



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 22, 2021

Specialist's Factual Report

METEOROLOGY

ERA22FA004

A. ACCIDENT

Location: Thomas, Georgia
Date: October 5, 2021
Time: 0544 eastern daylight time (EDT)
0944 coordinated universal time (UTC)
Airplane: Dassault Falcon F20; Registration: N283SA

B. METEOROLOGY SPECIALIST

Specialist Donald Eick
Operational Factors Division (AS-30)
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's 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). This specialist factual report contains the meteorological factors pertinent to the weather conditions surrounding the time of the accident. All times are reported as EDT based upon the 24-hour clock, local time is -4 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. 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 main wreckage site was located at latitude 33.530483° N, longitude 82.539617°, at an elevation of approximately 480 ft.

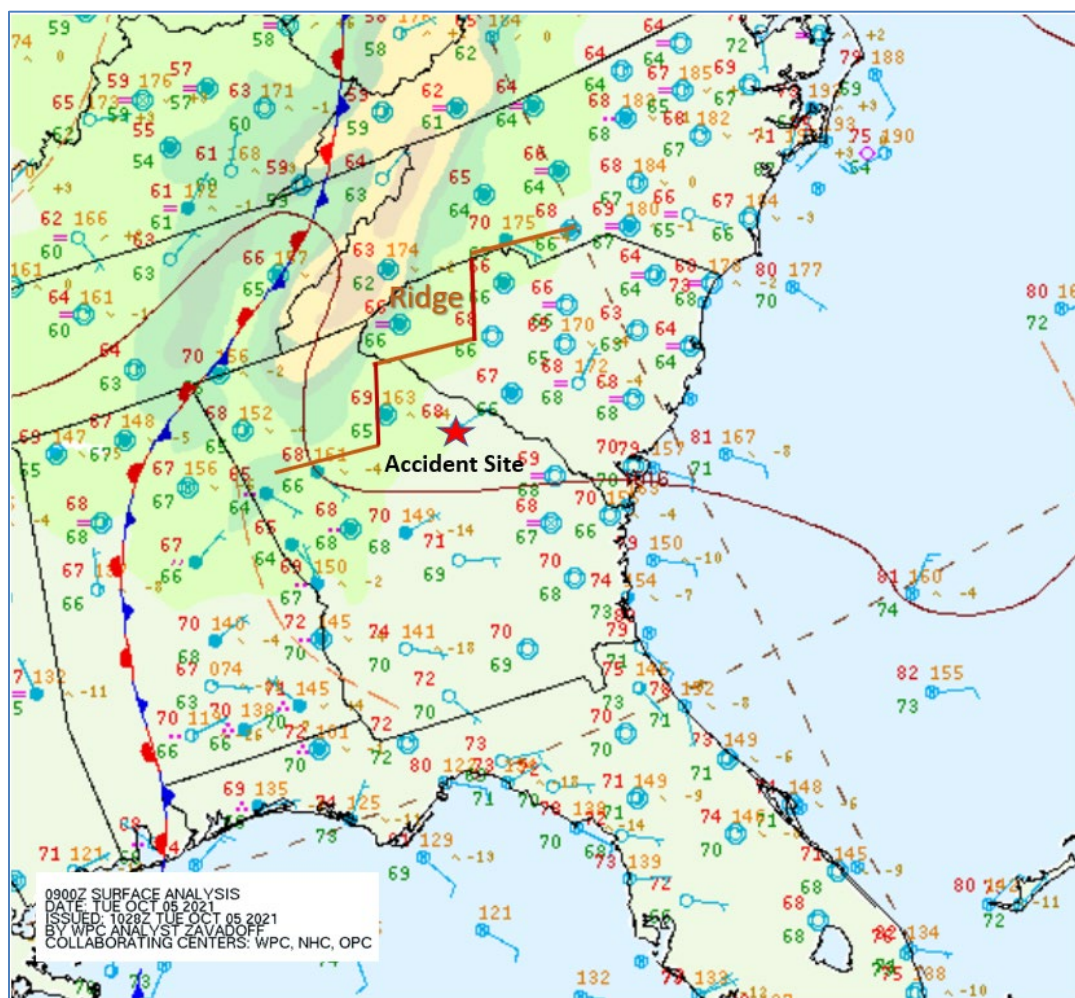
D. FACTUAL INFORMATION

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) and the WPC 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

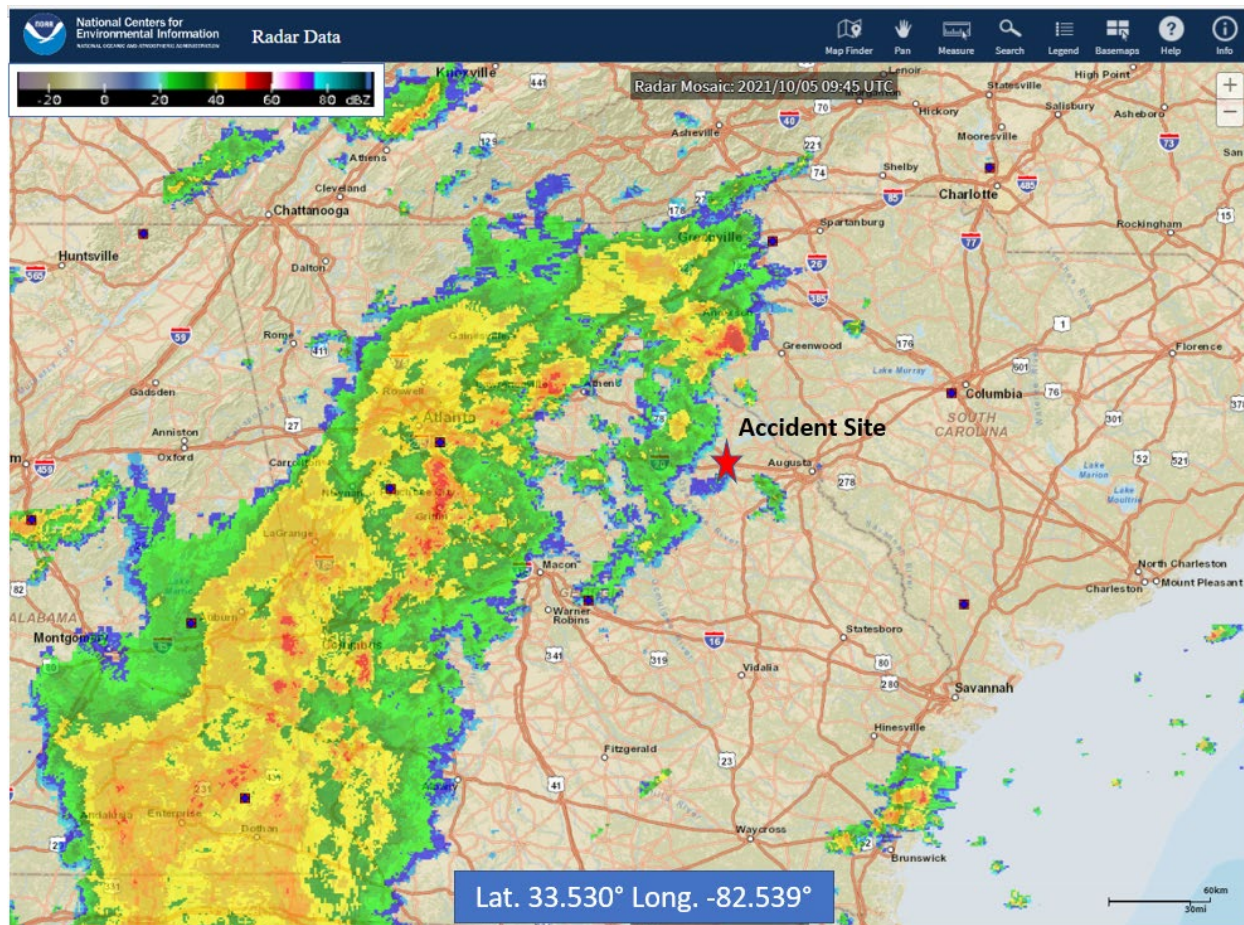
The NWS Surface Analysis Chart for 0500 EDT or 0900Z (figure 1) depicted a stationary front that extended from eastern Tennessee southwestward into extreme northwestern Georgia and northern Alabama, then southward across Alabama into the Gulf of Mexico. The station models depicted an extensive area of precipitation along and east of the stationary front across Alabama, the Florida panhandle, and western Georgia. A high-pressure ridge¹ also extended from North Carolina southwestward into eastern Georgia, with numerous stations reporting light winds, clear skies, and visibility restricted in mist and fog. The accident site was located on the warm air side of the front and south of the high-pressure ridge's axis. The station model immediately surrounding the accident site depicted light easterly wind of 5 knots or less, overcast clouds, with temperatures in the upper 60's degrees Fahrenheit (°F), with temperature-dew point spreads of 4° F or less.



¹ A high-pressure ridge is an elongated area of higher pressure and is typically associated with light winds, and fair weather.

1.2 National Composite Radar Image

A regional view of the NWS National Composite Radar Mosaic centered over Georgia for 0545 EDT is included as figure 2 with the approximate accident site marked by the red star. The image depicted a large area of echoes extending over Georgia, southeast Alabama, the Florida Panhandle, and into the Gulf of Mexico. The accident site was located about 10 miles east of the edge of the large area of echoes and immediately north of an area of light intensity echoes.



Based on the potential of echoes in the vicinity of the accident site, the closest NWS weather radar will be further documented in section 5.0 of this report.

1.3 Low-Level Significant Weather Prognostic Chart

The 12- and 24-hour Low-Level Significant Weather Prognostic Chart valid for the period is included as figure 3, and depicted the general flight categories², turbulence below 12,000 ft, and

² As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1

freezing levels. The 12-hour forecast valid for 0800 EDT is on the left and depicted an extensive area of instrument flight rule (IFR) conditions by a solid line over the eastern third of the country and included most of Georgia. A scalloped line depicted marginal visual flight rule (MVFR) conditions which extended over southeast Louisiana eastward and extended over the rest of Georgia and enclosed the area of IFR conditions. The 24-hour forecast on the right valid for 2000 EDT expected MVFR conditions over Georgia to prevail.

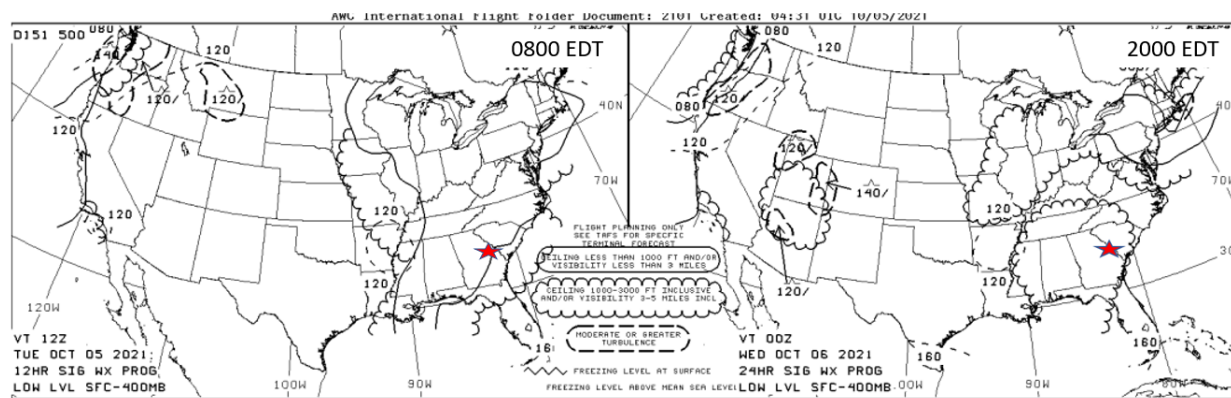


Figure 3 - 12-hour (left) and 24-hour (right) Low-Level Significant Weather Prognostic Chart valid for 0800 and 2000 EDT on October 5, 2021, with approximate accident site marked by red star.

2.0 Observations

The official observations issued surrounding the accident site were documented using Aviation Routine Weather Reports (METAR³) and Aviation Selected Special Weather Reports (SPECI). Cloud heights are reported above ground level (agl) in the following section, and the magnetic variation was estimated at 6° west based on the latest sectional chart for the area.

2.1 Thomson, Georgia

The closest weather reporting location was from the planned destination of Thomson-McDuffie County Airport (KHQU), Thomson, Georgia, which was located about 1 mile east of the accident site at an elevation of 501 ft. The airport had an Automated Surface Observation System (AWOS), which was not augmented by any human observers⁴. The Airport Facility Directory indicated that

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.

³ METAR is an abbreviation for Meteorological Aerodrome Report.

⁴ AWOS have several limitations in that they are unable to detect clouds that are not directly over the sensor, cloud type, clouds above 12,000 ft, very light precipitation such as drizzle, multiple forms of precipitation at the same time, shallow or patchy fog, blowing dust, smoke, volcanic ash, tornadoes, in-cloud and cloud-to-cloud lightning, or total depth of snow.

KHQU had a single runway 10/28 at 5,514 ft X 100 ft asphalt in good condition. The following conditions were reported surrounding the time of the accident.

KHQU weather at 0530 EDT, automated, wind calm, visibility 7 miles, scattered clouds at 4,900 ft agl, ceiling overcast at 9,000 ft, temperature 20° Celsius (C), dew point temperature missing, altimeter 30.03 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, lightning distant north, temperature 20.2° C, dew point missing.

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KHQU weather at 0550 EDT, automated, wind calm, visibility 7 miles in haze, scattered clouds at 1,200 ft agl, scattered at 3,300 ft, ceiling overcast at 9,000 ft, temperature 20° C, dew point temperature missing, altimeter 30.04 inHg. Remarks: automated station with a precipitation discriminator, lightning distant north and west, temperature 20.3° C, dew point missing.

The AWOS had an Automated Lightning Detection and Reporting System (ALDARS) to detect lightning and report thunderstorms in accordance with Federal Meteorological Handbook number 1 (FMH-1). Lightning frequency, type, and location are typically reported in an observation once detected. According to FHM-1 section 12.7.1(j) regarding remarks, when lightning is detected by an automated system it is reported as follows:

- *Within 5 nautical miles of the airport location point (ALP)⁵, it will be reported as “thunderstorm” (TS) in the main body of the report with no remark;*
- *Between 5 and 10 nautical miles of the ALP, it will be reported as “in the vicinity” (VCTS) in the body of the report with no remark;*
- *Beyond 10 but less than 30 nautical miles of the ALP, it will be reported in remarks only as “lightning distant” (LTG DSNT) followed by the direction from the ALP.*

An issue was also identified with the dew point sensor during the period of the accident, with the dew point temperature not reported between 0450 through 0730 EDT. A review of several days indicated that this typically occurs between 0450 and 0850 EDT daily, where the dew point is missing from the observations. This issue has since been corrected by the airport authority.

The general flight categories and the raw observations surrounding the period were as follows between 0330 through 0711 EDT were as follows.

VFR METAR KHQU 050730Z AUTO 08003KT 10SM VCTS BKN110 20/20 A3004 RMK AO2 LTG DSNT NW T02020202=

VFR METAR KHQU 050750Z AUTO 10003KT 10SM BKN042 OVC110 20/20 A3004 RMK AO2 T02030203=

VFR METAR KHQU 050810Z AUTO 09003KT 10SM OVC042 20/20 A3003 RMK AO2 LTG DSNT SW T02030203=

⁵ The Airport Location Point (ALP) is the permanent airport reference point defined by the latitude and longitude published in the Airport Facility Directory.

VFR METAR KHQU 050830Z AUTO 09004KT 10SM BKN042 BKN050 OVC100 20/20 A3003 RMK AO2 LTG DSNT W T0203////=

VFR METAR KHQU 050850Z AUTO 08003KT 7SM SCT045 OVC100 20/ A3003 RMK AO2 LTG DSNT N T0202////=

VFR METAR KHQU 050910Z AUTO 10003KT 7SM VCTS OVC090 20/ A3003 RMK AO2 LTG DSNT N T0202////=

VFR METAR KHQU 050930Z AUTO 00000KT 7SM SCT049 OVC090 20/ A3003 RMK AO2 LTG DSNT N T0202////=

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VFR METAR KHQU 050950Z AUTO 00000KT 7SM HZ SCT012 SCT033 OVC090 20/ A3004 RMK AO2 LTG DSNT N AND W T0203////=

MVFR METAR KHQU 051010Z AUTO 00000KT 5SM HZ SCT006 BKN020 OVC090 20/ A3004 RMK AO2 LTG DSNT N AND W T0203////=

MVFR METAR KHQU 051030Z AUTO 08003KT 5SM HZ SCT006 BKN022 OVC090 20/ A3004 RMK AO2 LTG DSNT N AND W T0203////=

MVFR METAR KHQU 051050Z AUTO 09003KT 5SM HZ SCT006 BKN045 OVC075 20/ A3004 RMK AO2 LTG DSNT W AND NW T0203////=

VFR METAR KHQU 051110Z AUTO 08003KT 7SM HZ SCT045 BKN075 OVC110 20/ A3005 RMK AO2 LTG DSNT W THRU NE T0203////=

The observations surrounding the time of the accident indicated light easterly winds of 5 knots or less, multiple layers of broken to overcast clouds, with visibility restrictions between 0450 and 0710 EDT in haze. Thunderstorms were reported in the vicinity of the station at several times prior to the accident, with lightning reported in the distance to the north and west at the time of the accident. The AWOS did not report any precipitation at the station prior to the accident.

A security camera video of the conditions immediately surrounding the time of the accident is included in the docket. The camera indicated light rain beginning near the time of the accident, with the accident airplane coming into view near 0541:51 EDT faintly in the left foreground, with the landing light of the aircraft becoming noticeably brighter at 0542:32 EDT. A lightning flash to the north of the station is observed at the time stamp 0542:43 EDT as the accident airplane continues the approach. The rain was light, with scattered droplets noted on the pavement which did not completely wet the surface.

2.2 Augusta, Georgia

The next closest weather reporting facility was 29 miles east-southeast of the accident site at Augusta Regional Airport at Bush Field (KAGS), Augusta, Georgia, at an elevation of 146 ft. The airport was also listed as the destination alternate if the flight could not land at KHQU. The airport had a federally installed and maintained Automated Surface Observation System (ASOS) and was

augmented during normal operating hours by air traffic control personnel and reported the following conditions at the approximate time of the accident.

KAGS weather at 0453 EDT, automated, wind calm, visibility 4 miles in mist, a few clouds at 7,500 ft agl, ceiling overcast at 9,500 ft, temperature 21° C, dew point temperature 19° C, altimeter 30.02 inHg. Remarks; automated station with a precipitation discriminator, sea-level pressure 1016.4-hPa, temperature 20.6° C, dew point temperature 19.4° C, 3-hour pressure tendency fallen 0.02-hPa.

The general flight categories and raw observations between 0148 and 0837 EDT were as follows.

LIFR SPECI KAGS 050548Z AUTO 00000KT 1/4SM FG VV001 20/19 A3003 RMK AO2 RVRNO=

LIFR METAR KAGS 050553Z AUTO 00000KT 1/2SM FG VV001 20/19 A3003 RMK AO2 SLP166 60003 T02000194 10222 20194 58003 RVRNO=

LIFR SPECI KAGS 050614Z AUTO 00000KT 3/4SM BR CLR 19/19 A3003 RMK AO2 T01940189 RVRNO=

IFR SPECI KAGS 050625Z AUTO 00000KT 2SM BR CLR 20/19 A3003 RMK AO2 T02000194=

VFR SPECI KAGS 050632Z AUTO 00000KT 8SM CLR 20/19 A3003 RMK AO2 T02000194=

VFR METAR KAGS 050653Z AUTO 00000KT 9SM FEW055 20/19 A3003 RMK AO2 SLP168 T02000194=

MVFR METAR KAGS 050753Z AUTO 00000KT 3SM BR FEW065 SCT085 20/19 A3002 RMK AO2 SLP164 T02000194=

MVFR METAR KAGS 050853Z AUTO 00000KT 4SM BR FEW075 OVC095 21/19 A3002 RMK AO2 SLP164 T02060194 58002=

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VFR METAR KAGS 050953Z AUTO 00000KT 9SM OVC085 21/19 A3002 RMK AO2 SLP163 T02060194=

VFR METAR KAGS 051053Z 00000KT 10SM OVC095 21/19 A3003 RMK AO2 SLP167 T02110194=

IFR SPECI KAGS 051137Z 00000KT 2 1/2SM BR FEW020 BKN110 21/19 A3004 RMK AO2 VIS 1 1/4V5 T02060194=

2.3 Aviation Weather Center's METAR Display

A display of the observation from the NWS Aviation Weather Center's METAR display at 0552 EDT with the regional radar overlaid is included as figure 4 with the accident site and KHQU within the red circle. The image depicts a small band of light echoes over the KHQU area, with KHQU reporting visibility 7 miles in haze at the time. Several stations surrounding KHQU were reporting visibility restrictions in haze, mist, and light to moderate rain. Numerous stations northwest, through west, and southwest reported IFR to LIFR conditions in moderate to heavy rain, and thunderstorms.

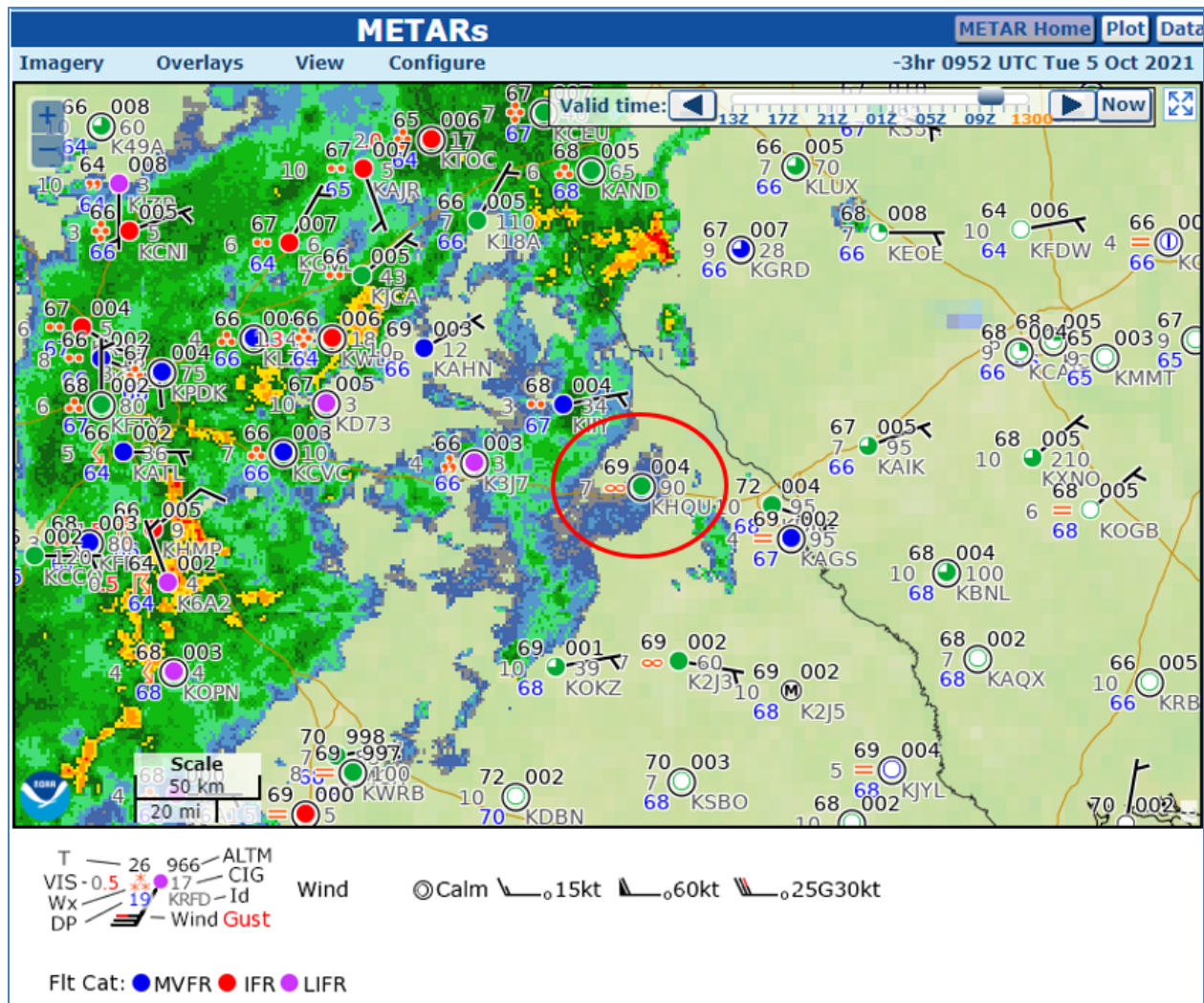


Figure 4 - NWS AWC METAR display for 0552 EDT centered over the KHQU area with radar overlaid.

3.0 Sounding

To determine the vertical structure and state of the atmosphere over the accident site a High-Resolution Rapid Refresh (HRRR)⁶ numerical model data was retrieved from the NOAA Air Resources Laboratory using the coordinates latitude 33.53°, and longitude -82.52° or the grid space closest to the accident site. The data was then plotted on a standard Skew T log P diagram⁷ from the surface to 450-hPa or approximately 20,000 ft for 0500 EDT using the complete Rawinsonde Observation RAOB software program⁸ and is included as figure 5.

⁶ 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.

⁷ 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.

⁸ RAOB – The Universal RAWinsonde OBservation program is an interactive sounding analysis program developed

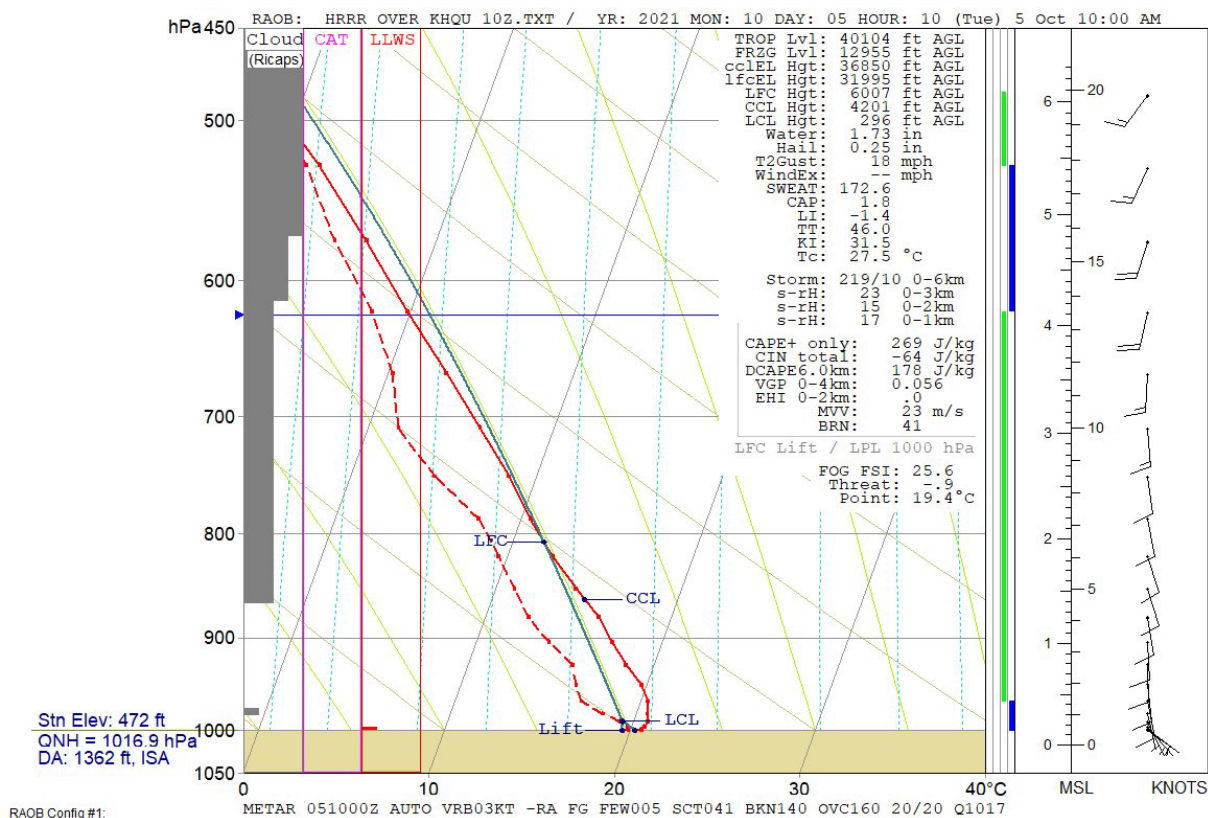


Figure 5 - HRRR numerical model sounding for 0500 EDT over the approximate accident site.

The HRRR 0500 EDT sounding indicated an elevation of 472 ft with a near surface temperature of 20.3° C (68.5° F), a dew point temperature of 19.6° C (67.3° F), with a relative humidity 96%, with a density altitude of 1,362 ft. A ground based temperature inversion⁹ to approximately 1,000 ft was noted. The sounding depicted the lifted condensation level (LCL)¹⁰ at 265 ft agl, the convective condensation level (CCL)¹¹ at 4,200 ft agl, and the level of free convection (LFC)¹² at 6,000 ft agl, which support multiple layers of clouds (indicated in gray on left axis). The freezing level was identified at approximately 13,000 ft (blue horizontal line). The precipitable water content was 1.73 inches. The atmosphere was characterized as conditionally unstable above the inversion with a Lifted Index (LI)¹³ of -1.4, and a K-Index¹⁴ of 31.5 which indicated the potential

by Eosonde Research Services (ERS) previously known as Environmental Research Services, The Villages, Florida.

⁹ An inversion is an increase in temperature with height.

¹⁰ Lifted Condensation Level (LCL) – is the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

¹¹ Convective Condensation Level (CCL) – is 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) – is the last level where a parcel becomes buoyant, or "warmer" than the environmental temperature at the same level. The LFC represents the bottom of the layer containing CAPE.

¹³ 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.

¹⁴ K-Index - The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The higher the K-Index value the greater the

for numerous or approximately 60% probability of airmass type thunderstorms. The sounding provided a convective available potential energy (CAPE)¹⁵ value of 269 Joules/kilogram. The tropopause height was near 40,100 ft, and the expected convective cloud tops or equilibrium level (EL)¹⁶ was near 37,000 ft. The RAOB analysis program supported the formation of radiation and rain-induced fog, with the fog point temperature of 19.4° C, and both the Fog Stability Index (FSI) and Fog Threat index supporting a high probability of radiational fog development. The RAOB analysis program also supported a low layer of stratiform type clouds at 500 ft agl, a scattered layer of clouds at 4,100 ft agl, a ceiling broken at 14,000 ft agl, and overcast clouds at 16,000 ft agl, and also supported light rain and fog at the time of the sounding.

The HRRR 0500 EDT wind profile indicated a light and variable surface wind, with winds from the east veering¹⁷ to the south immediately above the surface and slowly veering to the south-southwest above 18,000 ft. A low-level wind maximum was identified at 5,000 ft msl from 165° at 12 knots, with the mean 0 to 6 kilometer (km) or 18,000 ft wind from 190° at 13 knots. The level of maximum wind was identified at 40,240 ft or in the stratosphere from 250° at 52 knots. According to the RAOB analysis program no strong vertical wind shears were noted below 18,000 ft that supported any significant turbulence outside of any convective activity.

The HRRR parameters of height, pressure, temperature (T), dew point temperature (Td), relative humidity (RH%), wind direction and speed, clear air turbulence (CAT), and low-level wind shear (LLWS) below 10,000 ft are provided in the following table.

Height (ft-msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (deg/kts)	CAT (FAA)	LLWS
472	1000	20.3	19.6	96	128/ 3		
500	999	20.6	19.9	96	129/ 3		LIGHT
586	996	20.7	19.8	95	141/ 4		
758	990	20.8	19.3	91	156/ 5		
1018	981	20.6	18.2	86	169/ 6		
1427	967	20.4	16.8	80	170/ 8		
1960	949	19.7	16.2	80	174/ 9		
2593	928	18.5	15.6	83	179/ 10		
3331	904	17.3	13.9	80	177/ 10		
4117	879	16.1	12.3	78	172/ 11		
5019	851	14.3	11.0	81	165/ 12		
6046	820	12.4	9.5	82	165/ 11		
7210	786	10.5	7.7	83	170/ 10		
8526	749	8.5	4.5	76	173/ 11		
10011	709	6.0	1.6	73	176/ 13		

probability of air mass type thunderstorm development across the region.

¹⁵ Convective Available Potential Energy (CAPE) – 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. Observed values in thunderstorm environments often may exceed 1000 joules per kilogram (J/kg), and in extreme cases may exceed 5000 J/kg.

¹⁶ 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.

¹⁷ Veering refers to a clockwise turning of the wind direction with height and is indicative of warm air advection in the layer.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data were 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 infrared imagery were reviewed surrounding the period, and the closest images to the accident time documented. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km.

The GOES-16 infrared image at 0556 EDT at 4X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops associated with high clouds and strong convection is included as figure 6. The image depicted a large area of enhanced clouds (blue, yellow, to light blue areas) associated with cumulonimbus clouds extending over western South Carolina, southwestward over central and western Georgia, which was located to the southwest, west, through north of the accident site with the eastern edge of the higher cloud shield extending over the accident site. Low to mid-level stratiform layer clouds were also depicted over eastern Georgia and South Carolina, which extended over the accident site. The radiative cloud top temperature over the accident site was 242 Kelvin or -31.16°C , which corresponded to cloud tops near 29,000 ft.

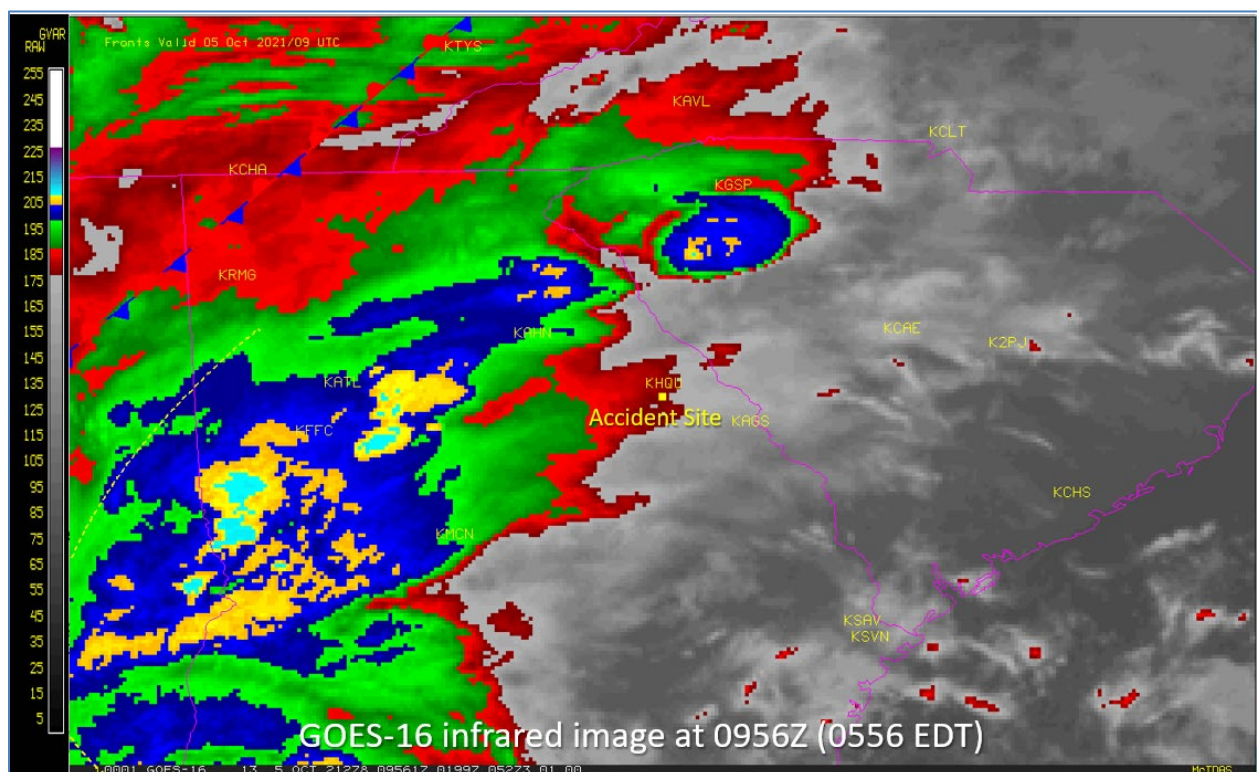


Figure 6 - GOES-16 infrared image for 0556 EDT at 4X magnification with accident site marked.

5.0 Weather Surveillance Radar Imagery

The closest Weather Surveillance Radar 1988 Doppler (WSR-88D)¹⁸ was from Robins Air Force Base (KJGX) with the antenna¹⁹ located in Jeffersonville, Georgia, approximately 66 miles southwest of the accident site. The level II data were obtained from the NCEI archive and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The data revealed that during the period the KJGX WSR-88D was operating in the precipitation mode volume scanning pattern 215 (VCP-215) where the radar makes 15 different elevation scans in about 6 minutes. Based on the distance of 66 miles from the KJGX radar antenna at a height of 618 ft, and assuming standard refraction of the lowest 0.48° base reflectivity beam indicated that the center was near 6,860 ft, with the antenna sampling the altitudes from 3,540 ft to 10,190 ft over the accident site.

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁰, 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)²¹ and is a general measure of echo intensity. Figure 7 is a table of the NWS former video integrator and processor (VIP) intensity levels (1-6)²² versus the WSR-88D's display levels (0-15), precipitation mode reflectivity in decibels (dBZ), and expected rainfall rates. Typically echoes over 15 dBZ are associated with measurable precipitation reaching the surface, with echoes less than 15 dBZ associated with low clouds and/or drizzle.

¹⁸ 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.

¹⁹ Radar Data Acquisition (RDA) is associated with the antenna and physical radar system, while the Radar Product Generate (RPG) is the basic control and display system for the operator at Robins AFB.

²⁰ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at 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.

²¹ dBZ - 10 log Ze.

²² Previous VIP Levels 1-6 was designed to provide color to the WSR-55 and WSR-74C radar systems, the newer WSR-88D has increased the color resolution to 16 levels.

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

Figure 7 - NWS VIP, WSR-88D levels, precipitation mode in dBZ, and rainfall rates.

The FAA has taken the NWS previous VIP levels 1 to 6 intensity levels and has redefined the intensity levels for pilots in Advisory Circular AC 00-24C - “Thunderstorm”. That AC further defines echoes less than 30 dBZ as “light” in intensity, “moderate” echoes 30-40 dBZ, “heavy” with echoes of >40-50 dBZ, and “extreme” intensity with echoes above >50 dBZ. These are the new standard radio phraseology terms used by air traffic controllers to describe weather conditions to pilots as shown in figure 8.

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

Figure 8 - Reflectivity in dBZ and corresponding echo intensity terminology.

Figure 9 is the KJGX WSR-88D 0.48° base reflectivity image for 0542:37 EDT with the flight track overlaid in white. The image depicted an extensive area of heavy to extreme echoes over Georgia during the period and along the flight path south of the Atlanta area. The closest area of extreme echoes was located about 30 miles north of KHQU with echoes of 64 dBZ. Echoes of 10 to 25 dBZ or light intensity echoes prevailed along the last 50 miles along the flight track into KHQU and over the accident site.

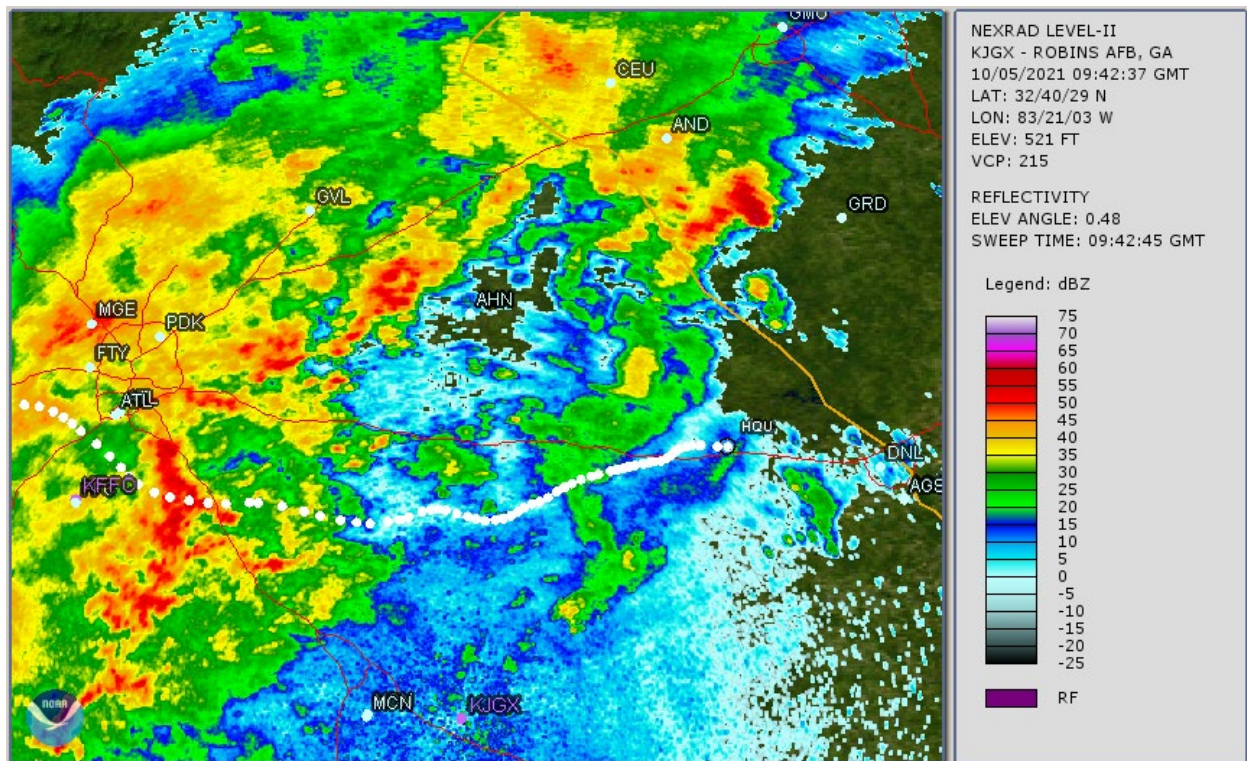


Figure 9 - KJGX WSR-88D 0.48° base reflectivity image at 0542:37 EDT with flight track overlaid.

Figures 10 and 11 are closeups of the KJGX WSR-88D 0.48° base reflectivity images at 0542:37 and 0547:45 EDT with the flight track overlaid for the period of the radar scan. The images show light intensity echoes of 5 to 25 dBZ extending over the track, which were moving northward with time. Echoes of 15 dBZ and stronger are typically associated with measurable precipitation at the surface, with drizzle and fog likely in echoes less than 15 dBZ.

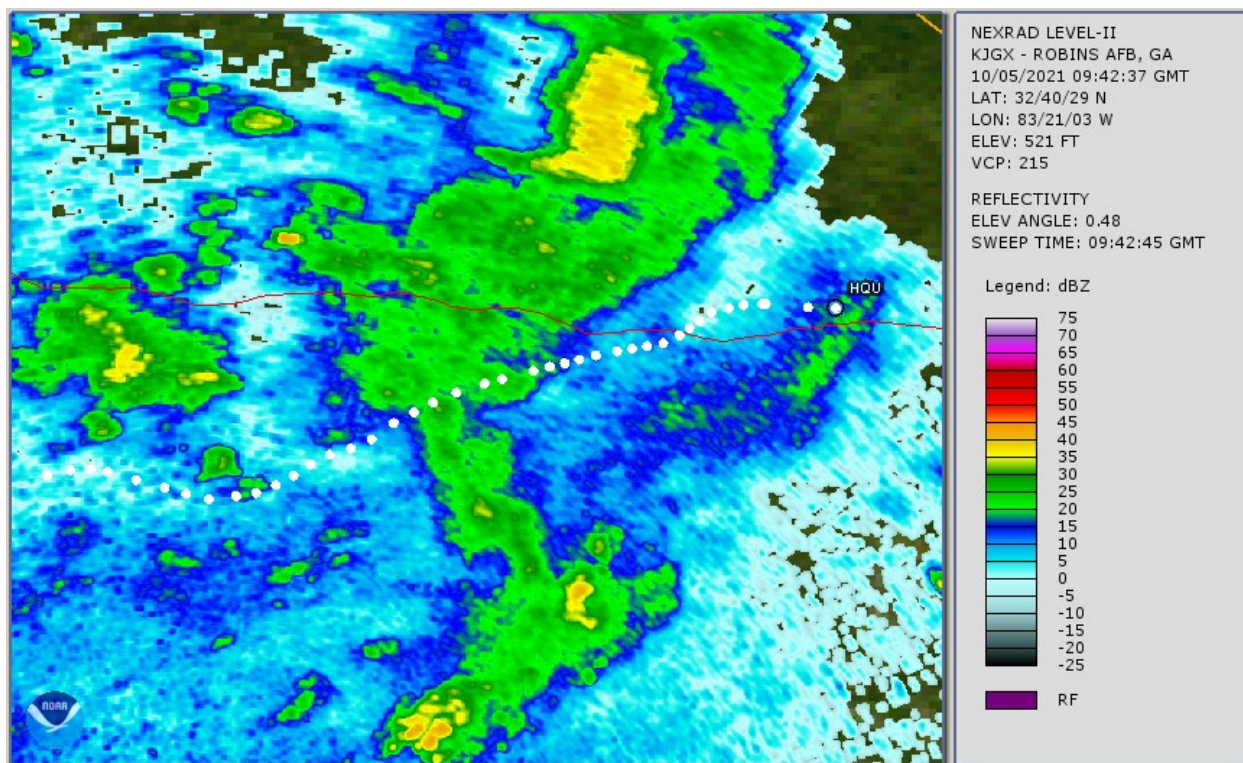


Figure 10 – Closeup of flight track and KJGX WSR-88D 0.48° base reflectivity image at 0542:37 EDT.

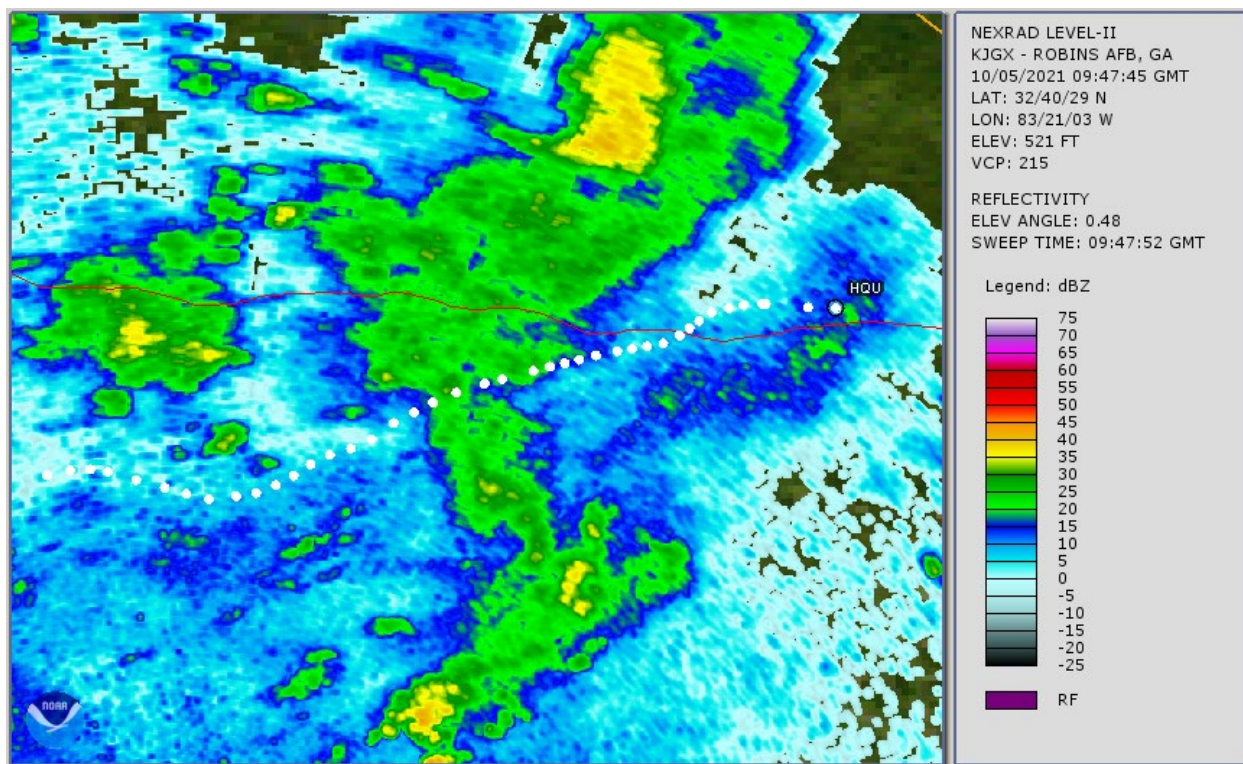


Figure 11 - Closeup of flight track and KJGX WSR-88D 0.48° base reflectivity image at 0547:45 EDT.

6.0 Pilot Reports

The following pilot reports (PIREPs)²³ were distributed into the national airspace between 0100 and 0800 EDT within 120 miles of the accident site. The reports are provided in standard code and format as received, with time in UTC.

ATL UA /OV ATL090015/TM 0745/FL360/TP A306/TB CONS MOD/RM ZTLFD

ATL UA /OV ATL/TM 0754/FL380/TP A306/TB CONS LGT INTMT MOD/RM ZTLFD

AHN UA /OV AHN020005/TM 0913/FL390/TP B752/TB LGT CONS/RM ZTLFD

Accident 0944Z

WRB UA /OV MCN/TM 1001/FL380/TP B763/TB CONS LGT CHOP/RM ZTLFD

AHN UA /OV AHN/TM 1006/FL400/TP B763/TB CONS LGT CHOP/RM ZTLFD

GSP UA /OV GSP RWY 4 DEP/TM 1035/FL021/TP CRJ7/SK TOPS 021

ATL UA /OV ATL180040/TM 1106/FLDURC/TP A321/TB CONS LGT CHOP/RM ZTLFD

GRD UA /OV IRQ156017/TM 1133/FL410/TP B737/TB LGT-MOD CHOP/RM ZTLFD

AHN UA /OV AHN010015/TM 1156/FL230/TP B712/TA 02/IC LGT RIME/RM ZTLFD

All the reports were from air carrier aircraft, and 8 out of 9 of the reports indicated light to moderate turbulence at altitude. One pilot report reported sky conditions on departure from Greenville Spartanburg International Airport (KGSP), Greer, South Carolina, located approximately 83 miles north of the accident site reported at 0635 EDT of cloud tops at 2,100 ft msl. At the time KGSP was reporting LIFR conditions with visibility about ½ mile in fog with a ceiling at 200 ft agl

7.0 NWS Forecasts

The forecasts issued from the NWS Columbia (KCAE), South Carolina, Weather Forecast Office (WFO), which was responsible for weather forecasts, alerts and warning for the Thomas, and Augusta, Georgia areas are documented below, as well as the forecasts available and issued from the Aviation Weather Center (AWC), located in Kansas City, Missouri.

7.1 Terminal Aerodrome Forecast

The NWS does not issue a Terminal Aerodrome Forecast (TAF) for KHQU. The closest TAF to the accident site was issued for the destination alternate airport of KAGS. While a TAF is only valid for a 5-mile radius of the airport, pilots will often refer to the closest TAF for a breakdown of wind, visibility, weather phenomena, and clouds over the region. The conditions forecast at the time the flight departed was issued at 0135 EDT and was valid for a 24-hour period beginning at

²³ Only includes PIREPs which were disseminated through normal weather circuits and do not include reports only broadcast to air traffic controllers via radio and not transcribed into the database.

0200 EDT. The forecast was as follows with the time applicable to the accident in bold italic print from 1-hour prior to until 1-hour after the estimated time of arrival.

TAF KAGS 050535Z 0506/0524 VRB03KT 6SM BR OVC100

TEMPO 0506/0510 2SM BR SCT015

FM051000 00000KT 4SM BR BKN007

TEMPO 0510/0514 2SM -SHRA BR SCT007 BKN015

FM051400 VRB03KT P6SM VCSH SCT035 BKN120

FM051800 11006KT 6SM -SHRA BR SCT035 BKN050

FM052300 00000KT P6SM OVC070=

The forecast from 0200 EDT expected variable winds at 3 knots, visibility 6 miles in mist, ceiling overcast at 10,000 ft agl, with a temporary condition between 0200 and 0600 EDT of visibility 2 miles in mist, scattered clouds at 1,500 ft agl. From 0600 through 1000 EDT, wind calm, visibility 4 miles, ceiling broken at 700 ft agl was forecast.

The TAF was amended at 0440 EDT and became as follows.

AMD TAF KAGS 050840Z 0509/0606 00000KT 3SM BR FEW070 SCT090

TEMPO 0509/0510 2SM BR SCT015

FM051000 00000KT 4SM BR BKN007

TEMPO 0510/0514 2SM -SHRA BR SCT007 BKN015

FM051400 VRB03KT P6SM VCSH SCT035 BKN120

FM051800 11006KT 6SM -SHRA BR SCT035 BKN050

FM052300 00000KT P6SM OVC070=

The amended TAF continued to expect IFR conditions to prevail between 0500 through 1000 EDT.

7.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short-term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF and provide some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The NWS KCAE AFD current at the time of the accident was issued at 0145 EDT and was as follows, with the long-term section excluded.

FXUS62 KCAE 050545

AFDCAE

Area Forecast Discussion

National Weather Service Columbia SC

145 AM EDT Tue Oct 5 2021

..SYNOPSIS...

Unsettled conditions are expected as a deep upper level trough develops over the eastern U.S., resulting in increased moisture and the passage of multiple upper level disturbances.

..NEAR TERM /UNTIL 7 AM THIS MORNING/...

Radar and latest mesoanalysis indicating scattered showers and isolated thunderstorms concentrated along a surface convergence zone, mainly affecting the southern Midlands and CSRA. With minimal upper dynamics this evening, think the convective activity over most of our FA will gradually diminish early tonight with loss of heating. Late tonight, a shortwave rounding the base of the upper closed low to our west, is progged to lift NE towards GA and may provide some shower activity towards our W/NW FA late tonight. Will adjust POPs accordingly.

.SHORT TERM /7 AM THIS MORNING THROUGH WEDNESDAY NIGHT/...

CAMs as well as the synoptic forecast models keep the most significant convective activity to the north and west of The Midlands and CSRA on Tuesday. Will go with scattered showers and isolated thunderstorms.

An upper level low pressure system over the central Mississippi River Valley continues to advect low level moisture into the region Wednesday through Thursday. SBCAPE values of 400-800 J/KG and PW values in excess of 1.5 inches should support scattered to numerous showers and isolated thunderstorms both days. Most locations should see .5 to 1.5 inches of rainfall during this time period with the heaviest amounts in the Western Midlands and Upper CSRA.

.AVIATION /06Z TUESDAY THROUGH SATURDAY/...

Fog and stratus has developed at OGB/AGS with periods of improving visibility. This will continue into sunrise as OGB currently has less mid/upper level cloud coverage and AGS is prone to fog. Closer to daybreak, a low stratus deck looks to move into the CSRA and Midlands, bringing restrictions into each of the other TAF sites. VFR improvement will be slow and intermittent through noon. Rain and thunderstorms possible once again mainly in the afternoon, however thunderstorm activity may be isolated enough to avoid TAF sites. Conditions deteriorating again late tonight.

EXTENDED AVIATION OUTLOOK... Patchy fog or low stratus possible each morning as deeper moisture moves over the region. Numerous showers and isolated thunderstorms possible through Friday.

.CAE WATCHES/WARNINGS/ADVISORIES...

GA...None.

SC...None.

\$\$

SYNOPSIS...

NEAR TERM...

SHORT TERM...

LONG TERM...

AVIATION...

7.3 Graphical Forecast for Aviation

The NWS Graphical Forecast for Aviation (GFA) are graphical depictions of surface wind, predominant precipitation and weather, color coded general flight categories of visibility, and cloud cover bases and tops, with the Graphical-Airmen's Meteorological Information (G-AIRMET)²⁴ for IFR conditions, mountain obscuration, icing conditions, and strong surface wind overlaid for the enroute phase of flight. The GFA is available at the NWS AWC website and through other weather briefing services and are provided every 3-hours out to 18-hours. The GFA

²⁴ AIRman's METeorological Information (AIRMET) is a concise description of weather phenomena that are occurring or may occur (forecast) along an air route that may affect aircraft safety. Compared to SIGMETs, AIRMETs cover less severe weather: moderate turbulence and icing, sustained surface winds of 30 knots or more, low-level wind shear, widespread instrument flight rule conditions due to low ceilings or restricted visibility, or mountain obscuration conditions.

charts issued at approximately 0300 EDT and valid during the period of the accident are included below.

Figure 12 is the GFA Surface Weather Forecast valid for 0500 EDT. Several areas of visibility less than 3 miles were indicated from South Carolina, Georgia, Alabama, and the Florida panhandle to the north and west of the accident site with light winds. Numerous thunderstorms and rain were expected over central and western Georgia, Alabama, and the Florida panhandle (indicated by dark red symbol). A Graphic-AIRMET (G-AIRMET) for IFR conditions expected over the region and enclosed the accident site due to fog.

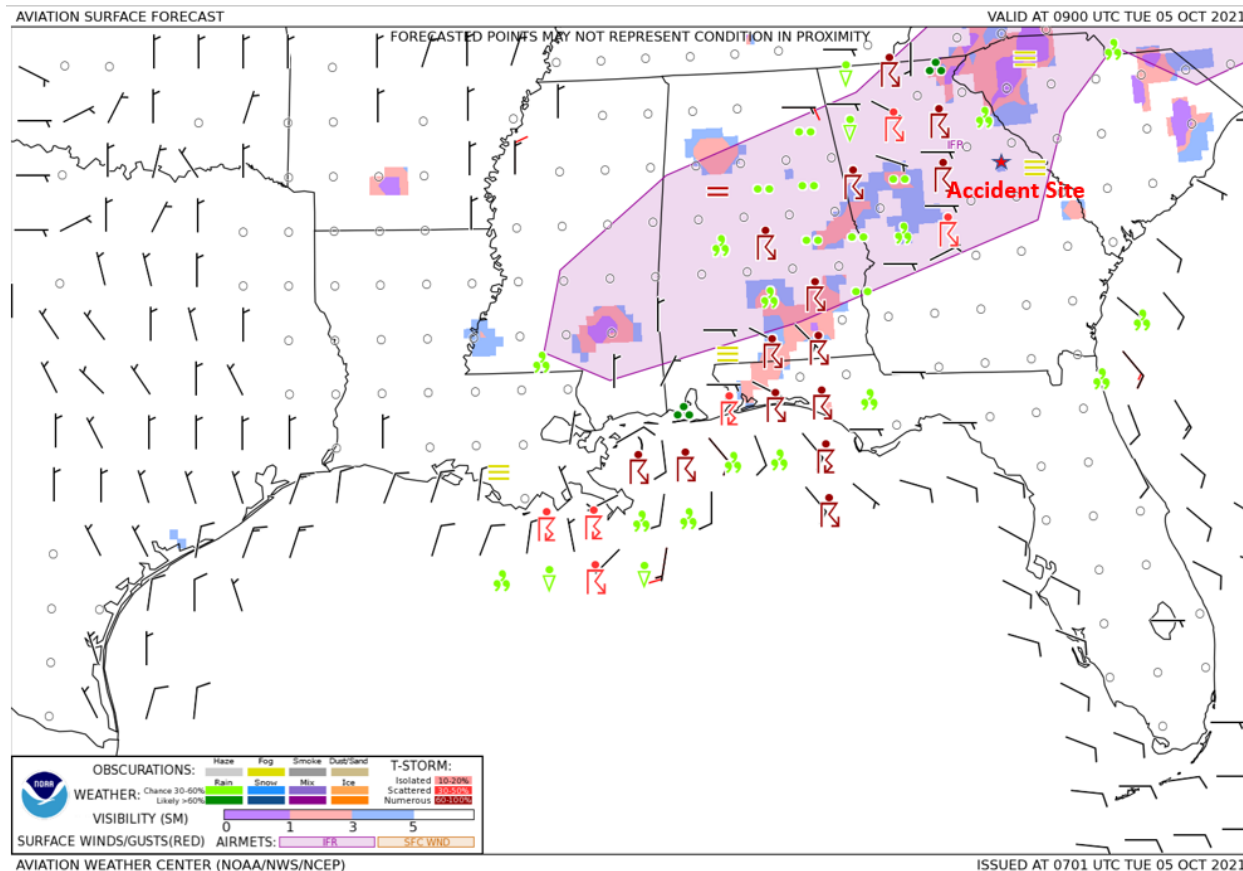


Figure 12 - GFA Surface Forecast valid for 0500 EDT with the approximate accident site noted.

The accompanying GFA Cloud Forecast valid for 0500 EDT is included as figure 13, with the approximate accident site also noted. The region from western South Carolina, across Georgia, Alabama, into the Florida panhandle indicated a significant area of broken to overcast clouds, which extended over the accident site. A broken layer of clouds at 1,000 ft msl layered to 38,000 ft²⁵, with cirrus type clouds above was indicated over the accident site. A G-AIRMET for icing (blue) extended over central Georgia west of the accident site. A G-AIRMET for mountain obscuration (pink) extended over northern Georgia, western South Carolina and North Carolina and extended north of the accident site.

²⁵ Chart provides cloud tops above 18,000 ft as “flight levels” or FL180, which provide cloud heights in hundreds of feet above msl.

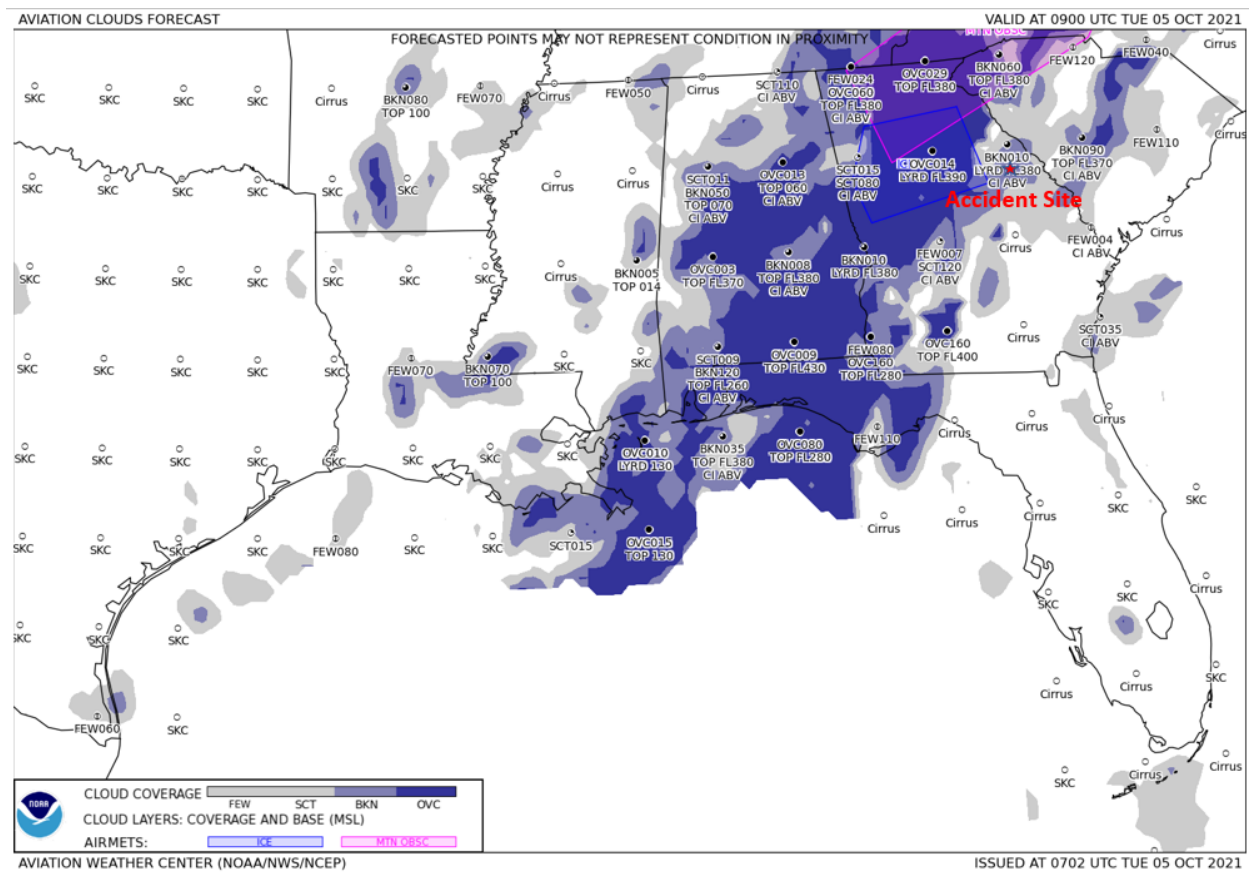


Figure 13 - GFA Cloud Forecast valid for 0500 EDT with the accident site noted.

7.4 Winds and Temperatures Aloft Forecast

The Winds and Temperature Aloft Forecast current at the time was issued at 0359 EDT and valid for use between 0400 and 1100 EDT. The forecast for the region was as follows.

```
FBUS31 KWN0 050759
FD1US1
DATA BASED ON 050600Z
VALID 051200Z FOR USE 0800-1500Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000
ATL 1519 1718+12 1817+07 1719+01 1823-10 2026-21 213238 234449 236361
CSG 2020 1821+12 1822+07 1622+02 1828-10 2026-21 212337 223248 225261
SAV 1414 1611+14 1713+09 1716+04 1918-10 2221-20 242836 243547 253057
CAE 1611 1708+13 1712+08 1714+03 2013-10 1915-21 232837 264148 243157
CHS 1415 1711+14 1810+09 1913+04 2115-10 2124-21 252936 263347 243257
GSP 1610 1913+12 1915+07 2016+02 2021-11 2123-22 213238 234449 254257
```

The point forecast locations in Georgia were for Atlanta (ATL), Columbus (CSG), and Savannah (SAV), and over South Carolina were for Columbia (CAE), Charleston (CHS), and Greer (GSP). While enroute to the destination, the accident aircraft passed south of ATL at 35,000 ft, the forecast for 34,000 ft indicated a wind from 230° at 34 knots with a temperature of -49° C.

The closest station to KHQU was for CAE located approximately 74 miles east-northeast of the accident site. The forecast for CAE for 3,000 ft expected a wind from 160° at 11 knots.

8.0 NWS Inflight Weather Advisories

Inflight Aviation Weather Advisories are forecasts to advise en route aircraft of development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) associated with FAA air route traffic control centers (ARTCCs). There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the Airmen's Meteorological Information (AIRMET), and the Center Weather Advisory (CWA). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

During the period, the NWS AWC had several Convective SIGMETs over eastern Alabama and Georgia over the general route of flight and another advisory immediately north of the accident site over northern Georgia and South Carolina, which did not extend over the accident site. Figure 14 is a depiction of the Convective SIGMETs 48E and 50E over the GOES-16 infrared satellite image for 0456 EDT. The NWS AWC also had several Graphic-AIRMETs current for IFR conditions and for moderate icing conditions between 13,000 ft and 26,000 ft over Georgia, which are shown in figure 15.

The NWS Atlanta CWSU had just opened²⁶ and issued a CWA for LIFR conditions in dense fog immediately after the accident for a region over Tennessee, South Carolina, and North Carolina well to the north of the accident site.

²⁶ The NWS CWSU hours of service are typically between 0500 to 2100 local time and may be adjusted by local agreements between the facility management and the Meteorologist-In-Charge.

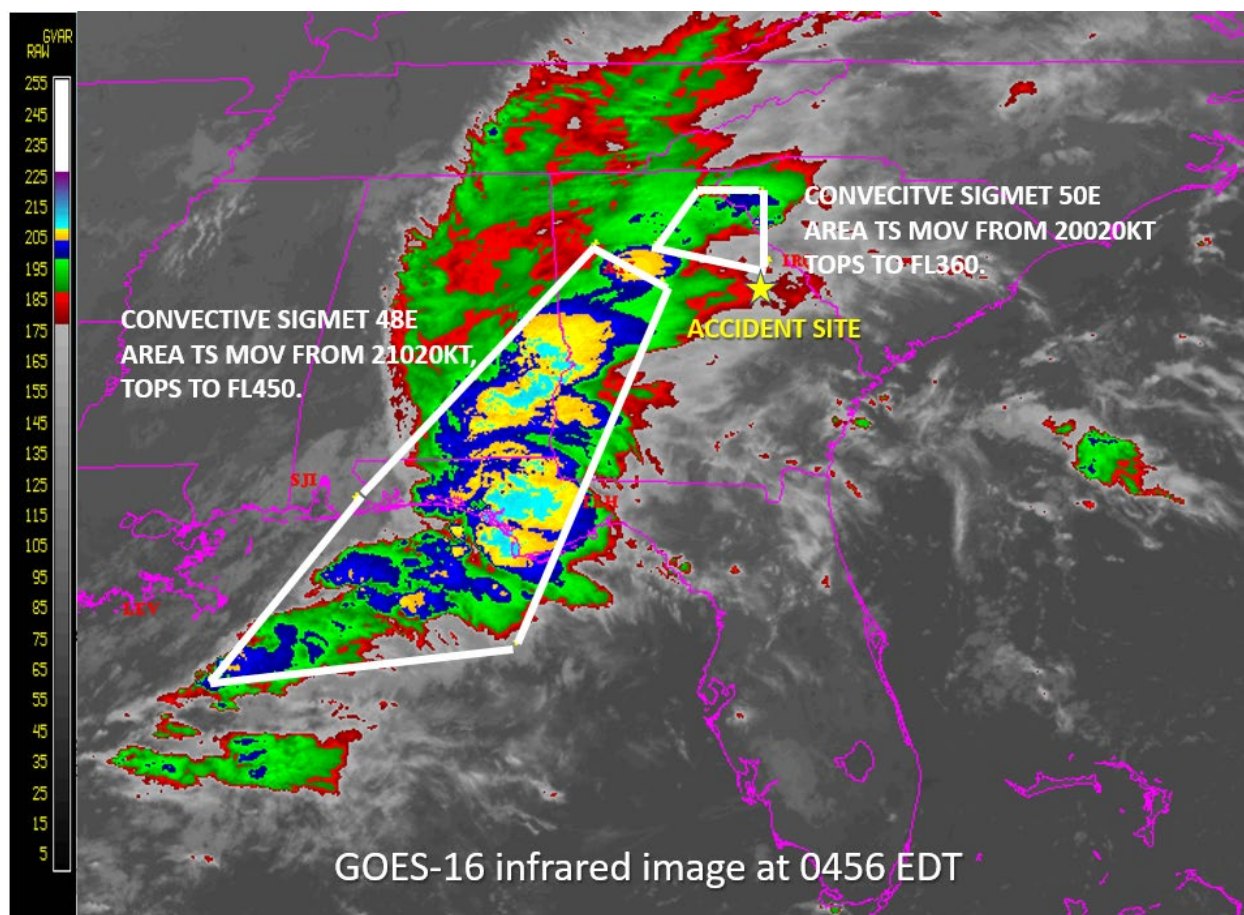


Figure 14 - GOES-16 infrared image at 0456 EDT with Convective SIGMETs 48E/50E overlaid.

The text of the Convective SIGMETs current for the period were as follows.

WSUS31 KPCI 050855
SIGE
MKCE WST 050855
CONVECTIVE SIGMET 48E
VALID UNTIL 1055Z
FL GA AL AND FL AL MS LA CSTL WTRS
FROM 30NW ATL-30ESE ATL-120SSW TLH-80SE LEV-40ESE SJI-30NW ATL
AREA TS MOV FROM 21020KT. TOPS TO FL450.

CONVECTIVE SIGMET 50E
VALID UNTIL 1055Z
SC GA
FROM 10W ODF-30E ODF-20W IRQ-30NE ATL-10W ODF
AREA TS MOV FROM 20020KT. TOPS TO FL360.

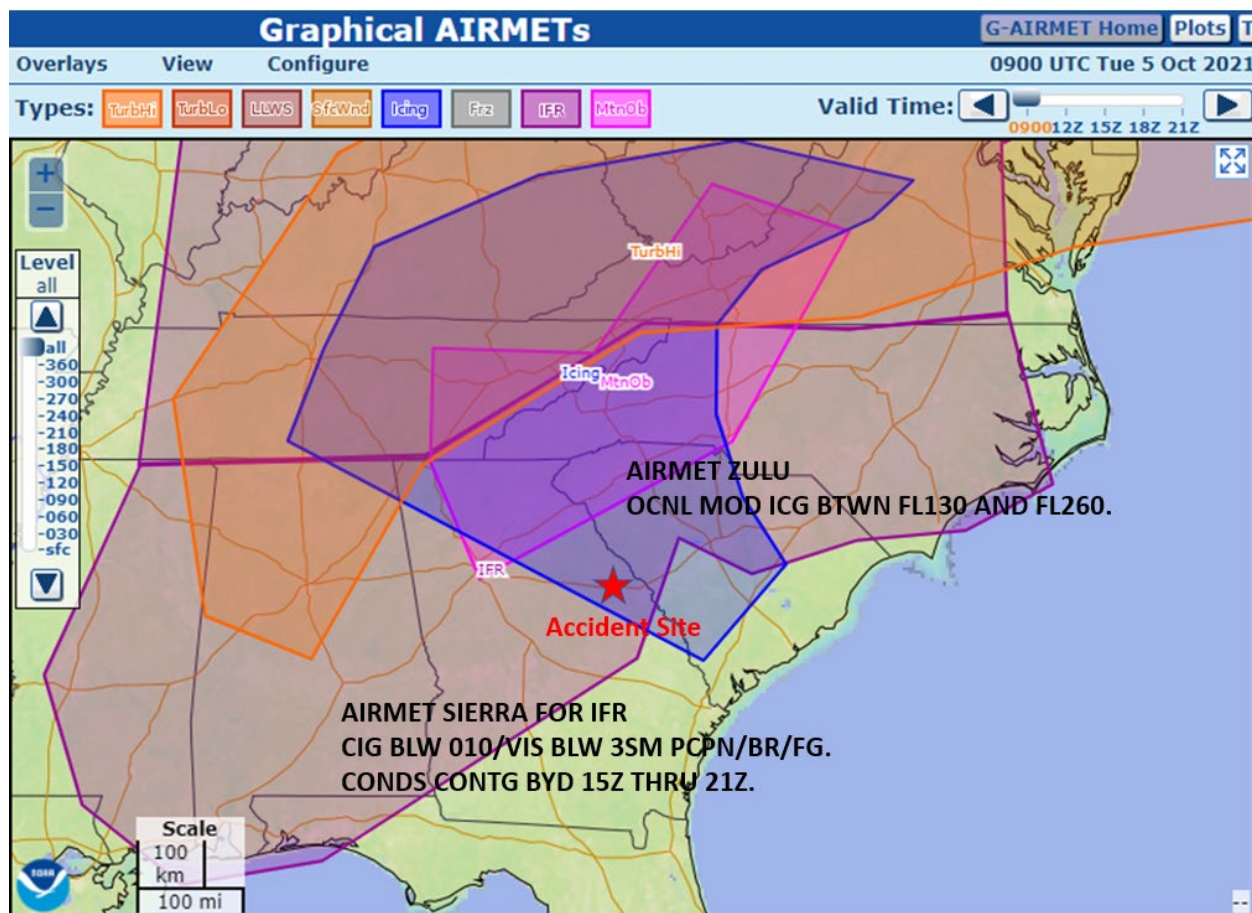


Figure 15 - Graphic-AIRMETS current over the southeast at 0500 EDT.

9.0 Pilot Preflight Weather Briefing

A search of the FAA contract Flight Service Station provider Leidos and 3rd party vendors using the Leidos Flight Service system showed that none had any contact or provided any service with N283SA on the day of the accident. A review of records from ForeFlight indicated that the copilot had an account with the company and while he did not request any formal weather document for the accident flight, the copilot did access their system and created a route string from KLBB to KHQU, and he had visited the individual airport pages for KLBB, KELP, KTCL, KTUL, and KHQU. The airport page includes information similar to the airport facility directory and provides a diagram of the airport, abbreviated NOTAMs²⁷ for that station, airport and approach and departure frequencies, as well as METARs, TAFs (if available), and the winds aloft data. While it is known the copilot accessed certain airports, it is unknown what data he reviewed. There was no record of the copilot reviewing any other weather imagery available on that site. In summary, there was no record of the captain of the accident flight having accessed any weather information regarding the flight. While the copilot did refer to ForeFlight for basic airport information, he did not specifically request a route briefing. It is therefore unknown, what specific

²⁷ NOTAM – refers to notice to airmen.

weather data either of the pilots may have reviewed prior to departure, or enroute on the accident flight.

10.0 Astronomical Data

The astronomical conditions were calculated using the United States Naval Observatory's Multiyear Interactive Computer Alamac (MICA) software for Thomas, Georgia. The time of the accident has been added for reference in italic bold type.

<i>Accident</i>	<i>0544 EDT</i>
Moonrise	0622 EDT
Begin civil twilight	0702 EDT
Sunrise	0727 EDT

At 0546 EDT the Moon was about 6° below the horizon and the Sun was more than 20° below the horizon, and dark nighttime conditions prevailed at the time of the accident.

E. Attachments

Attachment 1 – ForeFlight documentation.

Submitted by:

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Senior Meteorologist