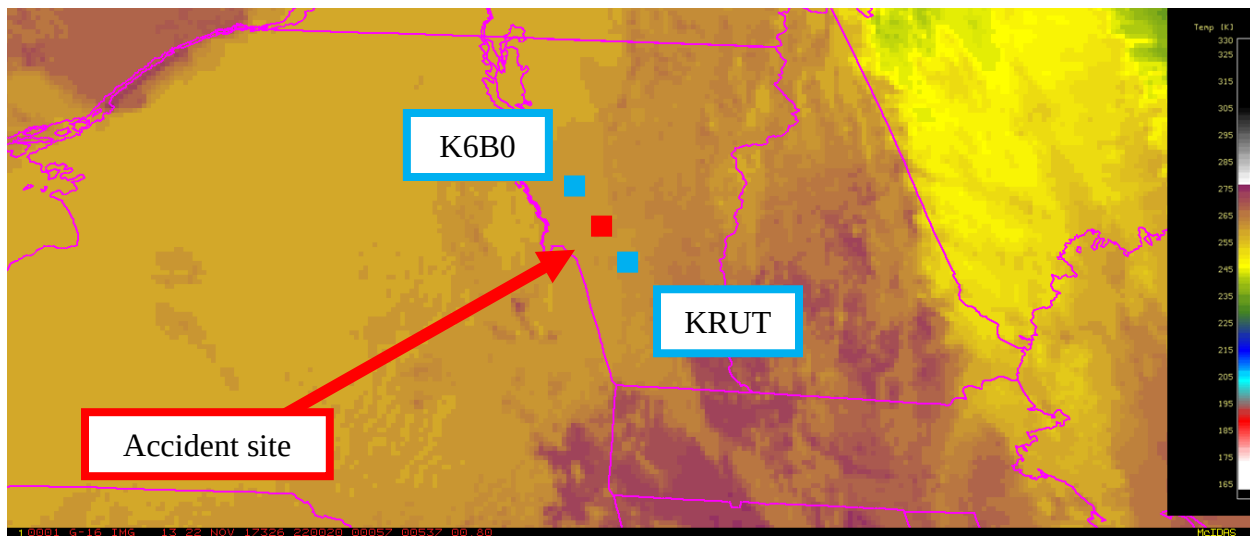


Figure 10 – GOES-16 infrared image at 1700 EST

6.0 Radar Imagery Information

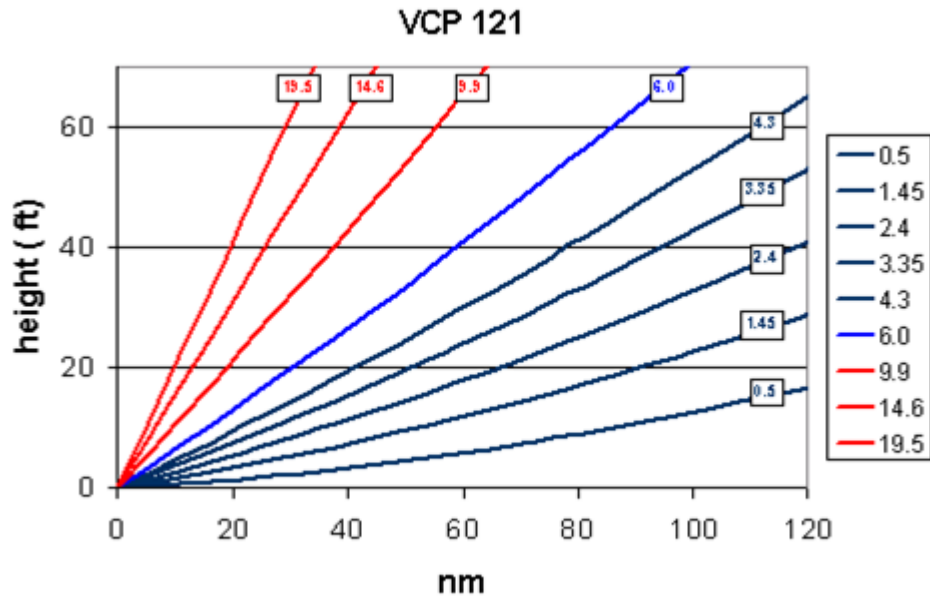
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁶ to the accident site was the Burlington, Vermont, radar (KCXX), which was located 46 miles north-northwest of the accident site at an elevation of 317 feet. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

6.1 Volume Scan Strategy

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

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 121 (VCP-121). 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 KCXX WSR-88D radar was operating in the precipitation mode (Mode A, VCP-121). 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.

¹⁶ The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.



VCP-121 Precipitation Mode Scan Strategy¹⁷

6.2 Beam Height Calculation

Assuming standard refraction¹⁸ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width¹⁹ information²⁰ of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	4,290 feet	2,020 feet	6,560 feet	4,540 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 2,020 feet and 6,560 feet msl over the accident site and these scans are the closest altitudes to the accident site before the accident occurred.

¹⁷ 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)

¹⁸ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁹ Beam width – A measure of the angular width of a radar beam.

²⁰ Beamwidth values are shown for legacy resolution products. Super resolution products would have an effective beamwidth that would be approximately half these values.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²¹ 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 (dBZ²²), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²³, “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.

6.4 Base Reflectivity and Lightning Data

Figures 11 and 12 present the KCXX WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1657 and 1703 EST, respectively, with a resolution of 0.5° X 250 m. The flight track has also been added in pink. There were no reflectivity values above the accident site at 1657 and 1703 EST, but base reflectivity values between -10 to 10 dBZ were located above the accident flight route between 1621 and 1718 EST (attachment 2). The precipitation areas were moving from northwest to southeast. There were no lightning strikes around the accident site at the accident time.²⁴

²¹ 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.

²² 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.

²³

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

²⁴ A review of Earth Networks Total Lightning network was done.

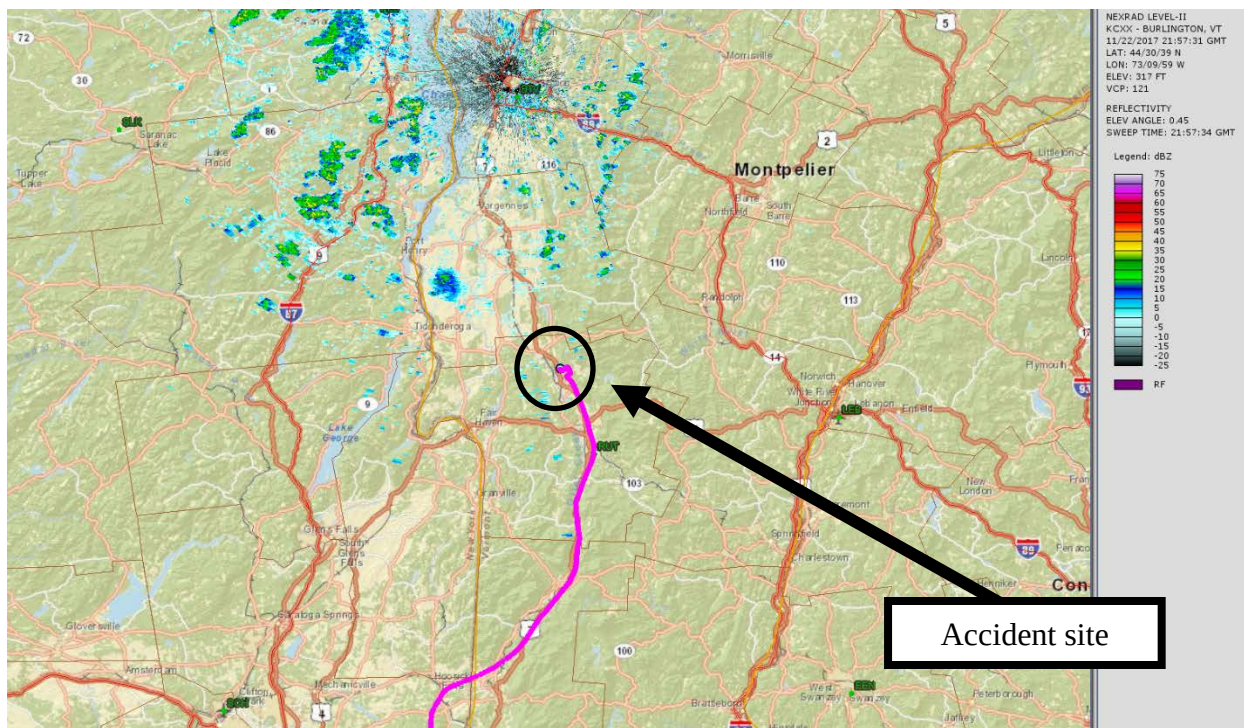


Figure 11 – KCXX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1657 EST with the accident site marked with black circle and ATC track as pink dots

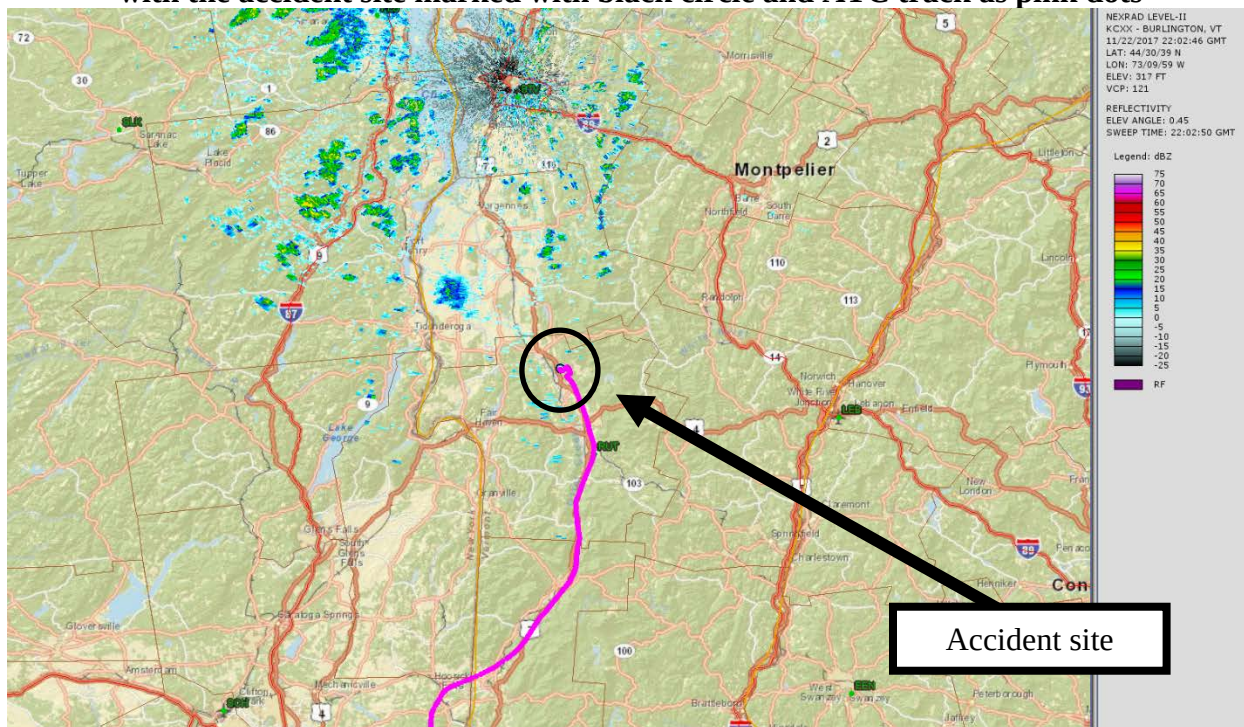


Figure 12 – KCXX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1703 EST with the accident site marked with black circle and ATC track as pink dots

7.0 Pilot Reports²⁵

All PIREPs within 100 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time were reviewed. Only PIREPs for below FL180²⁶ are provided below:

MHT UA /OV RWY35/TM 2003/FL014/TP C560/SK FEW014/WX -RA BR=

MHT UA /OV MHT/TM 2052/FL010/TP C172/WX +/- 10 KTS ON FINAL RWY 35=

MSS UA /OV PTD /TM 2114 /FL063 /TP PC12 /TA M09 /IC LGT CLR=

ALB UA /OV RKD/TM 2118/FL130/TP P46T/TA M07/IC LGT RIME=

MHT UA /OV MHT/TM 2142/FLR35/TP C560/WX +/- 5 KTS ON FINAL R35/TB LT CHOP=

ALB UA /OV 15 SW ALB/TM 2154/FL060/TP BE20/TA M6/IC LGT CLR=

MHT UA /OV MHT/TM 2225/FL015 /TP 737/WX +/- 10 KTS ON FINAL R35 1500 AND BELOW=

MHT UA /OV MHT/TM 2230/FL010/TP E145/WX +/- 15 FINAL RWY 35 1000 AND BELOW=

KLEB UA /OV LEB190008/TM 2343/FLDURD/TP H25B/SK OVC030=

Routine pilot report (UA); Over - runway 35 in Manchester, New Hampshire (MHT); Time – 1503 EST (2003Z); Altitude – 1,400 ft; Type aircraft – Cessna Citation V; Sky – Few clouds at 1,400 ft; Weather – Light rain and mist.

Routine pilot report (UA); Over - MHT; Time – 1552 EST (2052Z); Altitude – 1,000 ft; Type aircraft – Cessna 172; Weather – Plus or minus 10 knots on final into runway 35.

Routine pilot report (UA); Over - Potsdam, New York (PTD); Time – 1614 EST (2114Z); Altitude – 6,300 ft; Type aircraft – Pilatus PC-12; Temperature – -9° C; Icing – Light clear.

Routine pilot report (UA); Over - Rockland, Maine (RKD); Time – 1618 EST (2118Z); Altitude – 13,000 ft; Type aircraft – Piper PA-46; Temperature – -7° C; Icing – Light rime.

Routine pilot report (UA); Over - MHT; Time – 1642 EST (2142Z); Altitude – Runway 35; Type aircraft – Cessna Citation V; Weather – Plus or minus 5 knots on final into runway 35; Turbulence – Light chop.

Routine pilot report (UA); Over - 15 miles southwest of Albany, New York (ALB); Time – 1654 EST (2154Z); Altitude – 6,000 ft; Type aircraft – Beech 200 Super King Air; Temperature – -6° C; Icing – Light clear.

²⁵ Only pilot reports with the WMO header UBNY**, UBMA**, UBNH**, UBME**, UBCT**, and UBVT** identifier were considered.

²⁶ 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); Over - MHT; Time – 1725 EST (2225Z); Altitude – 1,500 ft; Type aircraft – Boeing B737; Weather – Plus or minus 10 knots on final to runway 35 from 1,500 ft and below.

Routine pilot report (UA); Over - MHT; Time – 1730 EST (2230Z); Altitude – 1,000 ft; Type aircraft – Embraer ERJ-145; Weather – Plus or minus 15 knots on final to runway 35 from 1,000 ft and below.

Routine pilot report (UA); Over - 8 miles from Lebanon, New Hampshire (LEB), on the 190° radial; Time – 1843 EST (2343Z); Altitude – During descent; Type aircraft – Hawker 800; Sky – Overcast clouds at 3,000 ft.

8.0 SIGMET and CWSU Advisories

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

No Center Weather Service Unit (CWSU) Center Weather Advisories were valid for the accident site at the accident time. No Meteorological Impact Statement (MIS) issued by the CWSU were valid for the accident site at the accident time.

9.0 AIRMETs

There were Airmen's Meteorological Information (AIRMET)s Sierra, Zulu, and Tango that were valid for the accident site at the accident time. The AIRMETs warned of IFR²⁷ conditions due to precipitation and mist, mountain obscuration conditions due to clouds, precipitation, and mist, moderate icing conditions below 7,000 ft, and moderate turbulence below 14,000 ft. The advisories were as follows:

WAUS41 KPCI 222045

WA1S

-BOSS WA 222045

AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 230300

.

AIRMET IFR...ME NH VT MA RI NY AND CSTL WTRS

**FROM 70NW PQI TO 60NE PQI TO 200SE ACK TO 150S ACK TO 40SSE PVD
TO 20SSW ENE TO 40ESE MPV TO 40SSW MPV TO 60E MSS TO YSC TO 70NW
PQI**

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z ENDG 03-06Z.

.

AIRMET MTN OBSCN...ME NH VT MA NY PA

**FROM 70NW PQI TO MLT TO CON TO 40SSE HNK TO JHW TO SYR TO MSS TO
YSC TO 70NW PQI**

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...PA WV MD VA

²⁷ Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 ft agl and/or less than 3 miles visibility.

FROM 30SE EWC TO JST TO 40ESE EKN TO 20NNE HNV TO HNN TO 30SE EWC
MTNS OBSC BY CLDS/BR. CONDS ENDG 00-03Z.

....

WAUS41 KPCI 222045

WA1Z

-BOSZ WA 222045

AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 230300

.
**AIRMET ICE...ME NH VT MA NY LO PA OH LE WV
FROM 70W YSC TO 50WSW CON TO 40SE HNK TO AIR TO CLE TO 30SE YYZ
TO 20E YOW TO 70W YSC
MOD ICE BLW 070. CONDS ENDG 00-03Z.**

.
AIRMET ICE...ME NH VT MA RI CT NY AND CSTL WTRS
FROM 70NW PQI TO 60NE PQI TO 110SE BGR TO 20NNW ACK TO 20SSE HTO
TO 60ENE MSS TO YSC TO 70NW PQI
MOD ICE BTN FRZLVL AND FL200. FRZLVL SFC-090. CONDS CONTG BYD 03Z
ENDG 06-09Z.

.
OTLK VALID 0300-0900Z...ICE LO PA OH LE
BOUNDED BY YYZ-ERI-50SW ROD-FWA-30SE ECK-YYZ
MOD ICE BTN FRZLVL AND FL180. FRZLVL 040-100. CONDS DVLPG 06-09Z.
CONDS CONTG THRU 09Z.

.
FRZLVL...RANGING FROM SFC-110 ACRS AREA
MULT FRZLVL BLW 110 BOUNDED BY 20S ACK-90SE ACK-120SE SBY-
20NE ECG-HMV-HNN-CVG-40WSW ROD-40ENE ROD-JST-20NNW SIE-20S
ACK
SFC ALG 40E CVG-50SSE APE-20S EKN-20WSW SAX-40SW CON-60NE PQI
040 ALG HNV-30N ORF-40SW ACK-40ESE HUL
080 ALG 60E ORF-120S ACK-140ENE ACK

....

WAUS41 KPCI 222045

WA1T

-BOST WA 222045

AIRMET TANGO UPDT 5 FOR TURB AND STG SFC WNDZ VALID UNTIL 230300

.
**AIRMET TURB...ME NH VT MA RI CT NY NJ PA WV MD DC DE VA AND CSTL
WTRS
FROM 20ENE YSC TO 60WSW YSJ TO 200SE ACK TO 160SE SIE TO HNV TO
20WSW JST TO 20SW SYR TO 60WSW MPV TO 20ENE YSC
MOD TURB BLW 140. CONDS CONTG BYD 03Z THRU 09Z.**

.
AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS
FROM 50NE PQI TO 200SE ACK TO 20ESE CSN TO 50WSW BKW TO HNN TO
CVG TO FWA TO 30SE ECK TO YOW TO YSC TO 50NW PQI TO 50NE PQI
MOD TURB BTN FL180 AND FL400. CONDS CONTG BYD 03Z ENDG 06-09Z.

.
AIRMET TURB...MA RI NY NJ WV MD DE VA NC SC GA FL AND CSTL WTRS
FROM 200SE ACK TO 160SE SIE TO 190ESE ECG TO OMN TO 110WNW EYW
TO 90WSW PIE TO 170SE LEV TO 130ESE LEV TO 40W CEW TO 50SW PZD
TO GQO TO HNV TO 50WSW BKW TO 20ESE CSN TO 200SE ACK
MOD TURB BTN FL240 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.

.
AIRMET STG SFC WND...ME NH MA AND CSTL WTRS
FROM 70SSE BGR TO 140E ACK TO 190SE ACK TO 90SSE ACK TO 30SE ENE
TO 70SSE BGR
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 00-03Z.
CONDS CONTG BYD 03Z ENDG 06-09Z.

.
OTLK VALID 0300-0900Z
AREA 1...TURB MA RI NY NJ WV MD DC DE VA NC SC GA FL AND CSTL
WTRS
BOUNDED BY 130E ACK-200SE ACK-160SE SIE-190ESE ECG-50SSE CHS-
90WSW PIE-170SE LEV-130ESE LEV-40W CEW-50SW PZD-GQO-HMV-50WSW
BKW-50N LYH-130E ACK
MOD TURB BTN FL240 AND FL410. CONDS CONTG THRU 09Z.

.
AREA 2...TURB ME NH VT MA RI CT NY NJ PA DE AND CSTL WTRS
BOUNDED BY 70NW PQI-50NE PQI-200SE ACK-200SSE HTO-80ESE SIE-
20WSW HNK-YSC-70NW PQI
MOD TURB BLW 120. CONDS CONTG THRU 09Z.

....

10.0 Terminal Aerodrome Forecast

KRUT had an NWS Terminal Aerodrome Forecast (TAF) issued by the Burlington, Vermont Weather Forecast Office (WFO) and the TAF valid at the accident time was an amended TAF issued at 1519 EST and was valid for a 22-hour period beginning at 1500 EST. The 1519 EST TAF for KRUT was as follows:

AMD TAF KRUT 222019Z 2220/2318 **32006KT P6SM VCSH OVC025**
FM230000 32010G17KT P6SM BKN035
FM230600 32007KT P6SM SCT120
FM231500 VRB03KT P6SM SCT150=

The TAF expected a wind from 320° at 6 knots, greater than 6 miles visibility, showers in the vicinity²⁸, and an overcast ceiling at 2,500 ft agl.

The previous TAF was issued at 1239 EST and was as follows:

TAF KRUT 221739Z 2218/2318 35008KT P6SM -RASN OVC008
FM222000 32008KT P6SM VCSH OVC015
FM230000 32010G17KT P6SM BKN035
FM230600 32007KT P6SM SCT120
FM231500 VRB03KT P6SM SCT150=

²⁸ In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

11.0 NWS Area Forecast Discussion

The NWS Office in Burlington, Vermont, issued the following Area Forecast Discussion (AFD) at 1524 EST (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed that ongoing IFR to MVFR conditions would improve into the evening hours with higher terrain obscuration conditions continuing:

FXUS61 KBTW 222024
AFDBTV

Area Forecast Discussion
National Weather Service Burlington VT
324 PM EST Wed Nov 22 2017

.SYNOPSIS...

A cold front will clear the North Country late this afternoon and this evening, bringing an end to the mix of rain and snow showers. Northwest winds will usher in colder air with partial clearing overnight. Thanksgiving will feature fair weather with partly to mostly cloudy conditions and chilly temperatures, as surface high pressure builds across New York and New England. Afternoon highs on Thanksgiving day will generally reach the low to mid 30s. Fair weather will continue on Friday with moderating temperatures. The next chance for widespread showers, mainly in the form of rain, will be Saturday with another cold front crossing the area.

&&

.NEAR TERM /THROUGH THURSDAY NIGHT/...

As of 322 PM EST Wednesday...Trending toward quieter weather conditions late this aftn/evening. The 850-700mb frontogenetic forcing is beginning to weaken and shift ewd across central/ern VT with precipitation ending as expected at 1830Z across the Champlain Valley. Developing NW flow in the wake of the sfc front will result in some continued orographic snow shower activity across the nrn Adirondacks and Green Mtns through the first half of tonight. Maintained mention of -SHSN across the nrn mtns through 06Z or so tonight. Otherwise, visible satellite imagery showing some upstream clearing across the Ottawa Valley of Ontario. Should see a few breaks this evening and overnight away from upslope mtn areas. Moderately strong sfc-850mb CAA expected, and associated steep lapse rates will promote some sfc wind gusts 15-25 mph mainly 22-06Z. Thereafter, ridge axis building ewd across nrn NY will result in gradually diminishing wind speeds. Will result in relatively cold overnight lows, mainly in the teens to low 20s, except mid 20s in the vicinity of Lake Champlain with the moderating influence of the relatively warm lake waters (still 48F at the King Street ferry dock).

Chilly and quiet weather conditions for traveling on Thanksgiving Day. High RH 700-500mb layer should maintain some SCT-BKN mid- level clouds, but should see light winds and highs in the low-mid 30s. Winds will turn light south by afternoon.

As ridge axis moves to the east and shortwave trough grazes the intl border, it appears that developing low-level SW 850mb flow may allow a few flurries or snow showers to develop off of Lake Ontario into srn St. Lawrence and Franklin counties. This would mainly be 23Z Thu thru 06Z Fri. Could see a dusting to 0.5" in spots, especially NY Route 3 corridor around Star Lake/Wanakena. Low temperatures on Thursday night expected mid-upr 20s, perhaps near 30F in srn St. Lawrence County with greater wind/cloud cover.

&&

.SHORT TERM /FRIDAY THROUGH FRIDAY NIGHT/...

As of 322 PM EST Wednesday...Pretty much quiet zonal flow across the region with surface high across Mid-Atlantic states nosing a bit into the region. We'll likely see filtered sunshine with moderating temperatures in the L40s and dry for Black Friday shoppers.

Energy of next northern stream shortwave to our north as it approaches for Saturday with associated cold front. The timing looks like any pcpn will hold off til early morning hours of Saturday. It will be cold enough Friday night for some -shsn mixed with -shra when pcpn arrives early Sat morning with lows in the 20s/30s.

&&

.LONG TERM /SATURDAY THROUGH WEDNESDAY/...

As of 322 PM EST Wednesday...Aforementioned cold front swings through Saturday with little fanfare as largely moisture starved and on the heels of this leading shortwave is another short wave Sat ngt-Sun to deepen the trough across the northeast and bring more instability snow showers on Sunday.

There may be some isold/sct traveling issues come Sunday with the mountain snow showers but nothing widespread or significant.

By Monday...trough exits with ridging developing in response to developing deep trof in the Rockies that will eventually lift across the Great Lakes and eventually our area by late next week.

High pressure positioned to our south and SW flow at all levels means another warm up. It will still be chilly on Monday but then we're under the influence of southwest flow thru mid week with temperatures in the 40s and possible 50s by mid week.

By Wednesday, discrepancies in handling the Rockies system with GFS less developed and quickly ejecting toward the east, while ECMWF has a more developed system with slower movement toward our area with Canadian closer to GFS. WPC shows warm frontlifting Tue Ngt/early Wed with front likely moving through late Wed and will play it as such.

&&

.AVIATION /21Z WEDNESDAY THROUGH MONDAY/...

Through 18z Thursday...Ongoing IFR-MVFR in low ceilings and mix rain/snow will gradually improve, especially after 21Z, as cold front and associated banded precipitation shifts east of VT.

Will see some continued flurries into this evening across the nrn Adirondacks and central/nrn Greens with HIR TRRN OBSCD.

Otherwise, precipitation will end with gradual lifting of ceilings back to VFR, and partial clearing working in from the Ottawa and St. Lawrence River Valleys. **Winds will likewise be shifting into the NW, with gusts 16-18kts possible through 09Z**

Thursday. Thereafter, high pressure builds into NY and New England with generally fair SCT-BKN VFR conditions for the balance of Thanksgiving Day.

Outlook...

Thursday Night: Mainly VFR, with local MVFR possible. Slight chance SHSN, mainly at SLK with ern end of lake effect snow band.

Friday: VFR. NO SIG WX. Friday Night: VFR. Slight chance SHRA, Slight chance SHSN. Saturday: Mainly VFR, with areas MVFR possible. Chance SHRA, Chance SHSN. Saturday Night:

Mainly MVFR, with local IFR possible. Chance SHSN, Chance SHRA. Sunday: Mainly MVFR, with areas VFR possible. Chance SHSN.

Sunday Night: Mainly VFR, with local MVFR possible. Chance SHSN. Monday: Mainly VFR, with local MVFR possible. Slight chance SHSN.

SHSN.

&&

.BTV WATCHES/WARNINGS/ADVISORIES...

VT...None.

NY...None.

&&

\$\$

12.0 Winds and Temperature Aloft Forecast

The NWS 1500 EST Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

FBUS31 KWN0 222000

FD1US1

DATA BASED ON 221800Z

VALID 230000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

ALB **3326 3230-10 3128-08** 2927-15 3143-23 3039-34 265342 246345 247652

The accident site was closest to the Albany, New York, (ALB) forecast point. The 1900 EST ALB forecast for use between 1500 and 2200 EST indicated a wind at 3,000 ft from 330° at 26 knots, a wind at 6,000 ft from 320° at 30 knots with a temperature of -10° C, and a wind at 9,000 ft from 310° at 28 knots with a temperature of -8° C.

13.0 Pilot Weather Briefing

A search of official weather briefing sources such as contract Automated Flight Service Station (AFSS) provider Leidos weather briefings and the Direct User Access Terminal Service (DUATS) was done. The accident pilot received official Leidos outlook weather briefings at 1814 EST on November 21 and at 1420 EST on November 22 (Attachments 3, 4, 5, 6, and 7). During the 1814 EST November 21 contact with Leidos, the weather briefer and accident pilot discussed a cold front moving through the area with scattered light precipitation, MVFR conditions at best, and AIRMET Sierra for mountain obscuration likely. The accident pilot asked for what the cloud tops might be, but the weather forecast did not go that far into the future yet. The pilot stated that “the only no-go thing is probably not fly in the clouds”, and stated that “I’d hate to fly in the clouds, in freezing weather.”

The 1420 EST November 22 contact with AFSS Leidos, the weather briefer and accident pilot discussed that the pilot would like to fly VFR because the pilot didn’t want to fly through clouds with potential icing issues. In addition, the weather briefer and accident pilot discussed widespread MVFR conditions, current METARs, that briefer had no PIREPs with cloud top reports along route of flight, current TAFs, current AIRMETs, current freezing level along the route of flight, that the mountains were obscured to the east and south of the intended destination airport, the weather conditions towards Albany, New York, winds aloft information, and that VFR flight was not recommended.

A search of archived data from ForeFlight was done and the accident pilot did not request nor receive weather briefing information from ForeFlight. It is unknown if the accident pilot checked or received anymore weather information before or during the accident flight.

14.0 Icing Potential²⁹

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 13 through 15 were the FIP icing probabilities and icing severity products, 1-hour forecast valid at 1700 EST at 1,000, 2,000, and 3,000 feet msl (similar values in the FIP are seen in the 2-hour forecast valid at both 1600 and 1700 EST, attachment 8). The FIP images indicated between a 40 to 80 percent probability of icing at 2,000 and 3,000 feet at 1700 EST at the accident site (figures 14 and 15). The 1,000 feet FIP and CIP levels were below the level of the terrain and therefore the accident site and the surrounding terrain have no icing probability. The FIP also indicated that the icing near the accident site would likely be light to moderate (figures 14 and 15). The FIP indicated an unknown potential for any Supercooled Large Droplet (SLD) over the accident area around the accident time (attachment 8). This FIP information was available on the NWS AWC website well before the accident flight departed Pittsfield, Massachusetts (departure location).³⁰

The CIP product indicated between a 30 to 80 percent probability of icing at 2,000 and 3,000 feet at 1700 EST at the accident site. The CIP also indicated that the icing near the accident site would likely be trace to moderate intensity (figures 17 and 18). The CIP also indicated an unknown chance of SLD near the accident site around the accident time (attachment 8). For more FIP and CIP information and altitudes please see attachment 8.

²⁹ B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cunning, 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. Cunning, 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>

³⁰ <https://www.aviationweather.gov/icing/fip>

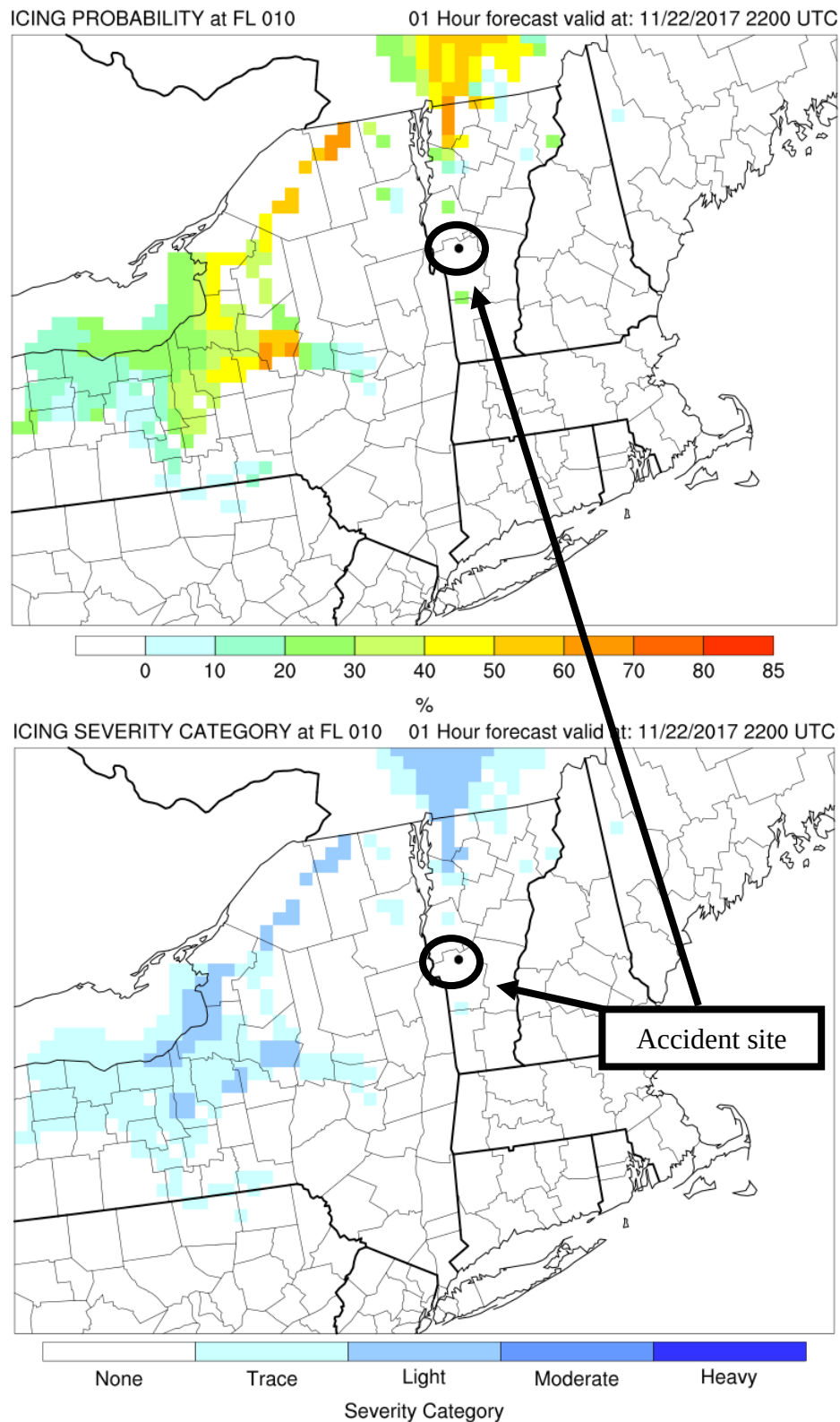
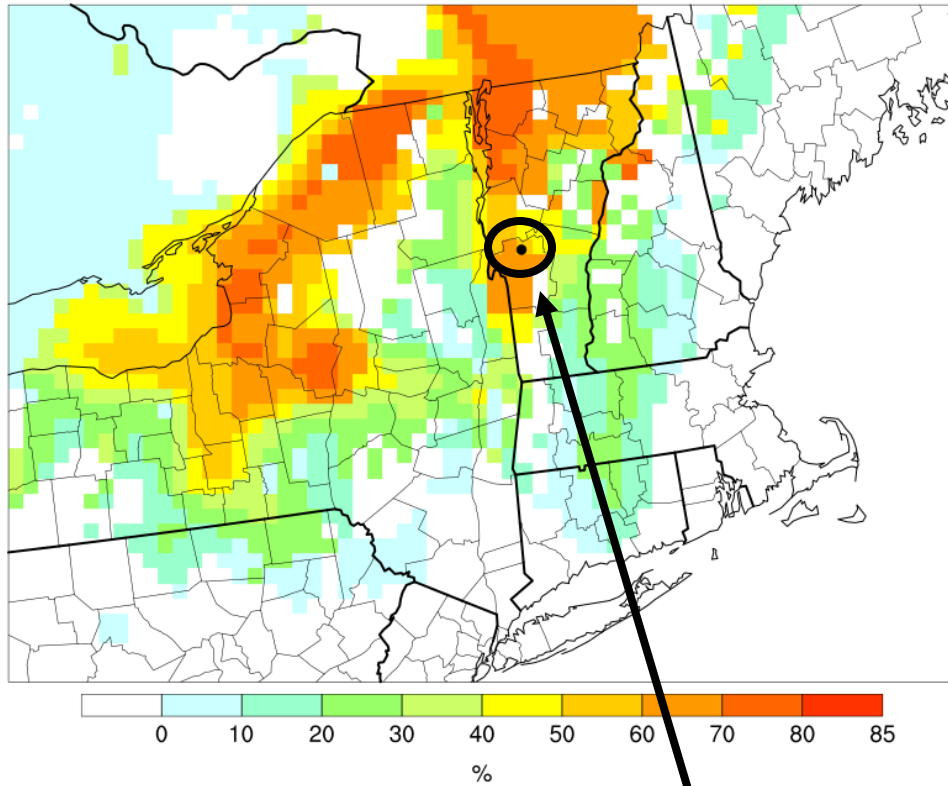


Figure 13 – (top) FIP probability of icing at 1,000 feet msl and (bottom) FIP severity of icing at 1,000 feet msl 1-hour forecast valid for 1700 EST

ICING PROBABILITY at FL 020 01 Hour forecast valid at: 11/22/2017 2200 UTC



ICING SEVERITY CATEGORY at FL 020 01 Hour forecast valid at: 11/22/2017 2200 UTC

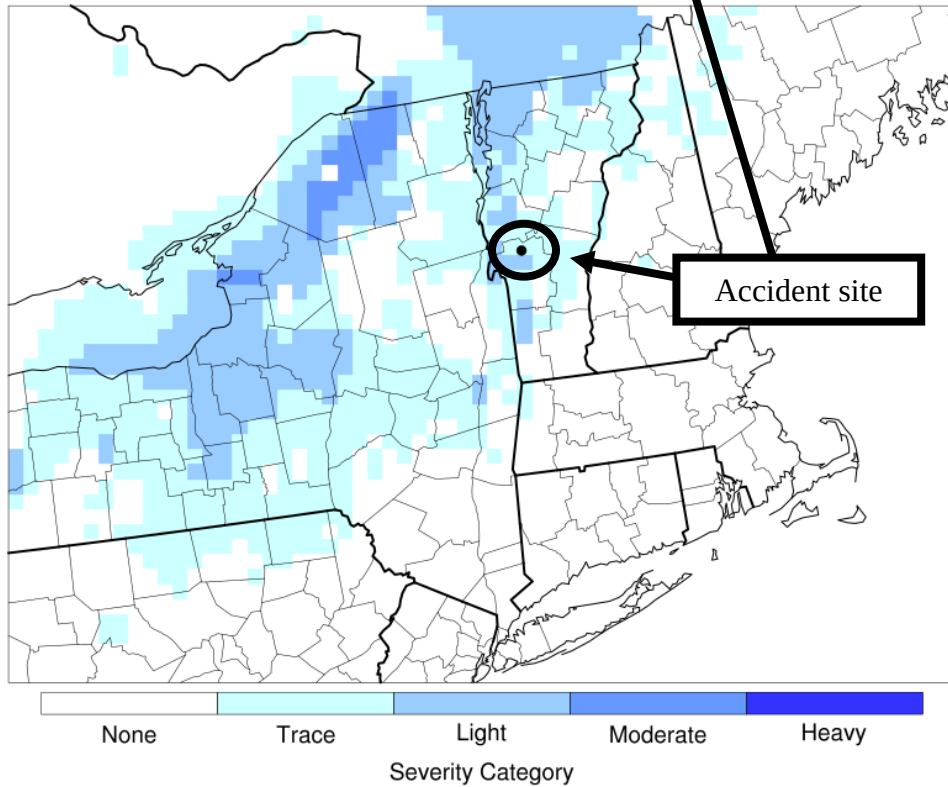
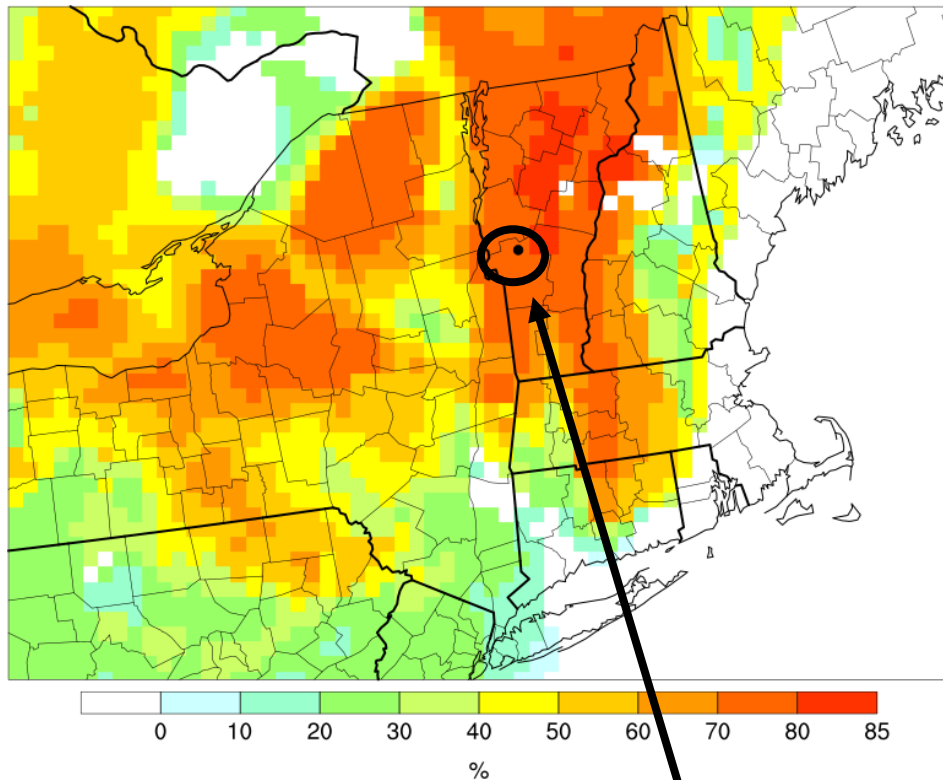


Figure 14 – (top) FIP probability of icing at 2,000 feet msl and (bottom) FIP severity of icing at 2,000 feet msl 1-hour forecast valid for 1700 EST

ICING PROBABILITY at FL 030

01 Hour forecast valid at: 11/22/2017 2200 UTC



ICING SEVERITY CATEGORY at FL 030

01 Hour forecast valid at: 11/22/2017 2200 UTC

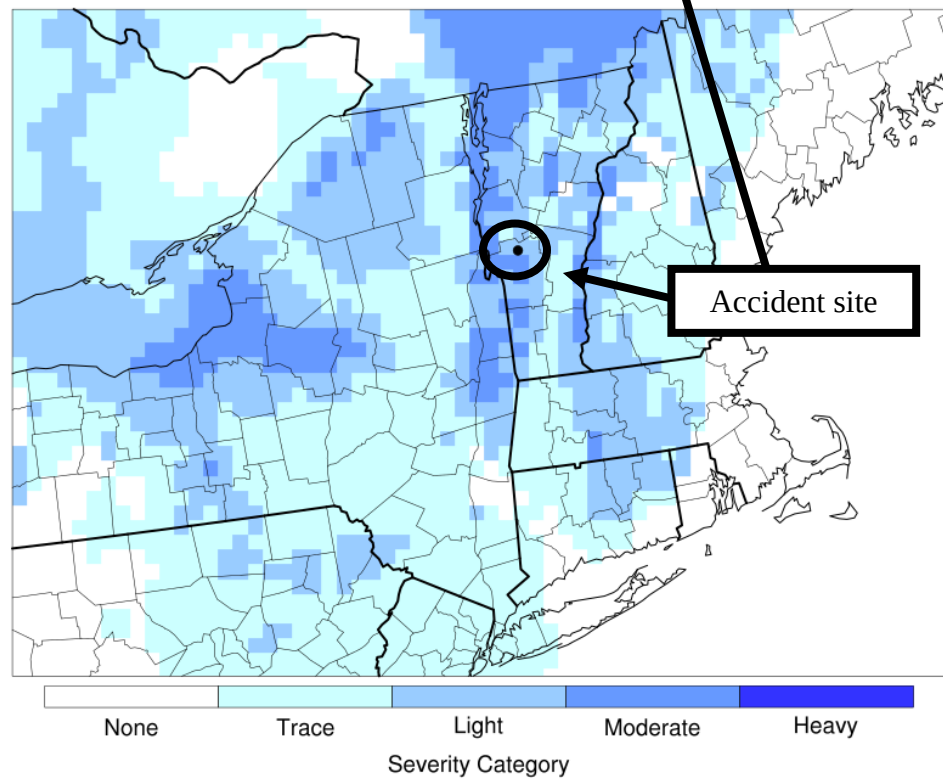


Figure 15 – (top) FIP probability of icing at 3,000 feet msl and (bottom) FIP severity of icing at 3,000 feet msl 1-hour forecast valid for 1700 EST

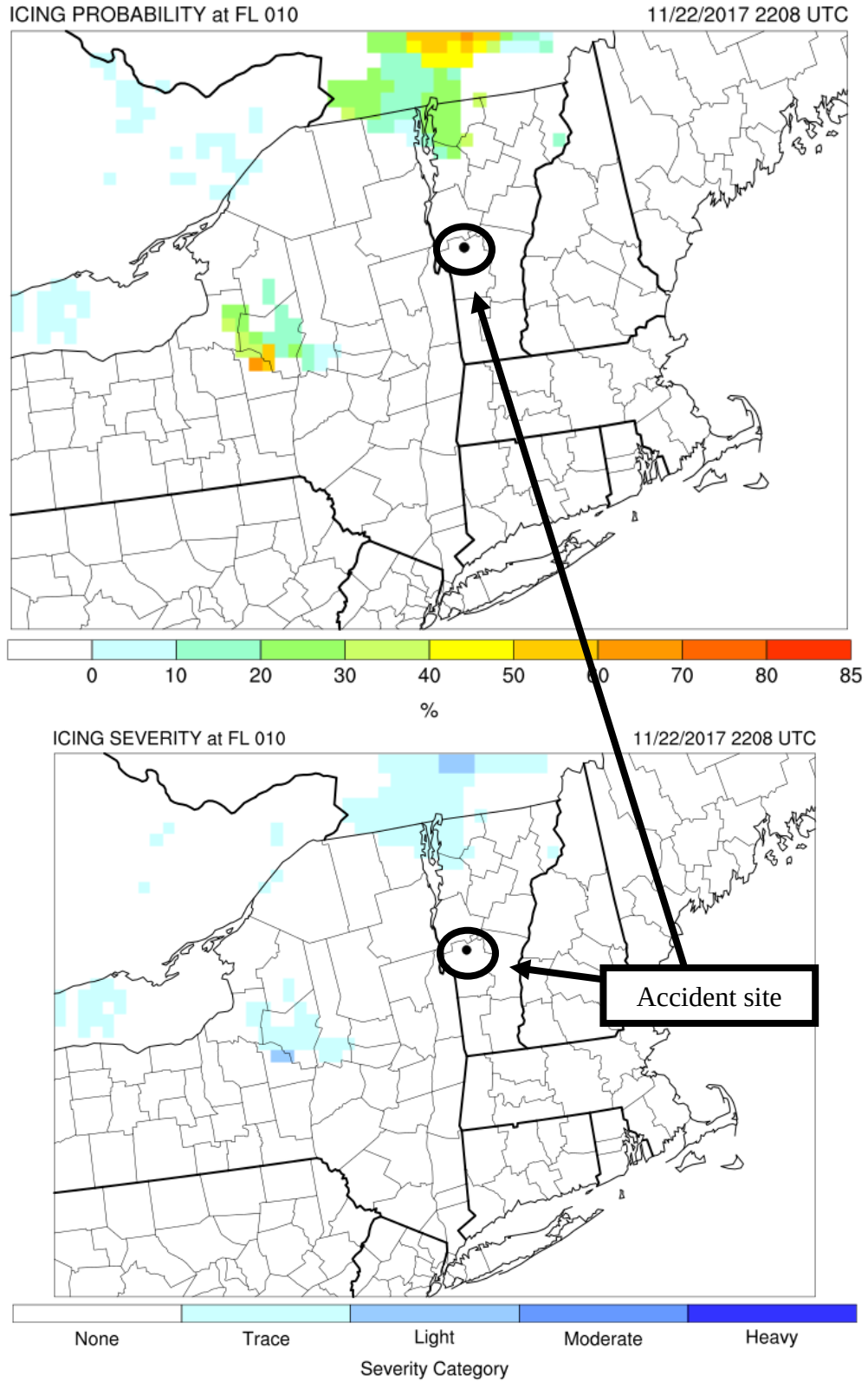


Figure 16 – (top) CIP probability of icing at 1,000 feet msl and (bottom) CIP severity of icing at 1,000 feet msl valid for 1700 EST

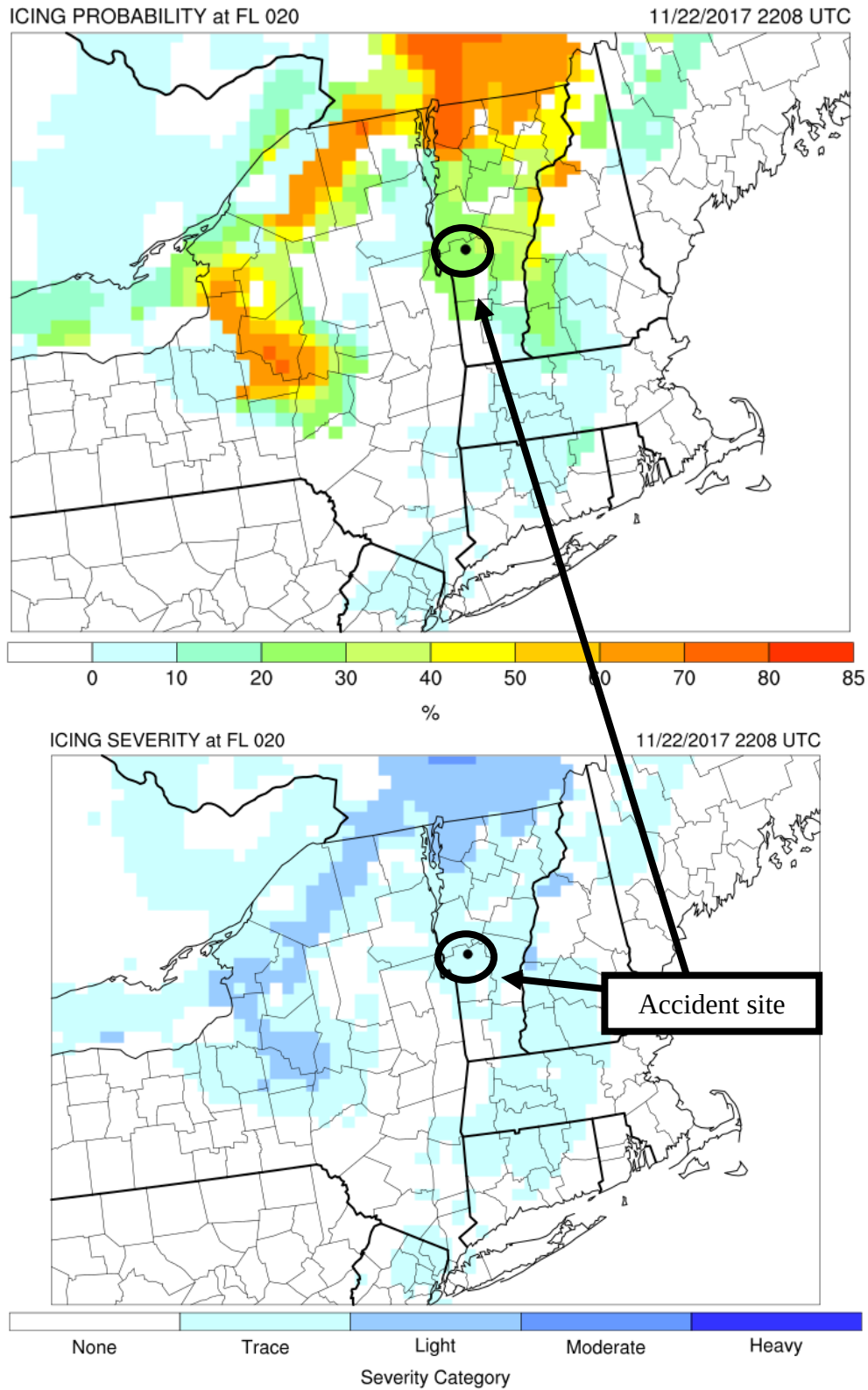
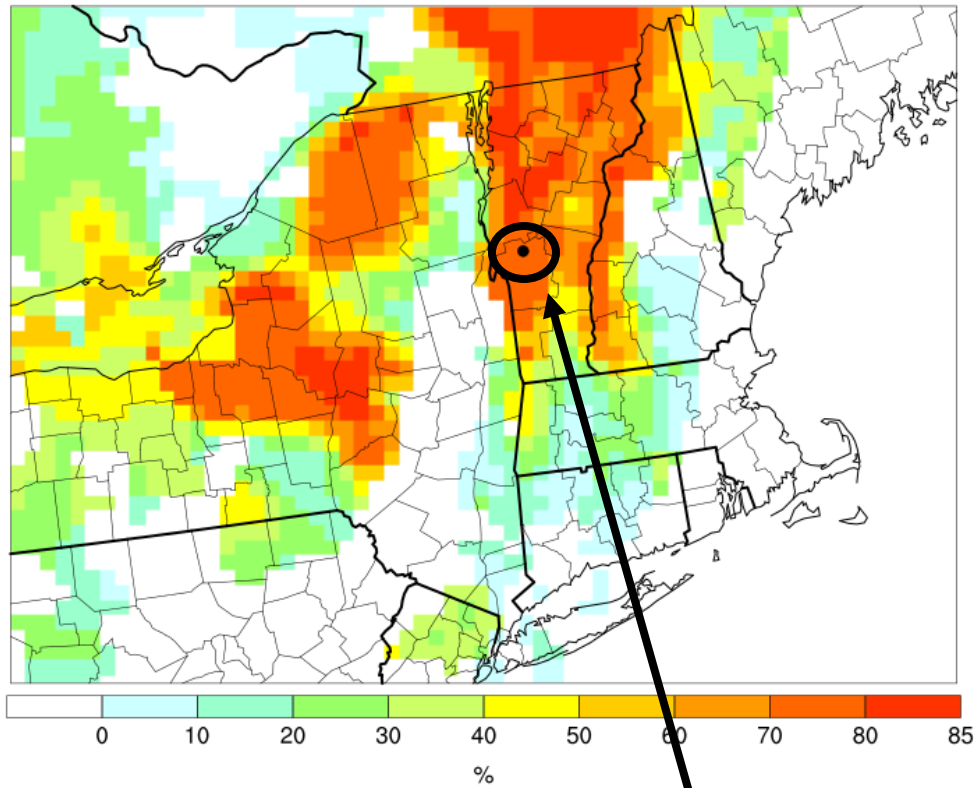


Figure 17 – (top) CIP probability of icing at 2,000 feet msl and (bottom) CIP severity of icing at 2,000 feet msl valid for 1700 EST

ICING PROBABILITY at FL 030

11/22/2017 2208 UTC



ICING SEVERITY at FL 030

11/22/2017 2208 UTC

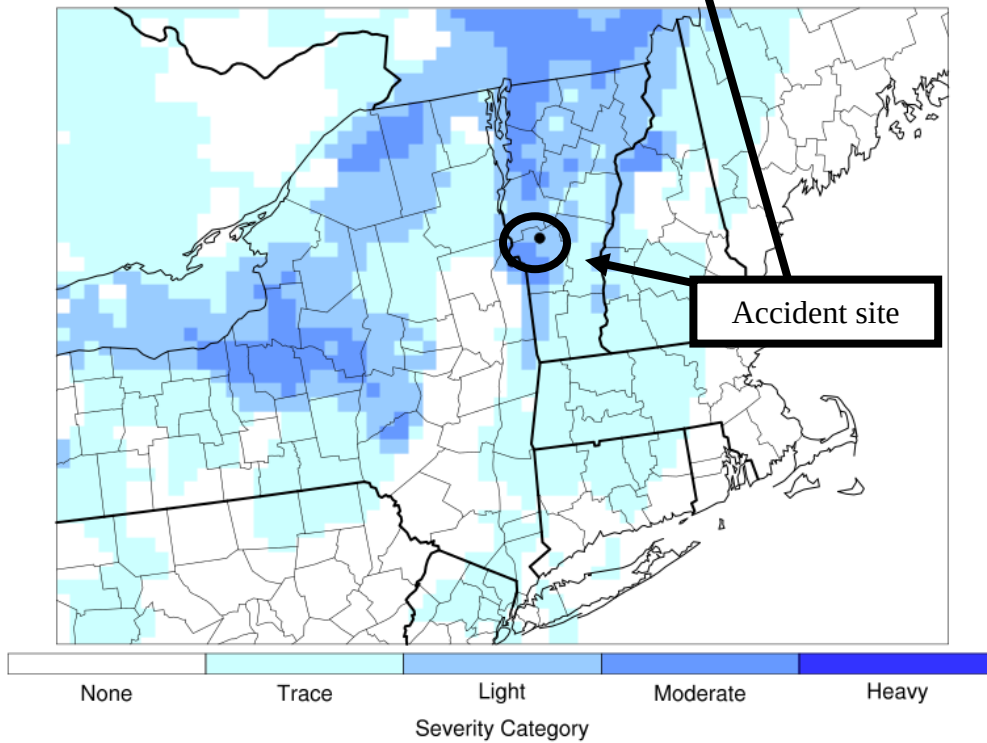


Figure 18 – (top) CIP probability of icing at 3,000 feet msl and (bottom) CIP severity of icing at 3,000 feet msl valid for 1700 EST

15.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on November 22, 2017, indicated the following:

SUN

Begin civil twilight	0625 EST
Sunrise	0657 EST
Sun transit	1141 EST
Sunset	1626 EST
End civil twilight	1657 EST
Accident	1700 EST

MOON

Moonrise	1014 EST
Moon transit	1504 EST
Accident	1700 EST
Moonset	1955 EST

The phase of the Moon was Waxing Crescent with 15% of the Moon's visible disk illuminated. The clouds above the accident site at the accident time would have not allowed any illumination from the Moon at the accident time.

E. LIST OF ATTACHMENTS

Attachment 1 – Infrared satellite animation from 1600 to 1745 EST

Attachment 2 – Animation of KCXX WSR-88D reflectivity for the 0.5° elevation scan initiated between 1621 and 1718 EST

Attachment 3 – GFA products provided to the accident pilot during the Leidos weather briefing from 1420 EST

Attachment 4 – Leidos contact with accident pilot at 1814 EST on November 21

Attachment 5 – Leidos text briefing information provided to accident pilot 1814 EST on November 21

Attachment 6 – Leidos contact with accident pilot at 1420 EST

Attachment 7 – Leidos text briefing information provided to accident pilot at 1420 EST

Attachment 8 – CIP and FIP products valid at 1600 and 1700 EST for the accident flight

Submitted by:

Paul Suffern
Senior Meteorologist

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