



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 30, 2020

Specialist's Factual Report

METEOROLOGY

ERA19LA257

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A. ACCIDENT

Location: Burnsville, NC
Date: August 22, 2019
Time: 1254 eastern daylight time (EDT)
1654 coordinated universal time (UTC)
Airplane: Cirrus SR22; Registration: N404PE

B. METEOROLOGIST

Don Eick
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On August 22, 2019, about 1254 EDT, a Cirrus SR22, N404PE, was substantially damaged following an encounter with weather and deployment of the Cirrus Airframe Parachute System (CAPS) near Burnsville, North Carolina. The commercial pilot and the student pilot-rated passenger were not injured. Instrument meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed for the personal flight, which was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 91. The airplane departed Donaldson Field Airport (KGYH), Greenville, South Carolina at 1216, with an intended destination of Medina Municipal Airport (1G5), Medina, Ohio.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are EDT based upon the 24 hour clock, local time is +4 hours to UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 35.745277° N and longitude 82.28833° W, after encountering weather at approximately 17,000 ft.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

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 (NCEP) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular “Aviation Weather Services”, AC 00-45H change 2.

1.1 Surface Analysis Chart

The central-east section of the NWS Surface Analysis Chart for 1100 EDT prior to the accident is included as figure 1 with the color topography added and the approximate accident site marked by a red star. The chart depicted a trough of low pressure¹ that extended from Virginia southwestward across western North Carolina along the Appalachian Mountains and in the immediate vicinity of the accident site. To the north of the accident site a low-pressure system at 1014-hectopascals (hPa)² was located over Ohio along a stationary front which stretched westward across Ohio and into Indiana and Illinois. South of the front over the Indiana and Kentucky border was a high pressure system at 1018-hPa with an outflow boundary³ immediately east bowing outward across Kentucky.

The station models in the immediate vicinity of the accident site depicted a cyclonic or counterclockwise shift in the winds across the trough, with winds from the northwest on the western side of the trough and from the west to southwest east of the trough, with wind speeds of 5 knots or less. The station model also depicted clear skies, with a temperatures of 80° F, with dew point temperatures above 69° F. Warmer temperatures in the upper 80’s and dew points above 75° F were identified east through south of the accident site.

¹ A trough is an elongated area of low-pressure and is often associated with fronts. Most troughs are associated with a wind shift, convergence, which results in the formation of clouds and precipitation.

² Hectopascal (hPa) is the new standard for reporting sea-level pressure and is interchangeable with the former term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa at a temperature of 59° Fahrenheit (F) or 15° Celsius (C).

³ An outflow boundary, also known as a gust front, is a storm-scale or mesoscale boundary separating thunderstorm-cooled air (outflow) from the surrounding air; similar in effect to a cold front, with passage marked by a wind shift and usually a drop in temperature and a related pressure jump. Outflow boundaries can persist for 24 hours or more after the thunderstorms that generated them dissipate and can travel hundreds of kilometers from their area of origin. New thunderstorms often develop along outflow boundaries, especially near the point of intersection with another boundary (cold front, dry line, another outflow boundary, etc.). Outflow boundaries can be seen either as fine lines on weather radar imagery or else as arcs of low clouds on weather satellite imagery. From the ground, outflow boundaries can be co-located with the appearance of roll clouds and shelf clouds.

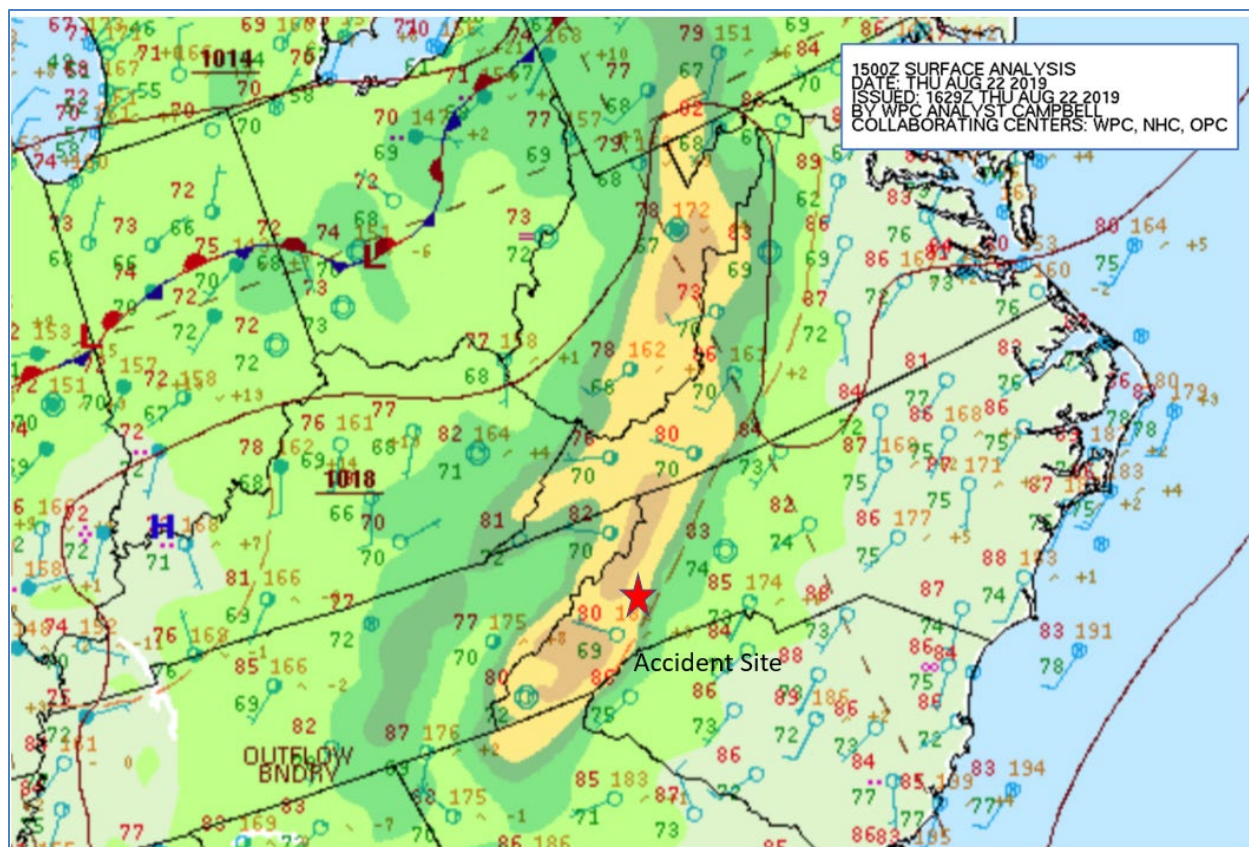


Figure 1 – Central-east section of the NWS Surface Analysis Chart for 1100 EDT with the accident site

The next Surface Analysis Chart was issued at 1400 EDT or approximately an hour after the accident and is depicted as figure 2. The chart continued to depict the trough of low pressure extending over the area to the eastern side of the Appalachian Mountains. Two high-pressure systems at 1018-hPa were depicted over western Virginia and over eastern Tennessee immediately north and west of the accident site. An outflow boundary was depicted across central Virginia and North Carolina east of the accident site. The station model in the vicinity of the accident site depicted calm winds, thunderstorm and rain showers, overcast clouds, with a temperature of 71° F, and a dew point of 66° F.

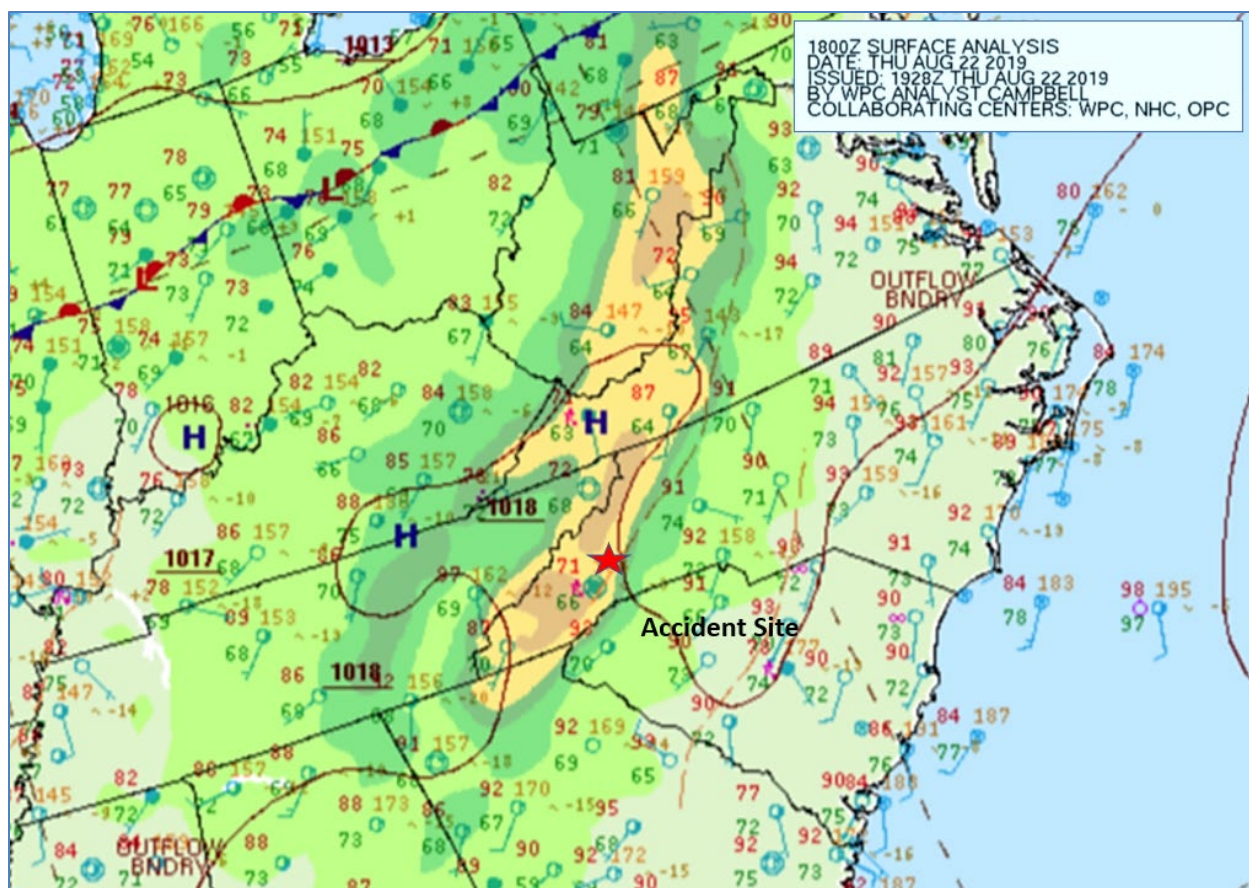


Figure 2 –Surface Analysis Chart for 1400 EDT with the accident site marked by the red star

1.2 12-hour Surface Prognostic Chart

The NWS WPC 12-hour Surface Prognostic Chart issued during the period and valid for 1400 EDT is included as figure 3. The chart depicted the low-pressure system in Ohio with a frontal wave with a cold front extending westward across southern Ohio, Indiana, Illinois, and Missouri, with a trough of low-pressure extending from New Jersey southeastward into South Carolina. A chance of rain showers and thunderstorms were expected over the entire route of flight with a likely⁴ or a greater than 40% probability of precipitation over western North Carolina and Virginia, eastern Kentucky, and Tennessee, and along the front in Ohio.

⁴ Likely – Measurable rain (≥ 0.01 " liquid equivalent) is likely at the valid time.

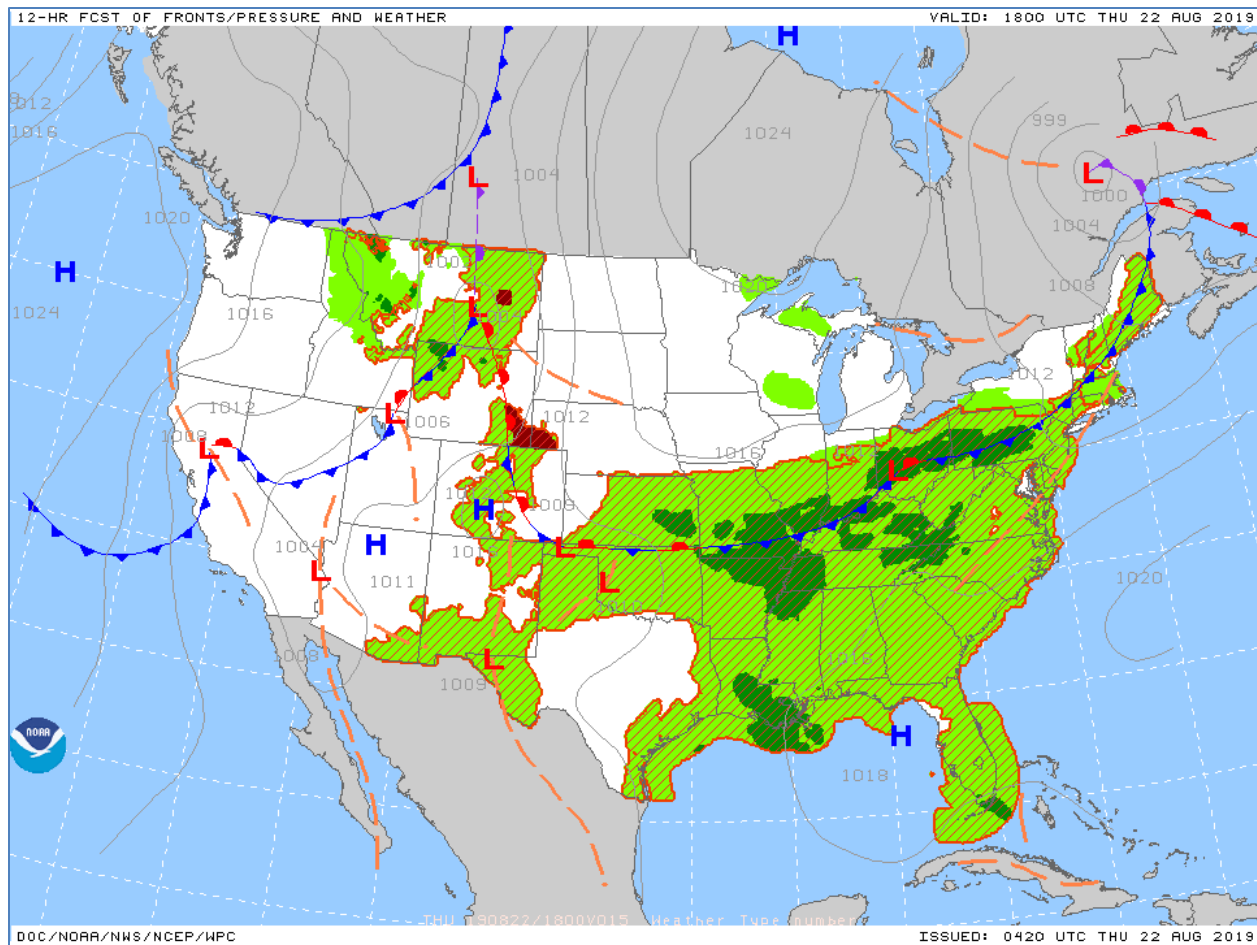


Figure 3 – NWS WPC 12-hour Surface Prognostic Chart valid for 1400 EDT

1.3 Convective Outlook

The NWS Storm Prediction Center (SPC) is tasked with providing timely and accurate forecasts and watches for severe thunderstorms and tornadoes over the contiguous United States. One of their primary products highlighting the expected areas of organized thunderstorms is the Convective Outlook (AC). The intent of the chart is to identify to users where the NWS SPC expects organized thunderstorms and severe thunderstorms⁵ to form. The SPC Convective Outlook issued at approximately 1230 EDT is included as figure 4 and depicted a marginal risk⁶ of severe thunderstorms were expected to develop over the proposed route of flight and the accident site.

⁵ A severe thunderstorm is one that produces a tornado, large hail over 1.0 inch in diameter, or outflow winds greater than 50 knots. While all thunderstorms imply the likelihood of severe turbulence, a severe thunderstorm implies a high likelihood of severe to extreme turbulence, wind shear, and a high probability of encountering hail.

⁶ Marginal Risk – an isolated area of severe thunderstorms of either limited organization and longevity, or very low coverage and marginal intensity are expected during the period.

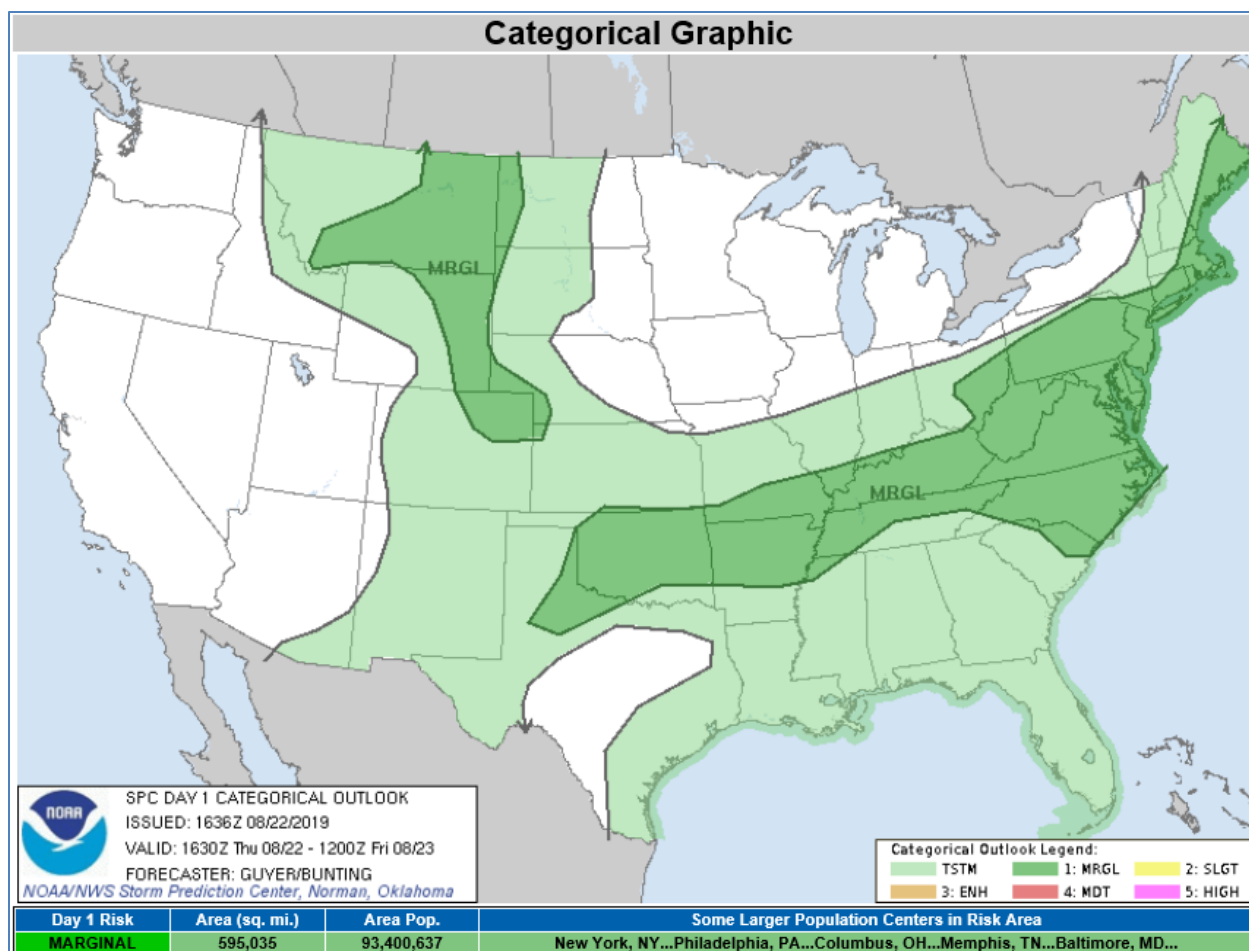


Figure 4 - NWS Storm Prediction Center's Convective Outlook issued at 1230 EDT

The narrative issued with the 1230 EDT Convective Outlook (AC) was as follows with the bold sections highlighting the mid-Atlantic region and the Carolinas discussion.

SPC AC 221636

Day 1 Convective Outlook

NWS Storm Prediction Center Norman OK

1136 AM CDT Thu Aug 22 2019

Valid 221630Z - 231200Z

...THERE IS A MARGINAL RISK OF SEVERE THUNDERSTORMS FROM THE SOUTHERN PLAINS TO THE MID-ATLANTIC STATES AND THE NORTHERN/CENTRAL HIGH PLAINS...

...SUMMARY...

Isolated damaging winds are possible this afternoon and evening from the southern Plains and Mid-South to the Mid-Atlantic States. Isolated severe hail and wind are also possible over the northern and central High Plains.

...Mid-Atlantic States/Carolinas...

A belt of cyclonically curved/moderately strong westerlies aloft will persist over the Upper Ohio Valley and Mid-Atlantic region, with a cold front gradually progressing southeastward across these regions through tonight. Thunderstorms are expected to develop/increase over the mountains and/or in association with ongoing persistent clusters. As low-level lapse rates steepen, damaging winds will be the primary risk. A few sustained/semi-organized clusters of storms may materialize this afternoon, particularly from south-central Pennsylvania southward to near/east of the Blue Ridge in Virginia/Northern Carolina. However, current thinking is that the overall severe storm coverage/risk magnitude will be a bit lower as compared to prior days across the region.

...Southeast Wyoming/Central High Plains...

To the north of an eastern Colorado-centered surface low, low-level upslope flow and differential heating in vicinity of the higher terrain is likely to contribute to isolated thunderstorm development this afternoon. Storms should intensify as they move east-southeastward within a moist/increasingly unstable environment. A few instances of isolated severe hail will initially be possible. Storms may gradually cluster with localized severe-caliber wind gust potential this evening across the southern Nebraska Panhandle/northeast Colorado vicinity, and possibly southwest Nebraska/northwest Kansas.

...Southern/eastern Montana to northern High Plains...

Isolated to scattered thunderstorms are expected to develop across this area during the afternoon, and into evening with eastward extent. Isolated severe gusts/hail are the main concerns. A relative concentration of convection is possible during about 00Z-06Z across portions of eastern Montana and perhaps northeastern Wyoming. During that time frame, some of the stronger low-level mass response and convergence (related to the approaching shortwave trough), and perhaps the leading fringe of mid/upper synoptic forcing, will impinge upon a narrow plume of relatively maximized buoyancy and boundary-layer moisture. Pre-convective MLCAPE of 1000-2000 J/kg is possible this evening near an axis from RAP-GGW, amidst well-mixed subcloud layers supporting strong-severe gust potential. However, weak mid/upper-level winds suggest that severe potential should remain fairly disorganized and/or short-lived.

...Southern Plains to Mid-South/Tennessee Valley...

Within a moist/unstable environment, surface-based thunderstorm development later this afternoon will be focused along zones of residual outflow/differential heating. While weak westerlies will generally prevail, ample heating/buoyancy could support localized severe-caliber downdrafts late this afternoon/early evening.

..Guyer/Bunting.. 08/22/2019

2.0 Observations

The closest observation location to the accident site was from Asheville Regional Airport (KAVL), Asheville, North Carolina, located approximately 23 miles southwest of the accident site at an elevation of 2,164 ft. The airport had an Automated Surface Observation System (ASOS) and was augmented by air traffic control personnel during normal operating hours. The area reported a magnetic variation of 7° W. Cloud heights are reported above ground level (agl) in the following METAR reports. Surrounding the time of the accident, the following conditions were reported.

KAVL special weather observation at 1242 EDT, wind from 340° at 9 knots, visibility 10 statute miles in thunderstorms, ceiling broken at 6,000 ft agl, temperature 28° C, dew point 18° C, altimeter 30.13 inches of mercury ("Hg). Remarks: automated station with a precipitation discriminator, lightning distant south, thunderstorm began at 1202 EDT ended at 1224 EDT, and began again at 1236 EDT, temperature 27.8° C, dew point 17.8° C.

KAVL special weather observation at 1254 EDT, wind from 340° at 12 knots, visibility 10 statute miles with thunderstorms in the vicinity, scattered clouds at 5,500 ft agl, ceiling broken at 7,000 ft, and broken at 10,000 ft, temperature 28° C, dew point 18° C, altimeter 30.13 "Hg. Remarks: automated station with a precipitation discriminator, lightning distant all quadrants, thunderstorm began at 1202 EDT ended at 1224 EDT, and began again at 1236 EDT, and ended at 1251 EDT, sea level pressure 1017.3-hPa, temperature 27.8° C, dew point 17.8° C.

KAVL special weather observation at 1328 EDT, wind from 340° at 21 knots gusting to 25 knots, visibility 10 statute miles in thunderstorms and light rain, scattered clouds at 6,000 ft agl, ceiling broken at 10,000 ft, and overcast at 12,000 ft, temperature 23° C, dew point 19° C, altimeter 30.14 "Hg. Remarks: automated station with a precipitation discriminator, lightning distant all quadrants, rain began at 1257 EDT, thunderstorm began at 1322 EDT, hourly precipitation (since 1254 EDT) 0.02 inches, temperature 22.8° C, dew point 19.4° C.

The general flight categories⁷ and raw METAR and SPECI observations reported during the period were as follows:

VFR METAR KAVL 221454Z 31004KT 10SM CLR 27/21 A3016 RMK AO2 SLP182 T02670206 51003=

VFR METAR KAVL 221554Z 32003KT 10SM CLR 29/20 A3014 RMK AO2 LTG DSNT N AND NW SLP177 T02940200=

VFR SPECI KAVL 221608Z VRB03KT 10SM TS FEW110 31/20 A3014 RMK AO2 LTG DSNT NW TSB02 T03060200=

VFR SPECI KAVL 221630Z 33011KT 10SM VCTS FEW065 29/19 A3013 RMK AO2 LTG DSNT N AND NW TSB02E24 T02890194=

VFR SPECI KAVL 221642Z 34009KT 10SM TS BKN060 28/18 A3013 RMK AO2 LTG DSNT S TSB02E24B36 T02780178=

VFR METAR KAVL 221654Z 34012KT 10SM VCTS SCT055 BKN070 BKN100 28/18 A3013 RMK AO2 LTG DSNT ALQDS TSB02E24B36E51 SLP173 T02780178=

Accident 1654Z

VFR SPECI KAVL 221728Z 34021G25KT 10SM -TSRA SCT060 BKN100 OVC120 23/19 A3014 RMK AO2 LTG DSNT ALQDS RAB1657 TSB22 P0002 T02280194=

⁷ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories based on weather conditions reported:

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

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

VFR METAR KAVL 221754Z 00000KT 8SM -TSRA FEW060 BKN100 OVC110 22/19 A3015 RMK AO2 LTG DSNT NE-S RAB1657 TSB22 SLP184 P0002 60002 T02170189 10306 20194 55003=

VFR SPECI KAVL 221808Z 14003KT 10SM FEW080 BKN110 22/19 A3014 RMK AO2 LTG DSNT ALQDS RAE08 TSE02 P0001 T02220194=

3.0 Model Sounding Plot

A High Resolution Rapid Refresh (HRRR)⁸ numerical model was retrieved from the NOAA Air Resources Laboratory and plotted on a standard Skew T log P diagram⁹ using the complete Rawinsonde Observation RAOB program software¹⁰. Figure 5 is the HRRR model sounding for 1300 EDT over the accident site from the surface to 450-hPa or approximately 22,000 ft.

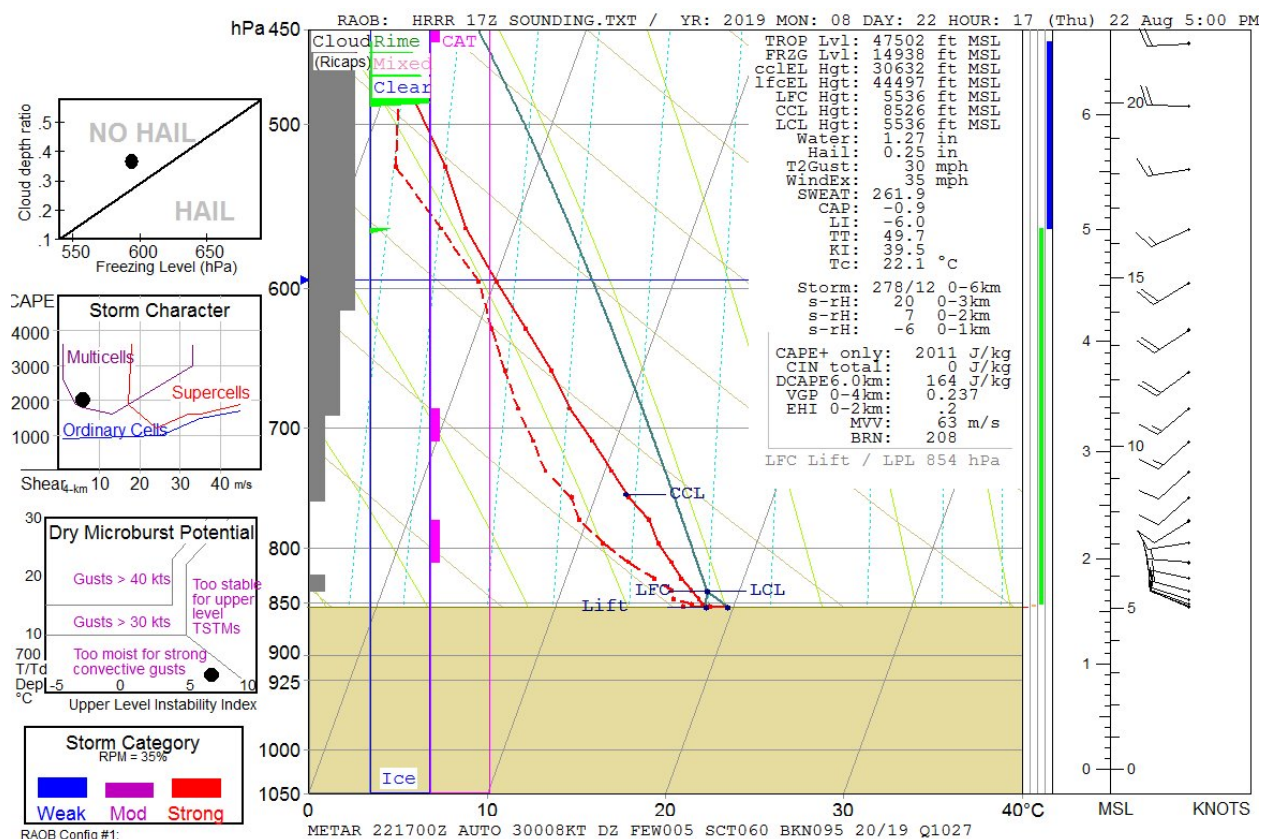


Figure 5 - The HRRR numerical model for 1300 EDT over the accident site

⁸ The HRRR is a National Oceanic and Atmospheric Administration (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.

⁹ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram 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.

¹⁰ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

The 1300 EDT HRRR sounding indicated an elevation of 5,033 ft over the accident site, with a near-surface temperature of 20° C, and a dew point of 19° C. The lifted condensation level (LCL)¹¹ and level of free convection (LFC)¹² were identified at approximately 500 ft agl (5,539 ft msl), with the convective condensation level (CCL)¹³ at 3,400 ft agl. The sounding supported multiple layers of clouds with the equilibrium level¹⁴ at 44,488 ft or the expected top of convective clouds. The precipitable water content was 1.27 inches. The sounding depicted an unstable atmosphere with a Lifted Index¹⁵ of -6.0 and a Convective Available Potential Energy (CAPE)¹⁶ of 2,011 J/kg, with the RAOB algorithm favoring scattered multicellular type thunderstorms. The maximum vertical velocity (MVV) of potential updrafts was estimated at 63 m/s or 126 knots, and the T2 Gust and WindEx of any potential outflow winds or microbursts was 30 knots (35 mph). The expected thunderstorm motion was from 280° at 12 knots. The freezing level was depicted at 14,900 ft msl and implied the potential of structural icing conditions in-clouds above this level.

The HRRR wind profile indicated a surface wind from 300° at 8 knots, with winds backing to the southwest with height above 5,000 ft through 16,000 ft. The mean 0 to 6 km (or 18,000 ft) wind was from about 250° at 16 knots. At the accident airplanes altitude of 17,000 ft the sounding depicted a wind from 250° at 17 knots, a temperature of -3.5° C, and a dew point of -5° C, with a relative humidity of about 86%.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The long wave infrared (band 13) imagery at a wavelength of 10.3 microns (μm) and a resolution of 2 km, and visible (band 2) at a wavelength of 0.64 μm and a resolution of 0.5 km were obtained surrounding the time of the accident. The

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

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 CCL - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

¹⁴ Equilibrium Level (EL) - On a sounding, the level above the level of free convection (LFC) at which the temperature of a rising air parcel again equals the temperature of the environment. The height of the EL is the height at which thunderstorm updrafts no longer accelerate upward. Thus, to a close approximation, it represents the height of expected (or ongoing) thunderstorm tops. However, strong updrafts will continue to rise past the EL before stopping, resulting in storm tops that are higher than the EL. This process sometimes can be seen visually as an overshooting tops or anvil dome. The EL typically is higher than the tropopause and is a more accurate reference for storm tops.

¹⁵ Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

¹⁶ Convective Available Potential Energy (CAPE) - is a measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.

infrared imagery provided standard satellite image with brightness or radiative cloud top temperatures.

Figure 6 is the GOES-16 infrared image for 1254 EDT at 4X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops typically associated with high cirriform and cumulonimbus type clouds. The image depicted several enhanced areas of clouds associated with cumulonimbus clouds to the south, west, north, and northeast of the accident site, with cumulus to cumulus congestus type clouds over the accident site. The brightness temperature over the accident site was 264 kelvin (-9.16°C), which corresponded to cloud tops near 24,000 ft based on the HRRR model sounding. The highest and colder cloud tops (yellow with the blue enhancement) to the north over Virginia and to the northeast over North Carolina indicated tops in excess of 40,000 ft.

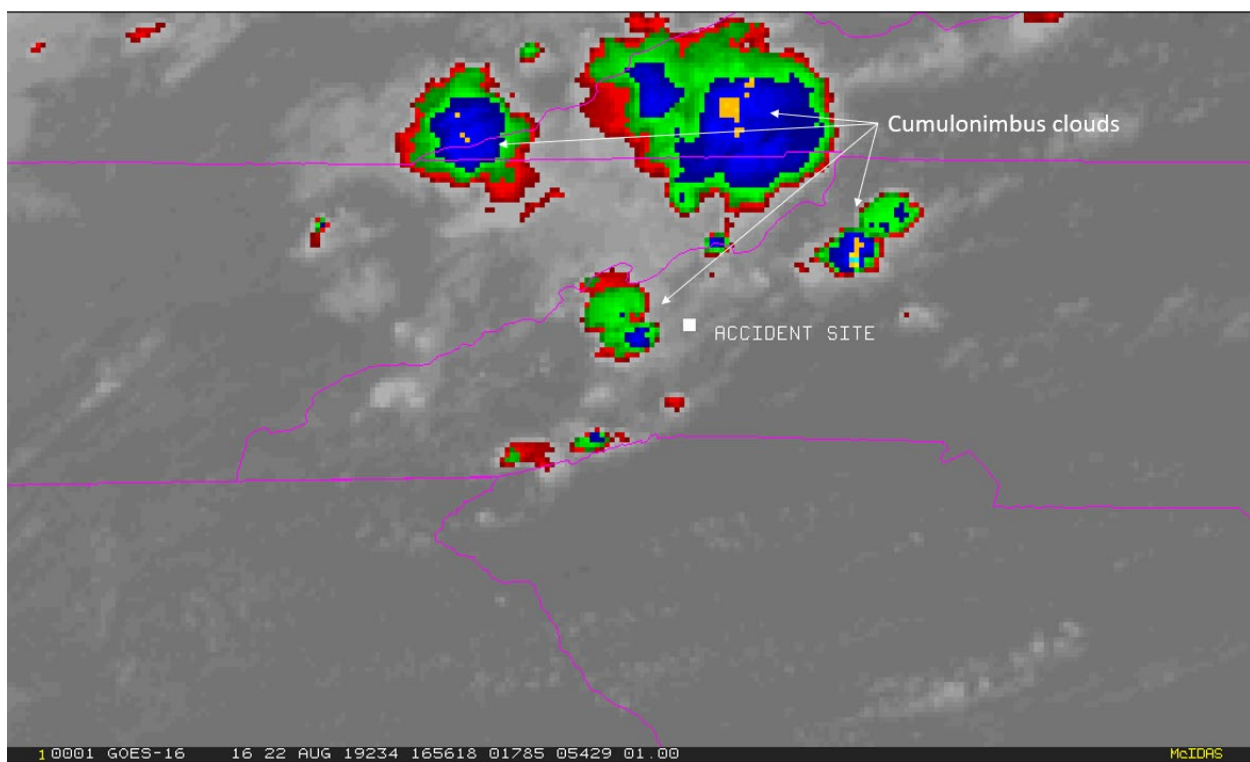


Figure 6 - GOES-16 infrared image for 1254 EDT at 2X magnification with temperature enhancement curve

The GOES-16 visible image for 1254 EDT at 2X magnification is included as figure 7. The visible image depicted several well developed cumulonimbus clouds developing southwest through west of the accident site with a line of cumulus congestus type clouds running northeast through southwest over the region and over the accident site.

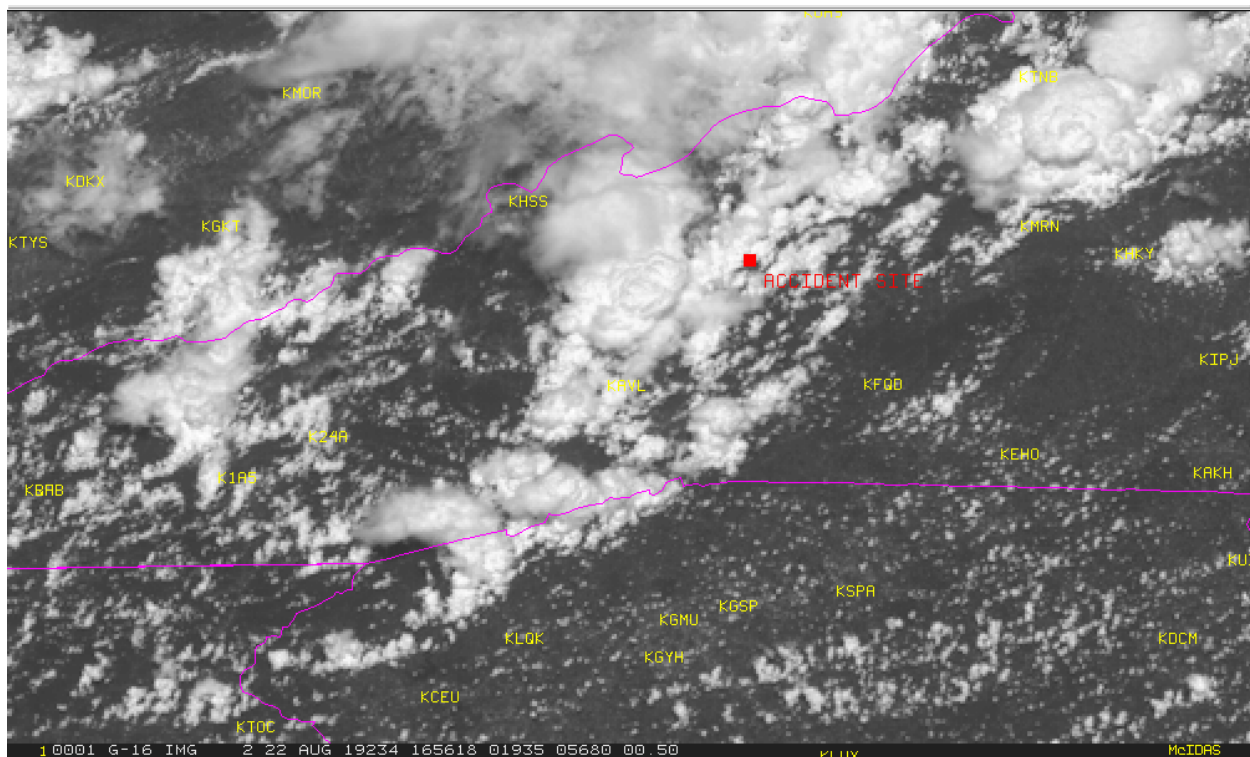


Figure 7 - GOES-16 visible image at 1256 EDT at 2X magnification

5.0 Radar Imagery

5.1 National Composite Radar Mosaic

The regional section of the National Composite Reflectivity Mosaic for 1250 EDT is included as figure 8 with the approximate accident site marked by a red star. Composite reflectivity images utilize all elevation scans during each volume scan to create the image. It is composed of the greatest echo intensity (reflectivity) from any elevation angle seen from the radar. It is used to reveal the highest reflectivity value in the column. Composite reflectivity image is one of the last radar image views, necessitated by the need for all elevation scans to be completed before this image can be produced. The chart depicted a broken line of echoes north-northeast to the south-southwest across the area, with the accident site located on the southern section of area of echoes. Other echoes were scattered across the area.

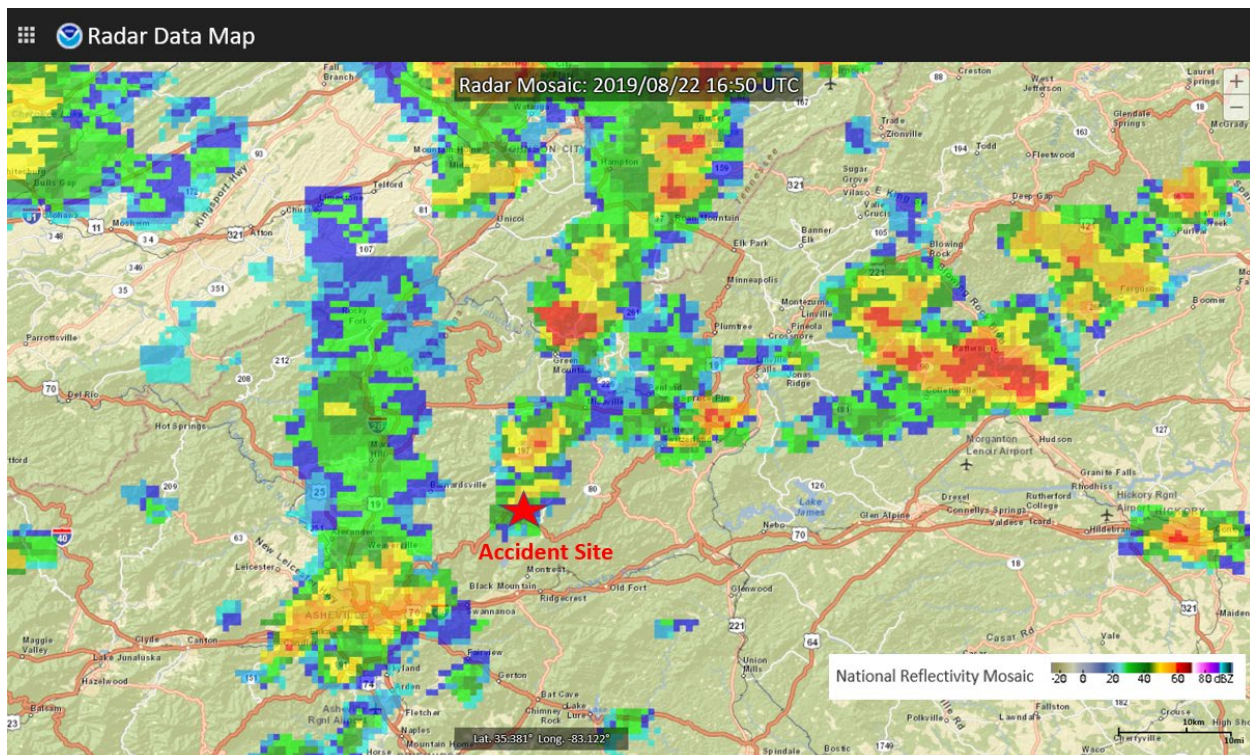


Figure 8 - Regional section of the National Composite Reflectivity Mosaic for 1250 EDT

5.2 Weather Radar Data

The closest Weather Surveillance radar-1988, Doppler (WSR-88D)¹⁷ to the accident site was from the NWS Greer (KGSP), South Carolina, located 52 miles south of the accident site. The Level II and III archive data were obtained from the NCEI using the Hierarchical Data Storage System and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

During the period the KGSP WSR-88D was operating in the precipitation mode and using the volume coverage pattern VCP-212, where the radar makes 14 different elevation scans every 4 1/2-minutes and is typically used during the period of severe weather.

Based on the distance from the radar and the antenna height of 1,068 ft, and assuming standard refraction, the KGSP 2.4° elevation scan beam was centered at approximately 16,090 ft and painting the altitudes between approximately 13,470 ft to 18,710 ft. The accident airplane was at an altitude of 17,000 ft at the time it encountered the echoes.

Reflectivity is normally displayed in decibels (dBZ)¹⁸ and is a general measure of echo intensity. Advisory Circular AC 00-24C – “Thunderstorm” has been issued to describe the intensity to pilots and is also used by air traffic controllers to describe precipitation intensity to pilots. The intensities are described in the following chart.

¹⁷ The WSR-88D is a S-band 10-centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

¹⁸ dBZ - 10 log Ze

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

5.3 Base Reflectivity Imagery

Figure 9 is the KGSP WSR-88D 0.48° elevation scan at 1258 EDT depicting the lowest elevation scan which is typically available for briefing purposes with the flight path overlaid in magenta. The flight is observed departing KGYH and climb out to the northwest and enter into an area of echoes of approximately 40 dBZ and greater, and abruptly turns right and descends rapidly from 17,000 ft at 1249 EDT.

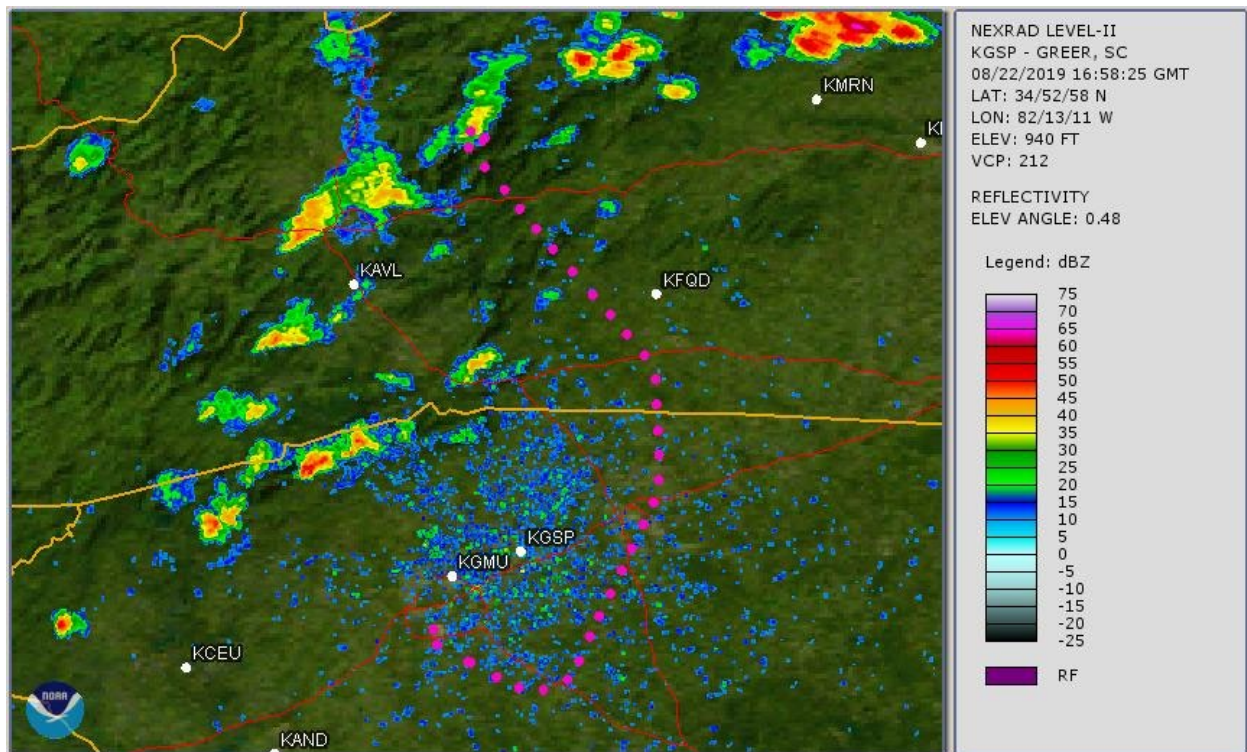


Figure 9 - NWS KGSP WSR-88D 0.48° base reflectivity at 1258 EDT with the flight track overlaid.

Figure 10 is a closeup of the KGSP WSR-88D 2.4° base reflectivity depicting the conditions at the accident airplanes altitude with two extreme intensity echoes to the northeast and to the southwest of the flight track. The aircraft enters into an area of echoes of 46.5 dBZ or “heavy intensity” precipitation echoes at approximately 17,000 ft, turns right and abruptly loses altitude.

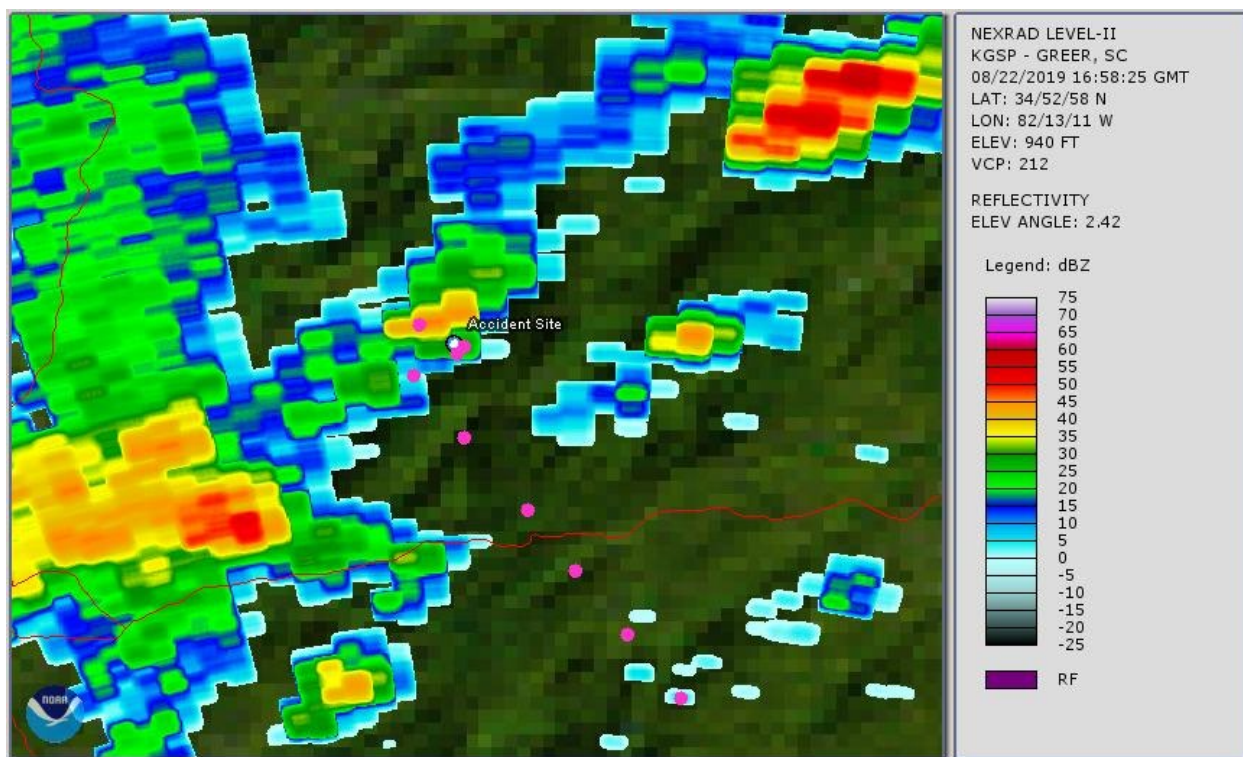


Figure 10 - KGSP WSR-88D 2.4° base reflectivity image at 1254 EDT with the flight track

Figure 11 is a composition of the KGSP WSR-88D scans for 0.88°, 1.42°, and 2.42° for 1254 EDT with the flight track from 1245 to 1254 EDT and the accident site marked. A review of the various elevation scans indicated the maximum reflectivity of 55.0 dBZ was identified on the 1.3° elevation scan or near 9,520 ft under the flight track.

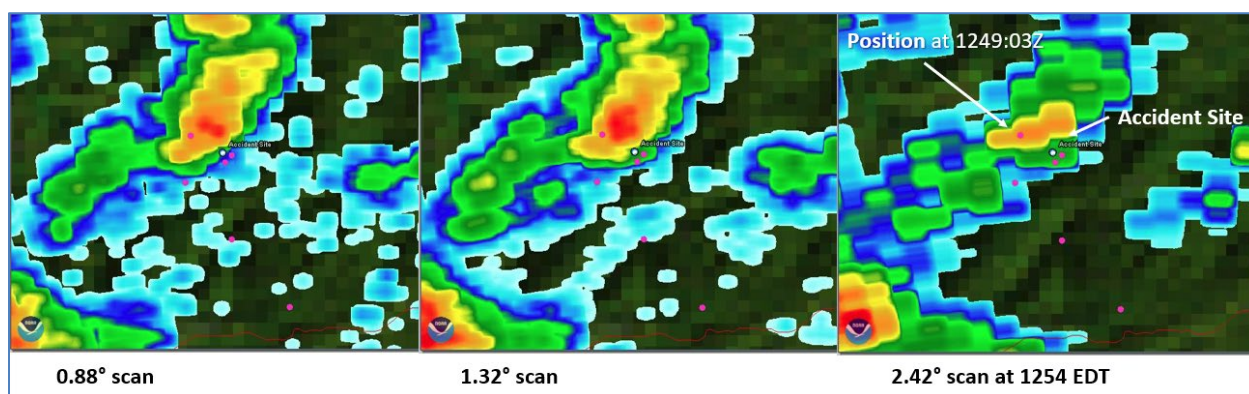


Figure 11 - Composite of the KGSP WSR-88D 0.88°, 1.32°, and 2.42° elevation scans at approximately 1254 EDT with the flight track overlaid

5.4 Consolidated Storm Prediction for Aviation Data

The Consolidated Storm Prediction for Aviation (CoSPA) images were retrieved for the period from 1240 EDT through 1300 EDT at 5-minute intervals are included as figures 12 through 16.

The approximate accident site is marked on image 12 and 15 for reference. The CoSPA images provided what was being displayed at the Air Route Traffic Control Center's (ARTCC) supervisor's position, with the general vertical integrated liquid (VIL) water levels 1-6 displayed similar to reflectivity level (see figure 17), over a the GOES-16 visible image, with lightning data and storm motion overlaid. The expected storm growth/decay is provided on the right. (not displayed) showed significant growth over the area with significant growth on the eastern side of the echo areas. The images depicted the storms over the area growing during the period with tops immediately southwest and northeast increase from 36,000 ft to 50,000 ft¹⁹ during the period and move east and northeastward at 10 knots. Lightning was depicted in the storms surrounding the accident site but not over the general route of flight or the echoes encountered.

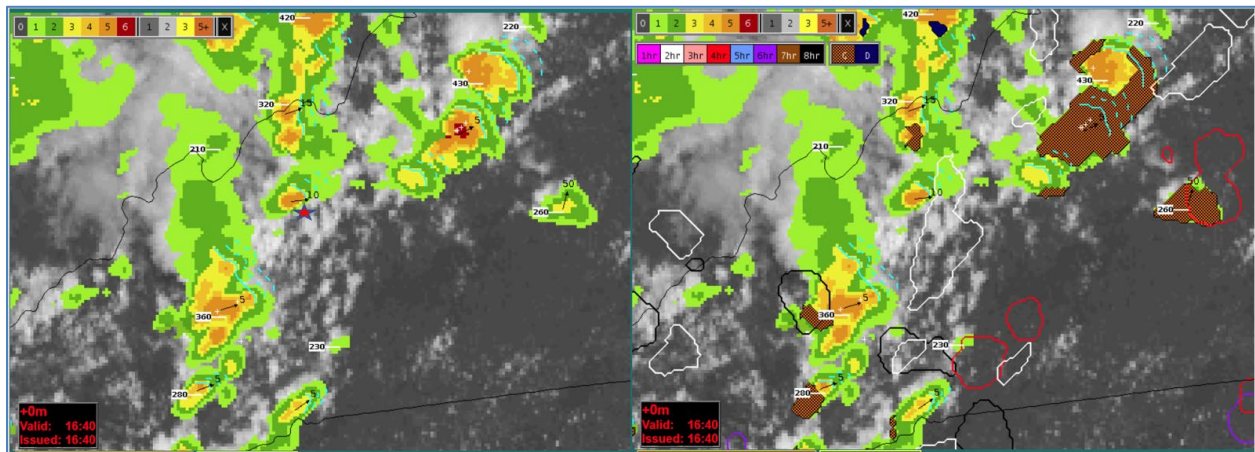


Figure 12 - CoSPA VIL display and growth/decay at 1240 EDT

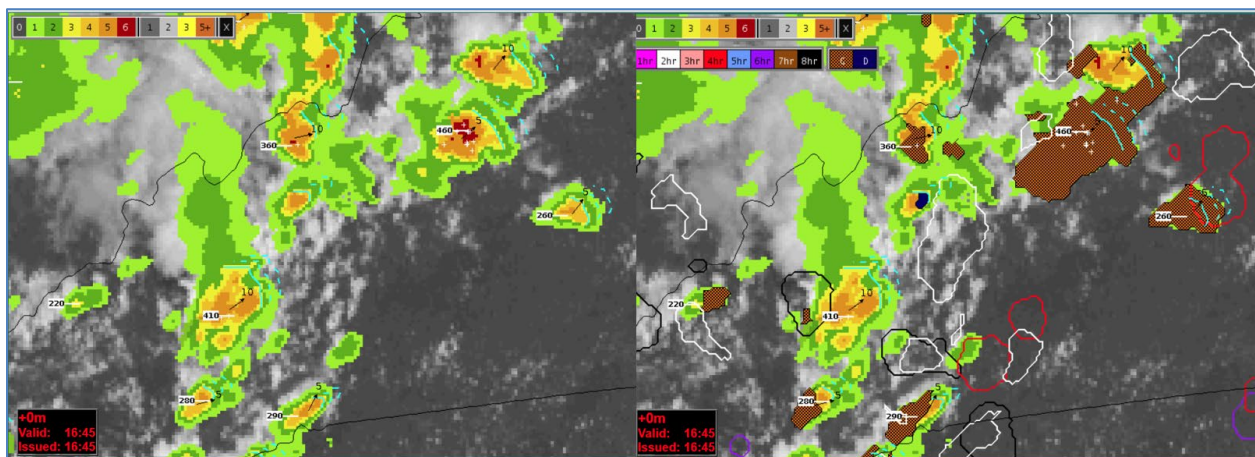


Figure 13 - CoSPA VIL display and growth/decay at 1245 EDT

¹⁹ CoSPA depicted the echo tops in reference to Flight Levels (FL) in hundreds of ft.

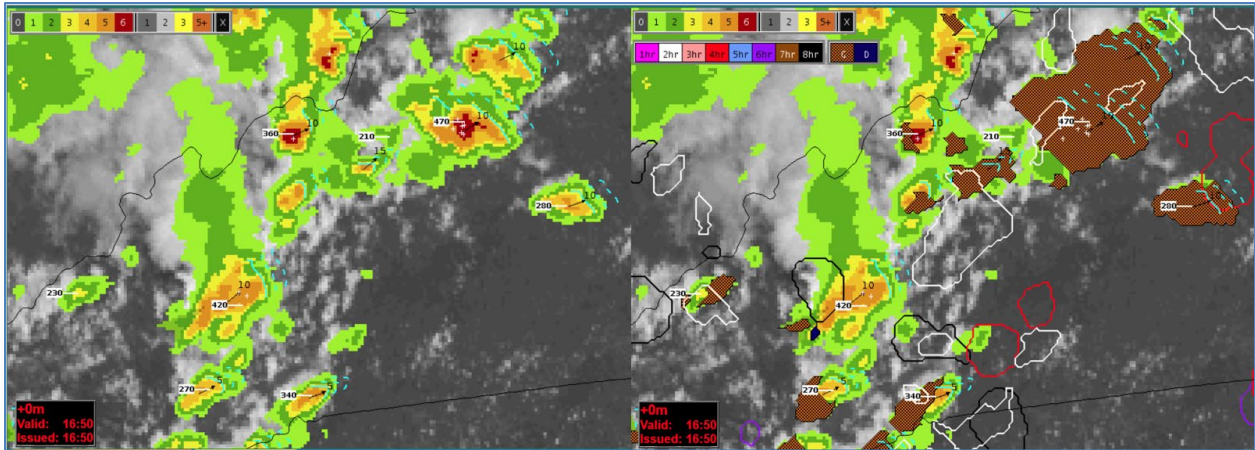


Figure 14 - CoSPA VIL display and growth/decay for 1250 EDT

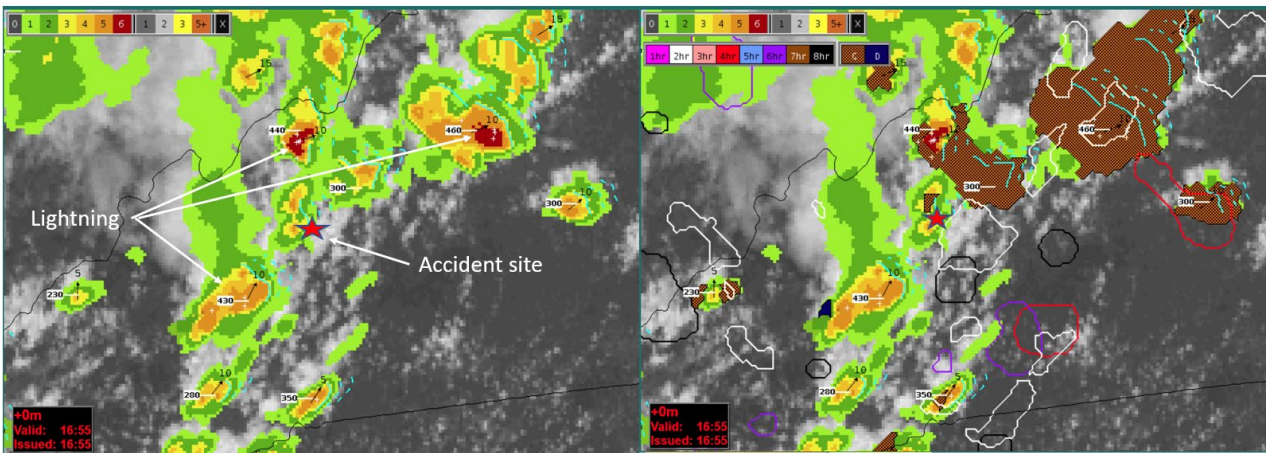


Figure 15 - CoSPA VIL display and growth/decay for 1255 EDT

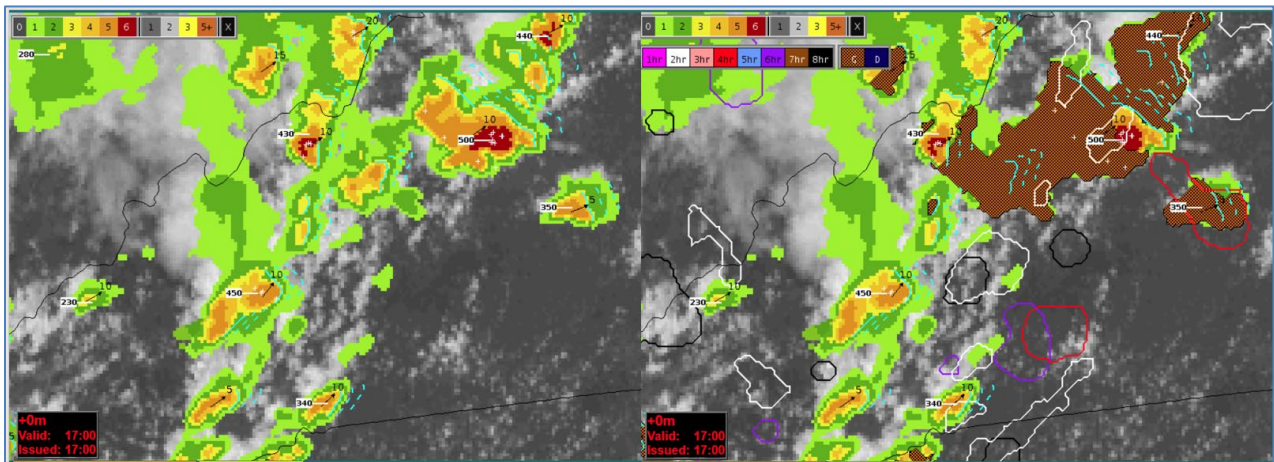


Figure 16 - CoSPA VIL display and growth/decay for 1300 EDT

VIP or VIL Levels	VIL (digital VIL)	VIL (kg/m ²)	Past and Current VIL	Forecast VIL
1	16	0.15	Level 1	Level 1
2	74	0.76	Level 2	Level 2
3	133	3.47	Level 3	Level 3/4
4	160	6.92	Level 4	Level 3/4
5	181	12.0	Level 5	Level 5/6
6	219	31.6	Level 6	Level 5/6

Figure 3 - CoSPA VIP scale for VIL

6.0 Pilot Reports

The following pilot reports (PIREPs) were reported in the vicinity surrounding the period of the accident, the reports are in standard code and abbreviations.

TRI UA /OV HMV180040/TM 1715/FL180/TP A321/TB MOD 170-180/RM IMC/ ZTLFD

AVL UA /OV SUG330030/TM 1721/FLUNKN/TP C56X/TB MOD 180-140/RM ZTLFD

AVL UA /OV FINAL TO RWY 35/TM 1735/FL001/TP TBM/SK OCV/WV +/- 5 KNOTS DOWN FINAL/RM BASES 028

SPA UA /OV SPA/TM 1920/FL060/TP CRJ2/SK B065V070

7.0 NWS Forecasts

7.1 Terminal Aerodrome Forecast

The closest NWS Terminal Aerodrome Forecast (TAF) to the accident site was from KAVL. The forecast current at the time of the accident was an amended forecast issued at 0903 EDT and was as follows.

*AMD TAF KAVL 221303Z 2213/2312 32003KT P6SM SCT050
 TEMPO 2213/2214 1/2SM FG VV002
FM221500 33004KT P6SM VCTS SCT045CB
 FM222200 21004KT P6SM BKN045
 PROB30 2222/2303 4SM TSRA OVC025CB
 FM230300 VRB02KT 6SM BR SCT060
 FM230600 VRB02KT 2SM BR SCT002 BKN019=*

The forecast for KAVL expected from 1100 through 1800 EDT expected a wind from 330° at 4 knots, visibility 6 miles or more, with thunderstorms in the vicinity, scattered clouds at 4,500 ft agl in cumulonimbus clouds.

7.2 Area Forecast Discussion

The NWS Greenville-Spartanburg (KGSP) Weather Forecast Office (WFO) located in Greer, South Carolina, was responsible for issuing the TAF for KAVL and weather alerts for the Burnsville area. The extended forecast section has not been reproduced below.

FXUS62 KGSP 221505

AFDGSP

Area Forecast Discussion

National Weather Service Greenville-Spartanburg SC

1105 AM EDT Thu Aug 22 2019

.SYNOPSIS...

A warm and humid airmass will persist across the region today as a cold front sets up from the Ohio Valley to the Mid-Atlantic. The front will approach the western Carolinas on Friday and then settle slowly south through the forecast area on Saturday. A cool and moist wedge of high pressure will set up behind the front on Sunday and linger through Monday. Another cold front will approach from the west during the middle of next week.

.NEAR TERM /THROUGH FRIDAY/...

As of 1045 AM EDT Thursday: With temp/dew point trends looking good, the only appreciable changes made to the near term forecast were made to increase pops for this afternoon/evening, especially along and north of the I-40 corridor where CAMs are beginning to focus more PM convection.

*A relatively flat upper level flow will exist atop the forecast area today, as a trough digs across the Great Lakes and suppresses the upper ridge to our south. While a few small vort maxes will ripple thru the quasi-zonal flow, the bulk of the height falls and upper forcing will be across the Ohio Valley and Central Appalachians. The low to mid lvl flow will increase slightly across the region ahead of this digging trough, resulting in a slight uptick in deep-layer shear (in the 15-20 kt) range. But overall, convection should remain fairly disorganized. **The latest SPC Day 1 Outlook does have a marginal risk that includes the northern half of the forecast area. Forecast soundings show potential for 2000-2500 J/kg of sbCAPE with some mid-lvl dry air that will increase the microburst potential. Convective coverage looks pretty scattered today, with the usual mountain-triggered storms starting first during early aftn hours, then expanding/drifted east across the NC foothills and piedmont mid-aftn thru early evening.** Coverage over NE GA and the Upstate looks more isolated. Temps will continue to be slightly above normal, similar to yesterday's highs, perhaps a deg or two cooler.*

Tonight, the right entrance region of an upper jet will pivot south to the TN Valley and western NC overnight. This combined with linger instability and increasing SWLY WAA 850 mb flow will support a chc PoP well into the night across the western third or so of the forecast area. Lows will be a couple categories above normal under partly to mostly cloudy skies.

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

*As of 245 am EDT Thursday: A sharp, positively tilted upper trough axis will stretch from a closed low center over eastern Quebec to the eastern Great Lakes by Friday. South of this trough, a surface cold front will settle southward toward the western Carolinas, but keeping the forecast area in the warm and moist sector through the day. **Abundant moisture, with profiles exhibiting PWAT values around 2 inches, will pool across the region ahead of the front. The moisture will combine with forcing from both the approaching frontal zone at low levels and right entrance region jet divergence aloft to generate fairly widespread showers and thunderstorms - especially across the northern tier of the forecast area. Surface based instability and 850 to 500 mb lapse rates will not be terribly impressive Friday afternoon given the warm and moist profiles, but a modest uptick in surface to 3 km bulk shear to around 25 to 30 kt along and north***

of I-40 could support a few severe thunderstorms. Heavy rainfall in the high precipitable water airmass may be the primary hazard, with flash flooding becoming possible with any training convection. However, confidence remains too low for any Flash Flood Watches at this point.

The boundary should steadily sag southward through the forecast area through the day on Saturday. Likely PoPs for showers and thunderstorms will continue, but with instability getting shunted to the southern half of the forecast area as cold air damming slowly sets up across the northwest NC piedmont late in the day. Lapse rates continue to appear fairly unimpressive through Saturday afternoon, but still cannot rule out a few severe storm along and south of the immediate wedge front in the pooled instability. Hydro concerns will once again arise with any training convection along or near the front.

..AVIATION /15Z THURSDAY THROUGH MONDAY/..

At KCLT and elsewhere: All sites currently VFR, though another round of scattered shra and tsra is expected this aftn, starting in the mountains and NC foothills, where VCTS will be carried in the 18-21z time frame. Then activity will work east, with more isolated coverage developing across the Upstate. Have kept in prob30 at most sites in the 21-03z time frame based on model consensus of timing, though these will likely be transitioned to tempos or possibly even prevailing convection at Foothills sites (KHKY, KCLT). A light, moist SWLY flow will continue tonight, which may support lingering shra and tsra across the western parts of the forecast area. Coverage should be more isolated and confidence is too low to keep any precip mention overnight. Mid clouds are expected overnight, but mountain valleys will likely fog up again, so will mention some IFR vsby at KAVL late. Sfc winds will prevail out of the SW and should stay under 10 kts today.

Outlook: SHRA/TSRA chances will remain across the area as a front lays over the area from the north and stalls through the weekend. Some morning fog and low stratus will be possible each day, especially in the mountain valleys. Cold air damming will set up over the weekend, keeping lower cigs possible.

..GSP WATCHES/WARNINGS/ADVISORIES...

GA...None.

NC...None.

SC...None.

SYNOPSIS...HG

NEAR TERM...Carroll

SHORT TERM...HG

LONG TERM...HG

AVIATION...ARK/Carroll

7.3 Winds Aloft Forecast

The NWS Winds Aloft Forecast current during the period for the route was valid for 0800 EDT and for use between 1000 through 1700 EDT and was as follows.

WINDS ALOFT FORECASTS

DATA BASED ON 221200Z

VALID 221800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
GSP	2408	2509+17	2612+11	2416+05	2513-07	2414-17	220932	140942	080553
CAE	2409	2509+16	2612+11	2514+05	2413-07	2418-17	191232	171042	121053
TYS	2205	2617+17	2518+11	2421+06	2421-07	2420-17	231531	241441	251853
TRI		2717+16	2616+11	2519+06	2520-07	2524-17	231931	232141	252454
CRW	2309	2724+17	2727+11	2527+05	2631-08	2537-17	253431	253342	253954
CVG	2512	2621+15	2630+10	2733+04	2728-07	2634-17	253532	253742	253954
CMH	2510	2615+13	2623+09	2733+04	2634-07	2640-18	254632	264742	255154

CLE 0412 2816+12 2720+07 2733+03 2545-09 2560-19 256532 266742 256854

The closest forecast point was for GSP approximately 50 miles southeast of the accident site. The forecast for 12,000 ft expected a wind from 240° at 16 knots with a temperature of 5° C, and at 18,000 ft expected wind from 250° at 13 knots with a temperature of -7° C.

8.0 Inflight Weather Advisories

The NWS Aviation Weather Center (AWC) issued Convective SIGMET 52E at 1155 EDT and valid for a 2-hour period until 1355 EDT for an area of embedded thunderstorm moving from 240° at 25 knots, with tops above 45,000 ft. The issuance of the Convective SIGMET implied the potential for severe icing, severe turbulence, low-level wind shear. Figure 20 is a plot of the advisory over the GOES-16 visible image at 1156 EDT with the departure and destination airports marked by a yellow squares and the accident site identified by a red square and located within the boundaries of the advisory. The text of the SIGMET follows the image.

Immediately after the accident, the NWS AWC issued Convective SIGMET 59E at 1255 EDT, which replaced the previous advisory. Figure 21 is a plot of the advisory over the GOES-16 visible satellite image at the time of issuance, followed by the text advisory. The accident site continued to be depicted within the boundary of the advisory.

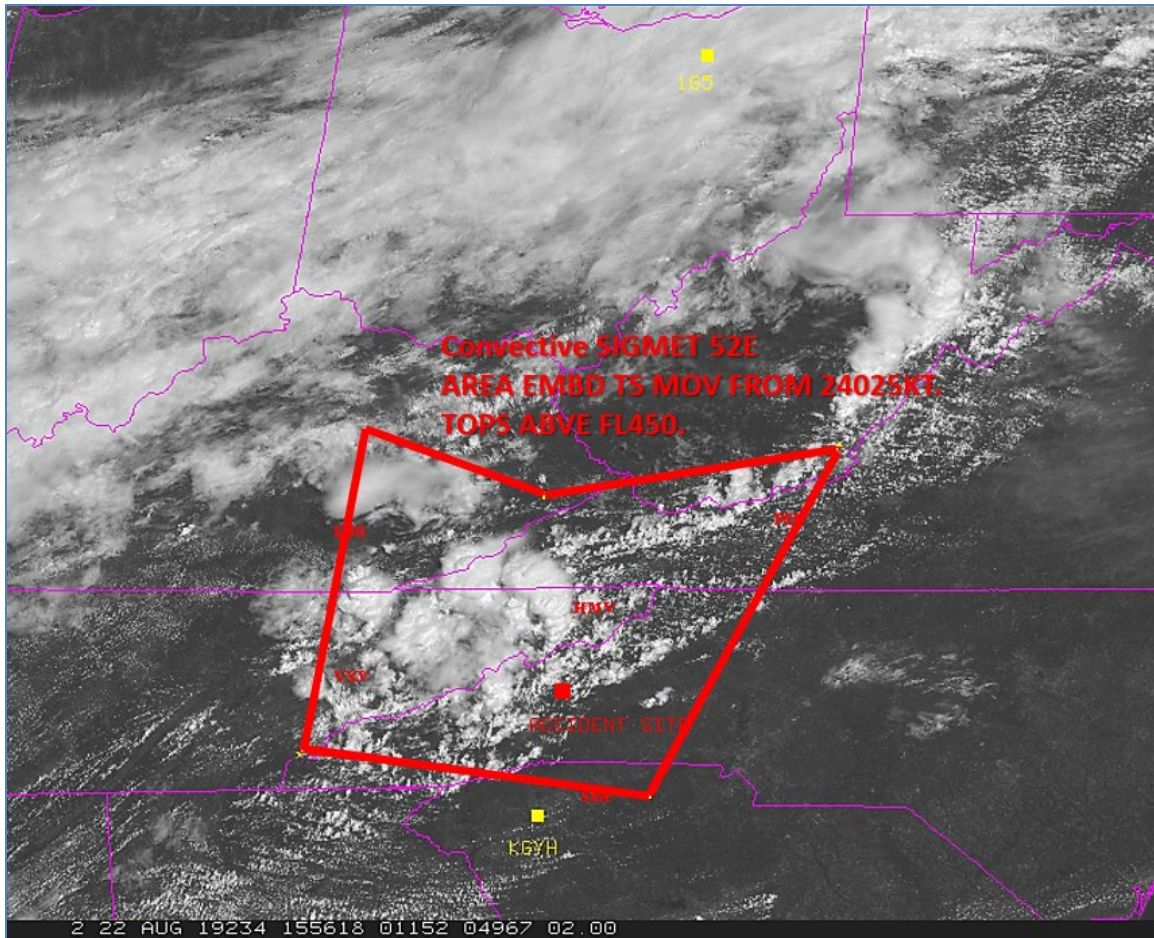


Figure 4 - Convective SIGMET 52E over the GOES-16 visible satellite image at 1156 EDT

WSUS31 KPCI 221555

SIGE

MKCE WST 221555

CONVECTIVE SIGMET 52E

VALID UNTIL 1755Z

VA NC WV SC TN KY

FROM 50N LOZ-60NNW HMM-40NNE PSK-20E SPA-40SSW VXV-50N LOZ

AREA EMBD TS MOV FROM 24025KT. TOPS ABV FL450.

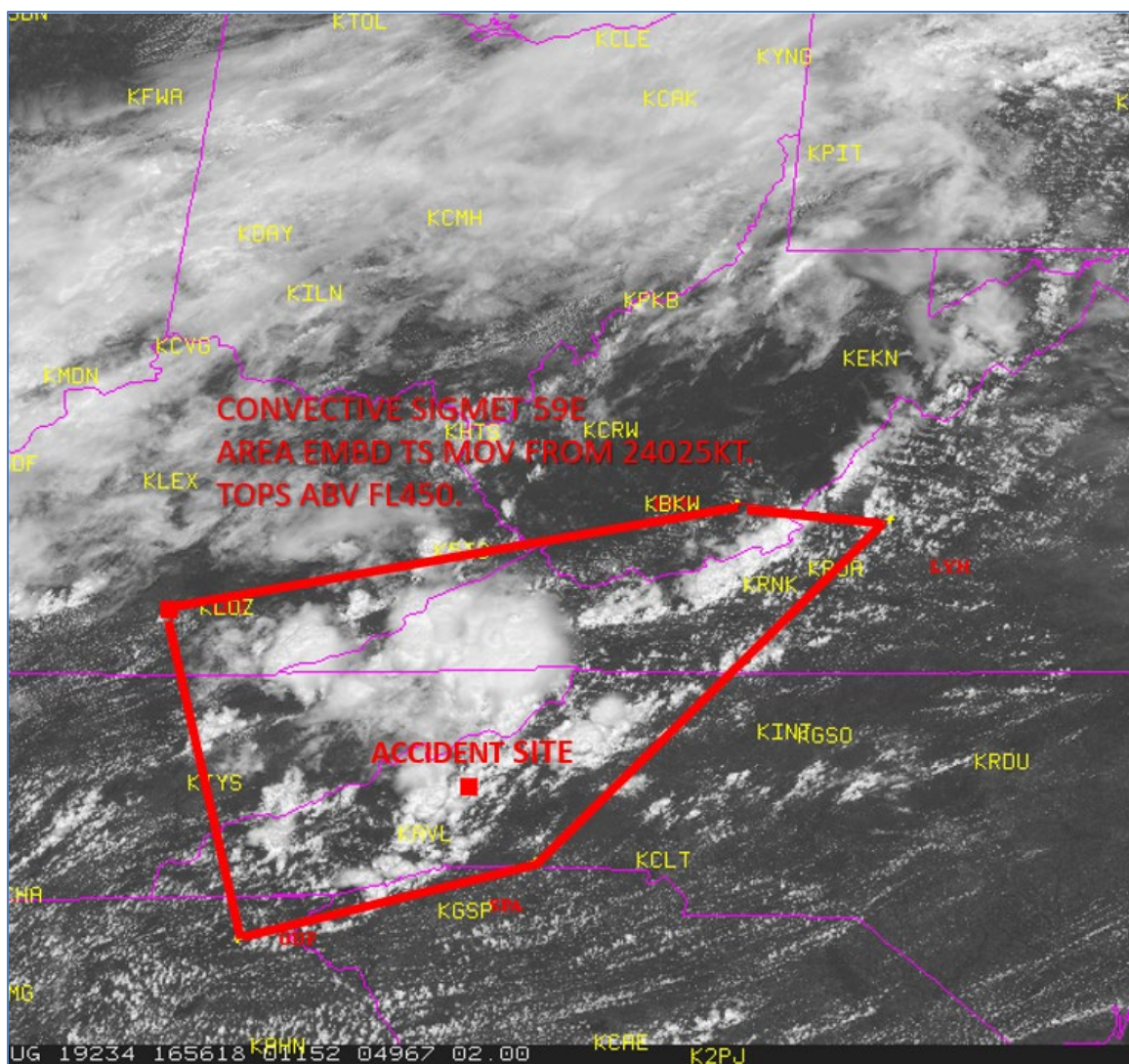


Figure 5 - Convective SIGMET 59E over the GOES-16 visible satellite image for 1255 EDT

WSUS31 KPCI 221655

SIGE

MKCE WST 221655

CONVECTIVE SIGMET 59E

VALID UNTIL 1855Z

VA NC WV SC GA TN KY

FROM 20E BKW-30NW LYH-20NNE SPA-20W ODF-20W LOZ-20E BKW

AREA EMBD TS MOV FROM 24025KT. TOPS ABV FL450.

9.0 Preflight Weather Briefing

The accident pilot obtained a standard route preflight weather briefing from the Federal Aviation Administration contract Flight Service Station provider Leidos at 1128 EDT immediately prior to departing KGYH. The briefing included Convective SIGMET 46E issued at 1055 EDT for area of embedded thunderstorm moving from 240° at 25 knots with tops to 40,000 ft. The advisory extended approximately 17 miles west of the accident site. Several AIRMETs for mountain obscuration over New York, Pennsylvania, Ohio, West Virginia, western Maryland, and Virginia.

The briefing also included METARs for the departure airport, and along the route of flight which indicated VFR to MVFR conditions prevailing along the route and surrounding the destination airport. The briefing also included the Graphic Forecast for Aviation S(GFA) Surface and Cloud forecasts for the eastern United States for 1100, 1400, and 1700 EDT. The TAFs nearest the departure and destination, and for selected stations enroute were also included with several stations expected a period of thunderstorms and rain during the period. The winds aloft forecast was also included as well as the notices to airmen (NOTAMs). The briefing also included the NWS SPC Convective Outlook bulletin issued at 0900 EDT which included a marginal risk of severe thunderstorms over the route of flight. A copy of the text from the briefing is included as attachment 1.

F. LIST OF ATTACHMENTS

Attachment 1 – FSS Weather Briefing obtain at 1128 EDT for N404PE

Submitted by:

Don Eick
Senior Meteorologist