NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

June 26, 2014

Group Chairman's Weather Study

METEOROLOGY

ERA12LA500

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A. ACCIDENT

Location: 3 miles north-northeast of Effingham, South Carolina
Date: August 11, 2012
Time: approximately 1310 eastern daylight time (1710 UTC[1])
Aircraft: Beech V35B, registration: N11JK

B. METEOROLOGY GROUP

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C. SUMMARY

On August 11, 2012, about 1310 eastern daylight time, a Beech V35B, N11JK, was substantially damaged during a forced landing following a loss of engine power near Effingham, South Carolina. The certificated private pilot and the passenger were not injured. Instrument meteorological conditions prevailed, and instrument flight rules flight plan was filed for the flight. The flight departed Manassas Regional Airport (HEF), Manassas, Virginia at 1052, and was destined for Flagler County Airport (XFL), Palm Coast, Florida. The personal flight was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist was not on scene for this investigation and gathered all the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are eastern daylight time (EDT) on August 11, 2012, 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 statute miles.

The accident location was located at latitude 34.11° N, longitude 79.73° W, elevation: 104 feet.

[1] UTC – is an abbreviation for Coordinated Universal Time.

E. 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 (NCEP), and the Hydrometeorological Prediction Center (HPC) 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-0045G CHG 1.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1400 EDT is provided as figure 1, with the approximate location of the accident site marked. The chart depicted a stationary front stretched northeastward from central Georgia up the East Coast. A cold front stretched southwestward from central Georgia into Alabama. Several outflow boundaries were located across South Carolina and Georgia and these outflow boundaries along with the frontal boundaries would act as lifting mechanisms to help produce clouds and precipitation. The station models around the accident site depicted air temperatures in the low 70's to mid 80's Fahrenheit (F), with temperature-dew point spreads of 15° F or less, a southwest to south wind between 5 and 20 knots, partly cloudy skies, and thunderstorms. The low-level environment surrounding the accident site was warm and moist as is typical for summer time in the Southeast and this helped to create moderately unstable conditions (further discussed in Section 4.0). These moderately unstable conditions combined with the lifting mechanisms would help to produce clouds, rain showers, and strong thunderstorms.

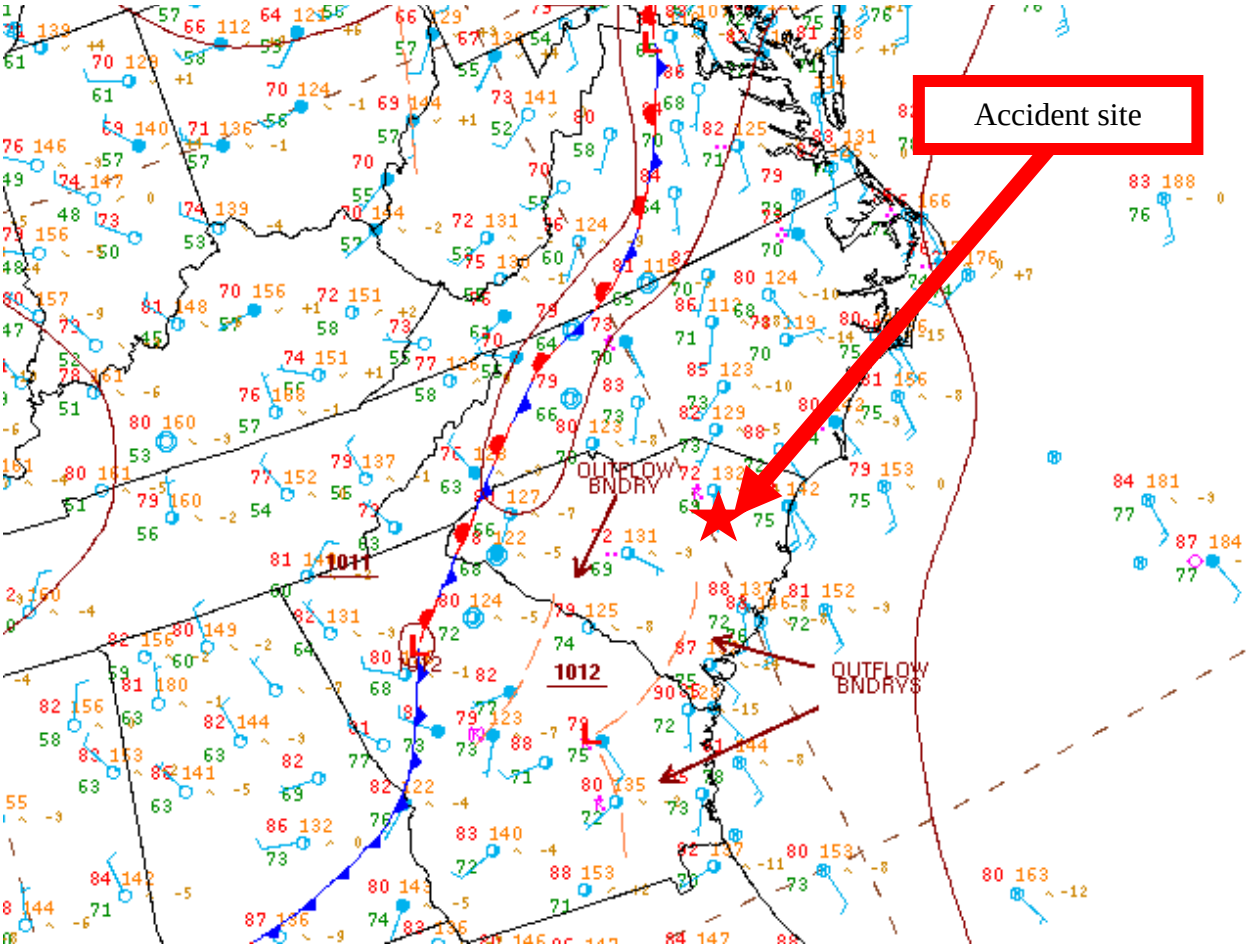


Figure 1 – NWS Surface Analysis Chart for 1400 EDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0800 EDT at 925-, 850-, 700-, 500-, and 250-hectopascals (hPa) are presented in figures 2 through 6. The 925- and 850-hPa charts depicted a low-level trough[2] just to the west of the accident site and with the warm moist surface environment (figure 1) clouds and precipitation would be expected to develop in central and eastern South Carolina. The 700- and 500-hPa charts also depicted a mid-level trough above the low-level trough and this mid-level trough would further act as a lifting mechanism for clouds and precipitation. Figure 6 showed an upper-level jet streak located south to north along the Appalachian Mountains with the accident location in the right entrance region of the upper-level jet streak, and this right entrance region is considered a favorable location for clouds and precipitation development due to enhanced mid and upper-level vertical motion.

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

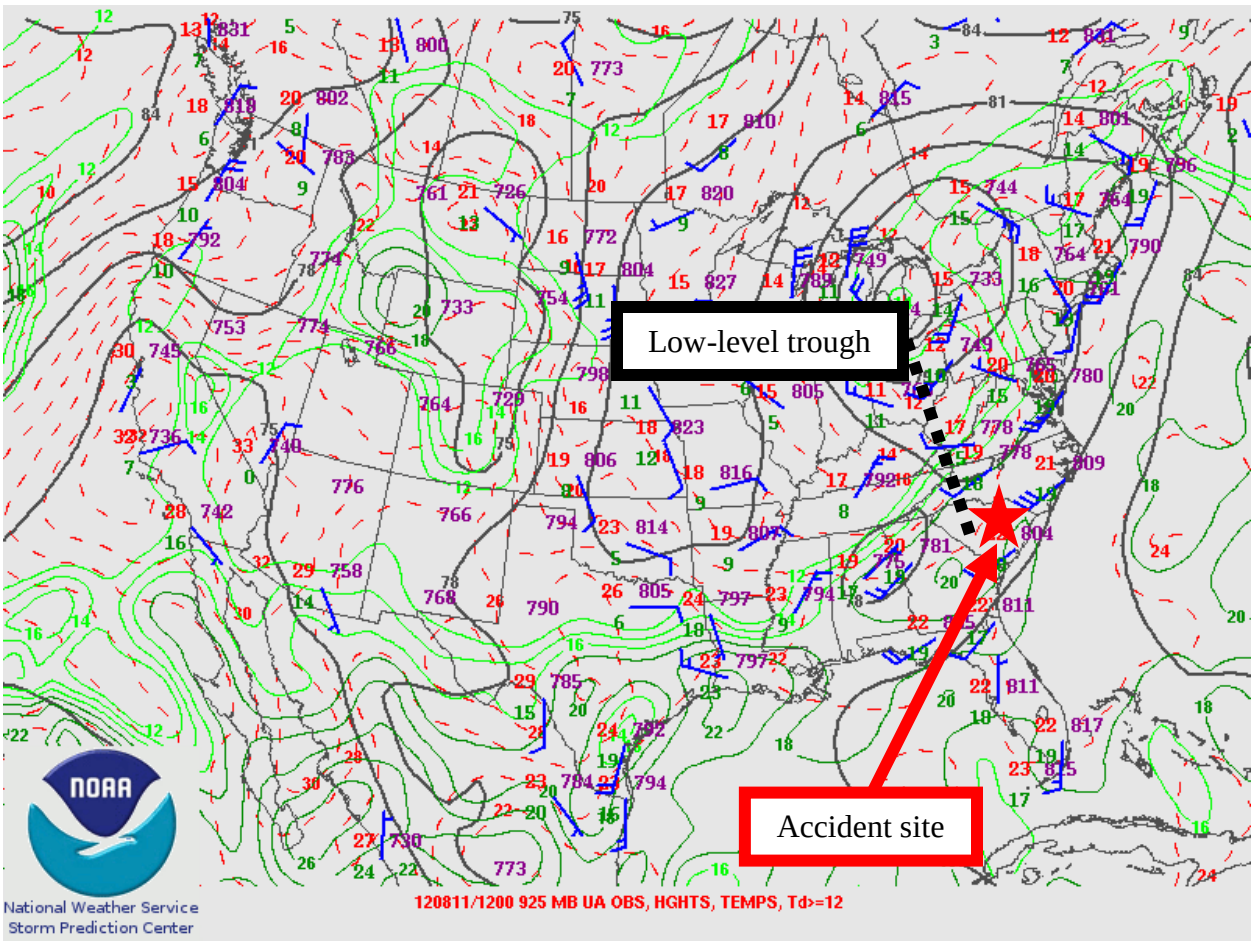


Figure 2 – 925-hPa Constant Pressure Chart for 0800 EDT

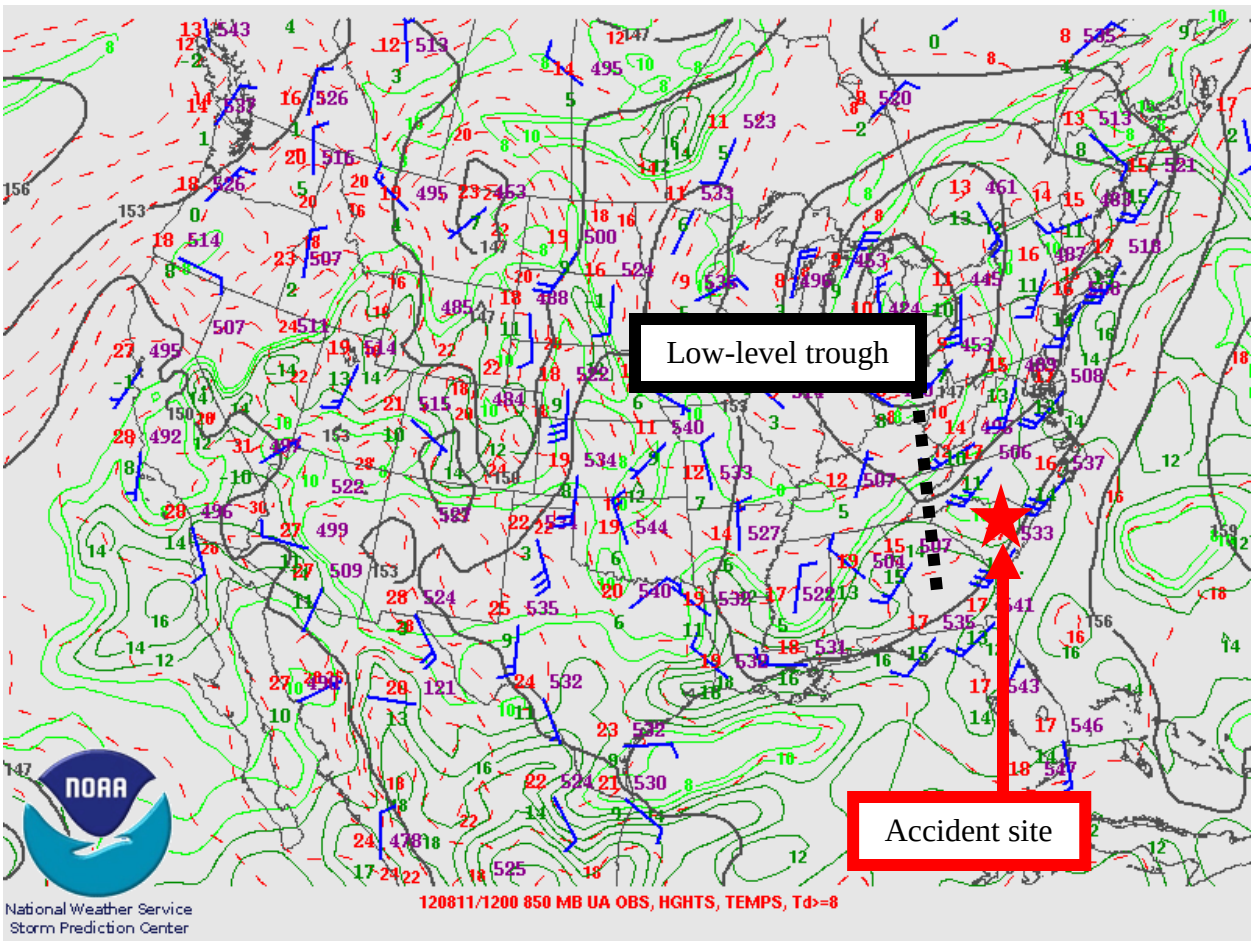


Figure 3 – 850-hPa Constant Pressure Chart for 0800 EDT

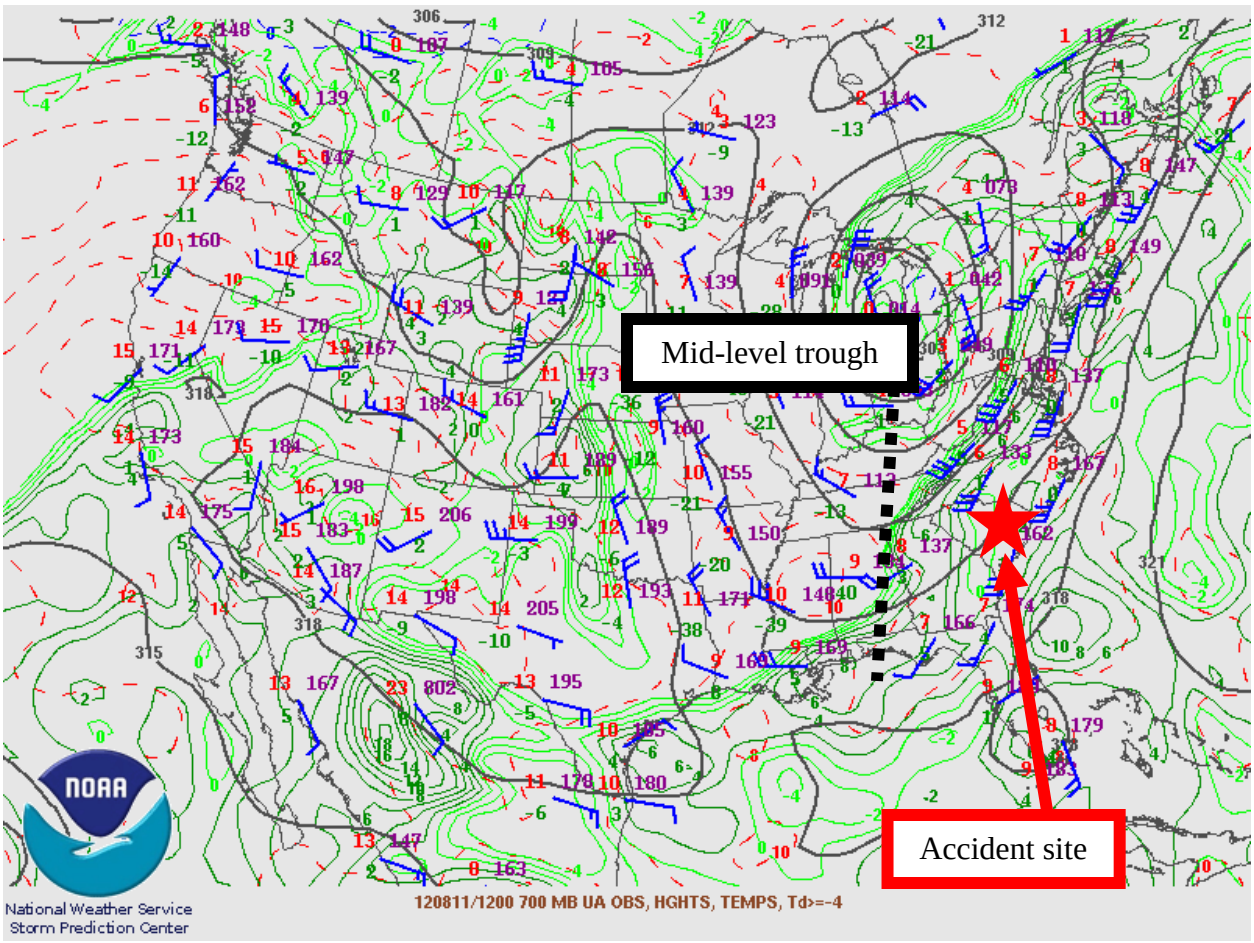


Figure 4 – 700-hPa Constant Pressure Chart for 0800 EDT

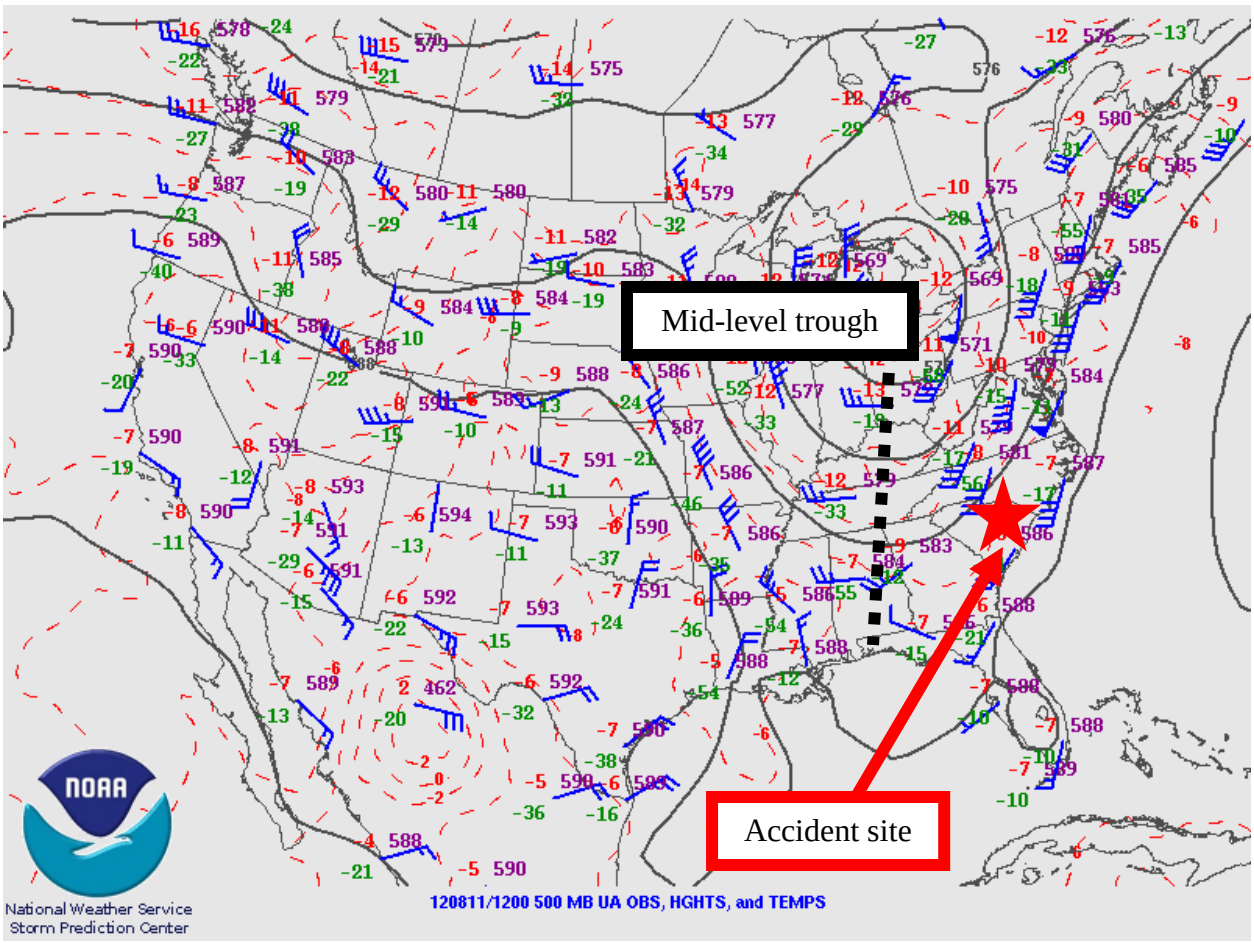


Figure 5 – 500-hPa Constant Pressure Chart for 0800 EDT

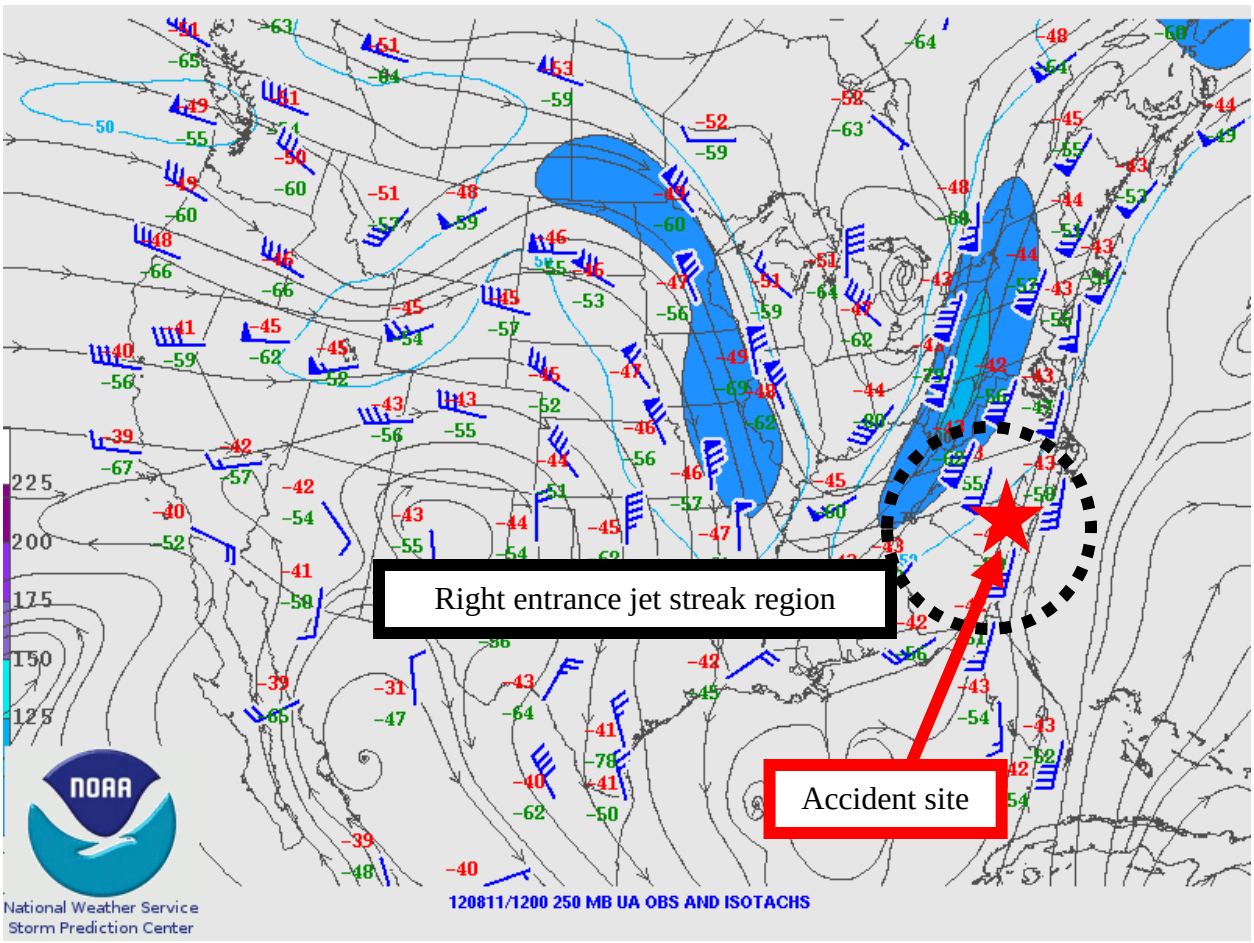


Figure 6 – 250-hPa Constant Pressure Chart for 0800 EDT

2.0 Storm Prediction Center Products

SPC issued the following day 1 Convective Outlook at 1219 EDT (figure 7) with areas of thunderstorms forecasted up and down the East Coast including the accident site, with a small chance of severe thunderstorms forecasted for the accident site. The accident site was located in an area where SPC forecasted a 5 percent chance of damaging thunderstorm winds or wind gusts 50 knots or greater within 25 miles of a point[3]:

SPC AC 111619

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1119 AM CDT SAT AUG 11 2012

VALID 111630Z - 121200Z

...NO SVR TSTM AREAS FORECAST...

[3] The bold sections in this NWS product and the rest of products in the weather study report are to highlight the individual sections that directly reference the weather conditions that are or will affect the accident location around the accident time.

UPPER LEVEL TROUGH FROM THE EASTERN GREAT LAKES TO THE GULF COAST STATES WILL ONLY SHIFT SLIGHTLY E/NEWD TODAY. A COUPLE OF SHORTWAVE IMPULSES ROTATING NEWD THROUGH THE LARGER-SCALE FLOW HOWEVER MAY HELP FOCUS THUNDERSTORM CLUSTERS THIS AFTERNOON INTO EARLY EVENING FROM THE CAROLINAS TO NEW ENGLAND AS A SFC COLD FRONT PUSHES EWD THROUGH SUNDAY MORNING. FURTHER WEST...A SHORTWAVE TROUGH LOCATED OVER MT LATE THIS MORNING WILL CONTINUE TO PROGRESS E/SEWD INTO THE PLAINS ALONG WITH A SFC COLD FRONT. THIS FEATURE WILL FOCUS THUNDERSTORM DEVELOPMENT ACROSS PORTIONS OF THE NRN INTO CNTRL PLAINS THIS AFTERNOON AND TONIGHT.

ELSEWHERE...THUNDERSTORM DEVELOPMENT IS EXPECTED ACROSS THE NRN GULF COAST INTO SOUTH TEXAS ALONG A SWD ADVANCING COLD FRONT AND ACROSS THE SOUTHWESTERN U.S. IN DEEP/MOIST S/SELY FLOW.

...NORTHEAST...

SCATTERED THUNDERSTORMS ARE EXPECTED TO DEVELOP AS SHORTWAVE IMPULSE CURRENTLY OVER WRN PA/NRN WV LIFTS NEWD TOWARD CNTRL/ERN NY. WIDESPREAD CLOUD COVER ACROSS THE REGION THIS MORNING WAS LIMITING DESTABILIZATION AND EXPECT AT BEST AROUND 1000 J/KG SBCAPE DURING PEAK HEATING. ADDITIONALLY...LAPSE RATES WILL REMAIN POOR DUE TO LIMITED SFC HEATING. ALTHOUGH DEEP LAYER BULK SHEAR ON THE ORDER OF 40-50 KTS WOULD LEND TO SOME THUNDERSTORM ORGANIZATION/FAST MOVING STORMS...ONLY LIMITED SEVERE POTENTIAL SEEMS LIKELY GIVEN THE AFOREMENTIONED POOR LAPSE RATES/LOW CAPE ENVIRONMENT. A FEW STRONGER STORMS THEREFORE ARE LIKELY WHERE BREAKS IN CLOUDS CAN SUFFICIENTLY HEAT/DESTABILIZE BOUNDARY LAYER...RESULTING IN ISOLATED STRONG WIND GUSTS.

...VA/CAROLINAS...

SIMILAR LIMITING FACTORS ARE IN PLACE FOR PORTIONS OF THE MID-ATLANTIC COAST AS FURTHER NORTH ACROSS NEW ENGLAND. WIDESPREAD CLOUD COVER THIS MORNING WILL CONTINUE INTO THE AFTERNOON...LIMITING DESTABILIZATION. ADDITIONALLY...POOR LAPSE RATES IN THE PRESENCE OF SBCAPE ON THE ORDER OF 1000-1500 J/KG WILL INHIBIT ROBUST UPDRAFT DEVELOPMENT. FORCING FOR ASCENT IS ALSO EXPECTED TO BE WEAKER AS A SECOND SHORTWAVE IMPULSE CURRENTLY ACROSS CNTRL KY/MIDDLE TN REMAINS WEST OF THE REGION WITH ONLY SMALL SCALE PERTURBATIONS MOVING THROUGH LARGER-SCALE FLOW. DEEP LAYER SHEAR ALSO DECREASES WITH SOUTHWARD EXTENT BUT SHOULD REMAIN SUFFICIENT FOR SEMI-ORGANIZED STORM CLUSTERS WITH THE POTENTIAL FOR ISOLATED STRONG WIND GUSTS THIS AFTERNOON.

...CNTRL HIGH PLAINS...

12Z MODELS CONTINUE TO INDICATE AT LEAST ISOLATED THUNDERSTORM DEVELOPMENT AHEAD OF SFC COLD FRONT FROM SW SD INTO WRN KS THIS AFTERNOON AND EVENING. STRONG SFC HEATING WILL RESULT IN STEEP LOW LEVEL LAPSE RATES WITH FORECAST SOUNDINGS INDICATING INVERTED-V PROFILES. LIMITING FACTORS FOR MORE WIDESPREAD SEVERE POTENTIAL INCLUDE LIMITED SFC MOISTURE AND WEAK INSTABILITY. OPERATIONAL MODELS AND FORECAST SOUNDINGS SUGGEST MLCAPE VALUES ON THE ORDER OF

500-1000 J/KG. AT THIS TIME...STORM COVERAGE APPEARS TO REMAIN SUFFICIENTLY ISOLATED THAT NO MORE THAN A LOCALLY DAMAGING WIND/HAIL THREAT WILL EXIST. HOWEVER...TRENDS WILL BE MONITORED FOR POTENTIAL UPGRADE AT 20Z.

...SW AZ/SE CA...
STRONG SFC HEATING WILL LEAD TO STEEP LOW LEVEL LAPSE RATES BENEATH DRY SUB-CLOUD LAYER. LIMITED INSTABILITY /AROUND 500 J/KG MLCAPE/ AND WEAK DEEP LAYER SHEAR SHOULD LIMIT SEVERE POTENTIAL BUT A FEW STORMS MAY PRODUCE LOCALLY STRONG/DAMAGING WIND GUSTS GIVEN LARGE SFC T-TD SPREAD.

..LEITMAN/HART.. 08/11/2012

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 2000Z

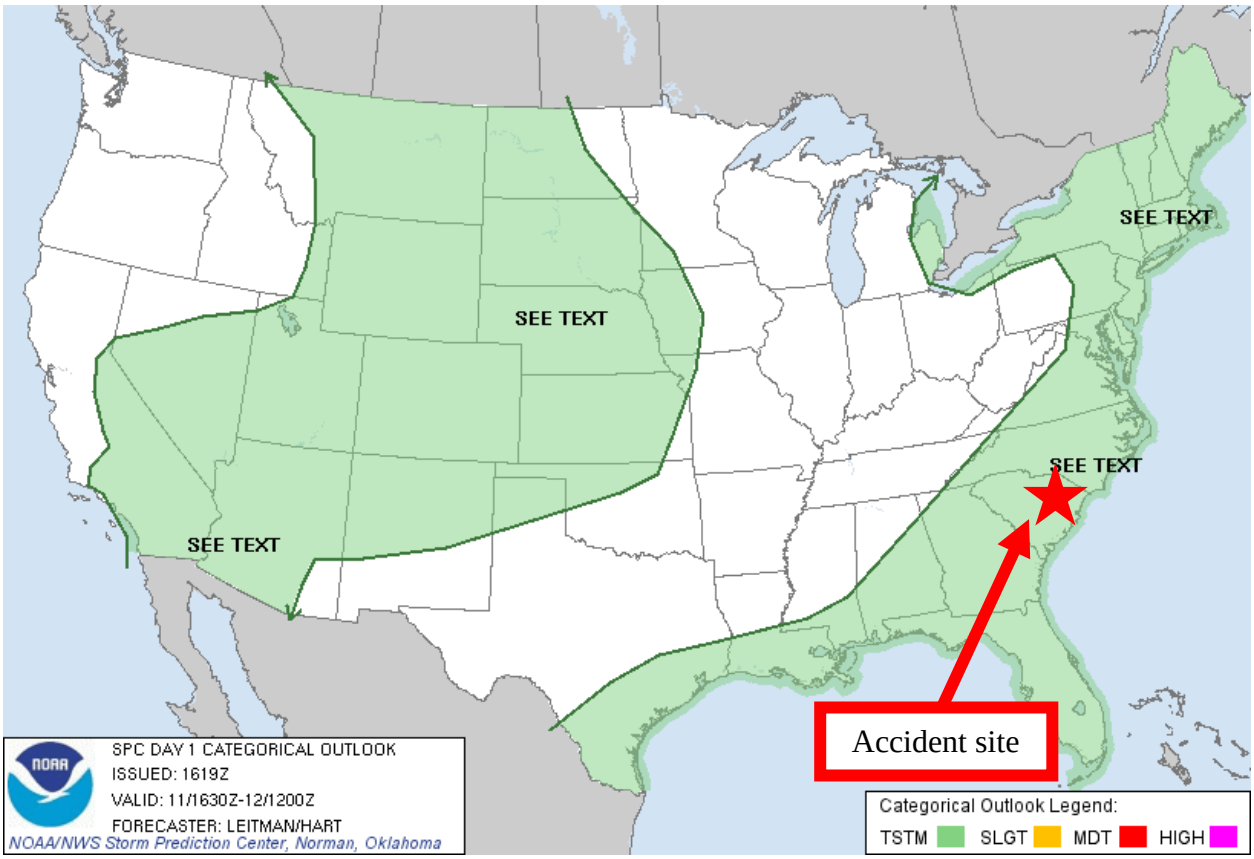


Figure 7 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

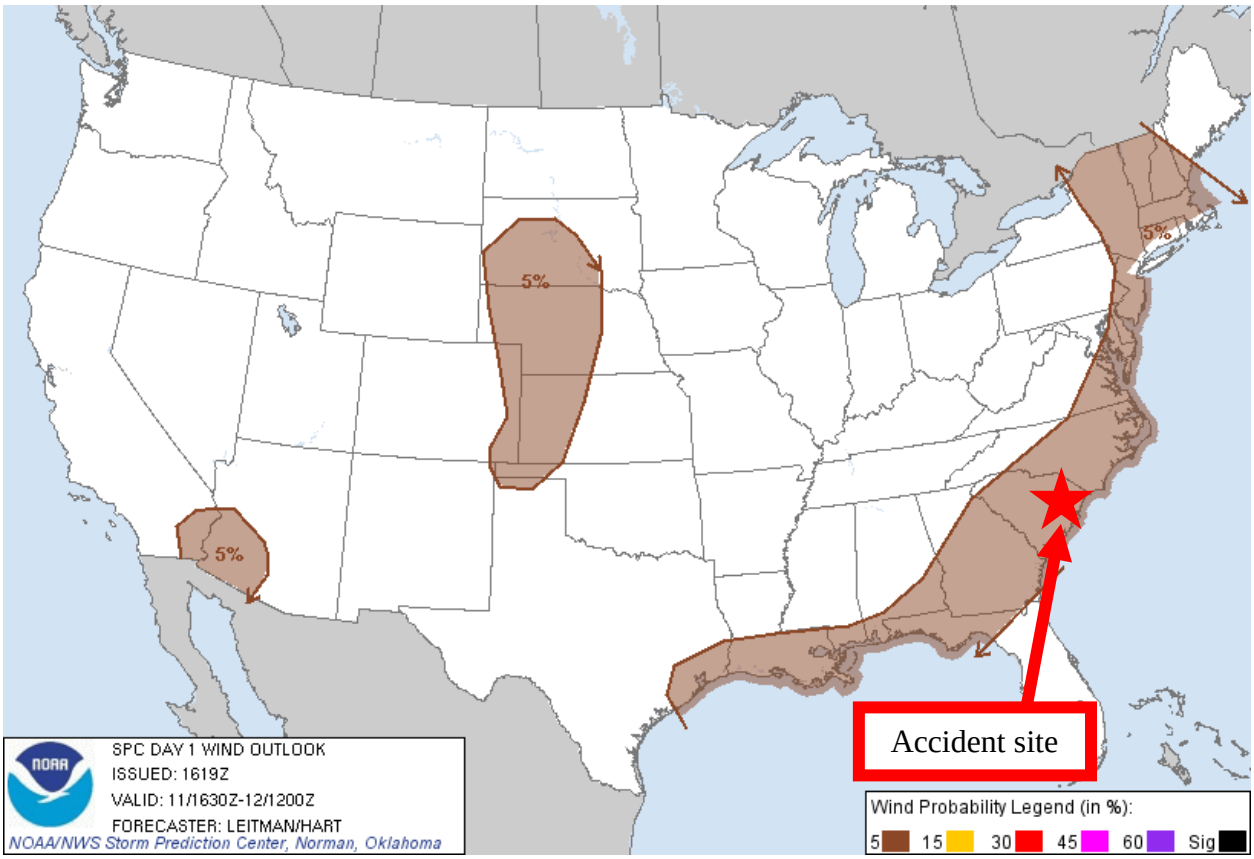


Figure 8 – Storm Prediction Center day 1 probability of damaging thunderstorm winds valid at the time of the accident

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language.

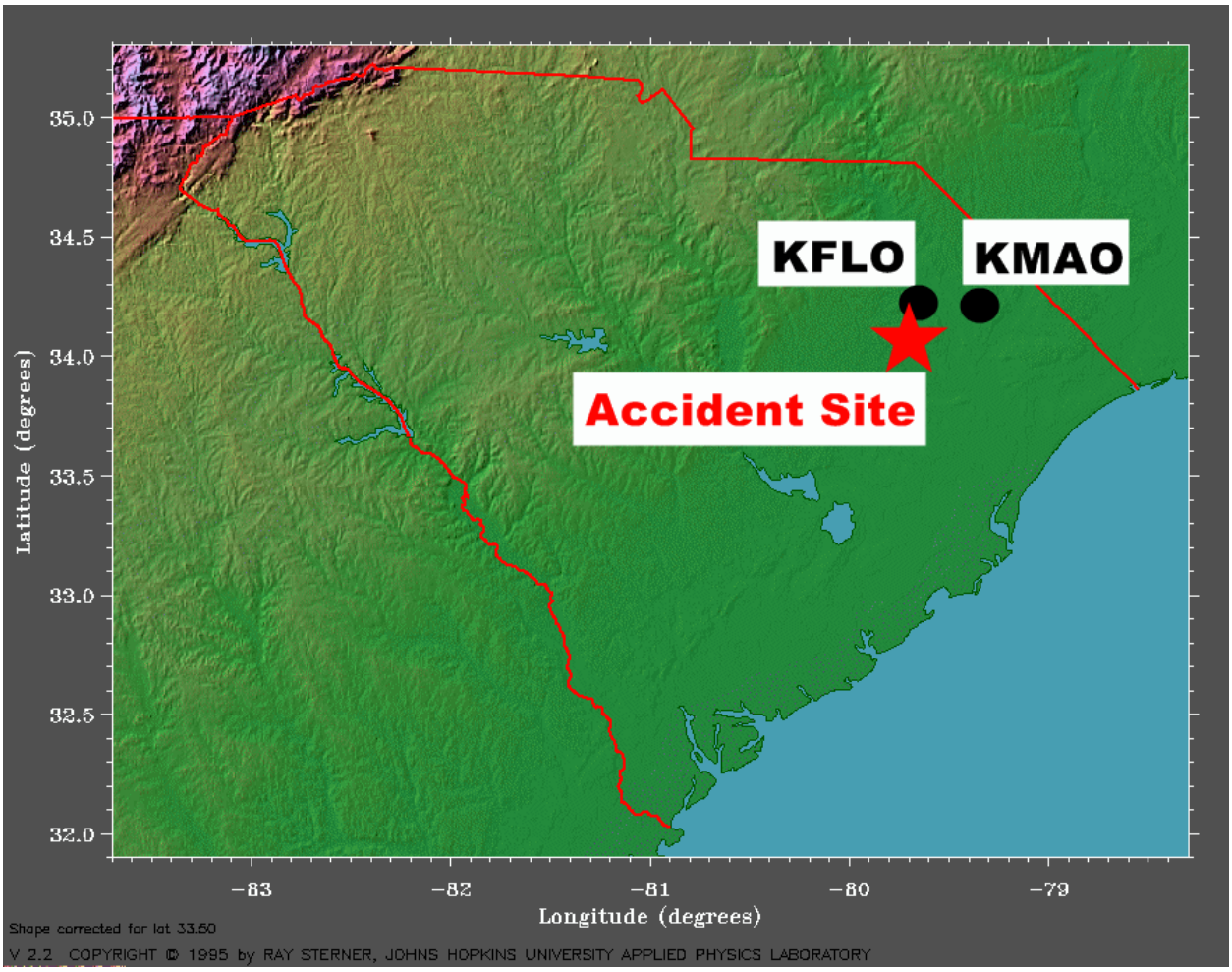


Figure 9 – Map of South Carolina with the location of the accident site and surface observation sites

Florence Regional Airport (KFLO) was the closest official weather station to the accident site located 3 miles east of Florence, South Carolina, and had an Automated Surface Observing System (ASOS[4]) whose reports were supplemented by the air traffic control tower. KFLO was located 4 miles north of the accident site, at an elevation of 147 feet, and had a 5° westerly magnetic variation[5] (figure 9). The following observations were taken and disseminated during the times surrounding the accident:

[0853 EDT] KFLO 111253Z 22008KT 10SM FEW009 27/23 A2991 RMK AO2 SLP125 T02670233=

[0953 EDT] KFLO 111353Z 24007KT 10SM SCT019 28/23 A2993 RMK AO2 SLP131 T02780228=

[4] ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.
[5] Magnetic variation – The angle (at a particular location) between magnetic north and true north.

[1006 EDT] KFLO 111406Z 24011G16KT 10SM BKN021 BKN027 28/23 A2994 RMK AO2=

[1053 EDT] KFLO 111453Z 20007KT 10SM BKN019 BKN033 BKN040 29/23 A2994 RMK AO2 SLP136 T02890228 53007=

[1100 EDT] KFLO 111500Z 20009KT 10SM SCT019 OVC033 29/23 A2994 RMK AO2=

[1153 EDT] KFLO 111553Z 22012KT 10SM SCT028 SCT100 BKN120 29/22 A2993 RMK AO2 SLP132 T02940222=

[1253 EDT] KFLO 111653Z 22006KT 10SM SCT034 SCT110 29/23 A2992 RMK AO2 SLP129 T02940228=

ACCIDENT TIME 1310 EDT

[1330 EDT] KFLO 111730Z 22008G25KT 1 3/4SM +RA BR FEW033 BKN049 22/20 A2997 RMK AO2 PK WND 26033/1714 RAB14 P0008=

[1333 EDT] KFLO 111733Z 25004KT 2SM TSRA FEW034 BKN049 BKN110 22/20 A2996 RMK AO2 PK WND 26033/1714 TSB33RAB14 P0009=

[1341 EDT] KFLO 111741Z 20005KT 6SM -TSRA FEW034 SCT049 BKN110 22/21 A2994 RMK AO2 PK WND 26033/1714 TSB33RAB14 PRESFR P0009=

[1353 EDT] KFLO 111753Z 20007KT 9SM -TSRA FEW049 BKN110 22/21 A2993 RMK AO2 PK WND 26033/1714 TSB33RAB14 SLP132 P0010 60010 T02220206 10306 20222 55004=

[1453 EDT] KFLO 111853Z 21007KT 6SM -TSRA BKN110 22/21 A2993 RMK AO2 SLP132 P0009 T02220211=

KFLO weather at 1153 EDT, wind from 220° at 12 knots, 10 miles visibility, scattered clouds at 2,800 feet agl, scattered clouds at 10,000 feet above ground level (agl), a broken ceiling at 12,000 feet agl, temperature of 29° Celsius (C), dew point temperature of 22° C, and an altimeter setting of 29.93 inches of mercury. Remarks: automated station with a precipitation discriminator, sea-level pressure 1013.2 hPa, temperature 29.4° C, dew point temperature 22.2° C.

KFLO weather at 1253 EDT, wind from 220° at 6 knots, 10 miles visibility, scattered clouds at 3,400 feet agl, scattered clouds at 11,000 feet agl, temperature of 29° C, dew point temperature of 23° C, and an altimeter setting of 29.92 inches of mercury. Remarks: automated station with a precipitation discriminator, sea-level pressure 1012.9 hPa, temperature 29.4° C, dew point temperature 22.8° C.

KFLO weather at 1330 EDT, wind from 220° at 8 knots with gusts to 25 knots, 1 and three-quarter miles visibility, heavy rain and mist, few clouds at 3,300 feet agl, a broken ceiling at 4,900 feet agl, temperature of 22° C, dew point temperature of 20° C, and an altimeter setting of 29.97 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 260° at 33 knots at 1314 EDT, rain began 1314 EDT, one-hourly precipitation of 0.08 inches.

KFLO weather at 1333 EDT, wind from 250° at 4 knots, 2 miles visibility, a thunderstorm and rain, few clouds at 3,400 feet agl, a broken ceiling at 4,900 feet agl, broken skies at 11,000 feet agl, temperature of 22° C, dew point temperature of 20° C, and an altimeter setting of 29.96 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 260° at 33 knots at 1314 EDT, rain began 1314 EDT, thunderstorm began at 1333 EDT, one-hourly precipitation of 0.09 inches.

Marion County Airport (KMAO) was the second closest official weather station located 3 miles east of Marion, South Carolina, and had an Automated Weather Observing System (AWOS[6]) whose reports were not supplemented by a human observer. KMAO is at an elevation of 92 feet, had a 6° westerly magnetic variation, and was located 20 miles east-northeast of the accident site (figure 9). The following observations were taken and disseminated during the times surrounding the accident:

[1055 EDT] KMAO 111455Z AUTO 21006KT 10SM SCT021 BKN029 BKN075 28/23 A2994 RMK AO2 LTG DSNT W=

[1115 EDT] KMAO 111515Z AUTO 21006KT 10SM SCT023 BKN031 BKN036 28/23 A2994 RMK AO2 LTG DSNT E=

[1135 EDT] KMAO 111535Z AUTO 20007KT 10SM SCT026 OVC033 28/23 A2995 RMK AO2=

[1155 EDT] KMAO 111555Z AUTO 19009KT 10SM SCT028 BKN035 BKN042 29/23 A2994 RMK AO2=

[1215 EDT] KMAO 111615Z AUTO 19009KT 10SM SCT026 BKN035 BKN042 29/23 A2993 RMK AO2=

[6] 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.

[1235 EDT] KMAO 111635Z AUTO 19010KT 10SM SCT028 BKN034 BKN065 30/23 A2993 RMK AO2 LTG DSNT W AND NW=

[1255 EDT] KMAO 111655Z AUTO 22006KT 10SM SCT030 SCT034 SCT060 30/23 A2991 RMK AO2 LTG DSNT W AND NW=

ACCIDENT TIME 1310 EDT

[1315 EDT] KMAO 111715Z AUTO 20009G14KT 10SM BKN034 BKN040 BKN065 31/22 A2992 RMK AO2 LTG DSNT W AND NW=

[1335 EDT] KMAO 111735Z AUTO 23010G15KT 190V250 10SM SCT036 BKN042 BKN048 31/22 A2991 RMK AO2 LTG DSNT W AND NW=

[1355 EDT] KMAO 111755Z AUTO 22005KT 10SM SCT036 BKN045 BKN100 30/22 A2991 RMK AO2 LTG DSNT N AND NW=

[1415 EDT] KMAO 111815Z AUTO 27017G26KT 2SM +TSRA SCT016 OVC038 23/21 A2994 RMK AO2 VIS 1V5 LTG DSNT ALQS P0021=

[1435 EDT] KMAO 111835Z AUTO 22003KT 10SM -TSRA SCT010 BKN090 OVC110 23/21 A2993 RMK AO2 LTG DSNT N THRU SE P0041=

KMAO weather at 1235 EDT, wind from 190° at 10 knots, 10 miles visibility, scattered clouds at 2,800 feet agl, a broken ceiling at 3,400 feet agl, broken skies at 6,500 feet agl, temperature of 30° C, dew point temperature of 23° C, and an altimeter setting of 29.93 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant[7] west and northwest.

KMAO weather at 1255 EDT, wind from 220° at 6 knots, 10 miles visibility, scattered clouds at 3,000 feet agl, scattered clouds at 3,400 feet agl, scattered clouds at 6,000 feet agl, temperature of 30° C, dew point temperature of 23° C, and an altimeter setting of 29.91 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant west and northwest.

KMAO weather at 1315 EDT, wind from 200° at 9 knots with gusts to 14 knots, 10 miles visibility, a broken ceiling at 3,400 feet agl, broken skies at 4,000 feet agl, broken skies at 6,500 feet agl, temperature of 31° C, dew point temperature of 22° C, and an altimeter setting of 29.92 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant west and northwest.

[7] 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).

The observations from the airports surrounding the accident site at the time of the accident indicated thunderstorms and lightning near the accident site at the accident time. Surface winds at the airports were variable and gusty around the accident time likely due to the strong winds initiated by the area of thunderstorms.

4.0 Upper Air Data

A North American Mesoscale (NAM) model sounding was generated for the accident site for 1400 EDT. The model sounding was plotted on a standard Skew-T log P diagram[8] with the derived stability parameters included in figure 10 (with data from the surface to 400-hPa, or 24,000 feet msl). This data was analyzed utilizing the RAOB[9] software package. The sounding depicted a moist conditionally unstable vertical environment with the Lifted Condensation Level (LCL)[10] at 1,543 feet msl, a Convective Condensation Level (CCL)[11] of 3,240 feet, and a Level of Free Convection (LFC)[12] at 2,801 feet. The freezing level was identified at 14,612 feet. The precipitable water value was 2.15 inches.

[8] 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.

[9] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.

[10] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

[11] Convective Condensation Level (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.

[12] Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

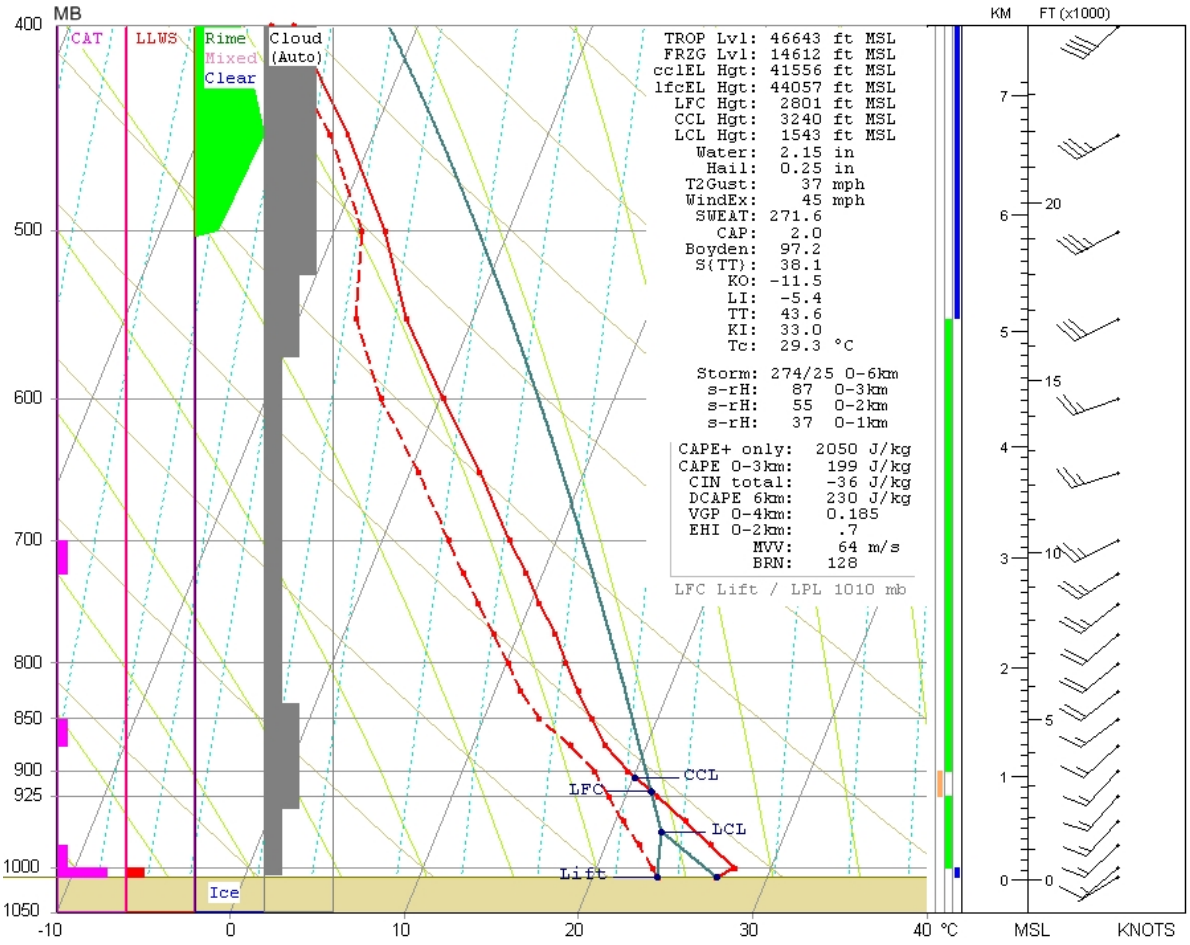


Figure 10 – 1400 EDT NAM model sounding

The 1400 EDT model sounding indicated a moist conditionally unstable environment with 2,050 J/kg of CAPE[13] lifting a parcel from the ground. This environment would have been supportive of cloud formation, rain showers, and thunderstorms. The maximum vertical velocity (MVV) possible within rain showers or thunderstorm updrafts was 64 meters per second (m/s) or 124 knots given the NAM model sounding environment. Any atmospheric lifting mechanism would have been enough to release the conditionally unstable vertical environment and help produce clouds, rain showers, and thunderstorms at the accident time. RAOB identified the possibility of clouds between the surface and 24,000 feet. Icing was likely in a layer between 19,000 and 24,000 feet.

The sounding wind profile indicated there was a surface wind from 236° at 7 knots and the wind increased in speed through 24,000 feet to around 40 knots. Low-level wind shear (LLWS) was indicated by RAOB, with several layers of possible clear-air turbulence from the surface through 10,000 feet.

[13] Convective Available Potential Energy (CAPE) – CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from the NCDC and processed with the NTSB's Man-computer Interactive Data Access System (McIDAS) workstation. Visible and infrared imagery (GOES-13 band 1 and 4) at a wavelength of 0.65 microns (µm) and 10.7 µm retrieved brightness temperatures for the scene. Satellite imagery surrounding the time of the accident, from 1100 EDT through 1500 EDT at approximately 15-minute intervals, were reviewed and the closest images to the time of the accident are documented here.

Figures 11 and 12 present the GOES-13 visible imagery from 1302 and 1315 EDT, at 2X magnification with the accident site highlighted with a red square. The visible imagery revealed cumuliform clouds at the accident site with the line of cumuliform clouds moving eastward with time. Figure 13 presents the GOES-13 infrared imagery from 1315 EDT at 8X magnification. Inspection of the infrared imagery indicated cooler (higher) clouds tops at and just to the west of the accident site at the accident time. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1400 EDT NAM sounding (figure 10), the approximate cloud-top heights over the accident site were 35,000 feet at 1315 EDT.

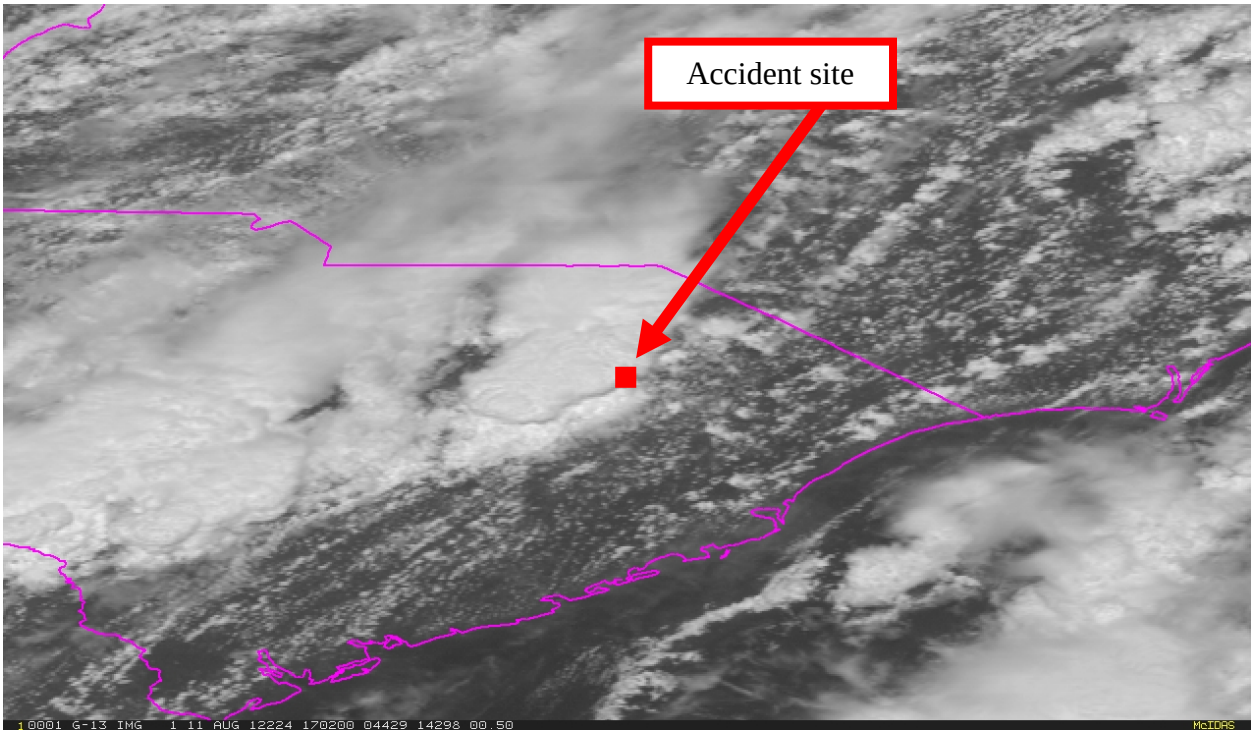


Figure 11 – GOES-13 visible image at 1302 EDT

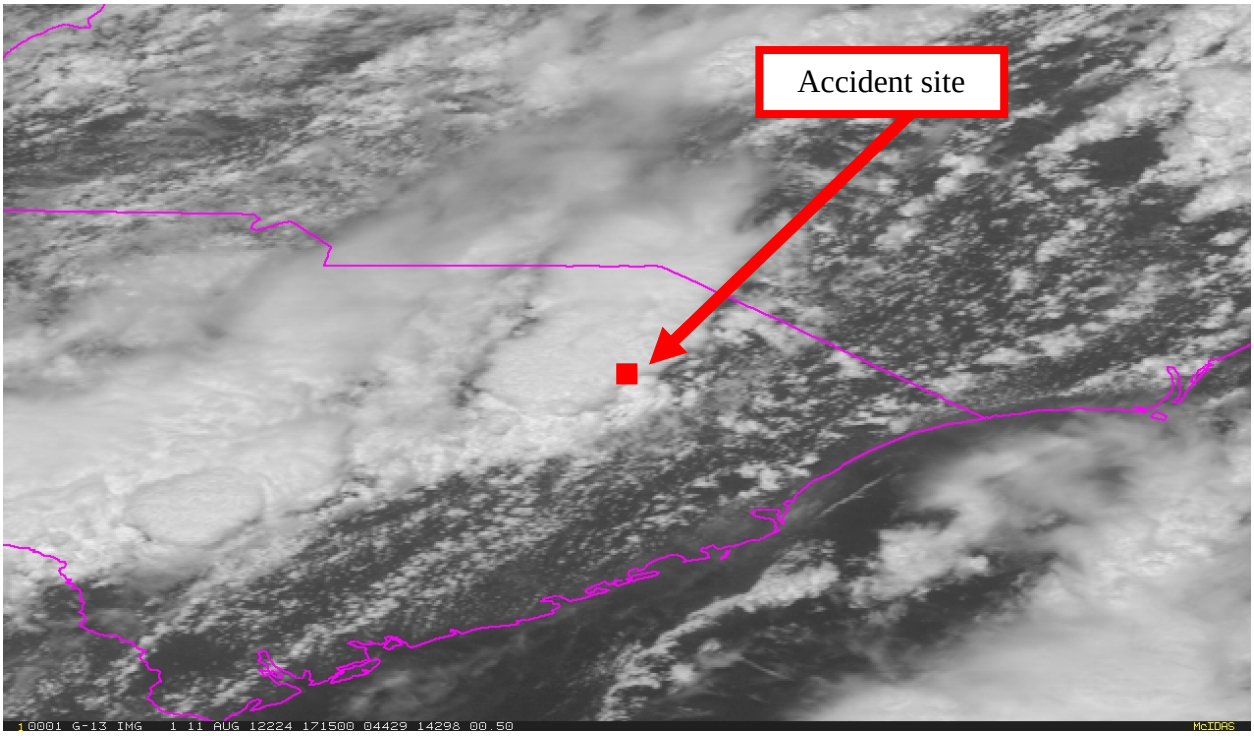


Figure 12 – GOES-13 visible image at 1315 EDT

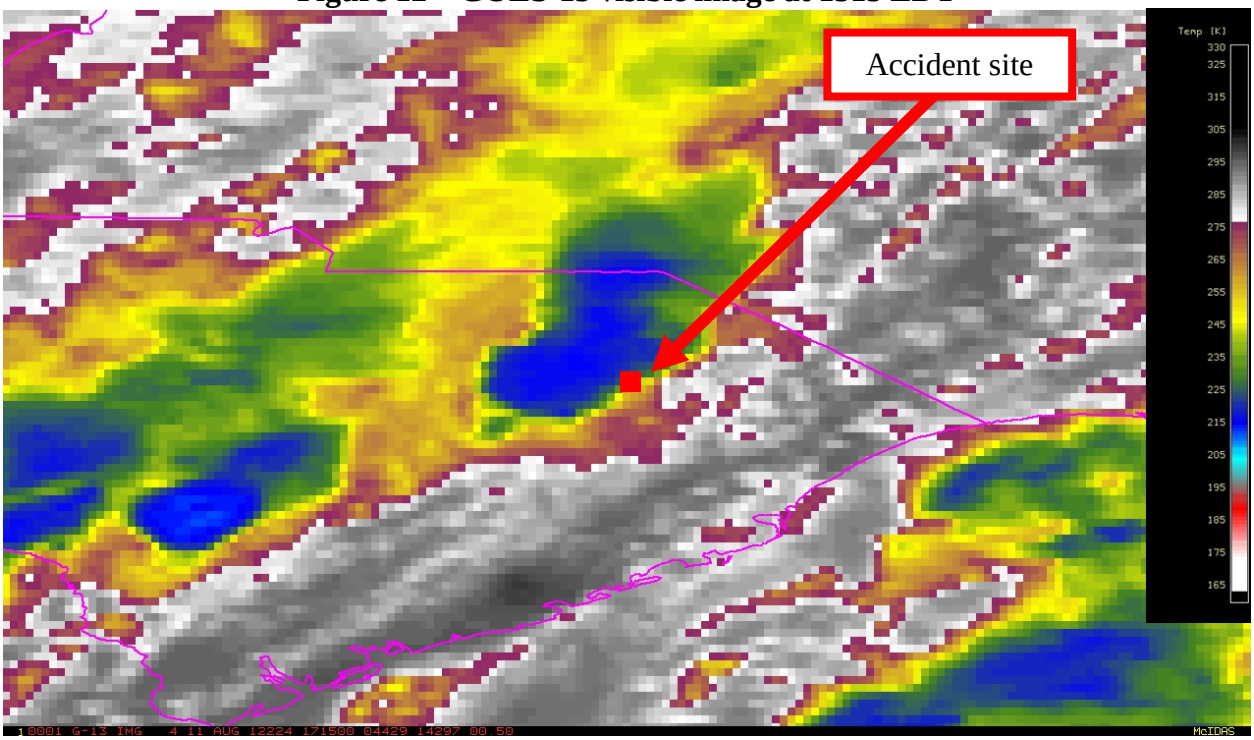


Figure 13 – GOES-13 infrared image at 1315 EDT

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D) was KLTX located near Wilmington, North Carolina, approximately 65 miles east of the accident site at an elevation of 64 feet. Level II archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

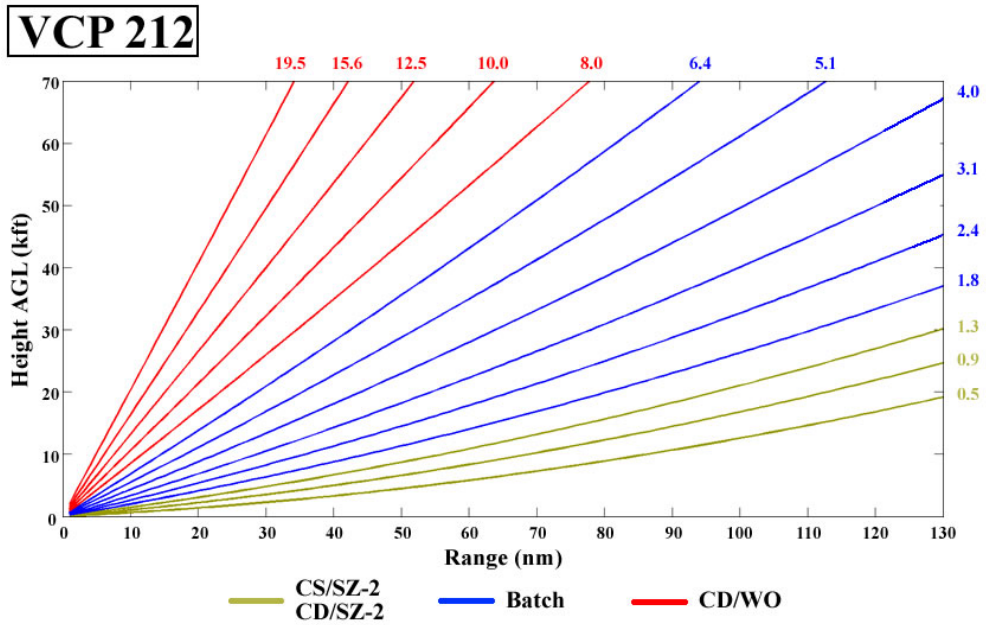
The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width[14]. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

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 two common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 212 (VCP-212). 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 KLTX WSR-88D radar was operating in the normal precipitation mode (Mode A, VCP-212). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

[14] Beam width – A measure of the angular width of a radar beam.



VCP-212 Precipitation Mode Scan Strategy

6.2 Beam Height Calculation

Assuming standard refraction[15] of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width information[16] 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°	6,570 feet	3,360 feet	9,770 feet	6,410 feet
1.3°	12,060 feet	8,860 feet	15,270 feet	6,410 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 3,360 feet and 9,770 feet msl over the accident site. The 1.3° elevation scan depicted the conditions between 8,860 feet and 15,270 feet msl over the accident site, and this antenna elevation is the closest to accident aircraft's altitude[17] before the aircraft descent after 1302 EDT.

[15] Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.
[16] Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.
[17] For more information see the ATC Factual Report.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[18] it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ[19]), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0	< 5	
	1	5 to 9	
	2	10 to 14	
1	3	15 to 19	.01 in/hr
Very Light	4	20 to 24	.02 in/hr
	5	25 to 29	.04 in/hr
2	6	30 to 34	.09 in/hr
Light to	7	35 to 39	.21 in/hr
Moderate			
3	8	40 to 44	.48 in/hr
Strong			
4	9	45 to 49	1.10 in/hr
Very Strong			
5	10	50 to 54	2.49 in/hr
Intense			
6	11	55 to 59	>5.67 in/hr
Extreme	12	60 to 64	
	13	65 to 69	
	14	70 to 74	
	15	> 75	

[18] 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.

[19] 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.

The Federal Aviation Administration (FAA) Advisory Circular AC 00-24B titled "Thunderstorms" dated January 2, 1983, also defines the echo intensity levels and potential weather phenomena associated with those levels. If the maximum VIP Level is 1 "weak" and 2 "moderate", then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very heavy" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts and turbulence.

6.4 Radar Summary

Figure 14 provides a radar summary image from 1315 EDT with reflectivity values over the southeastern United States, with the accident site located near an area with 45 to 55 dBZ values. These reflectivity values indicate very strong to extreme echoes near the accident site around the accident time.

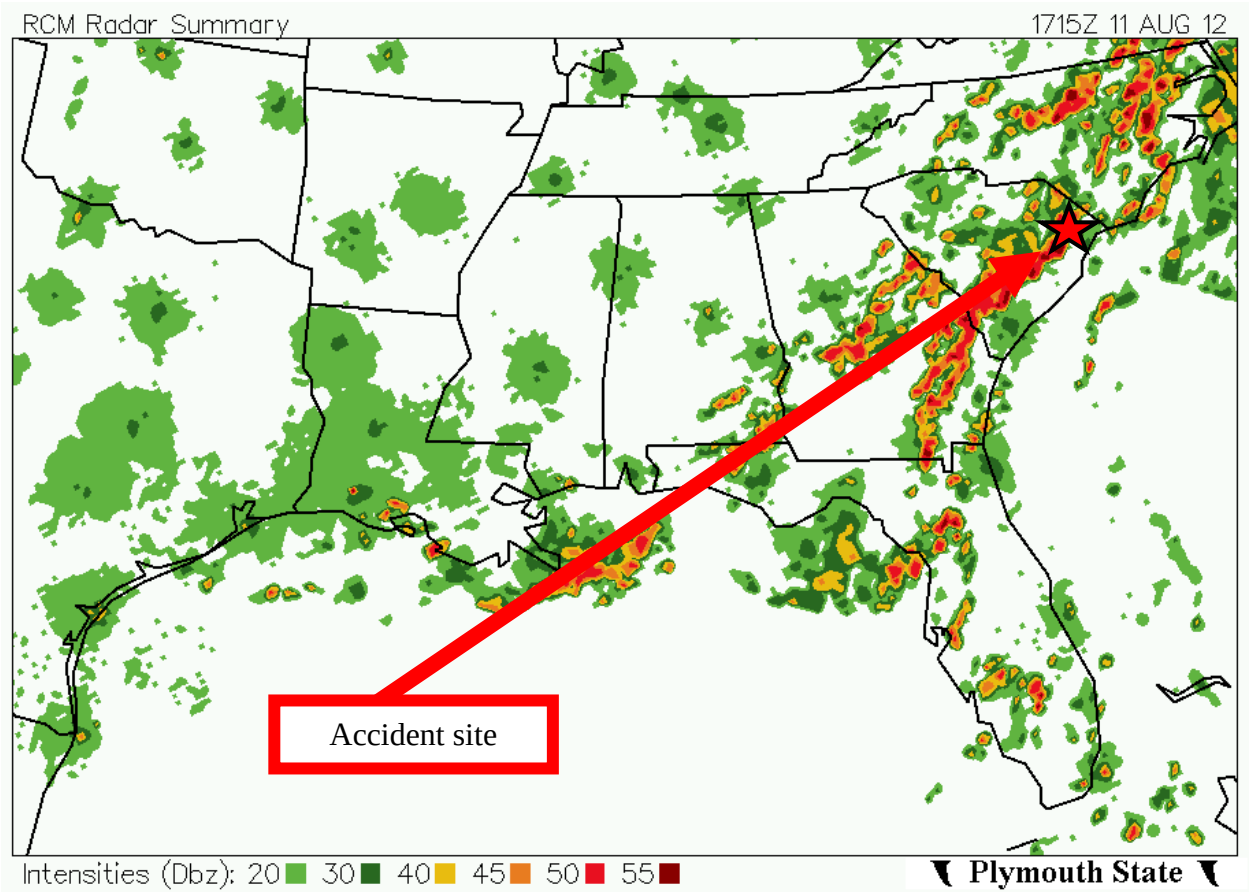


Figure 14 – Radar summary image for 1315 EDT with the accident site

6.5 Base Reflectivity and Lightning Data

Figures 15, 16, and 17 present the KLTX WSR-88D base reflectivity image for the 1.3° elevation scan initiated at 1301 EDT, and the base reflectivity image for the 0.5° elevation scans initiated at 1305 and 1310 EDT with a resolution of 0.5° X 250 m. 50 to 65 dBZ values occurred along the ATC flight track path in figures 15 through 17, indicating that the aircraft likely encountered very strong to extreme precipitation. Lightning flash[20] data from 1245 to 1305 EDT is plotted on figures 15 and 16 as white dots and the lightning flash data revealed that lightning occurred all around the accident aircraft's flight track with over 1,800 individual lightning flashes between 1245 and 1305 EDT. Given the base reflectivity and lightning data the accident aircraft flying southwestward around 12,000 feet msl[21] likely encountered very strong to extreme precipitation at and around the time of the accident.

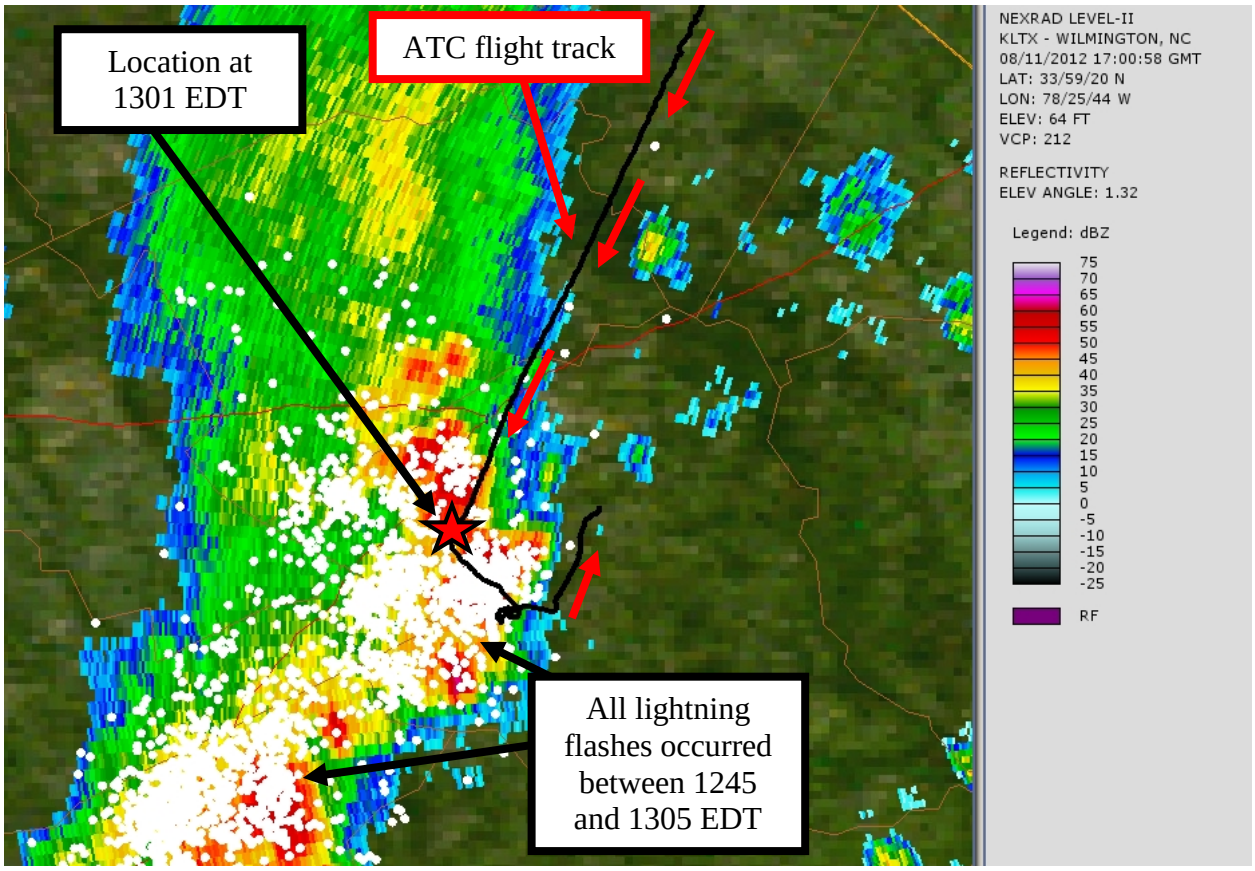


Figure 15 – KLTX WSR-88D reflectivity for the 1.3° elevation scan initiated at 1301 EDT with lightning flash data from 1245 to 1305 EDT

[20] Lightning Flash – This is one contiguous conducting channel and all the current strokes/pulses that flow through it. There are two types of flashes: ground flashes and cloud flashes.
[21] For more information see the ATC Factual Report.

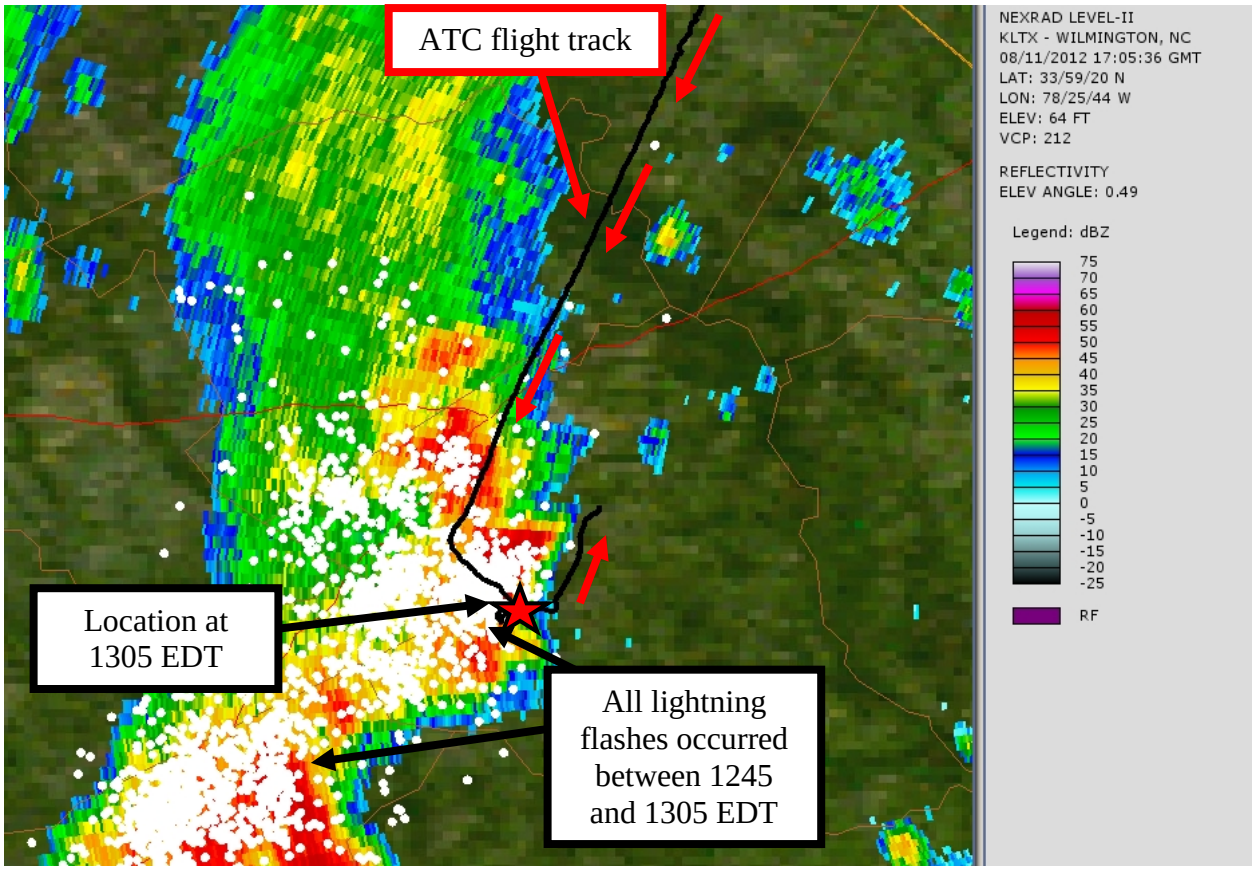


Figure 16 – KLTX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1305 EDT with lightning flash data from 1245 to 1305 EDT

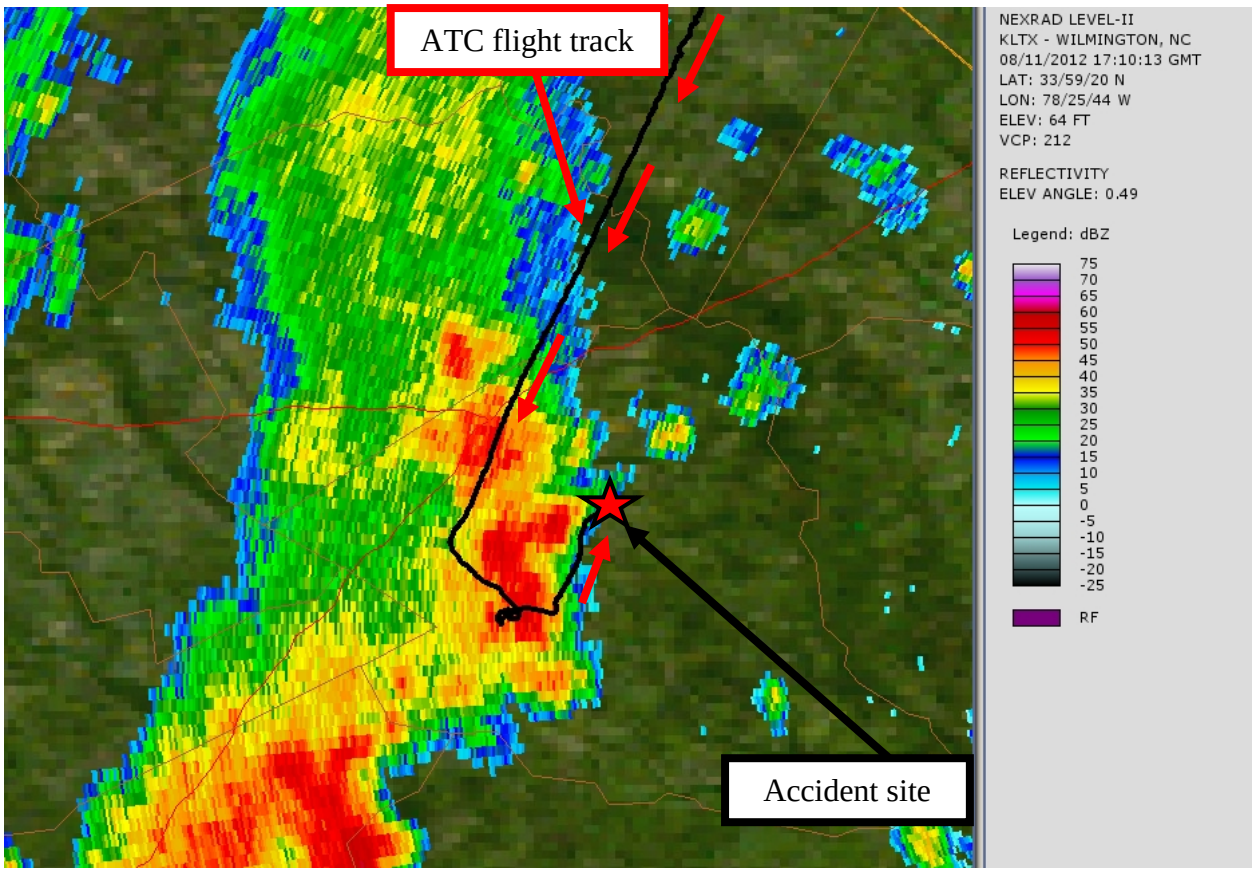


Figure 17 – KLTX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1310 EDT

6.6 3-Dimensional Radar Reflectivity Data

Figures 18 through 20 present a 3-dimensional view of the KLTX WSR-88D base reflectivity for the elevation scans initiated at 1301 EDT (figures 18 and 19) and 1305 EDT (figure 20). The accident aircraft's flight track obtained from ATC[22] was also plotted on the Google Earth image for a time comparison with the base reflectivity images. The images showed the accident flight encountering greater than 50 dBZ values at 1301 EDT and 1305 EDT. Much like the base reflectivity from Section 6.5 showed, the accident aircraft likely encountered intense to extreme precipitation while flying through a line of thunderstorms.

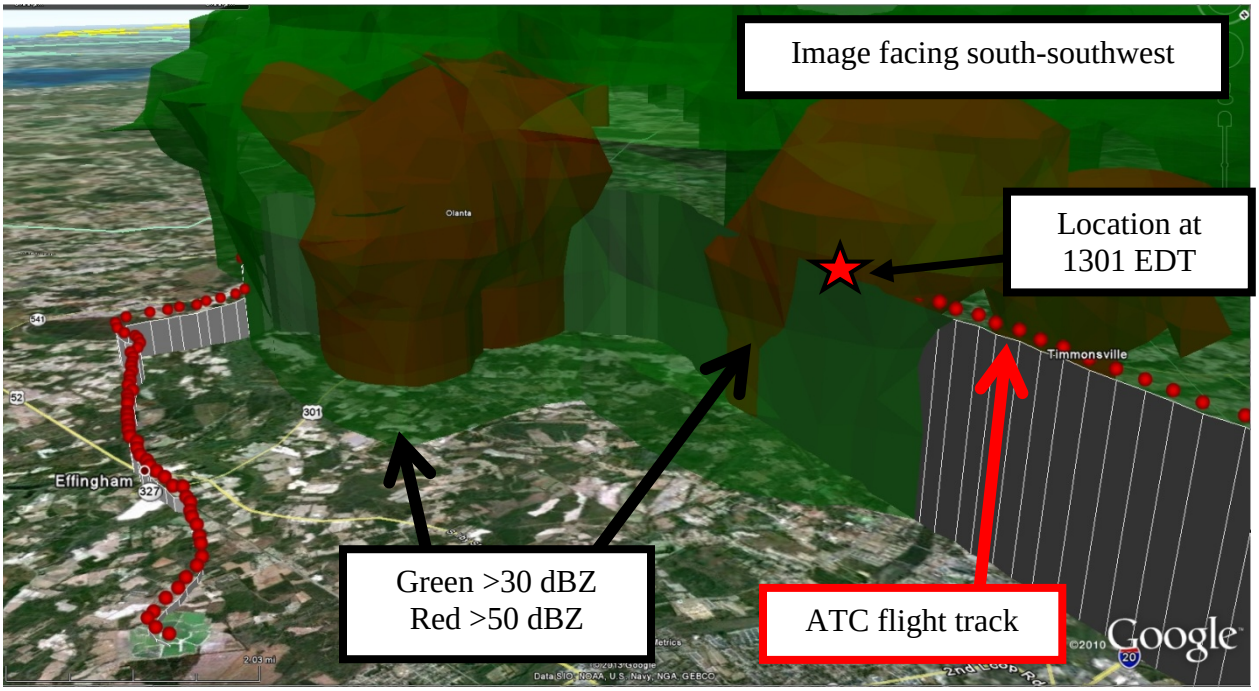


Figure 18 – 3-dimensional KLTX WSR-88D base reflectivity from the scan initiated at 1301 EDT and the ATC Flight Track

[22] For more information see the ATC Factual Report.

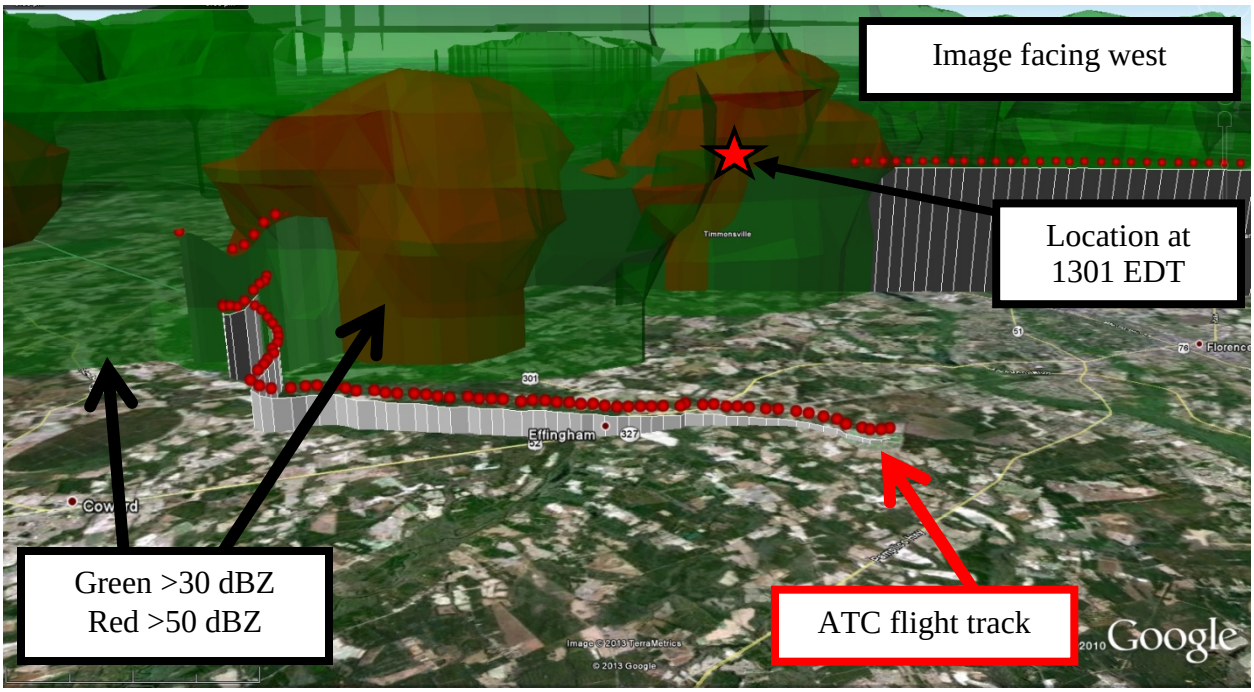


Figure 19 – 3-dimensional KLTX WSR-88D base reflectivity from the scan initiated at 1301 EDT and the ATC Flight Track

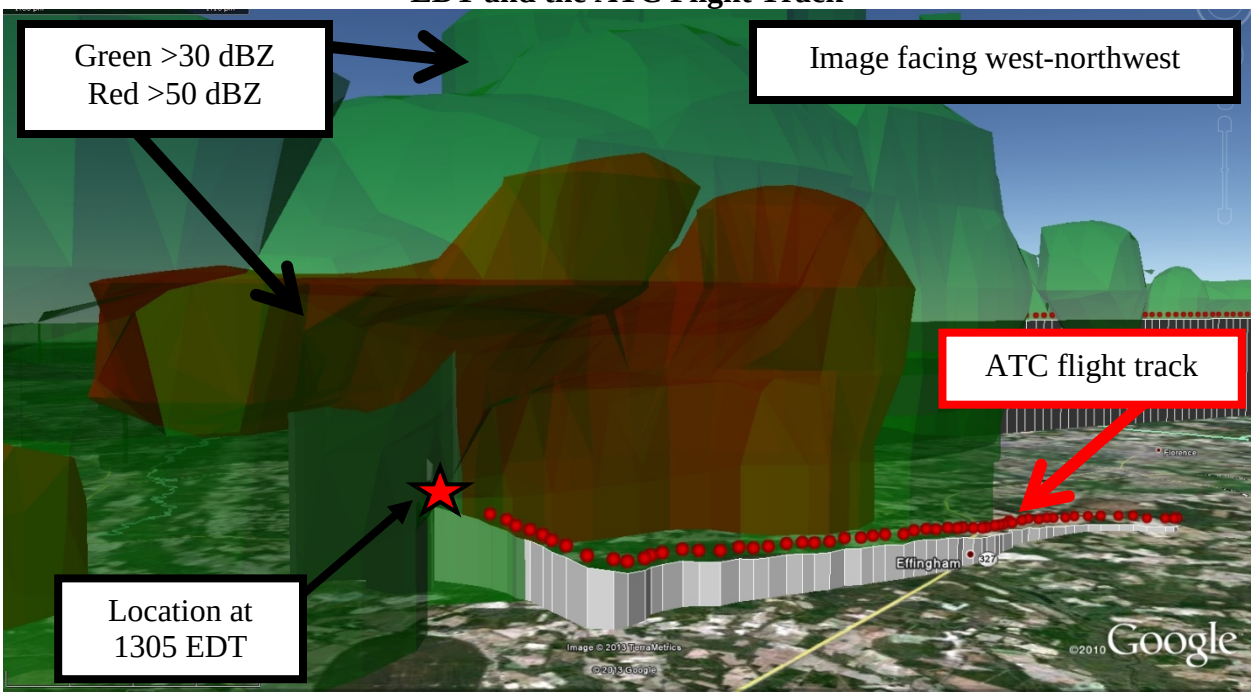


Figure 20 – 3-dimensional KLTX WSR-88D base reflectivity from the scan initiated at 1305 EDT and the ATC Flight Track

6.7 Dual-Polarization Weather Radar Data

The closest NWS WSR-88D with Dual-Polarization (dual-pol) technology was KLTX. Level III archive radar data was obtained from the NCDC utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width. The KLTX WSR-88D also produced: differential reflectivity (Zdr), correlation coefficient (CC), specific differential phase (KDP), and the hydrometeor classification algorithm (HC) having been upgraded with dual-pol technology.

6.8 Zdr, CC, KDP, and HC[23]

Zdr is the logarithm ratio of the horizontal power return to the vertical power return. Positive values of Zdr indicate that there is more horizontal power return than vertical power return[24]. A negative value of Zdr indicates that there is more vertical power return than horizontal power return indicating that the dominant hydrometeors are larger in the vertical than in the horizontal[25]. Near zero values of Zdr indicate that both the horizontal and vertical power return from with the volume scanned are of similar values, meaning the dominant hydrometeors are similar in size in both the vertical and horizontal[26].

CC is a measure of how similar the horizontal and vertical returned pulse characteristics are among all pulses in the sampled WSR-88D volume. CC provides information about the diversity of hydrometeors within the volume and the values range from 0 to 1[27]. Meteorological echoes tend to have CC values greater than 0.80, with values greater than 0.96 indicating that the meteorological targets within the volume are all very similar in size, shape, type (liquid versus solid), and orientation. CC values between 0.96 and 0.80 indicate that the meteorological targets within the volume have a higher diversity of sizes, shapes, types, and orientations as the CC trends lower. If hail is located within the volume scanned the CC values are typically between 0.80 and 0.96. Non-meteorological echoes have CC values less than 0.80 and these non-meteorological echoes can include but are not limited to bugs, chaff, smoke, and birds.

[23] Definitions for Zdr, CC, KDP, and HC adapted from training material from the NWS WDTB.
[24] A positive Zdr means that the dominant hydrometeors within the volume are larger in the horizontal than vertical (i.e. rain drops).
[25] A negative Zdr correlates to vertically oriented hydrometeors, i.e. vertically oriented crystals or conical graupel.
[26] A near zero Zdr is often an indication of hail or spherical rain drops.
[27] CC values greater than 1 indicate an untrustworthy signal due to low signal-to-noise ratio in areas of weak reflectivity.

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

HC is a product produced by the hydrometeor classification algorithm and the HC attempts to discriminate between 10 classes of radar echoes at every 250 m range bin. HC ingests reflectivity, Zdr, CC, Kdp, and velocity, along with radially averaged and smoothed fields of reflectivity and differential phase. HC then uses the height of the melting layer (which was around 15,000 feet msl at KLTX, figure 10) along with the previous data and assigns a radar class to each bin with a weighted value. The HC then applies a set of hard thresholds to reduce the number of clearly wrong class designations, and given the weight and likelihood of each of the 10 classes at each bin, the HC assigns the radar classification with the highest likelihood value to that particular bin.

6.9 Dual-Pol Imagery

Figure 20 and 21 present the KLTX WSR-88D base reflectivity, Zdr, CC, and KDP values for the 0.5° elevation scan initiated at 1301 EDT with a resolution of 1.0° X 250 m. The figures depicted 50 to 60 dBz values, Zdr values between 1 and 2 dB, CC values around 0.98 to 0.99, and KDP values between 1.0 and 3.0 °/km. Given the base reflectivity and dual-pol values, along with being below the environmental freezing level (figure 10) at 1301 EDT, the accident aircraft likely encountered heavy rain during the part of the flight between 1301 and 1305 EDT. Figures 22 and 23 paint a similar picture for the accident aircraft's location at 1305 EDT with even higher Zdr values between 2 and 4 dB, and the HC algorithm assigned the heavy rain classification for the area where the accident aircraft was at 1305 EDT. Between 1301 and 1305 EDT the accident aircraft likely experienced heavy rain, along with being in a very turbulent environment given that the accident aircraft's location is consistent with the typical location of the updraft within a line of thunderstorms.

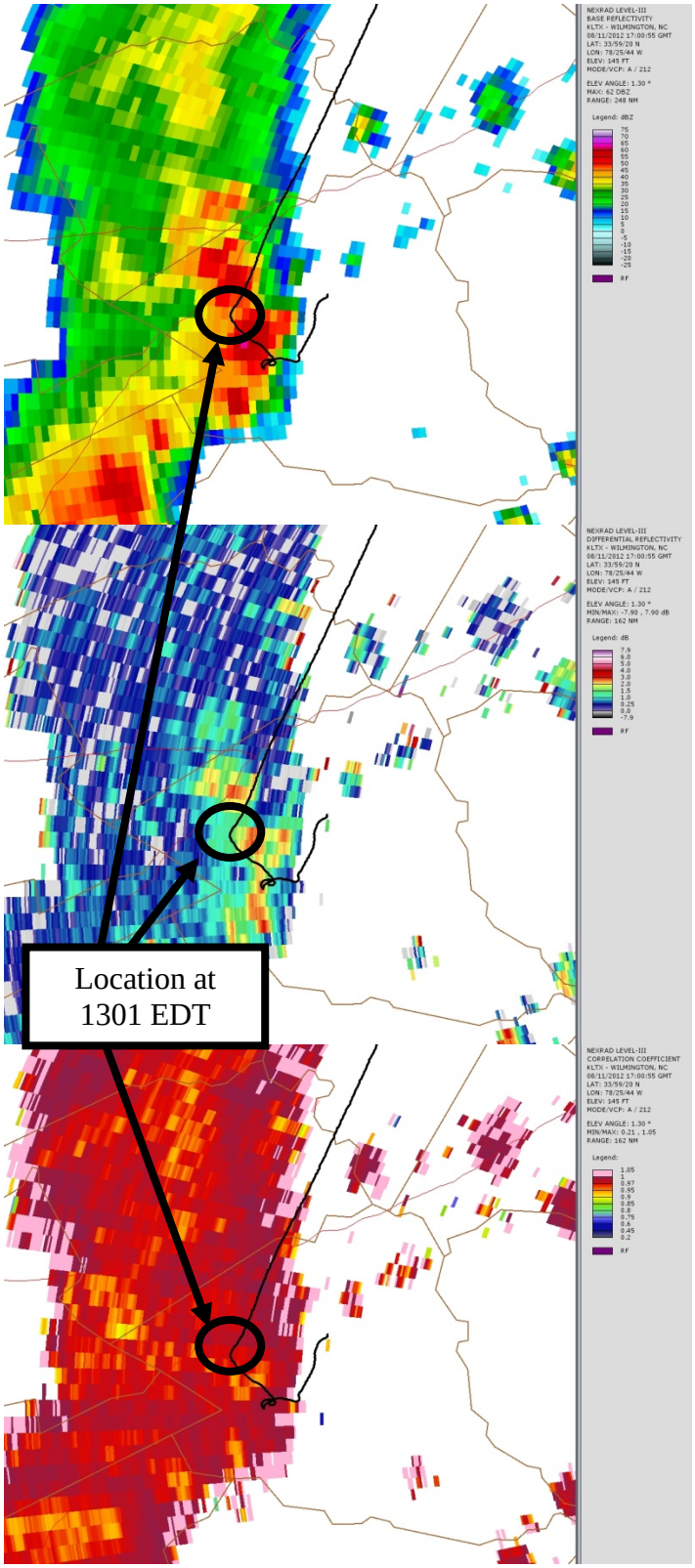


Figure 20 – KLTX WSR-88D 1.3° elevation scan for 1301 EDT (a) base reflectivity, (b) Zdr, and (c) CC

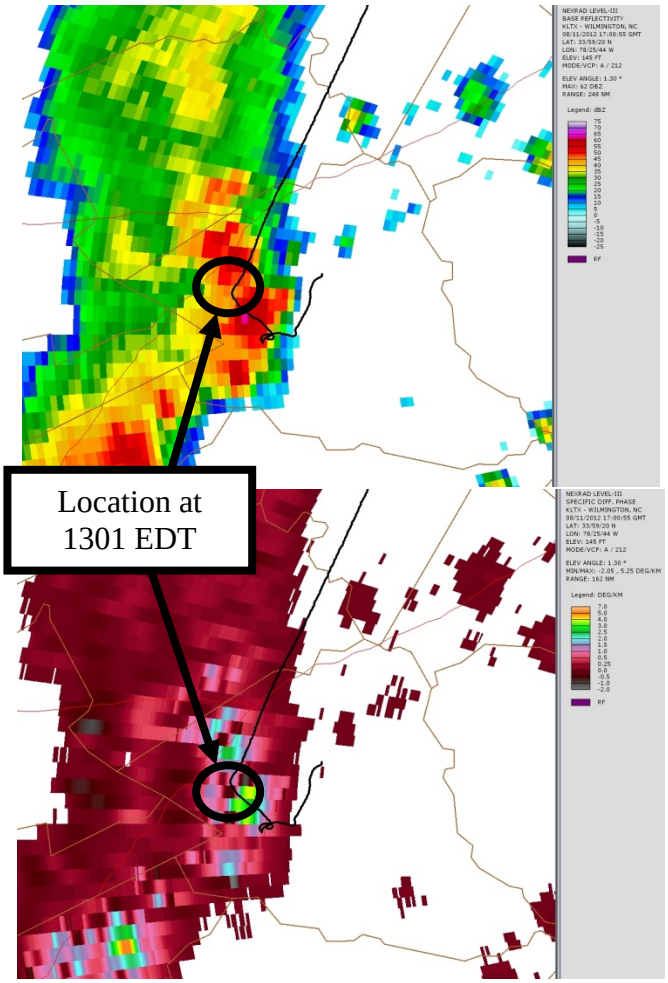


Figure 21 – KLTX WSR-88D 1.3° elevation scan for 1301 EDT (a) base reflectivity and (b) KDP

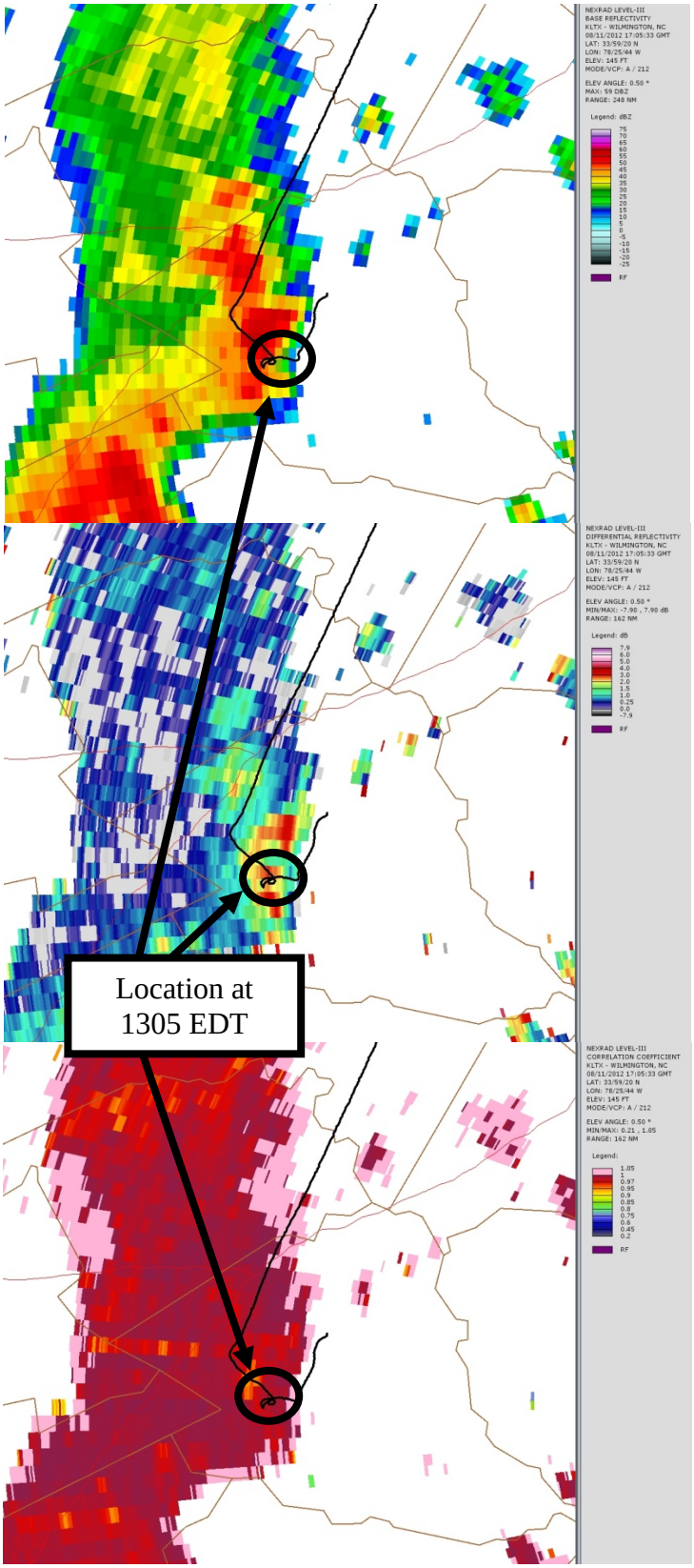


Figure 22 – KLTX WSR-88D 0.5° elevation scan for 1305 EDT (a) base reflectivity, (b) Zdr, and (c) CC

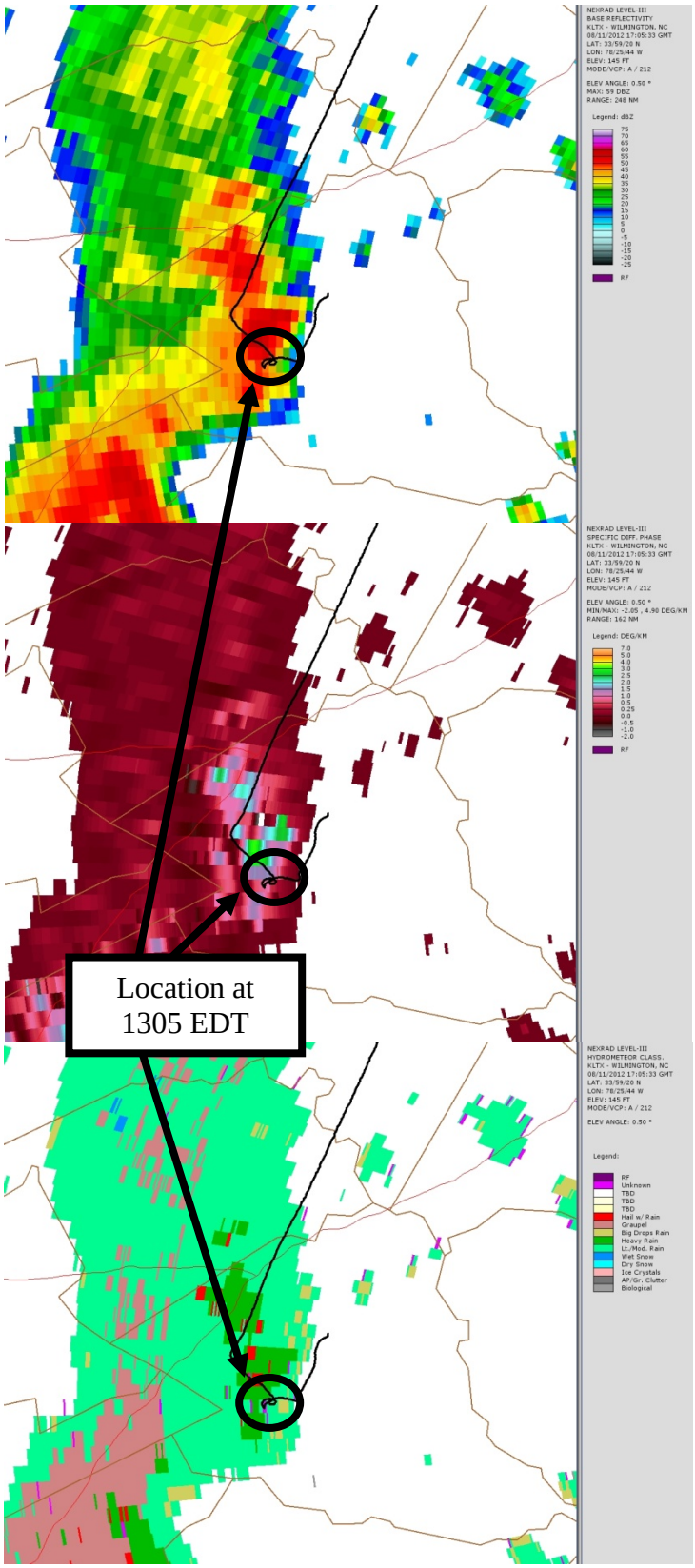


Figure 23 – KLTX WSR-88D 0.5° elevation scan for 1305 EDT (a) base reflectivity, (b) KDP, and (c) HC

7.0 Pilot Reports

Pilot reports (PIREPs) were reviewed close to the accident site from three hours prior to the accident time to three hours after the accident time and no PIREPs were disseminated.

8.0 SIGMET and CWSU Advisory

SIGMETs 26E and 23E were valid at the accident time along the accident route of flight[28]. These SIGMETs advised of a line of thunderstorms and an area of thunderstorms moving from 250° at 25 knots with tops above FL450[29]. The thunderstorm line was 35 miles wide (figure 24):

CONVECTIVE SIGMET 26E
VALID UNTIL 1855Z
SC GA
FROM 30NW FLO-30SSW FLO-20SSW CAE-20W AMG
LINE TS 35 NM WIDE MOV FROM 25025KT. TOPS ABV FL450.

CONVECTIVE SIGMET 23E
VALID UNTIL 1755Z
SC GA
FROM 30W FLO-40NNW CHS-60E MCN-40NW IRQ-30W FLO
AREA EMBD TS MOV FROM 25025KT. TOPS ABV FL450.

[28] See ATC Factual Report.
[29] Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. 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.

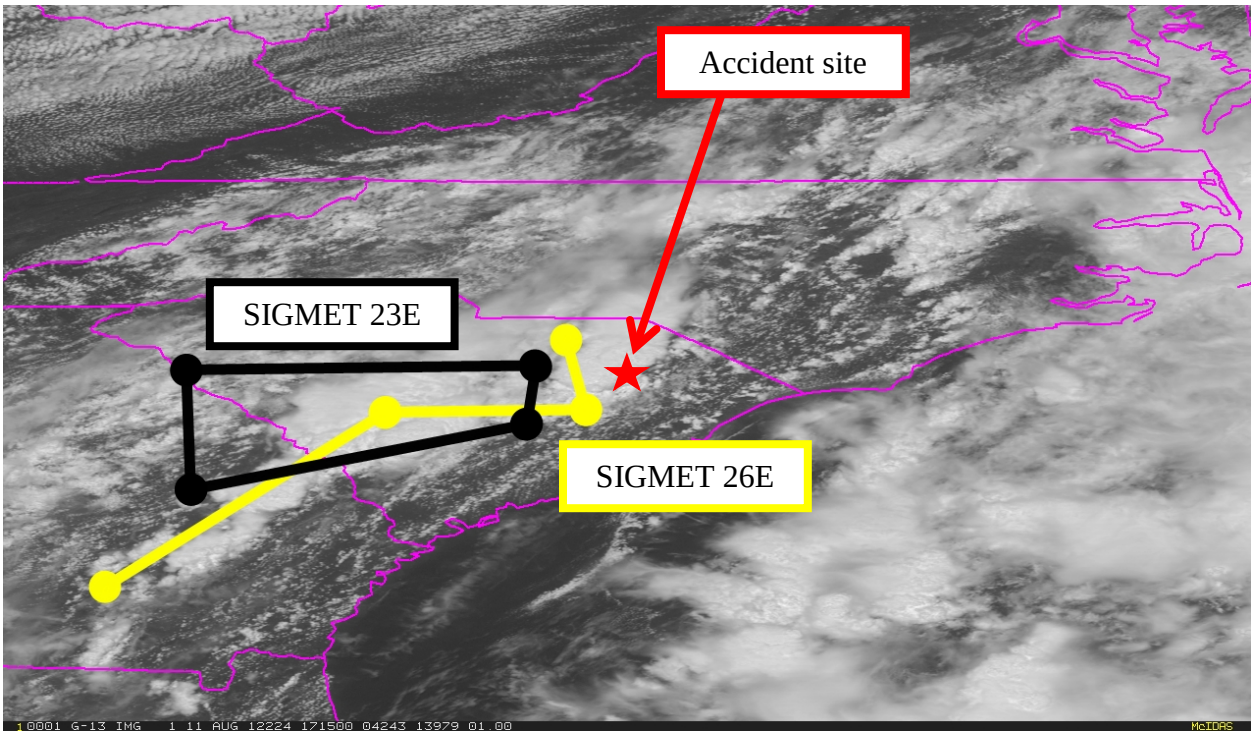


Figure 24 – SIGMET 26E and 23E valid at the time of the accident

No CWSU Advisory (CWA) was valid for the accident site at the accident time.

A Meteorological Impact Statement (MIS) was valid for the accident site at the accident time. This MIS advised of numerous thunderstorms developing and spreading over eastern South Carolina between 1200 and 1500 EDT:

FAUS20 KZJX 111158
ZJX MIS 01 VALID 111200-111900
...FOR ATC PLANNING PURPOSES ONLY...
UPR-MID LVL TROF OVR W FL PNHDL WITH NMRS TS
BTN SW GA/FL PNHDL/GULF WTRS...AFT 1330Z SPRDG
OVR INTERIOR PTNS SC...AND 16Z-19Z TS SPRDG OVR
E SC/S GA/FL PEN.SCT TS OVR ATLC THRU FCST PD.
VC
=

9.0 AIRMETs

No AIRMETs were active for the accident site at the accident time.

10.0 Terminal Aerodrome Forecast

KFLO (figure 9) was the closest site with a NWS TAF. The TAF valid at the time of the accident was issued at 1159 EDT and was valid for a 20-hour period beginning at 1200 EDT. The TAF forecast for KFLO was as follows:

KFLO 111559Z 1116/1212 **20009KT P6SM SCT019 BKN035**
TEMPO 1116/1120 VRB20G35KT 2SM TSRA BKN015CB
FM112000 19006KT P6SM SCT040 BKN100
TEMPO 1120/1124 VRB20G35KT 2SM TSRA BKN015CB=

The forecast expected wind from 200° at 9 knots, visibility greater than 6 miles, scattered clouds at 1,900 feet agl, a broken ceiling at 3,500 feet agl. Temporary conditions of wind variable at 20 knots with gusts to 35 knots, 2 miles visibility, a thunderstorm and rain, a broken ceiling of cumulonimbus clouds at 1,500 feet agl were forecast between 1200 and 1600 EDT.

11.0 Area Forecast

The Area Forecast issued at 0718 EDT forecasted a broken ceiling at 1,000 feet msl with the cloud tops at 10,000 feet msl. The ceilings were forecast to rise to 3,000 feet msl between 1100 and 1300 EDT. Scattered light rain showers and thunderstorms were forecast across central South Carolina with tops to FL380:

FAUS42 KKCI 111118 AAA
FA2W
_MIAC FA 111118 AMD
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 120300
CLDS/WX VALID UNTIL 112100...OTLK VALID 112100-120300
NC SC GA FL AND CSTL WTRS E OF 85W
.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS...CDFNT WRN NY-CNTRL PA-CNTRL VA-WRN NC-NRN GA. WRMFNT MA CSTL WTRS. 18Z WRMFNT SRN ME TO ME CSTL WTRS. CDFNT NERN NY-SWRN VA-WRN NC-NRN GA WITH LTL CHG THRU PD. 03Z WRMFNT CNTRL ME.
.
NC
APLCNS...BKN040 TOP 080. ISOL TSRA. CB TOP FL380. 15Z SCT060. TIL 20Z WDLY SCT -SHRA/TSRA. OTLK...VFR.
PIEDMONT...BKN030 LYRD 160. ISOL TSRA. CB TOP FL380. 15Z SCT030 BKN120 TOP FL240. SCT -SHRA/TSRA. OTLK...VFR SHRA TSRA.
CSTL PLAINS...BKN020 TOP 100. BKN CI. ISOL -TSRA. CB TOP FL400. 18Z BKN030 LYRD FL180. SCT -SHRA/TSRA. OTLK....VFR SHRA TSRA.
.
SC
APLCNS...BKN020 TOP FL180. ISOL -SHRA/TSRA. CB TOP FL360. 15Z SCT -SHRA/TSRA. 20Z SCT050. OTLK...VFR.
PIEDMONT...BKN010 TOP 100. BECMG 1517 BKN030. SCT -SHRA/TSRA. CB TOP FL380. OTLK...VFR TIL 01Z SHRA TSRA.
CSTL PLAINS...BKN040 TOP 140. ISOL -TSRA. CB TOP FL360. 15Z SCT040 SCT CI. 18Z WDLY SCT TSRA. OTLK...VFR TIL 02Z SHRA TSRA.
.
GA
N...BKN020 TOP FL180. ISOL -SHRA/TSRA. CB TOP FL430. BECMG 1618 BKN050 TOP 100. OTLK...VFR.

SW...BKN030 TOP 120. 11Z SCT -SHRA/WDLY SCT TSRA. CB TOP FL450.
BECMG 1618 BKN040. SCT -SHRA/TSRA. OTLK...VFR TIL 02Z SHRA TSRA.
SE...BKN060 TOP 120. BECMG 1517 WDLY SCT -SHRA/TSRA. CB TOP
FL420. OTLK...VFR TIL 02Z SHRA TSRA.
.
FL...UPDT
PNHDL...BKN040 TOP 160. SCT -SHRA/TSRA. OTLK...VFR TIL 02Z SHRA
TSRA.
NRN PEN...SCT CI. BECMG 1820 SCT050. ISOL TSRA. CB TOP FL450.
OTLK...VFR TIL 00Z TSRA.
CNTRL PEN...SCT-BKN CI. 18Z SCT050 BKN CI. WDLY SCT -TSRA. CB TOP
FL450. OTLK...VFR TIL 02Z TSRA.
SRN PEN...SCT040 BKN CI. ISOL -SHRA. 15Z SCT -SHRA/TSRA. CB TOP
FL450. OTLK...VFR TIL 02Z SHRA TSRA.
.
CSTL WTRS
ATLC WTRS
NC/SC...SCT030 SCT-BKN CI. WDLY SCT TSRA. CB TOP FL380. WND SW
G35KT. 15Z SCT -SHRA/TSRA. TIL 17Z WND SW G35KT. OTLK...VFR SHRA
TSRA.
GA/NRN FL...SCT030 SCT-BKN CI. ISOL TSRA. CB TOP FL400.
OTLK...VFR.
SRN FL...SCT040 BKN CI. ISOL TSRA. CB TOP FL420. OTLK...VFR TSRA.
GULF WTRS E OF 85W...SCT040 SCT-BKN CI. ISOL TSRA. CB TOP FL450.
OTLK...VFR.
....

12.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Wilmington, North Carolina, issued the following Area Forecast Discussion at 1035 EDT which discussed areas of developing thunderstorm and rain shower activity across central South Carolina. This area of stormy weather was expected to continue and slowly move eastward. MVFR[30] to IFR[31] conditions were expected as these thunderstorms moved eastward across the TAF sites:

FXUS62 KILM 111435
AFDILM
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE WILMINGTON NC
1035 AM EDT SAT AUG 11 2012
.SYNOPSIS...
AN APPROACHING COLD FRONT WILL BRING A GOOD CHANCE OF SHOWERS AND
THUNDERSTORMS THROUGH SUNDAY MORNING. THIS FRONT WILL STALL OVER THE
AREA AND DISSIPATE BY MONDAY. DRIER CONDITIONS ARE EXPECTED FOR THE
EARLY PART OF THE WEEK...BEFORE ANOTHER COLD FRONT BRINGS RENEWED
THUNDERSTORM CHANCES LATE TUESDAY AND WEDNESDAY. MORE SEASONABLE
WEATHER IS EXPECTED FOR THE END OF THE WEEK.
&&
.NEAR TERM /THROUGH TONIGHT/...

[30] Marginal Visual Flight Rules (MVFR) – Refers to the general weather conditions pilots can expect at the surface and MVFR criteria means a ceiling between 1,000 and 3,000 feet and/or 3 to 5 miles visibility inclusive.
[31] Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 feet agl and/or less than 3 miles visibility.

AS OF 10:30 AM SATURDAY...SIGNIFICANT AREA OF HEAVY RAIN AND THUNDERSTORMS DEVELOPING ACROSS MID STATE SOUTH CAROLINA. WITH THIS AREA EXPECTED TO PERSIST AND MOVE SLOWLY EAST...NORTHEAST...HAVE INCREASED POPS TO CATEGORICAL AND ADDED HEAVY RAIN WORDING TO WESTERN ZONES. THE 1200 UTC NAM HAS THIS AREA CAPTURED QUITE WELL. TRIMMED BACK HIGH TEMPERATURES IN THESE AREAS AS WELL. NO OTHER CHANGES. &&

.SHORT TERM /SUNDAY THROUGH MONDAY NIGHT/...

AS OF 300 AM SATURDAY...COLD FRONT WILL BE CROSSING THE CWA WHILE DISSIPATING EARLY SUNDAY. ALTHOUGH SOME GUIDANCE HAS THE FRONT CROSSING BEFORE THE START OF THE SHORT TERM...FAVOR THE SLOWER SOLUTIONS WHICH SHOW FROPA BY EARLY SUNDAY AFTN DUE TO SOMEWHAT BOUNDARY-PARALLEL MID LEVEL FLOW. FORECAST SOUNDINGS SUGGEST VERY DRY AIR WORKING IN FROM WEST TO EAST BEHIND THE FRONT...SO ANY PRECIP EARLY SUNDAY WILL FADE BY AFTN AND MUCH OF SUNDAY WILL BE PRETTY NICE WITH INCREASING SUNSHINE. DRY WESTERLY FLOW PERSISTS SUNDAY NIGHT AND MONDAY WITH PWATS FALLING TO BELOW ONE INCH. THIS COMBINED WITH A CONVECTIVE LID NEAR 800MB WILL PREVENT ANY CONVECTION MONDAY...AND WILL DROP INHERITED SCHC TO SILENT. TEMPS SUNDAY WILL BE AT OR SLIGHTLY BELOW CLIMO WITH SOME WEAK COOL AIR ADVECTION...BUT AMPLE AUGUST SUNSHINE WILL HELP RAISE TEMPS TO AROUND 90 DURING THE AFTN...FALLING TO AROUND 70 SUNDAY NIGHT. SIMILAR ON MONDAY...IF NOT A TOUCH WARMER...WITH LOWS ONCE AGAIN AROUND 70.

&&

.LONG TERM /TUESDAY THROUGH FRIDAY/...

AS OF 300 AM SATURDAY...BROAD UPPER TROUGHING PERSISTS THROUGH THURSDAY ACROSS THE SOUTHEAST BEFORE 500MB RIDGE BEGINS TO WORK BACK INTO THE AREA FOR FRIDAY. UPPER TROUGH AND HENCE SLIGHTLY LOWER 1000-500MB THICKNESSES WOULD GENERALLY SUGGEST MODERATE DIURNAL CONVECTIVE CHANCES DURING THE SUMMER...BUT OVERALL DO NOT ANTICIPATE WIDESPREAD STORMS THROUGH MUCH OF THE PERIOD. THE EXCEPTION WILL BE LATE TUESDAY AND WEDNESDAY AS A SHORTWAVE ROTATES DOWN THROUGH THE BASE OF THE TROUGH AND DRIVES A COLD FRONT TOWARDS THE ILM CWA. WINDS AHEAD OF THIS FEATURE FINALLY TURN SW ON TUESDAY...HELPING TO FORCE THE MID LEVEL THETA-E RIDGE INTO THE MID-ATLANTIC...SERVING AS THE FUEL FOR STORMS ALONG AND AHEAD OF THE COLD FRONT. TOO EARLY TO GET VERY SPECIFIC IN THE DETAILS...BUT WILL CARRY CHC POP BEGINNING LATE TUESDAY AND THROUGH WEDNESDAY FOR TSTMS. FRONT PUSHES OFFSHORE LATE WEDNESDAY LEADING TO DRIER AND COOLER CONDITIONS THURSDAY...BEFORE RIDGING DEVELOPS ALOFT FOR THE END OF THE WEEK. TEMPS WILL BE RIGHT AROUND CLIMO MOST DAYS...POTENTIALLY WARMING TO ABOVE CLIMO BY FRIDAY DUE TO INCREASING THICKNESSES AND RETURN OF SW RETURN FLOW.

&&

.AVIATION /12Z SATURDAY THROUGH WEDNESDAY/...

AS OF 12Z...EXPECT SCATTERED TO NUMEROUS SHOWERS AND THUNDERSTORMS TO DEVELOP DURING THE PERIOD. WHILE SHOWERS AND STORMS ARE POSSIBLE THROUGHOUT THE FORECAST PERIOD...THEY ARE MOST PROBABLE DURING THE 12 HOURS FROM APPROXIMATELY 18Z THROUGH 06Z. INTERMITTENT STORMS WILL BE ACCOMPANIED BY MVFR OR SHORT DURATION IFR CONDITIONS. S TO SW WINDS OF 10 TO 15 KT THIS AM WILL DIMINISH TO 5 TO 10 KT THIS AFTERNOON.

EXTENDED OUTLOOK...CHANCE OF MORNING MVFR VSBYS IN BR WITH A CHANCE OF SHOWERS AND THUNDERSTORMS THROUGH SUNDAY. VFR MONDAY THROUGH WED...OUTSIDE POSSIBLE SHOWERS AND STORMS TUESDAY NIGHT INTO WED.

&&
.MARINE...
NEAR TERM /THROUGH TONIGHT/...
AS OF 10:30 AM SATURDAY...WINDS AND SEAS ON THE WAY DOWN THIS MORNING AS EXPECTED. ALL HEADLINES HAVE BEEN DISCONTINUED. COULD STILL SEE SOME LOCALLY GENERATED HIGHER WINDS VIA CONVECTION BUT THESE WILL BE ADDRESSED BY MARINE WEATHER STATEMENTS AND SPECIAL MARINE WARNINGS.
SHORT TERM /SATURDAY THROUGH SUNDAY NIGHT/...
AS OF 300 AM SATURDAY...COLD FRONT WILL BE SLOWLY MOVING ACROSS THE AREA AT THE START OF THE PERIOD...WHILE AT THE SAME TIME WEAKENING. SW WINDS OF 10-15 KTS THROUGH SUNDAY WILL GRADUALLY VEER TO THE WEST AND EASE BY EARLY MONDAY AS FRONT WASHES OUT OVER THE WATERS. THESE WINDS WILL CREATE 3-4 FT SEAS SUNDAY AS THEY WORK IN TANDEM WITH AN INCREASING 2FT/9SEC SE SWELL. ALTHOUGH THE SE SWELL WILL PERSIST ON MONDAY...WAVE HEIGHTS WILL GRADUALLY DECAY DUE TO THE DECREASING WINDS...FALLING TO 2-3 FT THROUGH MONDAY NIGHT.
LONG TERM /MONDAY THROUGH TUESDAY/...
AS OF 300 AM SATURDAY...BERMUDA HIGH PRESSURE WILL CONTROL THE SYNOPTIC FLOW TUESDAY...BEFORE A COLD FRONT WORKS THROUGH THE AREA ON WEDNESDAY. THESE TWO FEATURES COMBINE TO CREATE INCREASING SW WINDS BY TUESDAY NIGHT...RISING FROM AROUND 10 KTS EARLY TUESDAY...TO AS MUCH AS 20 KTS BY EARLY WEDNESDAY...THANKS TO THE TIGHTENING PRESSURE GRADIENT AHEAD OF THE COLD FRONT. THESE WINDS FORCE RAPIDLY BUILDING WIND-WAVES...BECOMING 3-5 FT TUESDAY NIGHT AND EARLY WEDNESDAY...AND A SCEC MAY BE NEEDED FOR A TIME. FRONT WILL CROSS WEDNESDAY WHILE WEAKENING...AND WINDS WILL SLOWLY VEER TO THE WEST BY LATE WEDNESDAY WHILE EASING TO AROUND 10 KTS. SEAS FALL IN RESPONSE...BECOMING 2-3 FT BY THE END OF THE PERIOD.
&&
.ILM WATCHES/WARNINGS/ADVISORIES...
SC...NONE.
NC...NONE.
MARINE...NONE.
&&
$$

13.0 National Weather Service Hazardous Weather Outlook

A hazardous weather outlook was issued by the NWS in Wilmington, North Carolina, at 0542 EDT, which discussed the thunderstorms forming across northeast South Carolina and southeast North Carolina having the potential to produce gusty winds, local heavy rainfall, and isolated flooding:

NCZ087-096-099-105>110-SCZ017-023-024-032-033-039-053>056-120945-
ROBESON-BLADEN-COLUMBUS-INLAND PENDER-COASTAL PENDER-
INLAND NEW HANOVER-COASTAL NEW HANOVER-INLAND BRUNSWICK-
COASTAL BRUNSWICK-MARLBORO-DARLINGTON-DILLON-FLORENCE-MARION-
WILLIAMSBURG-INLAND HORRY-COASTAL HORRY-INLAND GEORGETOWN-
COASTAL GEORGETOWN-
542 AM EDT SAT AUG 11 2012
THIS HAZARDOUS WEATHER OUTLOOK IS FOR SOUTHEAST NORTH CAROLINA AND NORTHEAST SOUTH CAROLINA.
.DAY ONE...TODAY AND TONIGHT.
THUNDERSTORMS WILL HAVE THE POTENTIAL TO PRODUCE GUSTY WINDS AND

HEAVY RAINFALL. ISOLATED FLOODING MAY BE POSSIBLE IF STORMS ARE ABLE TO REDEVELOP AND SOAK THE SAME AREAS WITHIN A SHORT TIME.
.DAYS TWO THROUGH SEVEN...SUNDAY THROUGH FRIDAY.
NO HAZARDOUS WEATHER IS EXPECTED AT THIS TIME.
.SPOTTER INFORMATION STATEMENT...
SPOTTER ACTIVATION IS NOT EXPECTED AT THIS TIME.
$$

14.0 National Weather Service Special Weather Statement

A special weather statement was issued by the NWS in Wilmington, North Carolina, at 1229 EDT for the line of strong thunderstorms the accident aircraft would encounter. These thunderstorms were moving northeastward at 40 mph with pea size hail and gusty winds of 40 to 50 mph possible at the surface:

WWUS82 KILM 111629
SPSILM
SPECIAL WEATHER STATEMENT
NATIONAL WEATHER SERVICE WILMINGTON NC
1229 PM EDT SAT AUG 11 2012
SCZ017-023-024-032-033-039-111730-
DARLINGTON-DILLON-FLORENCE-MARION-MARLBORO-WILLIAMSBURG-
1229 PM EDT SAT AUG 11 2012
...STRONG THUNDERSTORMS WILL MOVE ACROSS WILLIAMSBURG...FLORENCE...
MARION...DILLON...MARLBORO AND DARLINGTON COUNTIES THROUGH 130 PM
EDT...
AT 1230 PM EDT...DOPPLER RADAR INDICATED STRONG THUNDERSTORMS ALONG A LINE EXTENDING FROM 7 MILES WEST OF LAMAR TO 16 MILES SOUTHWEST OF HEBRON CROSSROADS...OR ALONG A LINE EXTENDING FROM 7 MILES SOUTHEAST OF BISHOPVILLE TO 5 MILES EAST OF MANNING...MOVING NORTHEAST AT 40 MPH.
SOME LOCATIONS IMPACTED INCLUDE DARLINGTON...FLORENCE...KINGSTREE... LAKE CITY...BINGHAM...BLUE BRICK...BROWNSVILLE...CADES... CARTERSVILLE...CLAUSSEN...DARLINGTON RACEWAY AND EFFINGHAM.
HAZARDS INCLUDE...
PEA SIZE HAIL.
GUSTY WINDS OF 40 TO 50 MPH.
THUNDERSTORMS CAN POSE A VARIETY OF THREATS INCLUDING GUSTY WINDS...
SMALL HAIL...CLOUD TO GROUND LIGHTNING...AND LOCALIZED FLOODING. IT
IS RECOMMENDED THAT YOU REMAIN INDOORS UNTIL THE STORMS PASS.
&&
LAT...LON 3420 8012 3426 8013 3455 7947 3378 7933
3376 7935 3362 8004 3372 7998 3377 8000
3383 7991 3388 7989 3388 7994 3393 7997
3396 7996 3399 7990 3407 8003 3409 8008
3414 8015 3416 8016
TIME...MOT...LOC 1630Z 244DEG 33KT 3415 8015 3372 8009
$$

15.0 National Weather Service Weather Watches and Warnings

A severe thunderstorm warning was issued by the NWS in Wilmington, North Carolina, at 1255 EDT for a severe thunderstorm 6 miles south of Sardis, South Carolina. This thunderstorm was the thunderstorm the accident aircraft encountered. The severe thunderstorm was moving northeastward at 25 mph with damaging winds in access of 60 mph possible at the surface. The accident aircraft was located within the warning area at the time of the accident (figure 25):

WUUS52 KILM 111655
SVRILM
SCC041-111745-
/O.NEW.KILM.SV.W.0145.120811T1655Z-120811T1745Z/
BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE WILMINGTON NC
1255 PM EDT SAT AUG 11 2012
THE NATIONAL WEATHER SERVICE IN WILMINGTON NC HAS ISSUED A
* SEVERE THUNDERSTORM WARNING FOR...
  FLORENCE COUNTY IN NORTHEAST SOUTH CAROLINA
* UNTIL 145 PM EDT
* AT 1251 PM EDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED A
  SEVERE THUNDERSTORM CAPABLE OF PRODUCING DAMAGING WINDS IN EXCESS
  OF 60 MPH. THIS STORM WAS LOCATED 6 MILES SOUTH OF SARDIS...OR 11
  MILES NORTHWEST OF LAKE CITY...AND MOVING NORTHEAST AT 25 MPH.
* LOCATIONS IN THE WARNING INCLUDE BUT ARE NOT LIMITED TO...
   LAKE CITY...
   NEW HOPE...
   EFFINGHAM...
   FRIENDFIELD...
   EVERGREEN...
   HYMAN...
MORE DANGEROUS THUNDERSTORMS MAY DEVELOP AND AFFECT OTHER COMMUNITIES
IN THE WARNED AREA.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
SEVERE THUNDERSTORMS PRODUCE DAMAGING WIND IN EXCESS OF 60 MPH...
DESTRUCTIVE HAIL...DEADLY LIGHTNING AND HEAVY RAIN. FOR YOUR
PROTECTION MOVE TO AN INTERIOR ROOM ON THE LOWEST FLOOR OF YOUR HOME
OR BUSINESS.
&&
PLEASE REPORT HAIL...DOWNED TREES OR DAMAGING WINDS TO THE NATIONAL
WEATHER SERVICE IN WILMINGTON NC...TOLL FREE AT 800-697-3901 OR
877-633-6772...WHEN YOU CAN DO SO SAFELY.
LAT...LON 3425 7977 3425 7975 3427 7974 3429 7970
      3429 7968 3431 7967 3384 7948 3384 7981
      3388 7983 3389 7985 3388 7994 3390 7996
      3395 7998 3399 7990 3409 8007
TIME...MOT...LOC 1656Z 241DEG 21KT 3396 7988
$$

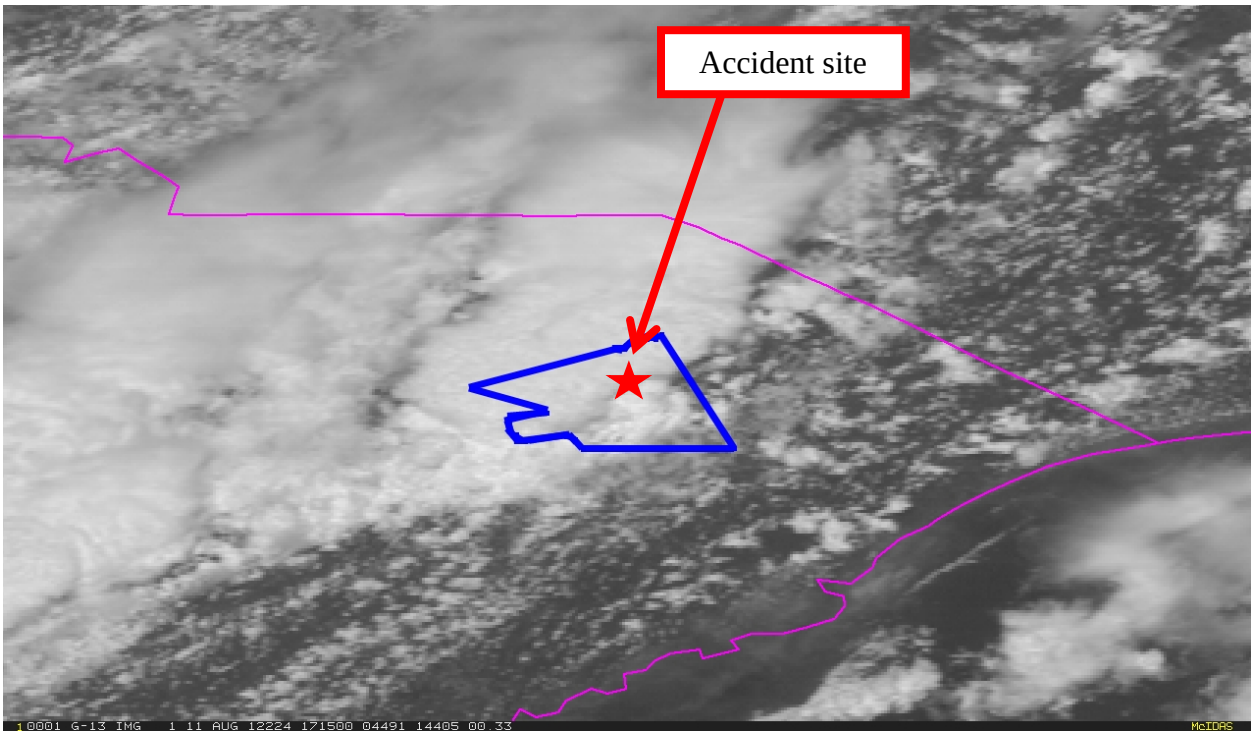


Figure 25 – Severe thunderstorm warning valid at the time of the accident

16.0 Pilot Weather Briefing

Attachment 1 is a print out of the text weather briefing information that the pilot received before taking off on the flight. Many of the text products in this weather briefing are the ones provided in this NTSB report, with KFLO TAF mentioning the possibility of thunderstorm activity as early as 1400 EDT in the 0720 EDT TAF provided in the text of the briefing. The pilot also received a verbal preflight weather briefing from Lockheed Martin Flight Service and the summary of that is provided as attachment 2. The briefer specifically mentions the line of thunderstorms in central South Carolina and how that could affect the pilot's route of flight. The pilot replies saying that they'll deal with the weather when they get there if they have to stop or deviate around it.

17.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on August 11, 2012, indicated the following:

SUN	
Begin civil twilight	0611 EDT
Sunrise	0638 EDT
Sun transit	1324 EDT
Sunset	2010 EDT
End civil twilight	2036 EDT

F. LIST OF ATTACHMENTS

Attachment 1 – Weather briefing provided by Flight Service via a text desktop app

Attachment 2 – Summary of the Lockheed Martin Flight Service phone weather briefing

Paul Suffern
NTSB, AS-30