



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

June 5, 2019

Weather Study

METEOROLOGY

ERA19FA130

Table Of Contents

A.	ACCIDENT	3
B.	METEOROLOGIST	3
C.	DETAILS OF THE INVESTIGATION	3
D.	FACTUAL INFORMATION	3
1.0	Synoptic Situation	3
1.1	Surface Analysis Chart	4
1.2	Upper Air Charts	4
2.0	SPC Products	9
3.0	Surface Observations	12
4.0	Upper Air Data	16
5.0	Satellite Data	18
6.0	Regional Radar Imagery Information	20
7.0	Pilot Reports	21
8.0	SIGMET	22
9.0	CWSU Advisories	22
10.0	AIRMETs	22
11.0	Graphical Forecasts for Aviation	24
12.0	Terminal Aerodrome Forecast	24
13.0	NWS Area Forecast Discussion	24
14.0	Winds and Temperature Aloft Forecast	27
15.0	Pilot Weather Briefing	27
16.0	Astronomical Data	28
E.	LIST OF ATTACHMENTS	28

A. ACCIDENT

Location: Cashiers, North Carolina
Date: March 14, 2019
Time: 1815 eastern daylight time
2215 Coordinated Universal Time (UTC)
Aircraft: Mooney M20C, Registration: N6075Q

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 daylight time (EDT) on March 14, 2019, and are based upon the 24-hour clock, where local time is -4 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 miles. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports and "P" for OCONUS airports.

The accident site was located at latitude 35.0625° N, longitude 83.1539° W at an approximate altitude of 3,150 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 southeastern United States section of the NWS Surface Analysis Chart for 2000 EDT is provided as figure 1 with the location of the accident site marked within the red circle. The chart indicated a cold front stretching from the Great Lakes region southward to the Gulf of Mexico and across central Tennessee west of the accident site.

The station models around the accident site depicted air temperatures in the upper 50's to mid 60's degrees Fahrenheit (°F), dew point temperatures in the low to mid 50's °F with a temperature-dew point spread of 8° or less, a southwest to southeast wind between 5 and 10 knots, overcast cloud cover in southwestern North Carolina, and light rain.

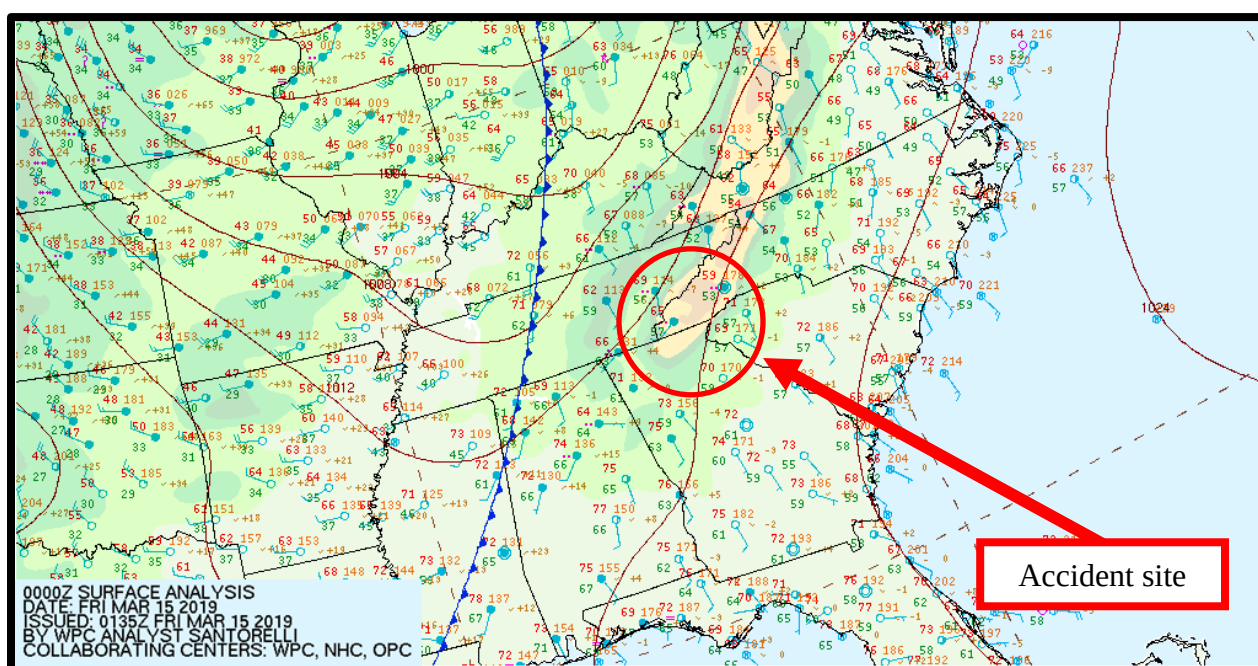


Figure 1 – NWS Surface Analysis Chart for 2000 EDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 2000 EDT at 925-, 850-, 700-, 500-, and 300-hectopascals (hPa) are presented in figures 2 through 6. There was a low- and mid-level trough² located west of the accident site across the central United States. Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. The wind was from the south at 20 knots at 925-hPa with the wind becoming southwesterly at 40 knots by 700-hPa (figure 4). At 300-hPa, the wind was from the west between 60 and 85 knots (figure 6).

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

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

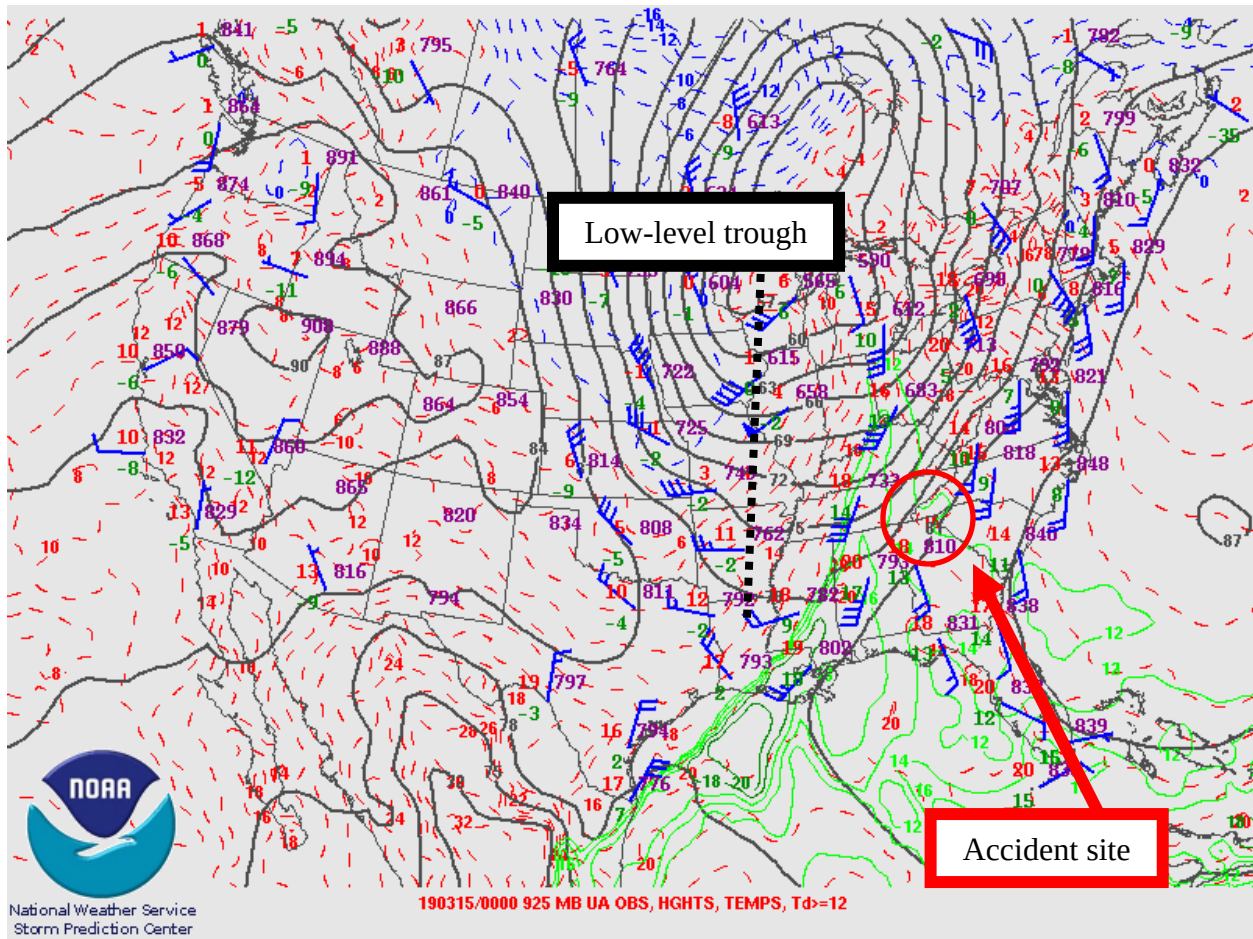


Figure 2 – 925-hPa Constant Pressure Chart for 2000 EDT

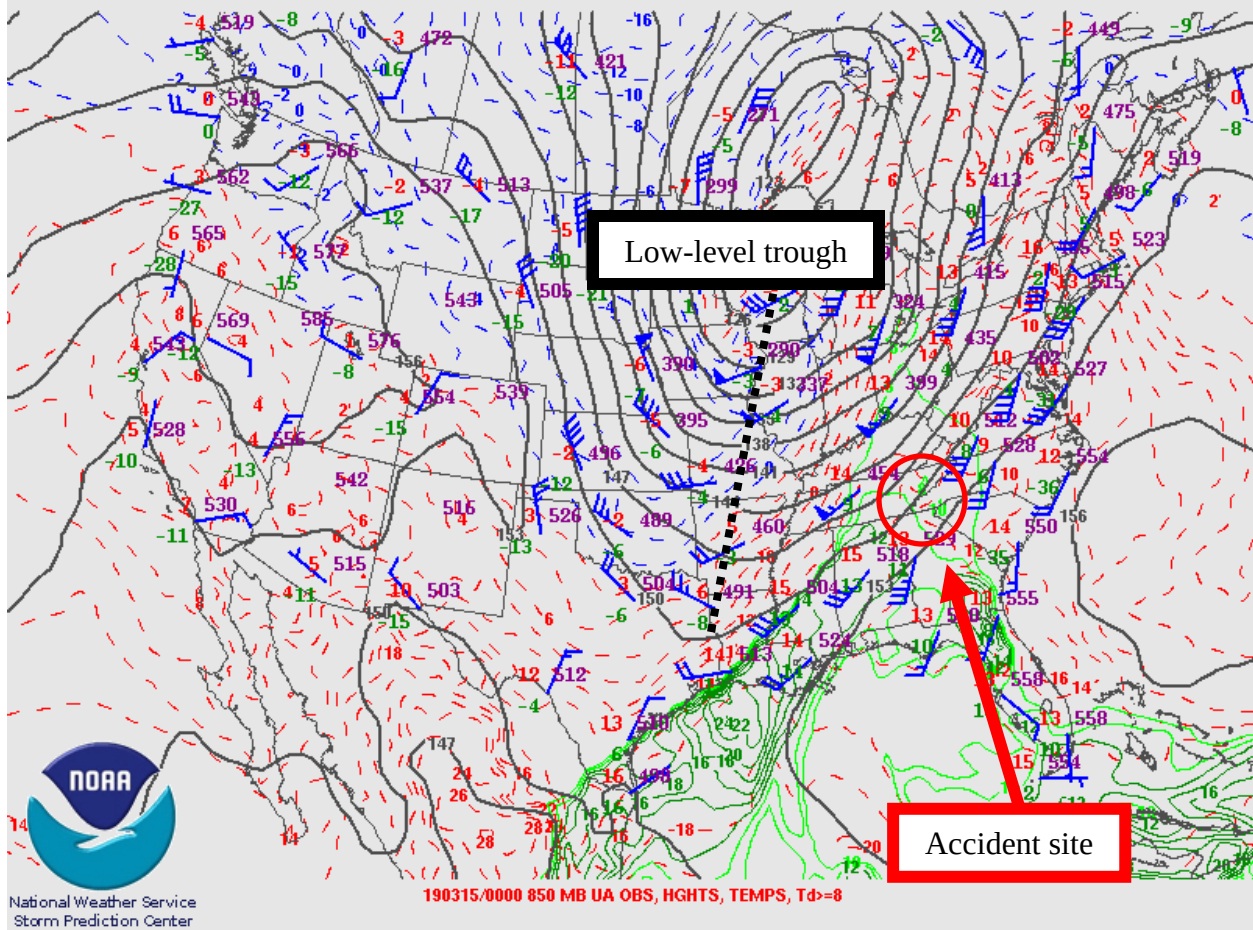


Figure 3 – 850-hPa Constant Pressure Chart for 2000 EDT

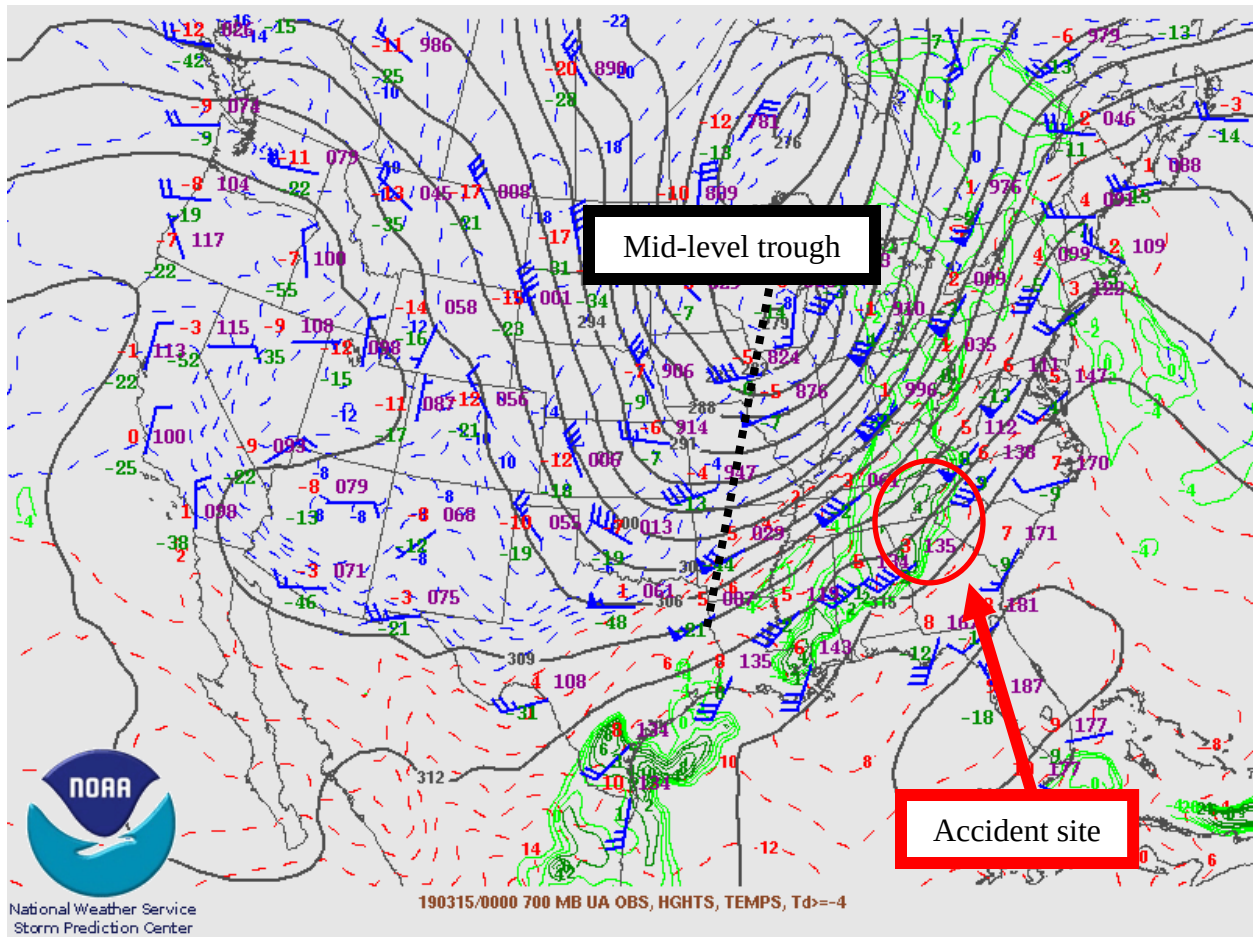


Figure 4 – 700-hPa Constant Pressure Chart for 2000 EDT

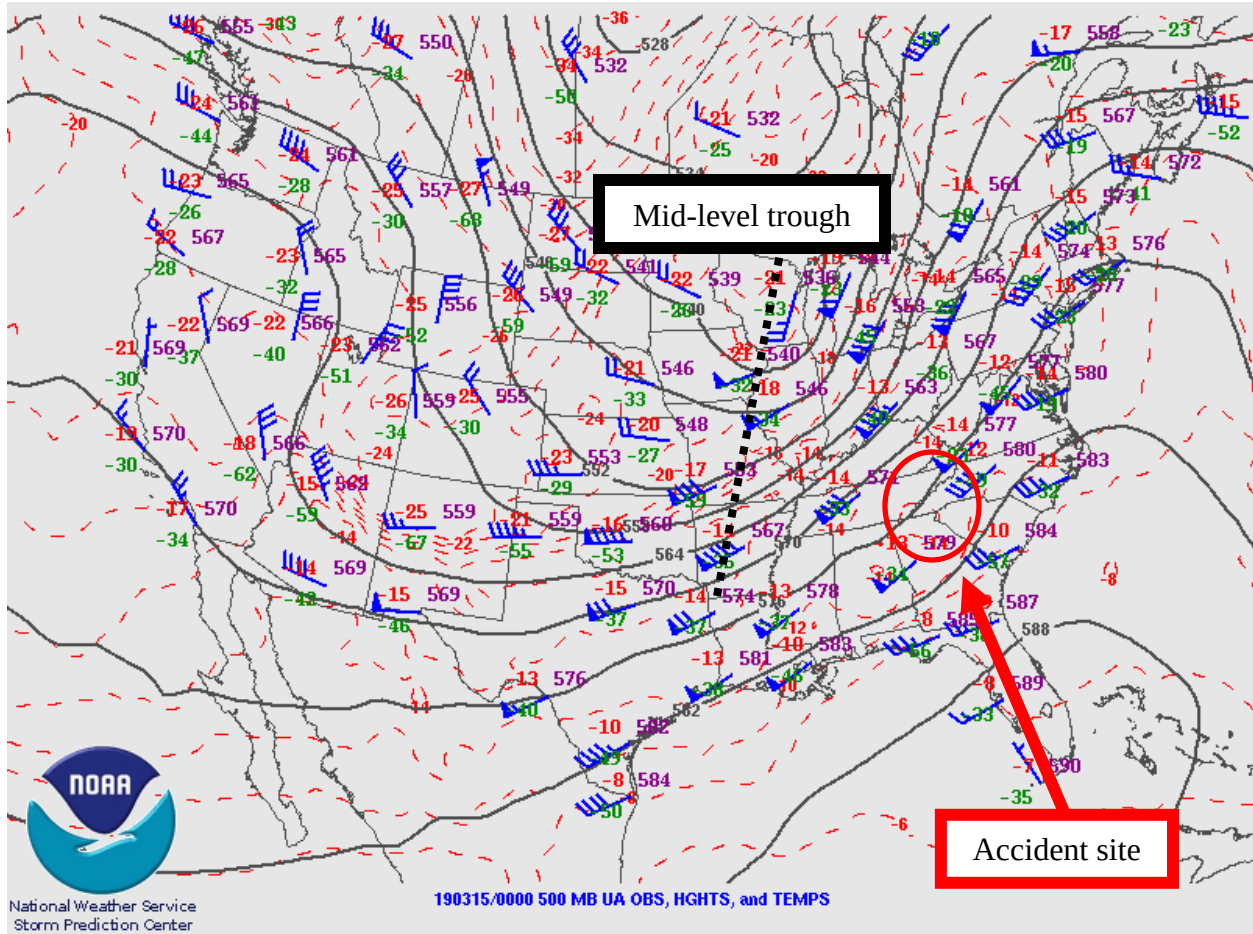


Figure 5 – 500-hPa Constant Pressure Chart for 2000 EDT

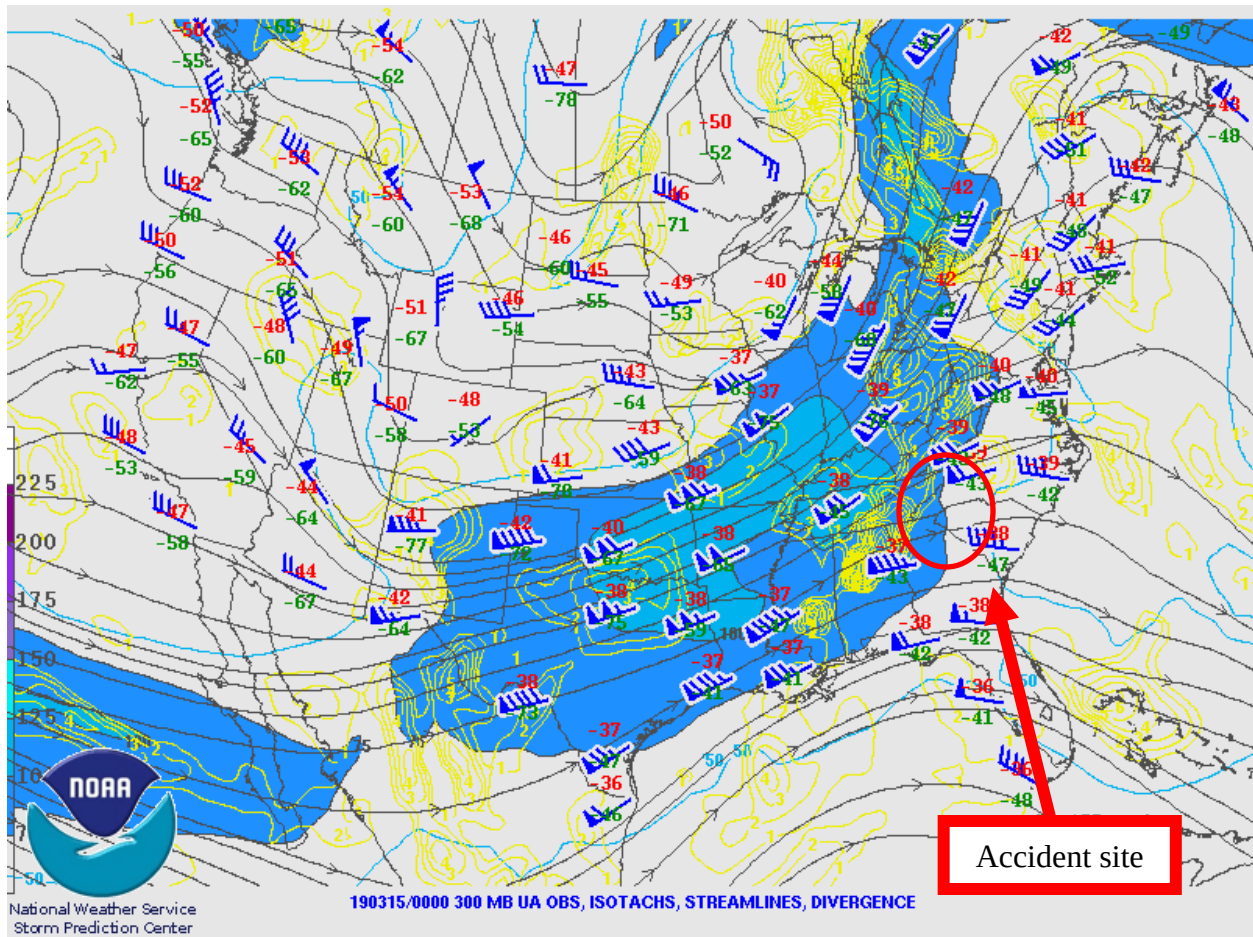


Figure 6 – 300-hPa Constant Pressure Chart for 2000 EDT

2.0 SPC Products

SPC issued the following Day 1 Convective Outlook at 1555 EDT (figure 7) with areas of general thunderstorms forecast for the accident site. SPC defines the “TSTM” area as an area that encloses where a 10% or higher probability of thunderstorms is forecast during the valid period. The thunderstorms were not forecast to occur near the accident site region until after sunset and during the overnight hours. The SPC Day 1 Convective Outlook text follows figure 7:

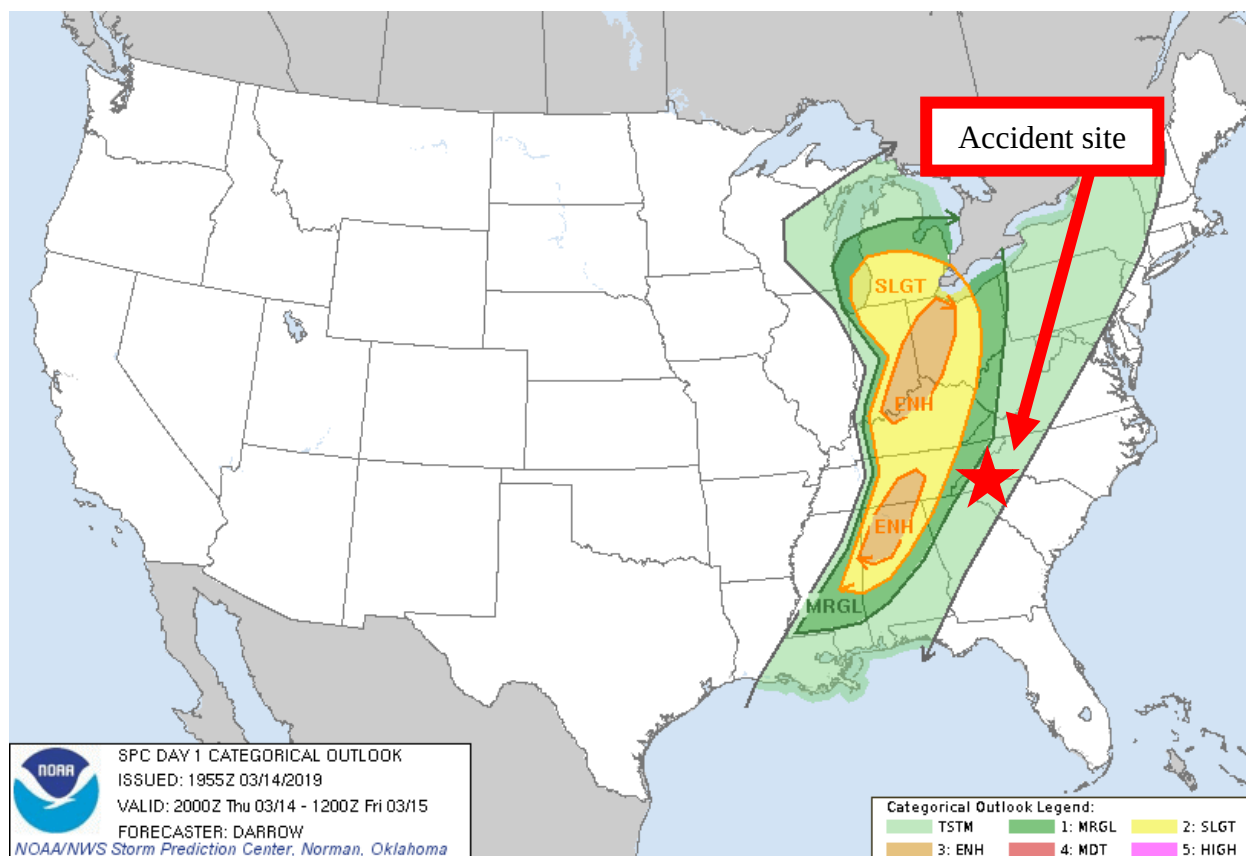


Figure 7 – SPC day 1 Convective Outlook valid at the time of the accident

SPC AC 141955

Day 1 Convective Outlook
 NWS Storm Prediction Center Norman OK
 0255 PM CDT Thu Mar 14 2019

Valid 142000Z - 151200Z

...THERE IS AN ENHANCED RISK OF SEVERE THUNDERSTORMS ACROSS PORTIONS OF THE GULF STATES AND OH VALLEY...

...SUMMARY...

Severe thunderstorms are likely from portions of the Southeast U.S. into the Ohio Valley and southern Great Lakes. Several tornadoes, a few of which could be strong, damaging winds and isolated large hail will be possible through this evening.

...20z Update...

Large-scale evolution of ongoing convective regime suggests three primary corridors of organized thunderstorm activity will be noted into the evening hours. 20z update will be predicated on these scenarios:

1. MS-TN: Strongest buoyancy currently extends across the central Gulf States into portions of northern AL. Over the last few hours

numerous supercells have evolved along a SW-NE oriented corridor along southern fringe of strong mid-high level flow. High-res model guidance supports this orientation/location of supercell activity. Given radar trends will separate the ENH Risk region to more accurately reflect this threat.

2. IN-OH: Early-morning supercells that developed along the OH River across western KY into southern IN continue in a SW-NE oriented fashion, but have shifted downstream in line with aforementioned high-res model guidance. While 14/19z ILN sounding does not exhibit more than weak instability, strongly sheared, surface-based instability has developed ahead of this activity. For these reasons will maintain ENH Risk across the OH Valley; however, will lower severe probs across southern KY/northern TN to express lower confidence in storm coverage.

3. Lower MI/northern IN: Scattered low-topped supercells are expected to spread across southern Lake MI into southwest lower MI over the next few hours. Weaker buoyancy across lower MI should influence updraft intensity across this region, but strong large-scale forcing is expected to contribute to the longevity of this activity as it moves into cooler boundary-layer air mass.

..Darrow.. 03/14/2019

.PREV DISCUSSION... /ISSUED 1126 AM CDT Thu Mar 14 2019/

...TN Valley to the OH Valley through this evening...

A deep surface cyclone in southeastern NE will move northeastward over IA/WI/upper MI by this evening, as an associated mid-upper jet streak ejects northeastward from MO toward the lower Great Lakes. A surface cold front will progress eastward from the mid MS Valley to the OH Valley, and southeastward into the lower MS Valley. A narrow corridor of low-level moistening and some surface heating in cloud breaks is expected immediately ahead of the cold front through this afternoon, which will support some destabilization as far northeast southern Lower MI.

The strongest low-level flow will develop northeastward across TN toward OH through the afternoon. Vertical shear will be very strong within the warm sector, with effective bulk shear of 70-80 kt and effective SRH of 400-600 m²/s². Boundary-layer dewpoints in the low 60s have spread as far north as the lower OH River as of late morning, and some additional moistening is expected to the northeast through the afternoon. Midlevel lapse rates are not particularly steep and surface heating will be slowed by the morning convection/clouds, so MLCAPE will likely remain in the 500-1000 J/kg range. Wind profiles will clearly favor supercells, as will the mode of initiation along and east of the front (not strong linear forcing for ascent). The vertical shear is on the high end for the modest buoyancy, but it appears the combination will be sufficient for the strongest/most sustained supercells to produced isolated strong tornadoes as the storms are roughly paced by the low-level destabilization.

Additional supercell development will be possible late this

afternoon into this evening along the trailing boundary in the vicinity of northwestern AL. Though the strongest low-level flow will develop north of this area by late afternoon, wind profiles will remain favorable for supercells/tornadoes given some heating in cloud breaks and an increase in low-level moisture through the afternoon.

...Central/northeastern IL to southern Lower MI this afternoon... Bands of convection are developing along the nose of the primary frontal surge/dry slot near and north of Saint Louis as of mid morning. The low levels are destabilizing northward across IL with surface heating in cloud breaks and boundary-layer dewpoints of 56-60 expected to reach northeastern IL by early afternoon. A broken band of low-topped thunderstorms is expected along the wind shift by this afternoon, when strong vertical shear will support supercells capable of producing tornadoes, damaging gusts, and marginally severe hail. The convection will subsequently spread northeastward toward lower MI later this afternoon. The degree of destabilization is more questionable compared to areas farther southwest, but wind profiles will strongly favor organized/supercell storms.

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NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 0100Z

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 8 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked. The pink line is the direct line between the departure (in Tennessee) and destination airports (in South Carolina).



Figure 8 – Sectional chart of accident area with the location of the accident site and the closest surface observation sites

The closest official weather reporting facility to the accident site was from Jackson County Airport (K24A), Sylva, North Carolina, at an elevation of 2,857 ft, and was 16 miles north-northwest of the accident site. K24A had an Automated Weather Observing System (AWOS³) whose reports were not supplemented and K24A had a 6° westerly magnetic variation⁴ (figure 8). The following observations were taken and disseminated during the times surrounding the accident:⁵

- [1620 EDT] METAR K24A 142020Z AUTO 14010KT 100V160 10SM OVC017 14/11
A3010 RMK AO2 T01400113=
- [1640 EDT] METAR K24A 142040Z AUTO 13011G16KT 10SM SCT014 OVC021 14/11
A3010 RMK AO2 T01420115=
- [1700 EDT] METAR K24A 142100Z AUTO 11009KT 10SM SCT014 OVC021 14/12
A3010 RMK AO2 T01410116=
- [1720 EDT] METAR K24A 142120Z AUTO 12007KT 10SM OVC021 14/12 A3010 RMK
AO2 T01420117=

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

[1740 EDT] METAR K24A 142140Z AUTO 13006KT 10SM OVC021 14/12 A3011 RMK AO2 LTG DSNT NW T01430118=

[1800 EDT] METAR K24A 142200Z AUTO 13006KT 10SM OVC023 15/12 A3010 RMK AO2 LTG DSNT W AND NW T01460118=

ACCIDENT TIME 1815 EDT

[1820 EDT] METAR K24A 142220Z AUTO 13006KT 10SM BKN025 BKN033 OVC045 15/12 A3010 RMK AO2 LTG DSNT W T01490119=

[1840 EDT] METAR K24A 142240Z AUTO 12004KT 10SM BKN027 OVC037 15/12 A3010 RMK AO2 T01500120=

[1900 EDT] METAR K24A 142300Z AUTO 12006KT 10SM OVC027 15/12 A3010 RMK AO2 T01520120=

K24A weather at 1740 EDT, automated, wind from 130° at 6 knots, 10 miles visibility or greater, an overcast ceiling at 2,100 ft above ground level (agl), temperature of 14 °Celsius (C), dew point temperature of 12 °C, and an altimeter setting of 30.11 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, lightning distant⁶ northwest, temperature 14.3 °C, dew point temperature 11.8 °C.

K24A weather at 1800 EDT, automated, wind from 130° at 6 knots, 10 miles visibility or greater, an overcast ceiling at 2,300 ft agl, temperature of 15 °C, dew point temperature of 12 °C, and an altimeter setting of 30.10 inHg. Remarks: automated station with a precipitation discriminator, lightning distant west and northwest, temperature 14.6 °C, dew point temperature 11.8 °C.

K24A weather at 1820 EDT, automated, wind from 130° at 6 knots, 10 miles visibility or greater, a broken ceiling at 2,500 ft agl, broken clouds at 3,300 ft agl, overcast clouds at 4,500 ft agl, temperature of 15 °C, dew point temperature of 12 °C, and an altimeter setting of 30.10 inHg. Remarks: automated station with a precipitation discriminator, lightning distant west, temperature 14.9 °C, dew point temperature 11.9 °C.

K24A weather at 1840 EDT, automated, wind from 120° at 4 knots, 10 miles visibility or greater, a broken ceiling at 2,700 ft agl, overcast clouds at 3,700 ft agl, temperature of 15 °C, dew point temperature of 12 °C, and an altimeter setting of 30.10 inHg. Remarks: automated station with a precipitation discriminator, temperature 15.0 °C, dew point temperature 12.0 °C.

Macon County Airport (K1A5) was the next closest official observation point. K1A5 was located at an elevation of 2,034 ft and was 16 miles northwest of the accident site (figure 8). K1A5 had an AWOS whose reports were not supplemented. The following observations were taken and disseminated during the times surrounding the accident:

⁶ Distant indicated that the lightning was beyond 10 miles but less than 30 miles from the center of the airport (or airport location point, [ALP]).

[1620 EDT] METAR K1A5 142020Z AUTO 22004KT 7SM OVC016 15/14 A3011 RMK AO2 T01490140=

[1640 EDT] METAR K1A5 142040Z AUTO 20005KT 10SM SCT012 OVC016 15/14 A3012 RMK AO2 T01500140=

[1700 EDT] METAR K1A5 142100Z AUTO 00000KT 10SM BKN020 BKN024 OVC033 16/14 A3011 RMK AO2 T01550143=

[1720 EDT] METAR K1A5 142120Z AUTO 11004KT 10SM SCT020 SCT029 OVC036 16/15 A3011 RMK AO2 T01580145=

[1740 EDT] METAR K1A5 142140Z AUTO 08005KT 10SM SCT028 OVC035 15/14 A3010 RMK AO2 T01520143=

[1800 EDT] METAR K1A5 142200Z AUTO 07003KT 10SM SCT024 SCT029 OVC035 16/15 A3011 RMK AO2 T01550145=

ACCIDENT TIME 1815 EDT

[1820 EDT] METAR K1A5 142220Z AUTO 00000KT 10SM SCT023 BKN029 OVC040 15/14 A3011 RMK AO2 T01530143=

[1840 EDT] METAR K1A5 142240Z AUTO 00000KT 10SM BKN025 BKN031 OVC037 16/15 A3010 RMK AO2 T01550145=

[1900 EDT] METAR K1A5 142300Z AUTO 08003KT 10SM BKN027 OVC035 16/15 A3010 RMK AO2 T01550145=

K1A5 weather at 1740 EDT, automated, wind from 080° at 5 knots, 10 miles visibility or greater, scattered clouds at 2,800 ft agl, an overcast ceiling at 3,500 ft agl, temperature of 15 °C, dew point temperature of 14 °C, and an altimeter setting of 30.10 inHg. Remarks: automated station with a precipitation discriminator, temperature 15.2 °C, dew point temperature 14.3 °C.

K1A5 weather at 1800 EDT, automated, wind from 070° at 3 knots, 10 miles visibility or greater, scattered clouds at 2,400 ft agl, scattered clouds at 2,900 ft agl, an overcast ceiling at 3,500 ft agl, temperature of 16 °C, dew point temperature of 15 °C, and an altimeter setting of 30.11 inHg. Remarks: automated station with a precipitation discriminator, temperature 15.5 °C, dew point temperature 14.5 °C.

K1A5 weather at 1820 EDT, automated, wind calm, 10 miles visibility or greater, scattered clouds at 2,300 ft agl, a broken ceiling at 2,900 ft agl, overcast clouds at 4,000 ft agl, temperature of 15 °C, dew point temperature of 14 °C, and an altimeter setting of 30.11 inHg. Remarks: automated station with a precipitation discriminator, temperature 15.3 °C, dew point temperature 14.3 °C.

K1A5 weather at 1840 EDT, automated, wind calm, 10 miles visibility or greater, a broken ceiling at 2,500 ft agl, broken clouds at 3,100 ft agl, overcast clouds at 3,700 ft agl, temperature of 16 °C, dew point temperature of 15 °C, and an altimeter setting of 30.10 inHg. Remarks: automated station with a precipitation discriminator, temperature 15.5 °C, dew point temperature 14.5 °C.

The observations from K24A and K1A5 surrounding the accident time indicated MVFR⁷ ceiling conditions with the surface wind remaining variable under 6 knots. At the time of departure from Knoxville Downtown Island Airport (KDKX) around 1720 EDT there were VFR⁸ conditions with ceilings at 7,500 ft agl.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)⁹ model sounding was created for the accident site for 1800 EDT with a station elevation of 3,301 ft.¹⁰ The 1800 EDT HRRR sounding was plotted on a standard Skew-T Log P diagram¹¹ with the derived stability parameters included in figure 9 with data from the surface to 600-hPa (or approximately 14,000 ft msl). This data was analyzed using the RAOB¹² software package. The sounding depicted the lifted condensation level (LCL)¹³ at 125 ft agl (3,426 ft msl), the convective condensation level (CCL)¹⁴ at 1,955 ft agl (5,256 ft msl), and the level of free convection (LFC)¹⁵ at 4,081 ft agl (7,382 ft msl). The sounding had a greater than 90% relative humidity from the surface through 8,500 ft msl. The freezing level was located at 12,574 ft msl. The precipitable water value was 0.77 inches.

⁷ Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria, which is a sub-category of VFR conditions, are a ceiling 1,000 to 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 6 miles visibility.

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

¹⁰ HRRR sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

¹¹ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

¹² RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

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.

¹⁵ 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.



The 1800 EDT HRRR sounding wind profile indicated a surface wind from 188° at 7 knots with the wind remaining from the south through 6,000 ft msl. The wind veered¹⁶ to the southwest by 7,000 ft msl and the wind speed increased to 30 knots by 5,000 ft and to 40 knots by 7,000 ft msl. RAOB indicated the possibility of low-level wind shear (LLWS) between the surface and 500 ft agl. RAOB indicated a moderate chance of light to moderate clear-air turbulence existed in several layers between the surface and 14,000 ft.

ERA19FA130

5.0 Satellite Data

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 (band 2) and infrared (bands 13) imagery 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 1500 EDT through 2200 EDT at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 10 and 11 present the GOES-16 visible imagery from 1800 and 1815 EDT at 2X magnification with the accident site highlighted with a red square. The GOES-16 imagery indicated overcast cloud cover above the accident site at the accident time. The lower cloud was more cumuliform in nature and the higher level cloud was more cirriform in nature. The cloud cover was moving from west to east.

Figure 12 presents the GOES-16 infrared imagery from 1815 EDT at 4X magnification and with a temperature enhancement curve applied with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant cloud cover over the accident site at the accident time with the lowest brightness temperatures (green colors, higher clouds) located above and to the southwest of the accident site. Based on the brightness temperatures above the accident site (242° Kelvin) and the vertical temperature profile provided by the 1800 EDT HRRR sounding, the approximate cloud-top heights over the accident site were 28,000 ft at 1815 EDT. It should be noted these figures have not been corrected for any parallax error.

A flight profile versus height was created using flight track data¹⁷ and included as figure 13 with the cloud ceiling height based on K1A5 observations, K24A observations, PIREPs (section 7.0) and the 1800 EDT HRRR sounding information at the accident time. The flight track profile versus height information indicated the accident flight did not descend into the cloud tops until around 1808:30 EDT (figure 13).

¹⁷ For more information, please see the factual information located in the docket for this accident.

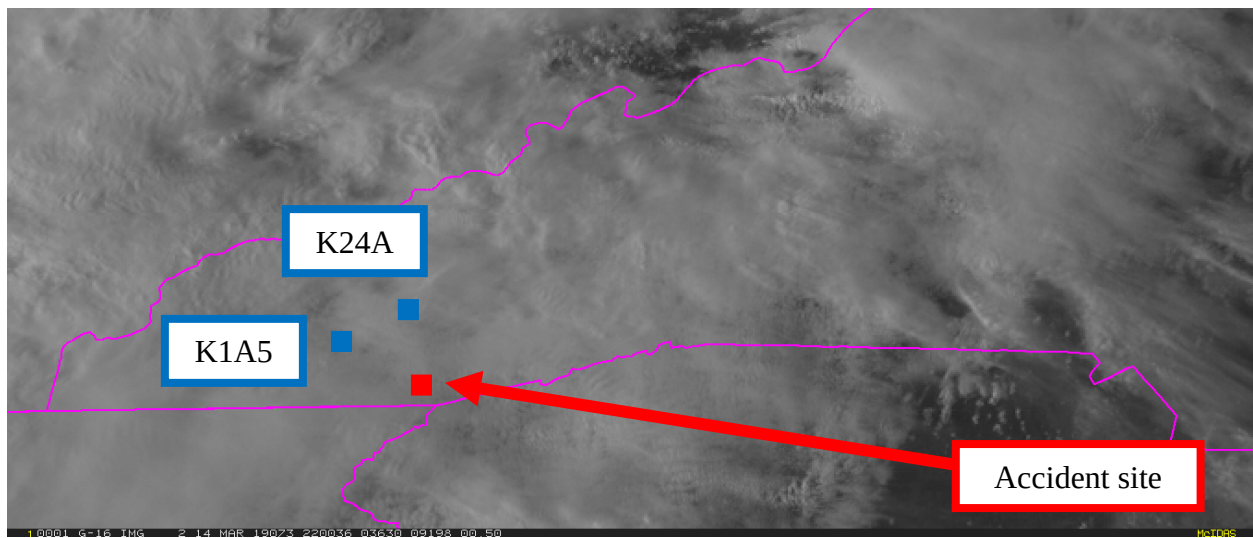


Figure 10 – GOES-16 visible image at 1800 EDT

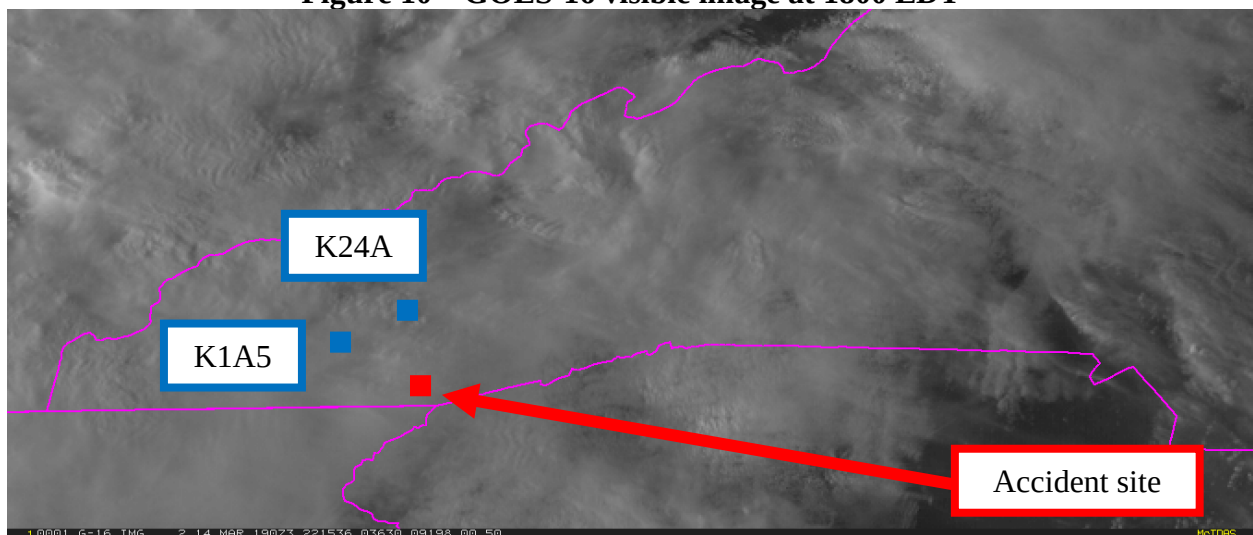


Figure 11 – GOES-16 visible image at 1815 EDT

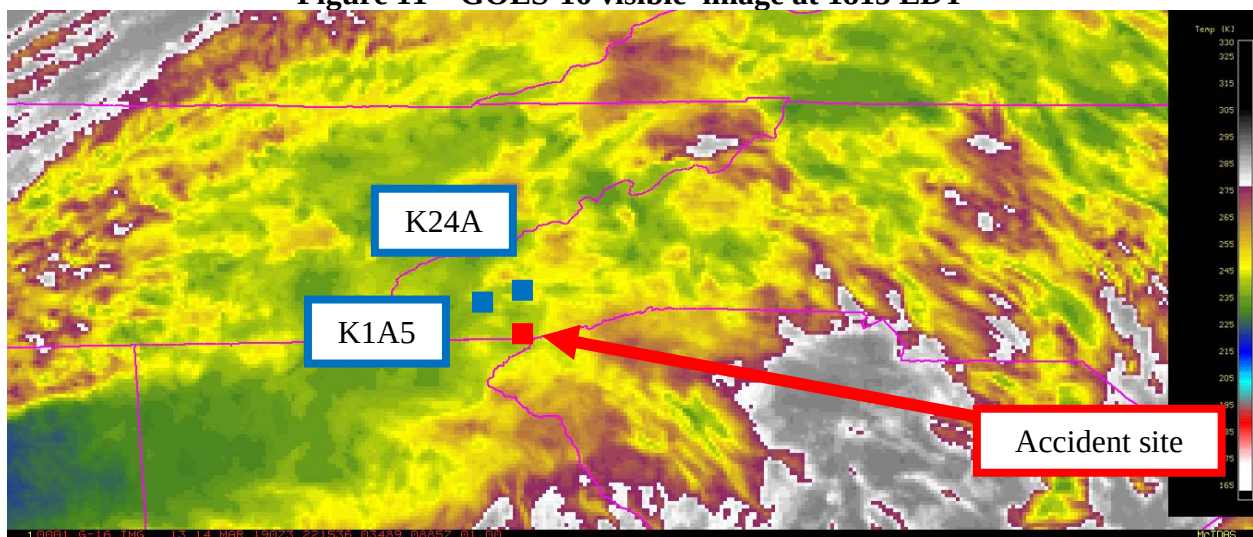


Figure 12 – GOES-16 infrared image at 1815 EDT

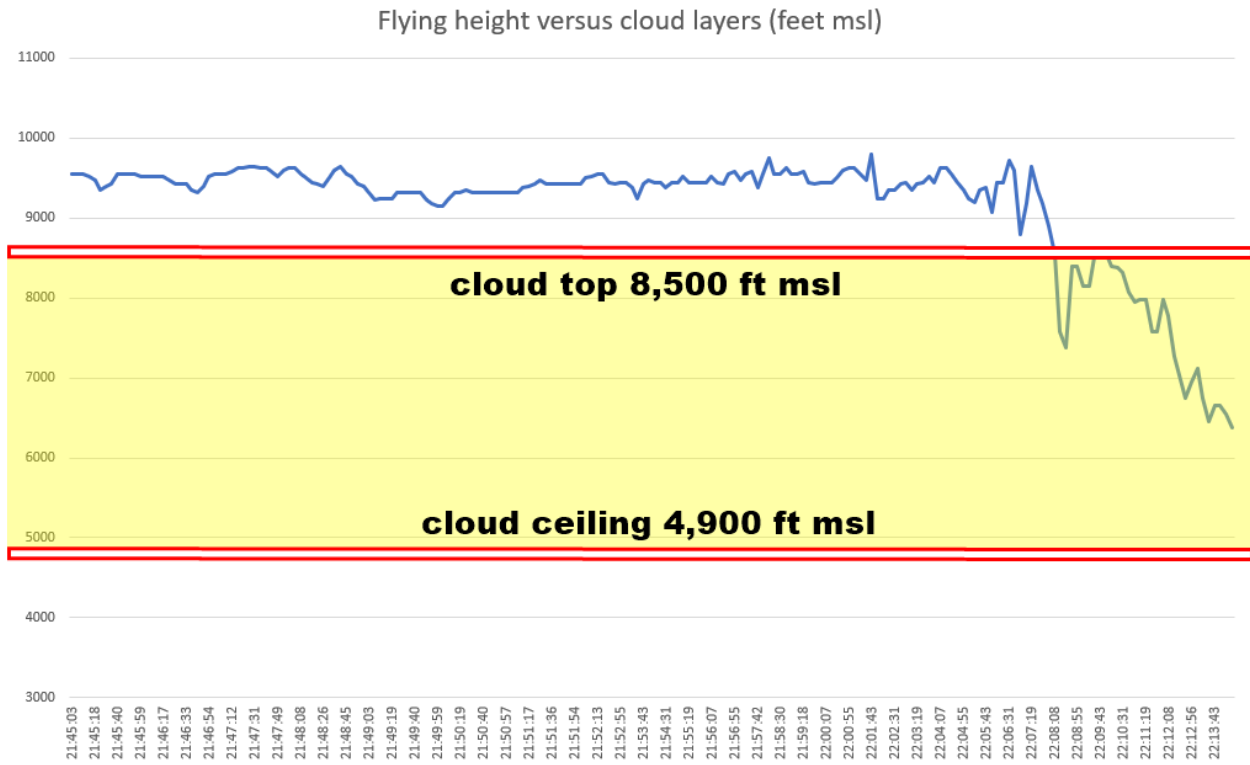


Figure 13 – Cloud layers with height (red line and color fill) and accident flight track (blue line)

6.0 Regional Radar Imagery Information

A regional view of the NWS National Composite Radar Mosaic is included as figure 14 for 1815 EDT with the approximate location of the accident site marked by a red circle. The image did not depict any precipitation echoes above the accident site around the accident time.

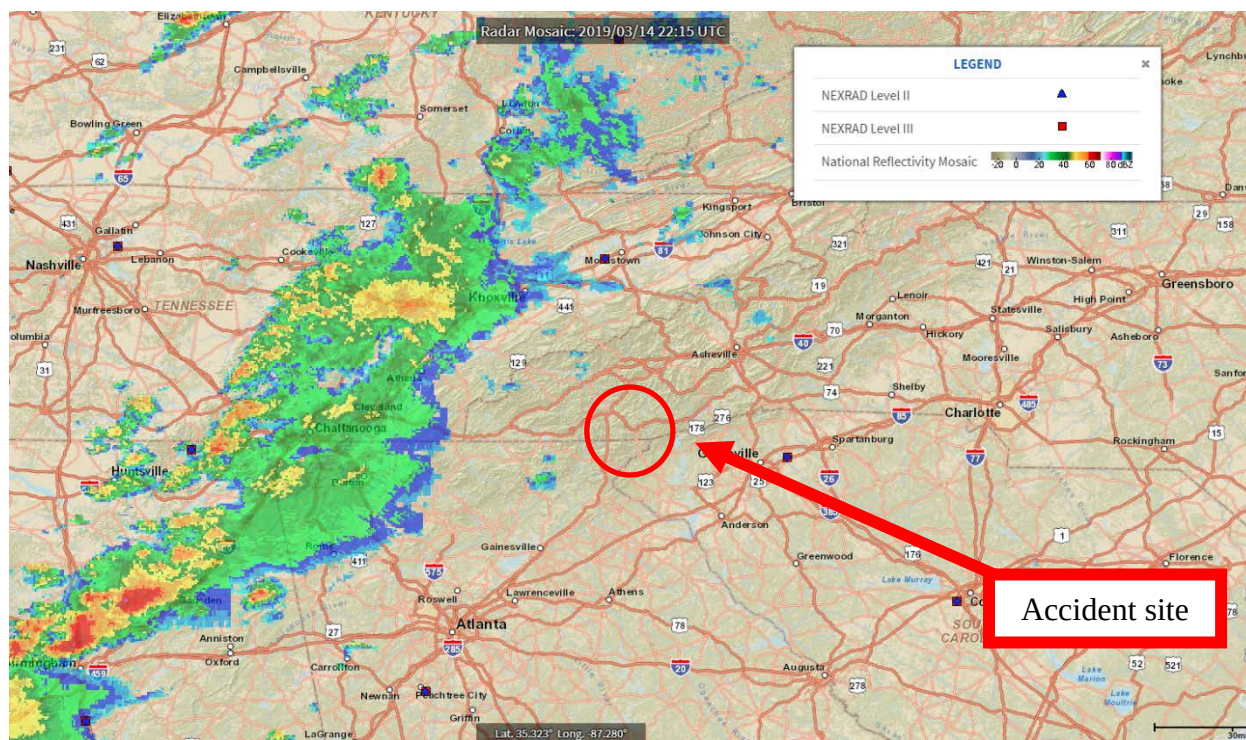


Figure 14 – Regional Composite Reflectivity image for 1815 EDT

7.0 Pilot Reports¹⁸

All pilot reports (PIREPs) within 75 miles of the accident site from about three hours prior to the accident time to about one hour after the accident time for below FL200¹⁹ are provided below:

AVL UA /OV AVL160015/TM 1905/FL083/TP A320/SK TOP083

GYH UA /OV GYH/TM 1914/FL085/TP C310/SK BKN039-TOP085

AVL UA /OV AVL350003/TM 1929/FL035/TP PA31/SK BASES 035

AVL UA /OV AVL350005/TM 2033/FL044/TP C25B/SK BASES 044

AVL UA /OV AVL170006/TM 2044/FL041/TP C560/SK BASES 041

AVL UA /OV AVL350003/TM 2102/FL042/TP A320/RM BASES /042

GSP UA /OV GSP360010/TM 2119/FL049/TP CRJ7/SK B049

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

¹⁸ Only pilot reports with the World Meteorological Organization (WMO) header UBNC**, UBSC**,UBTN**, and UBGA** identifier were considered.

¹⁹ 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) Asheville Regional Airport, North Carolina (AVL)²⁰; Over – 15 miles from AVL on the 160° radial; Time – 1505 EDT (1905Z); Altitude – 8,300 ft; Type aircraft – Airbus A320; Sky – Cloud tops at 8,300 ft msl.

Routine pilot report (UA) Donaldson Field Airport, South Carolina (GYH); Over – GYH; Time – 1514 EDT (1914Z); Altitude – 8,500 ft; Type aircraft – Cessna 310; Sky – Broken clouds at 3,900 ft msl with cloud tops at 8,500 ft msl.

Routine pilot report (UA) AVL; Over – 3 miles from AVL on the 350° radial; Time – 1529 EDT (1929Z); Altitude – 3,500 ft; Type aircraft – Piper PA-31 Navajo; Sky – Cloud bases at 3,500 ft msl.

Routine pilot report (UA) AVL; Over – 5 miles from AVL on the 350° radial; Time – 1633 EDT (2033Z); Altitude – 4,400 ft; Type aircraft – Cessna Citation Jet; Sky – Cloud bases at 4,400 ft msl.

Routine pilot report (UA) AVL; Over – 6 miles from AVL on the 170° radial; Time – 1644 EDT (2044Z); Altitude – 4,100 ft; Type aircraft – Cessna Citation V; Sky – Cloud bases at 4,100 ft msl.

Routine pilot report (UA) AVL; Over – 3 miles from AVL on the 350° radial; Time – 1702 EDT (2102Z); Altitude – 4,200 ft; Type aircraft – Airbus A320; Sky – Cloud bases at 4,200 ft msl.

Routine pilot report (UA) Greenville Spartanburg International Airport, South Carolina (GSP); Over – 10 miles from GSP on the 360° radial; Time – 1719 EDT (2119Z); Altitude – 4,900 ft; Type aircraft – Bombardier CRJ700; Sky – Broken clouds at 4,900 ft msl.

8.0 SIGMET

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

9.0 CWSU Advisories

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

10.0 AIRMETs

There were Airmen's Meteorological Information (AIRMET) advisories Sierra and Tango valid for the accident site at the accident time for below FL200. AIRMET Sierra warned of mountain obscuration conditions due to clouds, precipitation, and mist, while AIRMET Tango warned of moderate turbulence below 12,000 ft msl and LLWS conditions:

²⁰ AVL and KAVL used interchangeably.

WAUS42 KKCI 142045

WA2T

-MIAT WA 142045

AIRMET TANGO UPDT 3 FOR TURB AND LLWS VALID UNTIL 150300

.

AIRMET TURB...NC SC GA AND CSTL WTRS

FROM 160SE SIE TO 190ESE ECG TO 40SSW ECG TO 20NNW CAE TO 50SE

MCN TO 40SSE LGC TO GQO TO HMV TO 20NE ECG TO 160SE SIE

MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET TURB...NC SC GA FL AND CSTL WTRS

FROM 100E ORF TO 40ESE ECG TO 20SSE CAE TO 30NE PZD TO 60SSW TLH

TO 60SE SJI TO 40W CEW TO 50SW PZD TO GQO TO HMV TO 20NE ECG TO

100E ORF

MOD TURB BLW 120. CONDS CONTG BYD 03Z THRU 09Z.

.

LLWS POTENTIAL...NC SC GA ME NH VT MA RI CT NY LO NJ PA OH LE WV

MD DC DE VA AND CSTL WTRS

BOUNDED BY 60W PQI-20ESE MLT-40SSE BOS-20ENE ORF-40W ECG-30SSW

**CSN-20NNE GSO-30NW IRQ-50SSW GQO-GQO-HMV-HNN-CVG-FWA-20E DXO-MSS-
YSC-60W PQI**

LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.

.

OTLK VALID 0300-0900Z

AREA 1...TURB NC SC GA ME NH VT MA RI CT NY LO NJ PA OH LE WV MD

DC DE VA AND CSTL WTRS

BOUNDED BY 70NW PQI-20NE PQI-60SE ACK-180S ACK-160SE SIE-20NE

ECG-30N LGC-GQO-HMV-HNN-CVG-FWA-DXO-MSS-YSC-70NW PQI

MOD TURB BTN FL180 AND FL410. CONDS CONTG THRU 09Z.

.

AREA 2...TURB NC SC GA ME NH VT MA RI CT NY NJ PA WV MD DC DE VA

AND CSTL WTRS

BOUNDED BY 70NW PQI-60NE PQI-150ENE ACK-140S ACK-60SE ECG-20W

CHS-30SSE MCN-50SW PZD-GQO-HMV-20SSW HAR-30NNW ALB-MSS-YSC-70NW

PQI

MOD TURB BLW 120. CONDS CONTG THRU 09Z.

....

WAUS42 KKCI 142045

WA2S

-MIAS WA 142045

AIRMET SIERRA UPDT 3 FOR IFR AND MTN OBSCN VALID UNTIL 150300

.

AIRMET IFR...FL AND CSTL WTRS

FROM 20ENE CEW TO 70S CEW TO 100SSE SJI TO 40W CEW TO 20ENE CEW

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG AFT 00Z.

.

AIRMET MTN OBSCN...NC SC GA WV MD VA

FROM 20WNW EMI TO 20N GSO TO CLT TO ATL TO GQO TO HMV TO HNN TO

40SW AIR TO 20WNW EMI

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

.

OTLK VALID 0300-0900Z

AREA 1...IFR NC SC GA

BOUNDED BY 20SE HMV-20E ODF-20S LGC-GQO-20SE HMV

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG AFT 06Z. CONDS

CONTG THRU 09Z.

.
AREA 2...MTN OBSCN NC SC GA PA WV MD VA
BOUNDED BY HAR-20N GSO-CLT-ATL-GQO-HMV-HNN-AIR-HAR
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG THRU 09Z.

....

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident flight are shown in attachment 1. The GFA surface forecast products indicated VFR conditions would be likely with a chance of rain shower activity (30 to 60 percent chance) for 1700 EDT and likely (greater than 60 percent change) rain shower activity by 2000 EDT. The surface wind was forecast from the south at 5 to 10 knots. The GFA cloud forecast products indicated a cloud ceiling at 4,000 to 5,000 ft msl with cloud tops at 8,000 to 9,000 ft msl. For more information please see attachment 1.

12.0 Terminal Aerodrome Forecast

KAVL was the closest site with a NWS Terminal Aerodrome Forecast (TAF) located 37 miles northeast of the accident site. The KAVL TAF valid at the accident time was issued at 1436 EDT and was valid for a 23-hour period beginning at 1500 EDT. The 1436 EDT TAF for KAVL was as follows:

KAVL 141836Z 1419/1518 **18012G18KT P6SM OVC012**
FM142300 17007KT P6SM VCSH OVC010
PROB30 1504/1506 6SM -SHRA BR OVC010
FM150600 18007KT 5SM -SHRA BR OVC008
FM151200 20007KT 3SM -SHRA BR OVC006
PROB30 1512/1515 -TSRA OVC010CB
FM151500 22007KT 6SM -SHRA BR OVC010=

The TAF expected a wind from 180° at 12 knots with gusts to 18 knots, greater than 6 miles visibility, and an overcast ceiling at 1,200 ft agl.

13.0 NWS Area Forecast Discussion

The NWS Office in Greenville-Spartanburg, South Carolina, issued the following Area Forecast Discussion (AFD) at 1438 EDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed lower VFR to MVFR ceilings into the evening hours with gusty surface winds. Rain showers were not expected to develop until the late evening and overnight hours:

FXUS62 KGSP 141838
AFDGSP

Area Forecast Discussion
National Weather Service Greenville-Spartanburg SC
238 PM EDT Thu Mar 14 2019

.SYNOPSIS...

Showers and thunderstorms return to the area through the end of the work week as a cold front moves through the area. Dry conditions return this weekend as high pressure builds in, and cooler temperatures are expected next week.

&&

.NEAR TERM /THROUGH FRIDAY/...

As of 230 pm EDT: Conditions will rapidly degrade from the west over the next 12 hours or so as convection moving east across the mid-South makes a run toward the southern Appalachians ahead of the associated cold front. With instability much better to our west late this afternoon, and most of the strong dynamical support lifting well northwest of the region as the upper low continues to phase in over the midwest, the convection should exhibit a weakening trend as it approaches the southwest NC mountains this evening. This is the prediction among all of the convection-allowing models, however, they do have some reasonably good coverage reaching the southwest NC mountains from 8 pm to midnight. It would not at all be surprising if short-fused SPSs for gusty winds become needed along and south of the Smokies. The gradient southwesterly flow will pick up as well, but any sustained winds/gusts nearing wind advisory criteria should be limited to the very highest mountain ridges. Expect a very mild night, with min temps in the 50s mountains to lower 60s piedmont given abundant cloudiness east of the approaching front.

The surface cold front should move through the western mountains around daybreak, cross the foothills through the late morning hours, and then move east of I-77 during the afternoon hours. Shear appears rather unidirectional across the region through the period of the pre-frontal convection, but surface to 3 km bulk shear does rise to near 40 kt east of the mountains. Surface-based CAPE values should be 600 J/kg or less as the shower band traverses the region, with instability bubbling up mainly just east of the area Friday afternoon. This is in line with the latest SPC Day 2 Marginal outlook across central/eastern NC. However, lapse rates will gradually steepen up to greater than 6 deg C/km tonight through Friday along and ahead of the frontal zone, so isolated to scattered thunder will be warranted throughout. Expect a window of heavier rainfall in the southwest mountains tonight/Friday morning, but this should not be excessive given current stream/river levels. Isolated showers could persist near the TN border late in the day Friday in moist-low level post-fropa NW flow.

&&

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

As of 230 PM EDT Thursday: A broad upper trough will set up over the eastern CONUS for the upcoming weekend, maintaining a jet streak over the Tennessee Valley to the Mid-Atlantic. This will keep the forecast area within the cirrus/altostratus side of the jet, so a fair amount of high clouds will continue to stream over the area thru the period. But overall, things dry out by late Friday evening and remain dry thru Sunday, as a modest 1025-1030 mb area of high pressure builds in from the west. Temps will be seasonable, slightly

above normal Friday night and Saturday, then slightly below normal Saturday night and Sunday, thanks to a persistent NWLY CAA flow atop the region.

&&

.LONG TERM /MONDAY NIGHT THROUGH THURSDAY/...

As of 100 PM Thu: A secondary cold front looks to push southward thru the region early Monday, with dry and cold high pressure expanding south behind it. This will keep temps several degrees below normal thru the middle part of next week. Within the broad-scale upper trough over the eastern CONUS, an embedded shortwave will swing across the CWFA Monday or Monday night. The GFS remains the most amplified with this feature, and is alone among the major models in depicting precip accompanying it. Thus we will continue to advertise a dry fcst at that time. There is better agreement on a better defined wave advecting across the Appalachians late Wed into Thu, and this warrants some PoPs for the mountains and some of the foothills. As temps cool to near freezing in those areas Wednesday night, it is possible for rain to change to snow.

&&

.AVIATION /19Z THURSDAY THROUGH TUESDAY/...

At KCLT and elsewhere: Anticipate mainly lower VFR cigs late this afternoon into this evening in moistening and strengthening SW flow ahead of an approaching cold front. MVFR cigs will gradually redevelop overnight from the west. KAVL will be the main exception, where some early IFR cigs will persist this afternoon in the best area of SSE upslope moisture. Otherwise, shower coverage will blossom from the west late this evening and then overnight across the foothills, and through Friday morning at KCLT, with a rumble of thunder possible at all sites. Cigs should be mainly MVFR tempo IFR during the period of the best shower coverage ahead of the front. Southwest winds will be gusty at times through the period throughout.

Outlook: Dry weather will develop over the weekend and likely persist into early next week.

Confidence Table...

	18-24Z	00-06Z	06-12Z	12-18Z
KCLT	High 100%	High 100%	High 90%	High 100%
KGSP	High 99%	High 100%	High 91%	High 91%
KAVL	High 89%	High 91%	High 94%	High 83%
KHKY	High 91%	High 98%	High 91%	High 88%
KGMU	High 96%	High 93%	High 90%	High 89%
KAND	High 96%	High 99%	High 90%	High 98%

The percentage reflects the number of guidance members agreeing with the scheduled TAF issuance flight rule category. Complete hourly experimental aviation forecast consistency tables and ensemble forecasts are available at the following link:

www.weather.gov/gsp/aviation

&&

.GSP WATCHES/WARNINGS/ADVISORIES...
GA...None.
NC...None.
SC...None.

&&

\$\$

14.0 Winds and Temperature Aloft Forecast

The NWS 1559 EDT Winds and Temperature Aloft forecast valid for 2000 EDT for the closest point to the accident site is included below:

FBUS31 KWN0 141959
FD1US1
DATA BASED ON 141800Z
VALID 150000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

GSP 1826 2336+10 2446+07 2356+02 2554-12 2560-22 266738 277248 266450

The accident site was closest to the Greenville-Spartanburg, South Carolina, (GSP) forecast point. The GSP forecast for use between 1600 EDT and 2300 EDT indicated a wind at 3,000 ft from 180° at 26 knots, at 6,000 ft a wind from 230° at 36 knots with a temperature of 10 °C, at 9,000 ft a wind from 240° at 46 knots with a temperature of 7 °C, and at 12,000 ft a wind from 230° at 56 knots with a temperature of 2 °C.

15.0 Pilot Weather Briefing

The accident pilot did not request nor receive a weather briefing through Leidos.

A check of ForeFlight was done and revealed that the accident pilot filed a flight plan and requested a weather briefing at 2040 EDT on March 13 for the accident flight through ForeFlight (attachment 2). The weather briefing package contained all the standard weather information, however, this weather briefing was requested close to 21 hours before the departure of the flight and therefore all the aviation weather advisories and warnings did not go far enough into the future to cover the proposed departure time. In addition, Leidos captured the ForeFlight weather briefing information in text form (attachments 3 and 4). It is unknown if the accident pilot checked or received any additional weather information before or during the accident flight.

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on March 14, 2019, indicated the following:

SUN	
Begin civil twilight	0720 EDT
Sunrise	0745 EDT
Sun transit	1342 EDT
Accident	1815 EDT²¹
Sunset	1939 EDT
End civil twilight	2004 EDT

E. LIST OF ATTACHMENTS

Attachment 1 – GFA products available before the accident flight for around the accident time

Attachment 2 – Accident flight information via ForeFlight

Attachment 3 – ForeFlight text weather briefing information captured by Leidos part 1

Attachment 4 – ForeFlight text weather briefing information captured by Leidos part 2

Submitted by:

Paul Suffern
Senior Meteorologist

²¹ Inserted accident time for reference and context.

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