



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 5, 2016

Group Chairman's Weather Study Report

METEOROLOGY

ERA15FA173

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A. ACCIDENT

Location: 3 miles northeast of Saucier, Mississippi
Date: March 30, 2015
Time: approximately 1537 central daylight time (2037 UTC¹)
Aircraft: Bell 206L-1, registration: N50KH

B. METEOROLOGY GROUP

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C. SUMMARY

For a summary of the accident, please see the *NTSB factual report*, which is available in the docket for this investigation.

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 central daylight time (CDT) on March 30, 2015, and are based upon the 24-hour clock, where local time is -5 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 30.67° N, longitude 89.09° W, elevation: 205 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 Weather Prediction Center (WPC) 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 1600 CDT is provided as figure 1 with the approximate location of the accident site marked. The chart depicted a cold front north of the accident site stretched from west to east from eastern Oklahoma through central Mississippi and eastward into southern North Carolina. A surface high pressure center with a pressure of 1020-hectopascals (hPa) was located in western Tennessee and another surface high pressure center with a pressure of 1024 hPa was located in the northeastern Gulf of Mexico. The station models around the accident site depicted air temperatures in the upper 70’s to low 80’s Fahrenheit (F), with temperature-dew point spreads of 15° F or more, a southwest wind between 5 and 15 knots south of the cold front and a north to west wind north and along the cold front between 5 and 10 knots, and most clear skies. The surface wind converging near the accident site around the location of the cold front could have acted as a lifting mechanism to help produce clouds and precipitation. This lifting mechanism would need to be supported by mid-level unstable air or other lifting mechanisms (section 1.2) for widespread clouds and precipitation.

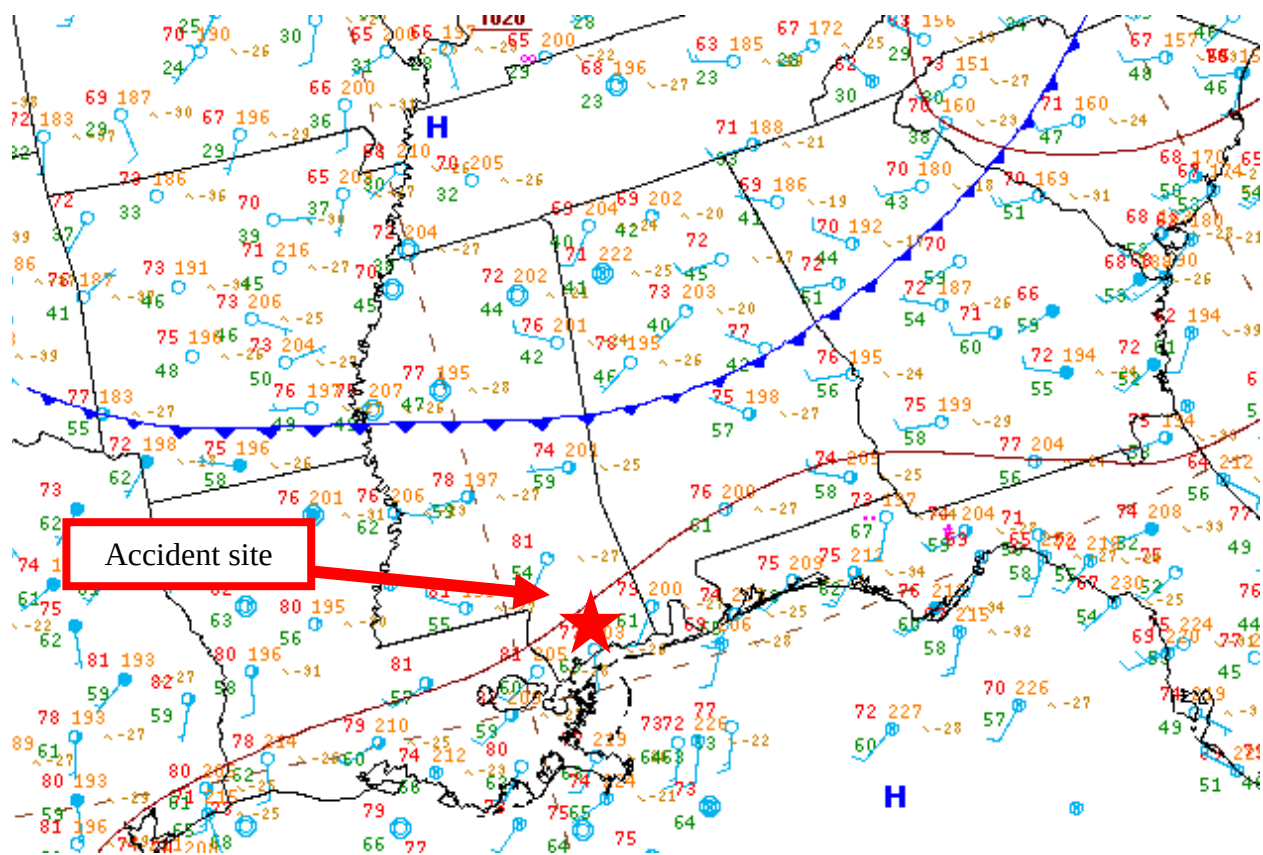


Figure 1 – NWS Surface Analysis Chart for 1600 CDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1900 CDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. The upper air charts do not indicate an environment favorable for widespread clouds and precipitation with no large scale mid-level troughs² moving eastward across the accident site around the accident time. The 925- and 850-hPa charts depicted a west wind of 15 to 25 knots with that wind increasing in speed to over 70 knots by 300-hPa with the wind direction from the northwest. The mid- and upper-level environment was not conducive for widespread clouds and precipitation near the accident site at the accident time.

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

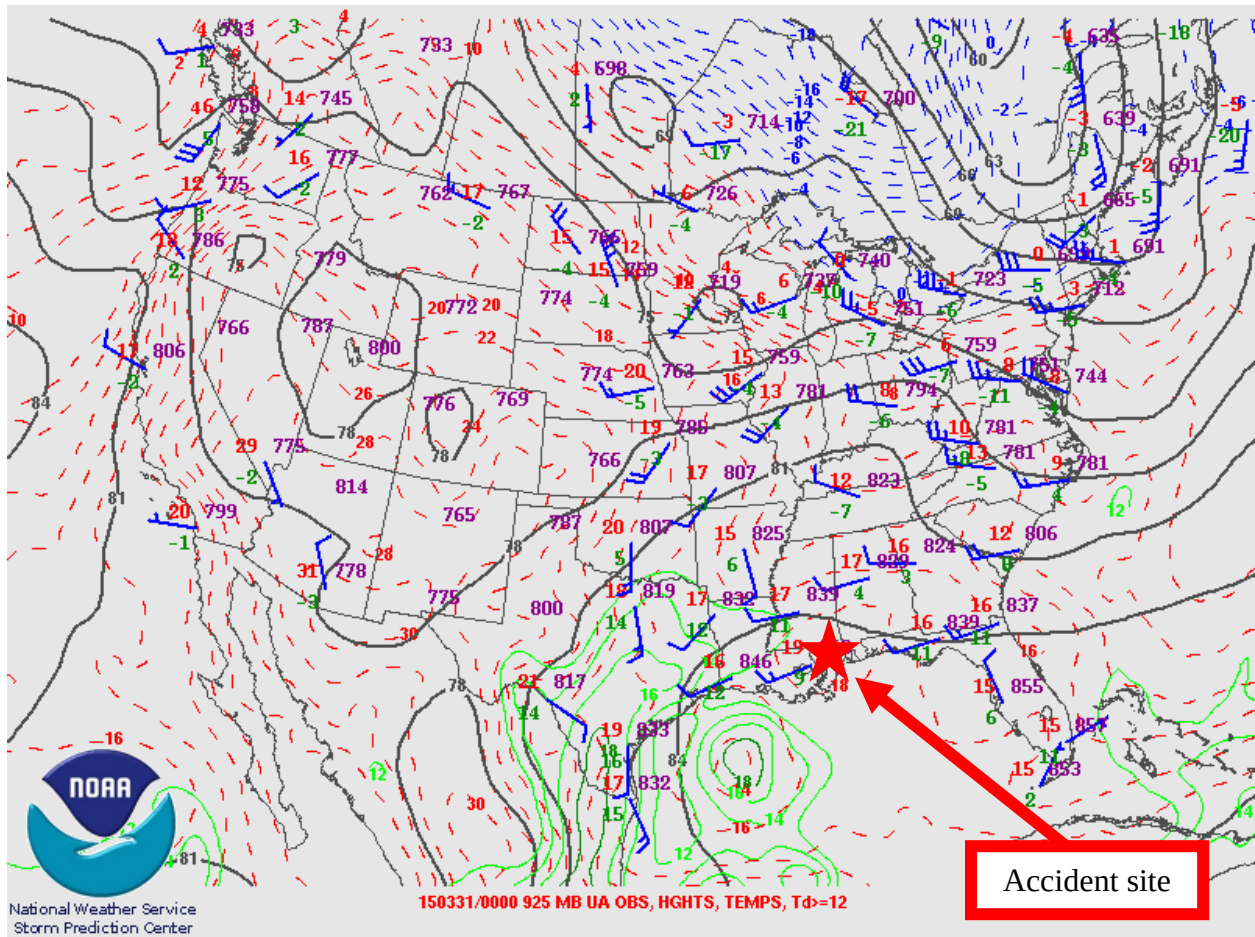


Figure 2 – 925-hPa Constant Pressure Chart for 1900 CDT

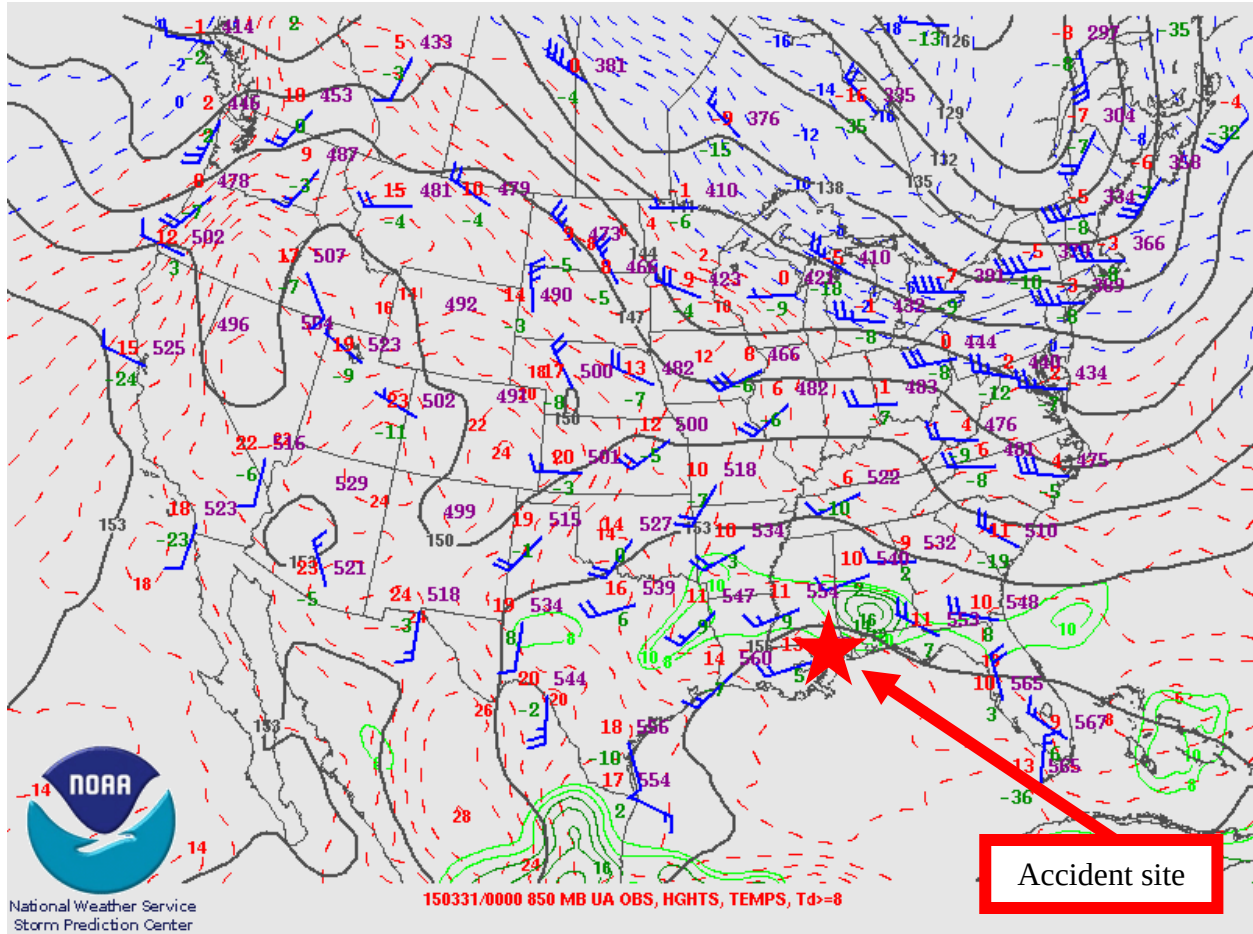


Figure 3 – 850-hPa Constant Pressure Chart for 1900 CDT

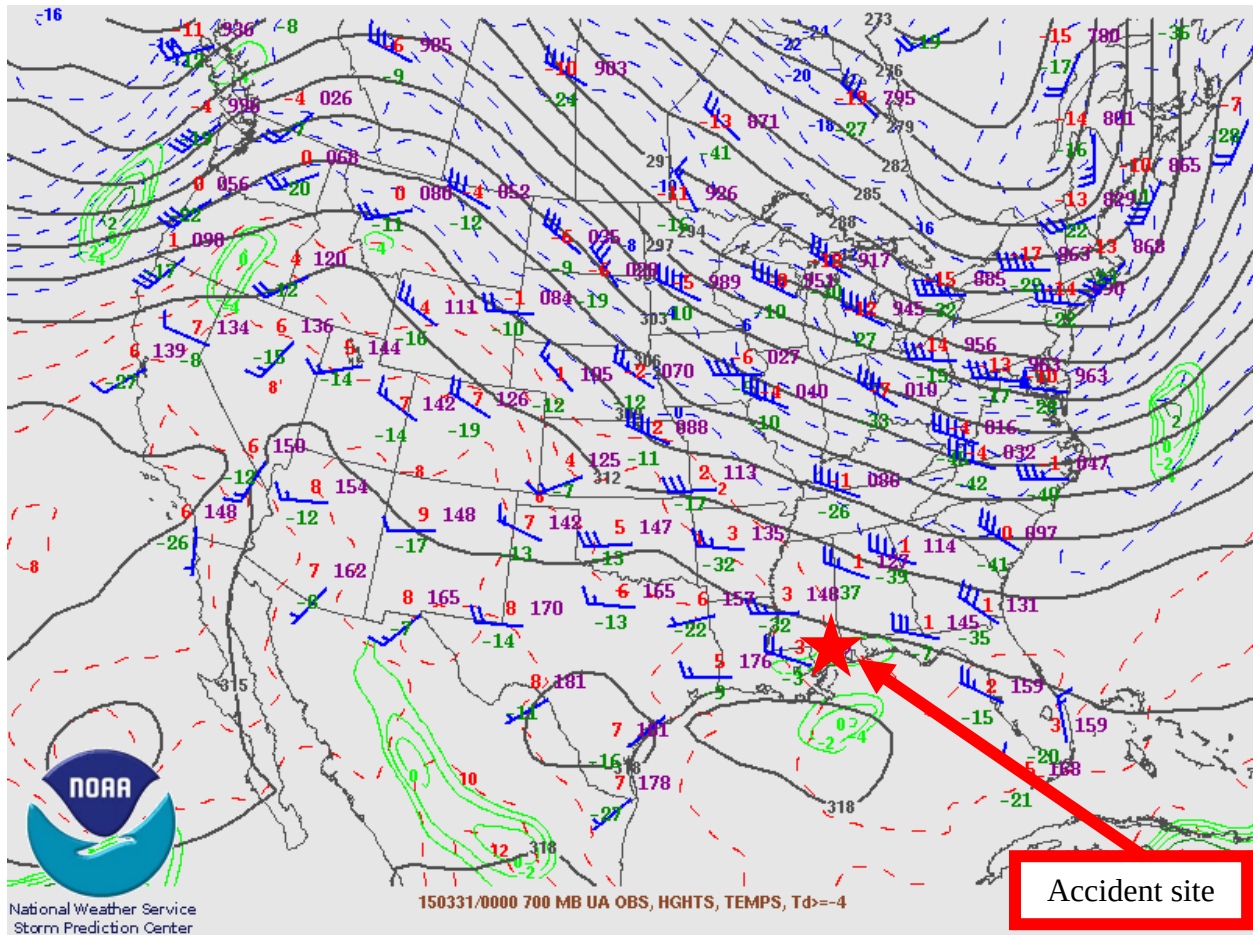


Figure 4 – 700-hPa Constant Pressure Chart for 1900 CDT

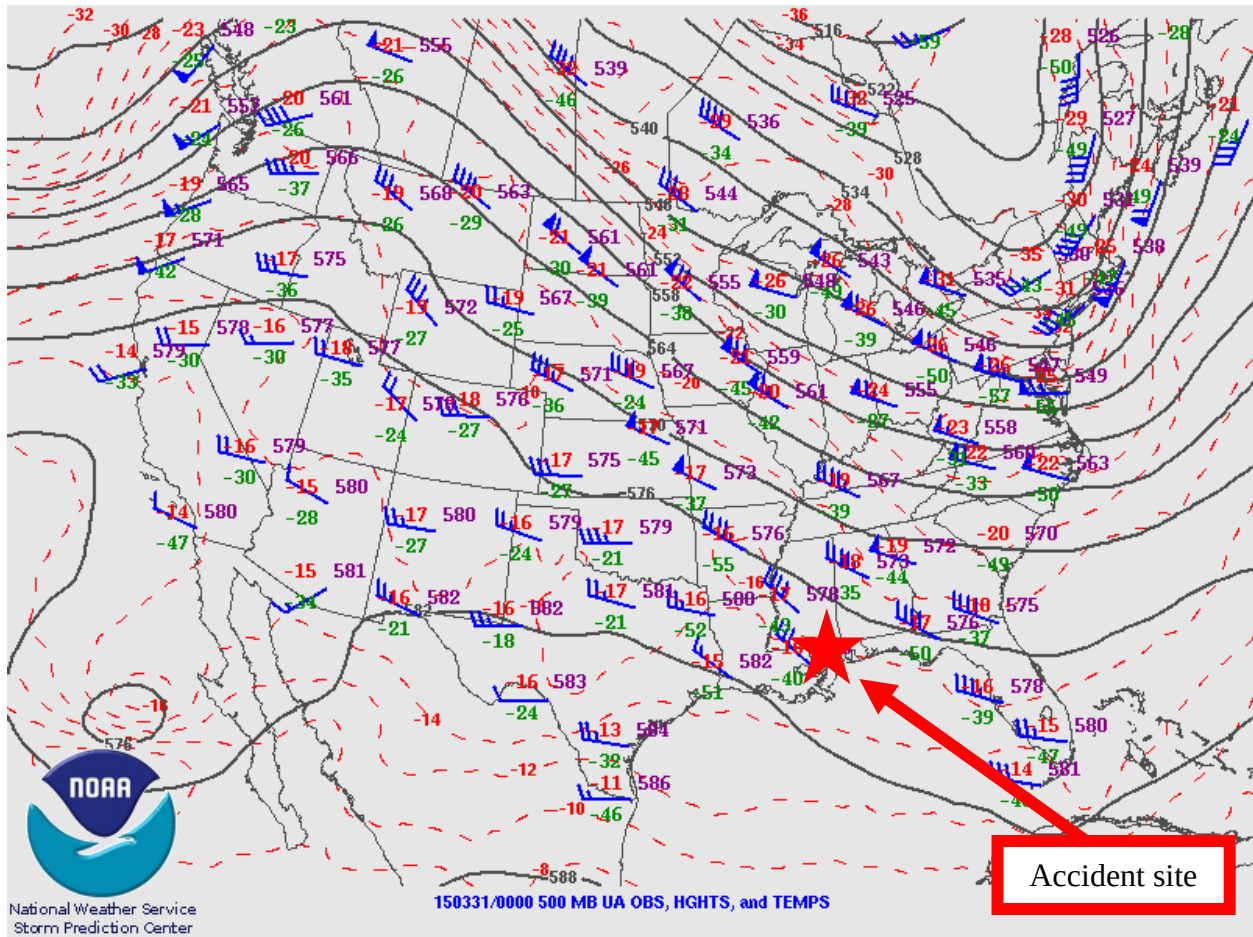


Figure 5 – 500-hPa Constant Pressure Chart for 1900 CDT

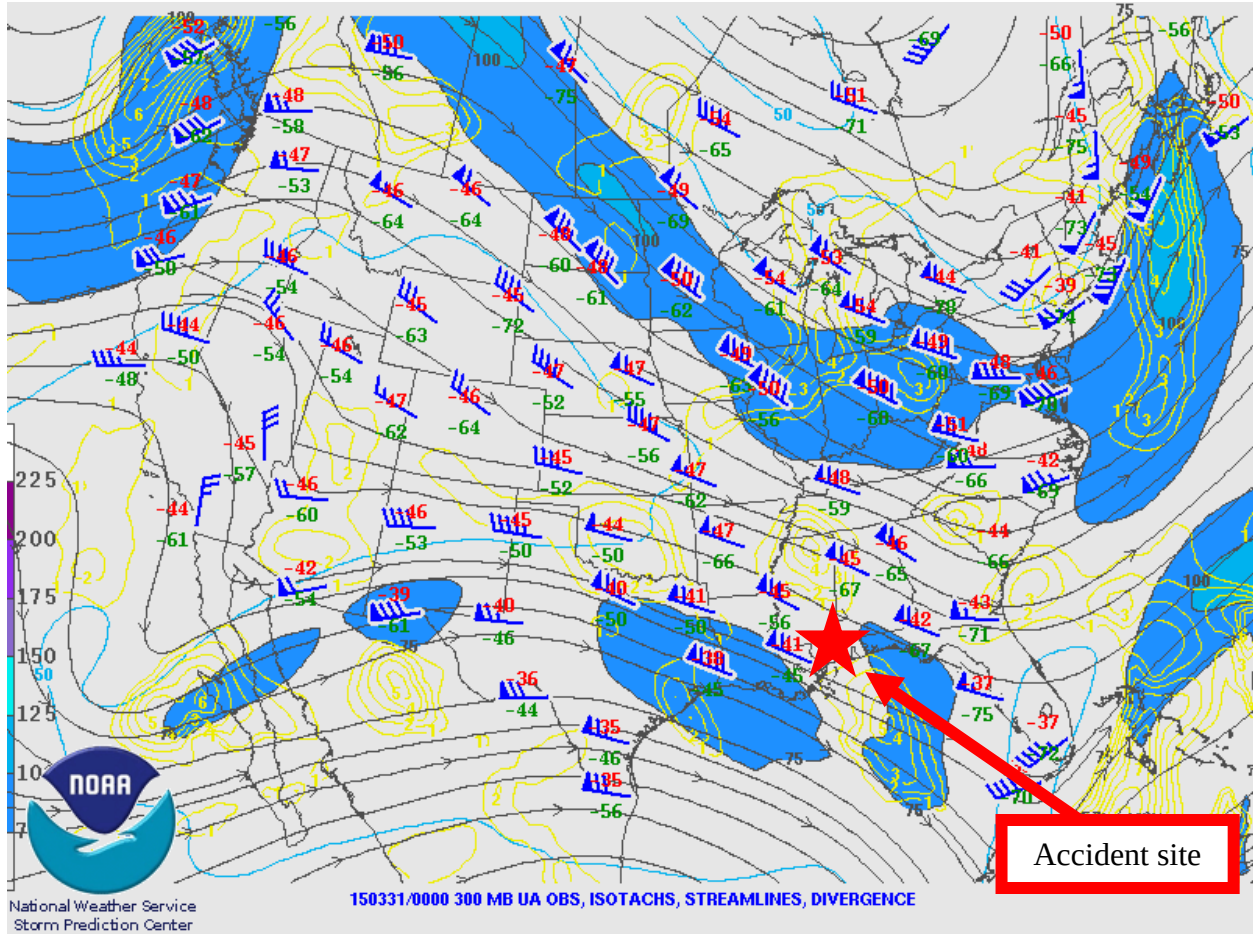


Figure 6 – 300-hPa Constant Pressure Chart for 1900 CDT

2.0 Storm Prediction Center Products

SPC issued the following Day 1 Convective Outlook at 1445 CDT (figure 7) with areas of thunderstorms forecasted for the accident site with the chance for severe thunderstorms remaining east of the accident site:

SPC AC 301945

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
0245 PM CDT MON MAR 30 2015

VALID 302000Z - 311200Z

...THERE IS A MRGL RISK OF SVR TSTMS FROM SRN AL INTO THE FL
PANHANDLE...

...SUMMARY...

AN ISOLATED SEVERE THUNDERSTORM OR TWO WILL BE POSSIBLE THIS
AFTERNOON ACROSS PORTIONS OF SOUTHWEST GEORGIA...SOUTHERN
ALABAMA...AND THE FLORIDA PANHANDLE.

...SERN U.S...

EARLIER THOUGHTS REGARDING SEVERE THREAT ACROSS THE SERN U.S. REMAIN. WEAK BUOYANCY...BUT STEEP LOW-LEVEL LAPSE RATES EXTEND ACROSS SRN AL INTO THE FL PANHANDLE. SCT TSTMS HAVE DEVELOPED ALONG A NARROW CORRIDOR ACROSS THE NRN FL PANHANDLE AND THIS ACTIVITY SHOULD SPREAD SEWD INTO A MORE STABLE REGIME SHORTLY. OTHER SHOWERS ARE DEVELOPING UPSTREAM ACROSS SERN GA AND ISOLATED MARGINAL SEVERE TSTMS REMAIN POSSIBLE ACROSS THIS REGION.

..DARROW.. 03/30/2015

.PREV DISCUSSION... /ISSUED 1117 AM CDT MON MAR 30 2015/

...SWRN GA...SRN AL...FL PANHANDLE...

WATER VAPOR LOOPS INDICATE THE SRN EXTENT OF ASCENT ATTENDANT TO AN ERN-CONUS SHORTWAVE TROUGH GLANCING PARTIALLY MODIFIED GULF MOISTURE /LOWER 60S SFC DEWPOINTS/ EXTENDING FROM PARTS OF E TX TO SRN AL AND THE FL PANHANDLE. DEEP WLY/WNWLY FLOW SAMPLED BY AREA VWPS WILL BE PROHIBITIVE OF SUBSTANTIAL POLEWARD FLUXES OF RICHER MOISTURE...AND 12Z RAOBS INDICATE THAT DEEPER MOISTURE IS LACKING /PW VALUES GENERALLY AOB 1 INCH/. REGARDLESS...MODEST FRONTAL CONVERGENCE AT THE NRN EXTENT OF THE MODIFIED-GULF-MOISTURE ZONE COUPLED WITH DIURNAL HEATING MAY ENCOURAGE CONVECTIVE DEVELOPMENT AS THE AFOREMENTIONED ASCENT GLANCES THE REGION AND INTERACTS WITH BACKGROUND DIURNALLY STRENGTHENING BAROCLINIC CIRCULATIONS. HOWEVER...ONLY MODEST LOW-LEVEL CONVERGENCE AND THE LACK OF RICHER DEEP MOISTURE MAY BE HOSTILE FOR THE SUSTENANCE OF DEEP UPDRAFTS. NEVERTHELESS...12Z JAN/LIX RAOBS SAMPLE H7-H5 LAPSE RATES AROUND 7-8 C/KM SUGGESTING THAT UPDRAFT ACCELERATIONS MAY BE ENHANCED IN THE PRESENCE OF 25-40 KT OF EFFECTIVE BULK SHEAR TO SUPPORT A FEW STRONGER STORMS. LONG...STRAIGHT HODOGRAPHS THROUGH THE CLOUD LAYER MAY SUPPORT SPLITTING CELLS WITH LOCALIZED STRONG WIND GUSTS AND HAIL...POSSIBLY REACHING SVR THRESHOLDS ON AN ISOLATED BASIS.

...ELSEWHERE...

ISOLATED DIURNALLY ENHANCED TSTMS MAY AFFECT PORTIONS OF THE SRN ROCKIES AND VICINITY INTO SERN AZ WITHIN THE WARM CONVEYOR PRECEDING A MIGRATORY MIDLEVEL CYCLONE OFF THE BAJA CA COAST. ISOLATED TSTMS MAY ALSO OCCUR TONIGHT NEAR AND N OF THE RED RIVER VALLEY OF THE SOUTH IN RESPONSE TO WEAK WAA ALONG A NOCTURNALLY STRENGTHENING LLJ -- ALBEIT ACCOMPANIED BY ONLY MODEST MASS FLUXES. A FEW TSTMS MAY ALSO AFFECT THE PACIFIC NW COAST TONIGHT AS A SHORTWAVE TROUGH APPROACHES. AN ISOLATED TSTM OR TWO MAY AFFECT LOWER MI AND NRN OH LATE TONIGHT AS FORCING FOR ASCENT IN THE EXIT REGION OF A MIDLEVEL SPEED MAX CROSSES THE REGION...THOUGH A DEARTH OF MOISTURE AND PAUCITY OF BUOYANCY WILL LIKELY LIMIT SUCH POTENTIAL. SEVERE THUNDERSTORMS ARE NOT EXPECTED.

CLICK TO GET WUUS01 PTSDY1 PRODUCT

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

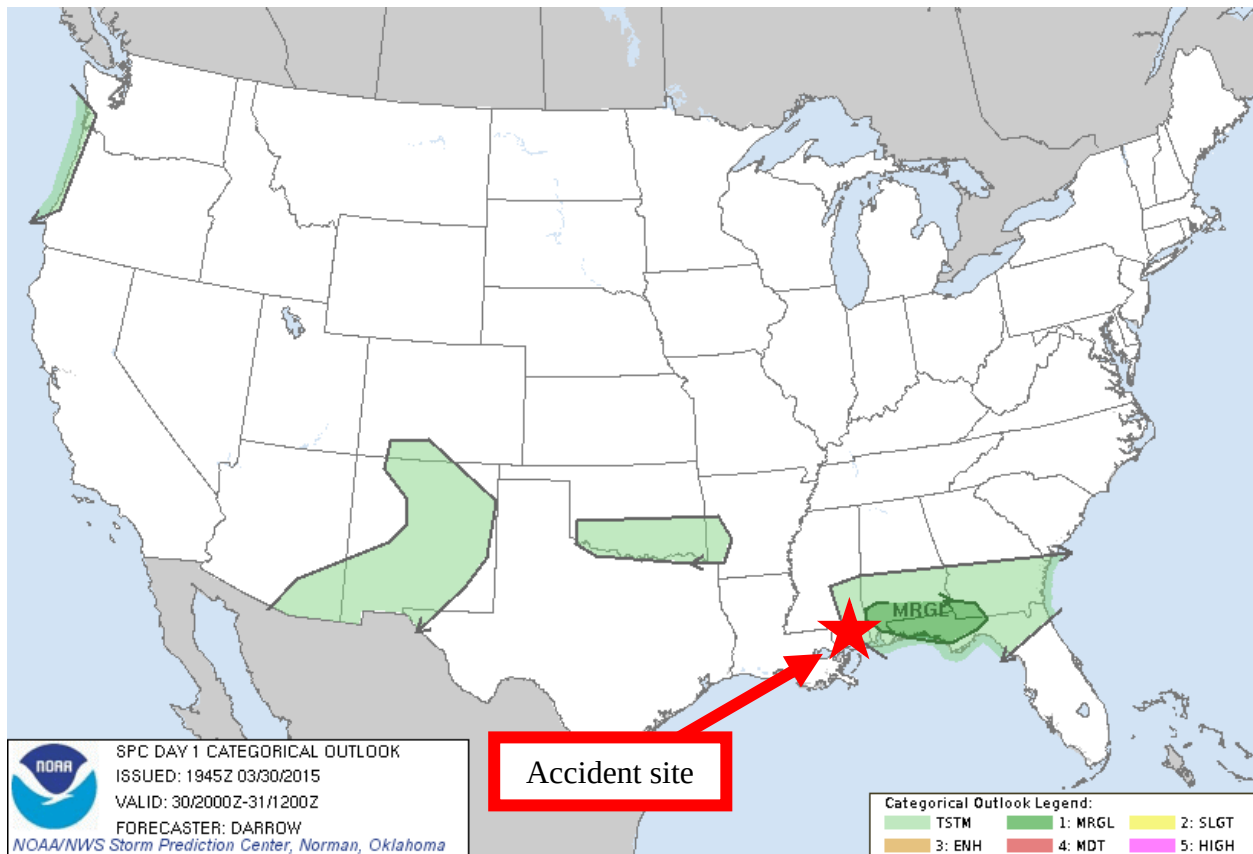


Figure 7 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

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.

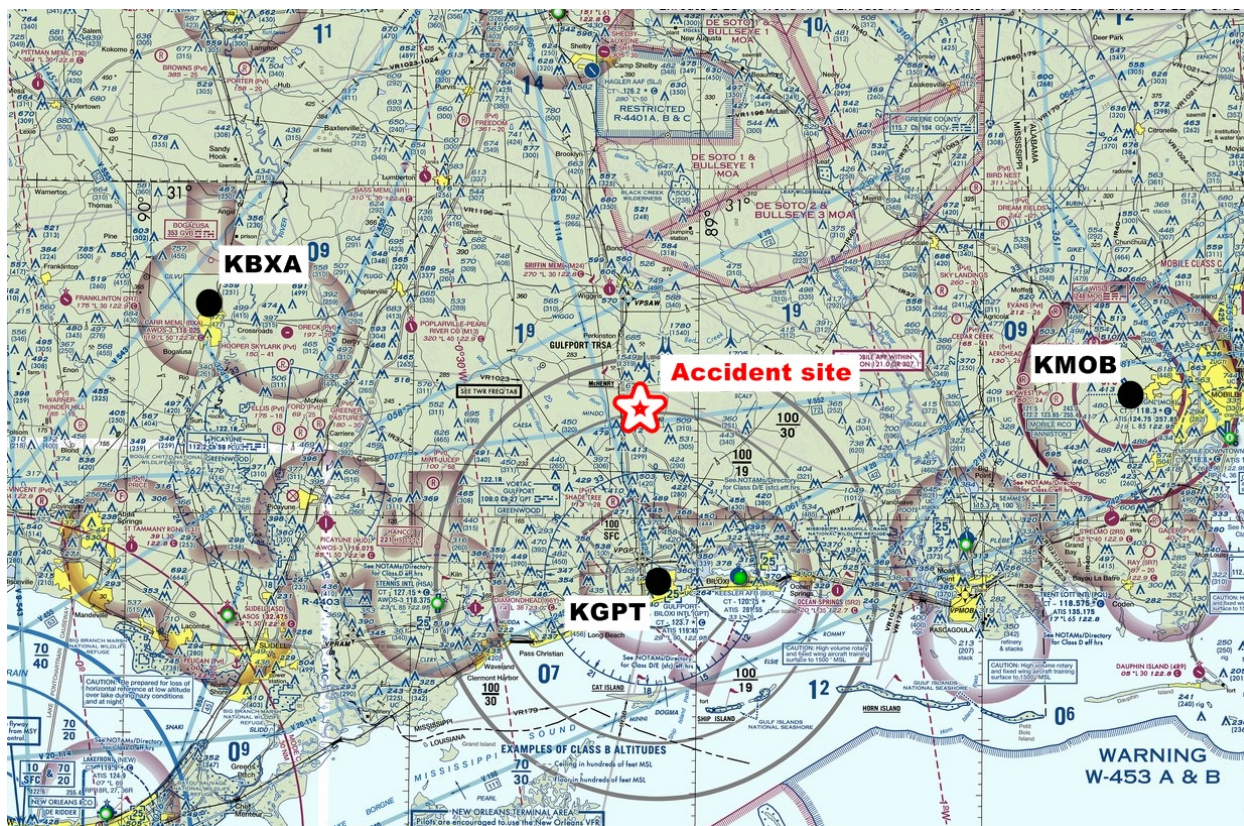


Figure 8 – Map of Mississippi and Alabama with the location of the accident site, surface observation sites, and weather radar

Gulfport-Biloxi International Airport (KGPT) was the closest official weather station to the accident site. KGPT was located 3 miles northeast of Gulfport, Mississippi, and had an Automated Surface Observing System (ASOS³) whose reports were supplemented by the tower air traffic control. KGPT was located 16 miles south-southeast of the accident site, at an elevation of 29 feet, and had a 2° easterly magnetic variation (figure 8). The following observations were taken and disseminated during the times surrounding the accident: ⁴

[0953 CDT] KGPT 301453Z 28007KT 10SM FEW060 24/17 A3024 RMK AO2
SLP241 T02390167 50007 \$=

[1053CDT] KGPT 301553Z 25009G19KT 10SM BKN035 BKN044 BKN050 24/16
A3025 RMK AO2 SLP241 T02440161 \$=

[1153 CDT] KGPT 301653Z 20008KT 10SM BKN035 BKN060 24/17 A3023
RMK AO2 SLP234 T02440172 \$=

³ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁴ 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.

**[1253 CDT] KGPT 301753Z AUTO 18010KT 10SM SCT039 SCT049 BKN065
25/17 A3021 RMK AO2 SLP230 T02500172 10250 20156 58011 \$=**

**[1353 CDT] KGPT 301853Z 18010KT 10SM FEW040 SCT050 BKN080 24/17
A3019 RMK AO2 SLP221 T02440172=**

ACCIDENT TIME 1435 CDT

**[1453 CDT] KGPT 301953Z 20009G21KT 10SM CLR 26/17 A3015 RMK AO2
SLP210 T02610167=**

**[1553 CDT] KGPT 302053Z 19010G16KT 170V230 10SM CLR 25/17 A3013
RMK AO2 SLP203 T02500172 56026=**

**[1653 CDT] KGPT 302153Z 19009G15KT 10SM CLR 25/18 A3012 RMK AO2
SLP198 T02500178=**

**[1753 CDT] KGPT 302253Z 19010KT 10SM CLR 24/18 A3011 RMK AO2 SLP196
T02390178=**

**[1853 CDT] KGPT 302353Z 20005KT 10SM CLR 23/18 A3011 RMK AO2 SLP194
T02330178 10261 20233 56009=**

**[1953 CDT] KGPT 310053Z VRB05KT 10SM CLR 23/18 A3011 RMK AO2 SLP197
T02280178=**

KGPT weather at 1253 CDT, wind from 180° at 10 knots, 10 miles visibility, scattered clouds at 3,900 feet above ground level (agl), scattered clouds at 4,900 feet agl, a broken ceiling at 6,500 feet agl, temperature of 25° Celsius (C), dew point temperature of 17° C, and an altimeter setting of 30.21 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1023.0 hPa, temperature 25.0° C, dew point temperature 17.2° C, 6-hourly maximum temperature of 25.0° C, 6-hourly minimum temperature of 15.6° C, 3-hourly pressure decrease of 1.1 hPa, maintenance is needed on the system.

KGPT weather at 1353 CDT, wind from 180° at 10 knots, 10 miles visibility, few clouds at 4,000 feet agl, scattered clouds at 5,000 feet agl, a broken ceiling at 8,000 feet agl, temperature of 24° C, dew point temperature of 17° C, and an altimeter setting of 30.19 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1022.1 hPa, temperature 24.4° C, dew point temperature 17.2° C.

KGPT weather at 1453 CDT, wind from 200° at 9 knots with gusts to 21 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 26° C, dew point temperature of 17° C, and an altimeter setting of 30.15 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1021.0 hPa, temperature 26.1° C, dew point temperature 16.7° C.

KGPT weather at 1553 CDT, wind from 190° at 10 knots with gusts to 16 knots, wind varying between 170° and 230°, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 25° C, dew point temperature of 17° C, and an altimeter setting of 30.13 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1020.3 hPa, temperature 25.0° C, dew point temperature 17.2° C, 3-hourly pressure decrease of 2.6 hPa.

George R Carr Memorial Air Field (KBXA) was the closest official site north of the accident site, located 2 miles north of Bogalusa, Louisiana, and had an Automated Weather Observing System (AWOS⁵) whose reports were not supplemented. KBXA was located 41 miles west-northwest of the accident site, at an elevation of 119 feet, and had a 0° westerly magnetic variation (figure 8). The following observations were taken and disseminated during the times surrounding the accident:

[1315 CDT] KBXA 301815Z AUTO 29008KT 10SM 27/14 A3022 RMK AO2 T02680144=

[1335 CDT] KBXA 301835Z AUTO 28008KT 10SM 27/13 A3021 RMK AO2 T02720132=

[1355 CDT] KBXA 301855Z AUTO 26007KT 220V300 10SM 28/14 A3020
RMK AO2 T02840137=

[1415 CDT] KBXA 301915Z AUTO 24005KT 10SM 29/13 A3019 RMK AO2 T02850127=

**[1435 CDT] KBXA 301935Z AUTO 25010G15KT 10SM 28/12 A3018 RMK AO2
T02840118=**

ACCIDENT TIME 1435 CDT

**[1455 CDT] KBXA 301955Z AUTO 26010G14KT 10SM 29/12 A3017 RMK AO2
T02890117=**

**[1515 CDT] KBXA 302015Z AUTO 30007G14KT 10SM 28/11 A3016 RMK AO2
T02770111=**

[1535 CDT] KBXA 302035Z AUTO 27008KT 10SM 29/12 A3016 RMK AO2 T02890115=

[1555 CDT] KBXA 302055Z AUTO 27008KT 250V320 10SM 30/12 A3014
RMK AO2 T02950116=

[1615 CDT] KBXA 302115Z AUTO 28010KT 10SM 29/12 A3014 RMK AO2 T02920117=

[1635 CDT] KBXA 302135Z AUTO 24008KT 10SM 28/11 A3013 RMK AO2 T02830112=

⁵ 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.

KBXA weather at 1415 CDT, wind from 240° at 5 knots, 10 miles visibility, temperature of 29° C, dew point temperature of 13° C, and an altimeter setting of 30.19 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 28.5° C, dew point temperature 12.7° C.

KBXA weather at 1435 CDT, wind from 250° at 10 knots with gusts to 15 knots, 10 miles visibility, temperature of 28° C, dew point temperature of 12° C, and an altimeter setting of 30.18 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 28.4° C, dew point temperature 11.8° C.

KBXA weather at 1455 CDT, wind from 260° at 10 knots with gusts to 14 knots, 10 miles visibility, temperature of 29° C, dew point temperature of 12° C, and an altimeter setting of 30.17 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 28.9° C, dew point temperature 11.7° C.

KBXA weather at 1515 CDT, wind from 300° at 7 knots with gusts to 14 knots, 10 miles visibility, temperature of 28° C, dew point temperature of 11° C, and an altimeter setting of 30.16 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 27.7° C, dew point temperature 11.1° C.

The observations from KGPT and KBXA indicated VFR⁶ ceilings at the surface at the time of the accident with no visibility restrictions. The surface wind, however, was quite variable close to the accident site, with KGPT south of the accident site having a south to southwest wind between 10 and 20 knots, and KBXA west to northwest of the accident site having a west to northwest wind between 5 and 15 knots. These two surface wind directions would allow for the surface wind to be convergent (or come together) at the surface allowing for vertical motion and a chance of low-level wind shear (LLWS). The possibility of LLWS will be further discussed in section 4.0.

⁶ Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 6 miles visibility.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Slidell, Louisiana (KLIX), with a site number 72233, located 43 miles west-southwest of the accident site at an elevation of 10 feet. The 1900 CDT sounding from KLIX was plotted on a standard Skew-T log P diagram⁷ with the derived stability parameters included in figure 9 (with the chart plotted from the surface to 700-hPa, or 10,000 feet msl). This data was analyzed utilizing the RAOB⁸ software package. The sounding depicted the Lifted Condensation Level (LCL)⁹ at 4,577 feet msl, a Convective Condensation Level (CCL)¹⁰ of 5,978 feet, and a Level of Free Convection (LFC)¹¹ at 5,197 feet. The freezing level was located at 11,858 feet. The precipitable water value was 0.98 inches.

⁷ 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.

⁸ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

⁹ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁰ 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.

¹¹ 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.

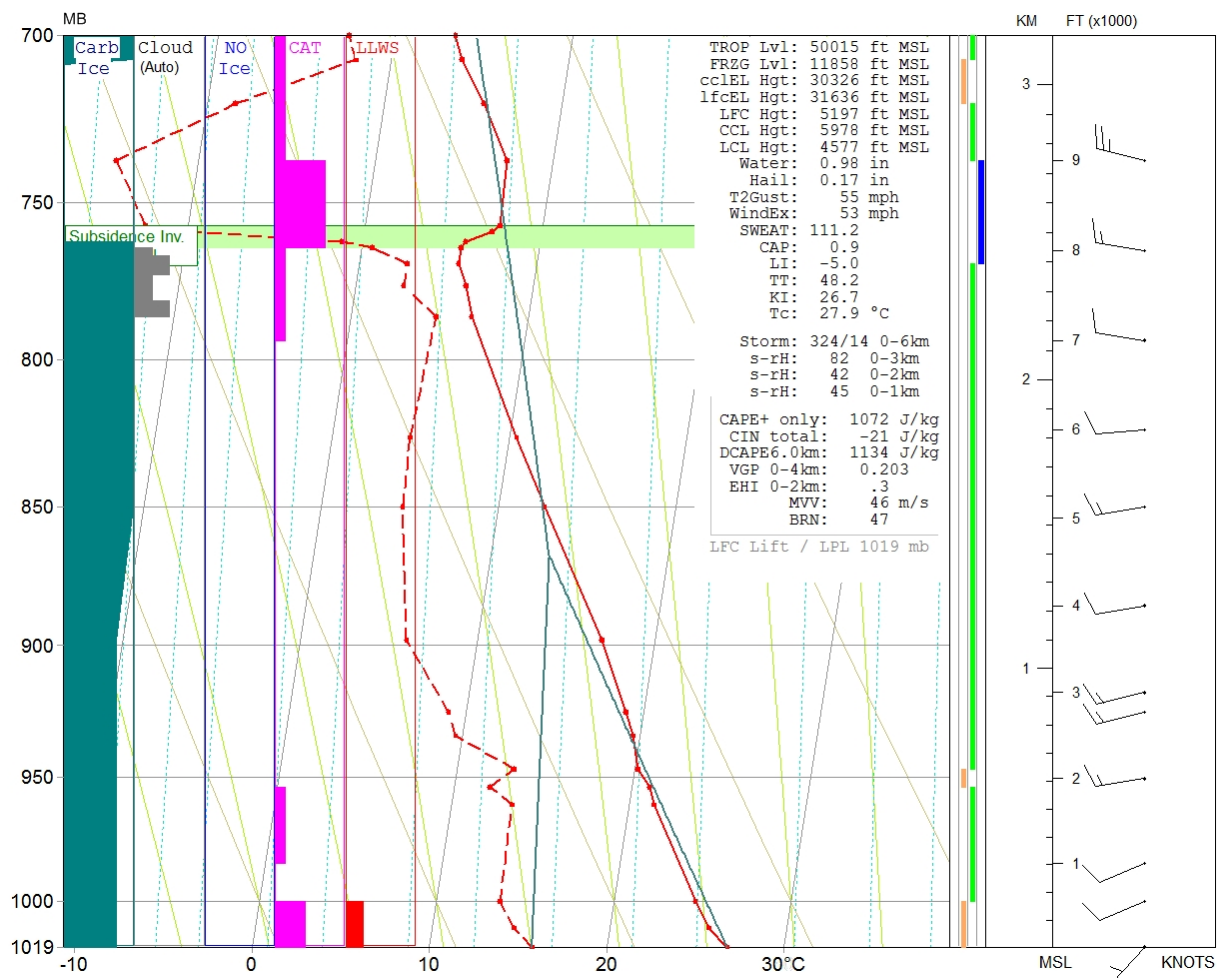


Figure 9 – 1900 CDT KLIX sounding

The 1900 CDT KLIX sounding indicated a relatively dry environment from the surface through 7,000 feet msl. RAOB indicated that clouds were not likely until 7,500 feet msl, with clouds likely from 7,500 through 9,000 feet msl. The environment was relatively unstable from the surface through 8,000 feet msl, which would allow for air to rise and fall easily with lifting mechanisms in the area of the accident site (section 1.1).

The sounding wind profile indicated a surface wind from 220° at 3 knots with the wind increasing to 15 knots by 500 feet msl while remaining out of the southwest. The wind remained near 15 knots through 8,000 feet msl with the wind becoming more westerly, and the wind only increased to 25 knots by 9,000 feet msl. LLWS was identified by RAOB between the surface and 1,000 feet msl, with several layers of clear air turbulence from the surface through 10,000 feet. Given the vertical environment of the lowest 2,000 feet msl, LLWS and gusty wind conditions would be expected at the accident site at the accident time. Flying in and around a large fire could have also affected the flight conditions, but that would have depended on how close the flight got to the fire and will be further explored in section 6.4.

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 wavelengths 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 CDT through 1800 CDT at approximately 15-minute intervals, were reviewed and the closest images to the time of the accident are documented here.

Figures 10 and 11 present the GOES-13 visible imagery from 1430 and 1445 CDT at 3X magnification with the accident site marked by a red square. The visible imagery indicated abundant cloud cover over and around the accident site at the accident time with that cloud cover moving from west to east. The cloud cover was oriented in west to east bands with the clouds looking cumuliform in nature. The cumuliform nature of the clouds would be consistent with the unstable air from the surface through 8,000 feet msl (section 4.0). Figure 12 presents the GOES-13 infrared imagery from 1430 CDT at 8X magnification. The infrared imagery indicated some cloud cover over the accident site at the accident time, however, the clouds are too small to have realistic brightness temperatures. The brightness temperatures from the infrared satellite data is one of the main tools used to determine the cloud top temperature and therefore the cloud top height. Cloud top heights will not be able to be determined in this case.

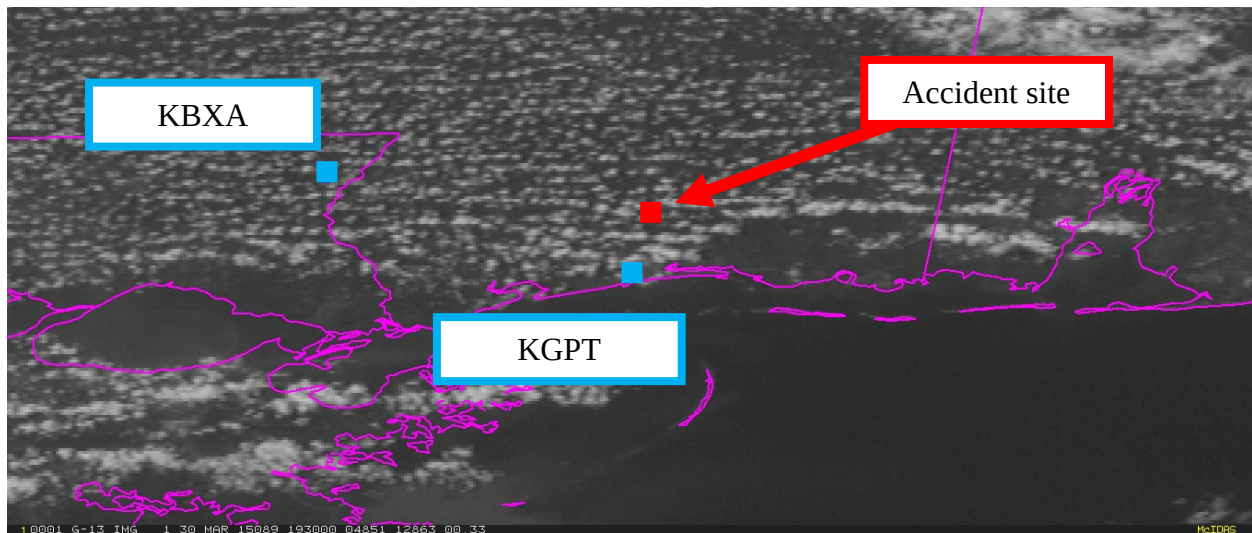


Figure 10 – GOES-13 visible image at 1430 CDT

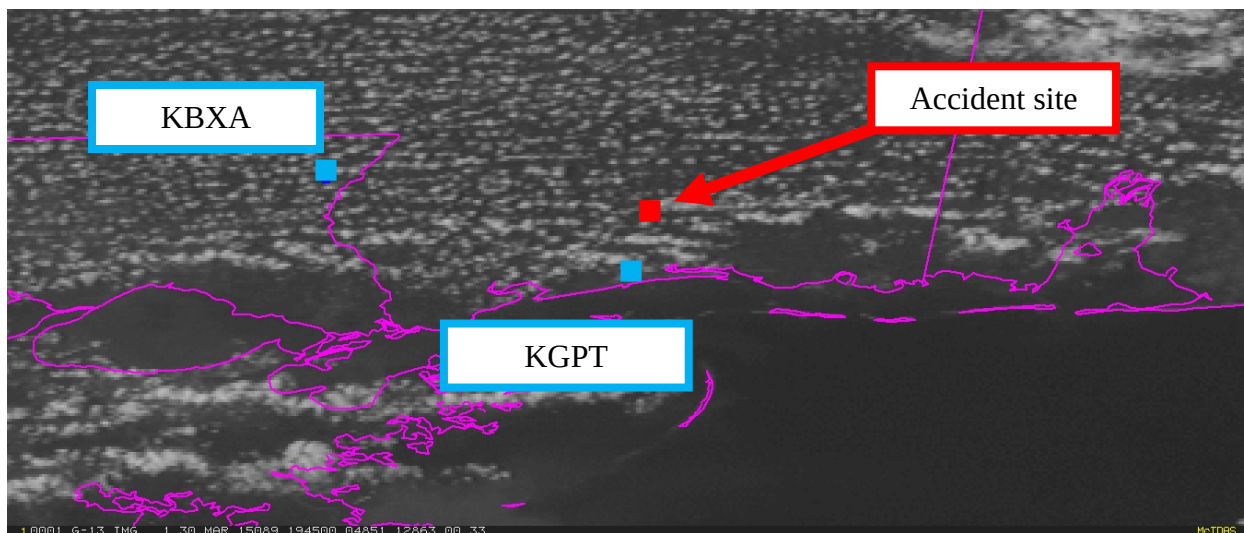


Figure 11 – GOES-13 visible image at 1445 CDT

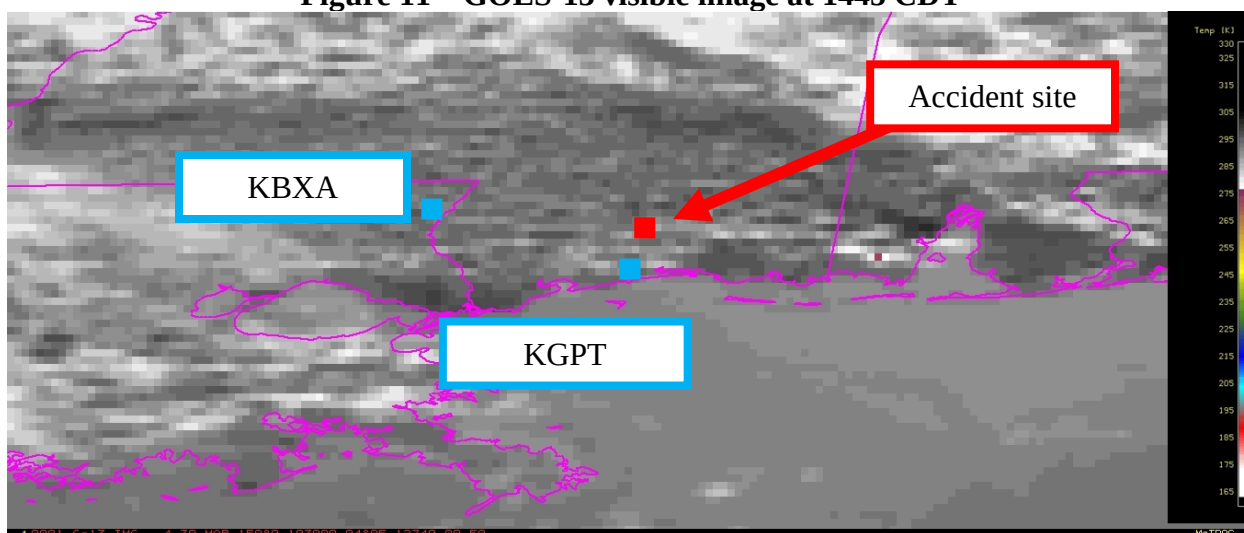


Figure 12 – GOES-13 infrared image at 1430 CDT

6.0 Radar Imagery Information

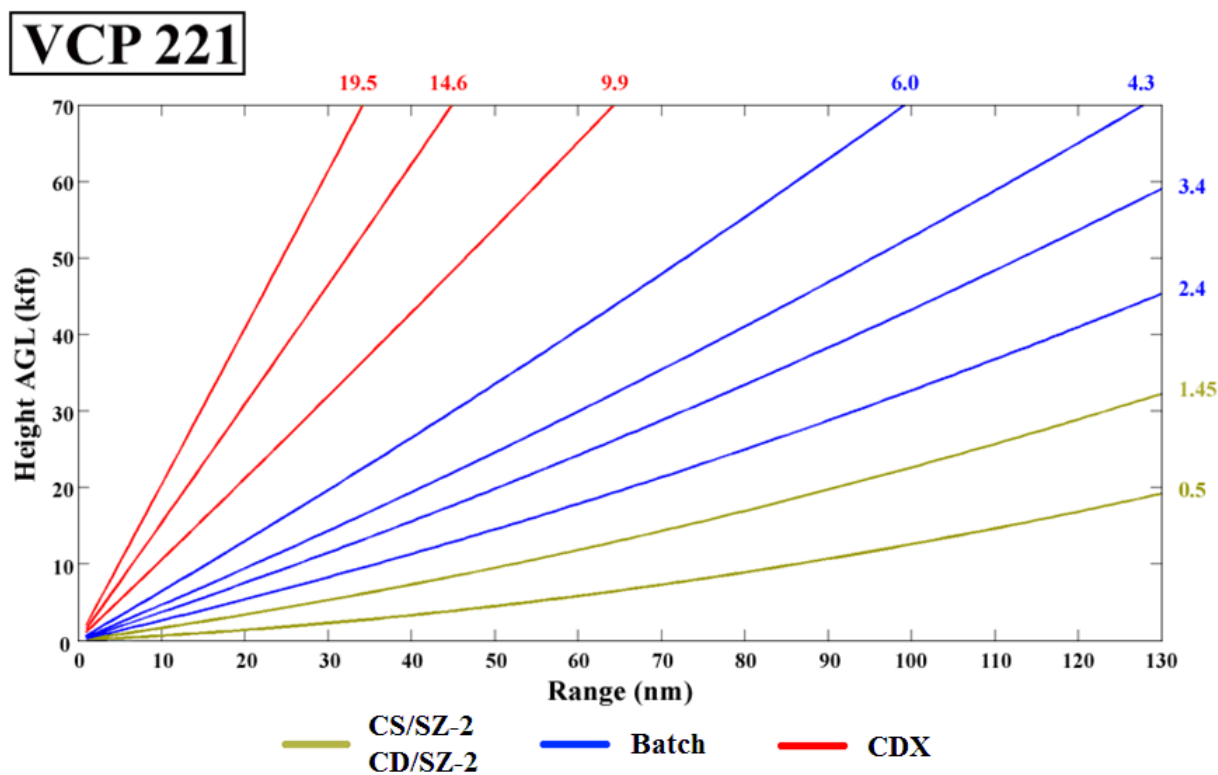
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹² was from KMOB, in Mobile, Alabama, which was located 44 miles east of the accident site with an elevation of 208 feet. Level II and III archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

¹² The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

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 9 elevation scans from 0.5° to 19.5° about every six minutes. This particular scanning strategy is documented as volume coverage pattern 221 (VCP-221). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period (VCP-32). During the period surrounding the accident, the KMOB WSR-88D radar was operating in the precipitation mode (Mode A, VCP-221). 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.



VCP-221 Precipitation Mode Scan Strategy

6.2 Beam Height Calculation

Assuming standard refraction¹³ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width¹⁴ information¹⁵ 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°	3,940 feet	1,770 feet	6,110 feet	4,340 feet

Based on the beam heights, the 0.5° elevation scan depicted the conditions between 6,630 feet and 12,650 feet msl over the accident site and these are the closest altitudes¹⁶ to the accident flight level before the accident occurred.

¹³ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

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

¹⁵ Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.

¹⁶ For more information please see the ATC data.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁷ 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 (dBZ¹⁸), 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 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	

¹⁷ 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.

¹⁸ 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 Base Reflectivity

Figures 13, 14, and 15 presents the KMOB WSR-88D base reflectivity images for the 0.5° elevation scan initiated at 1430, 1434, and 1439 CDT with a resolution of 0.5° X 250 m, and GPS flight track data. There were reflectivity targets at the accident site stretching east-northeastward from the accident site at the accident time. These reflectivity targets were not precipitation related (section 6.7), but the reflectivity targets were the smoke and particulates from the fire burning before, during, and after the accident time near the accident site. There were no lightning strikes at or near the accident site at the accident time.

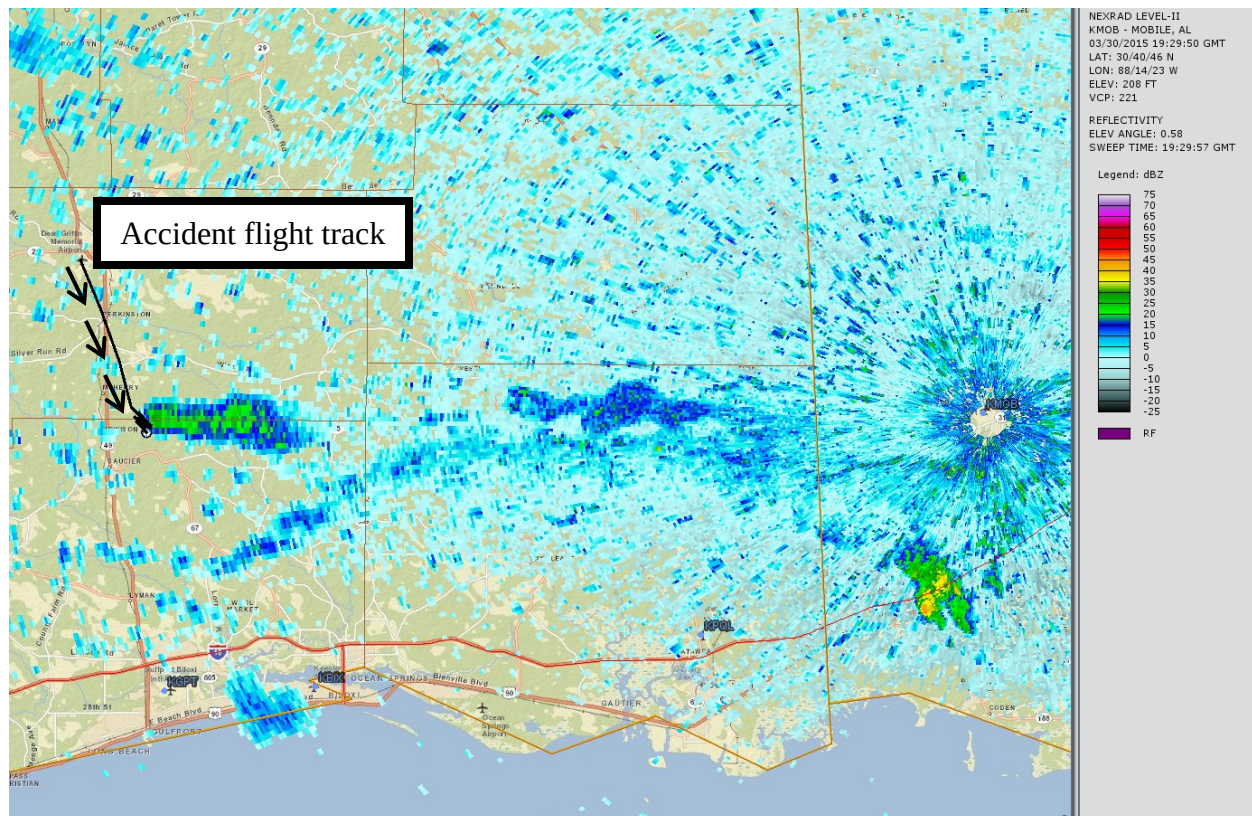


Figure 13 – KMOB WSR-88D reflectivity for the 0.5° elevation scan initiated at 1430 CDT with GPS flight track data

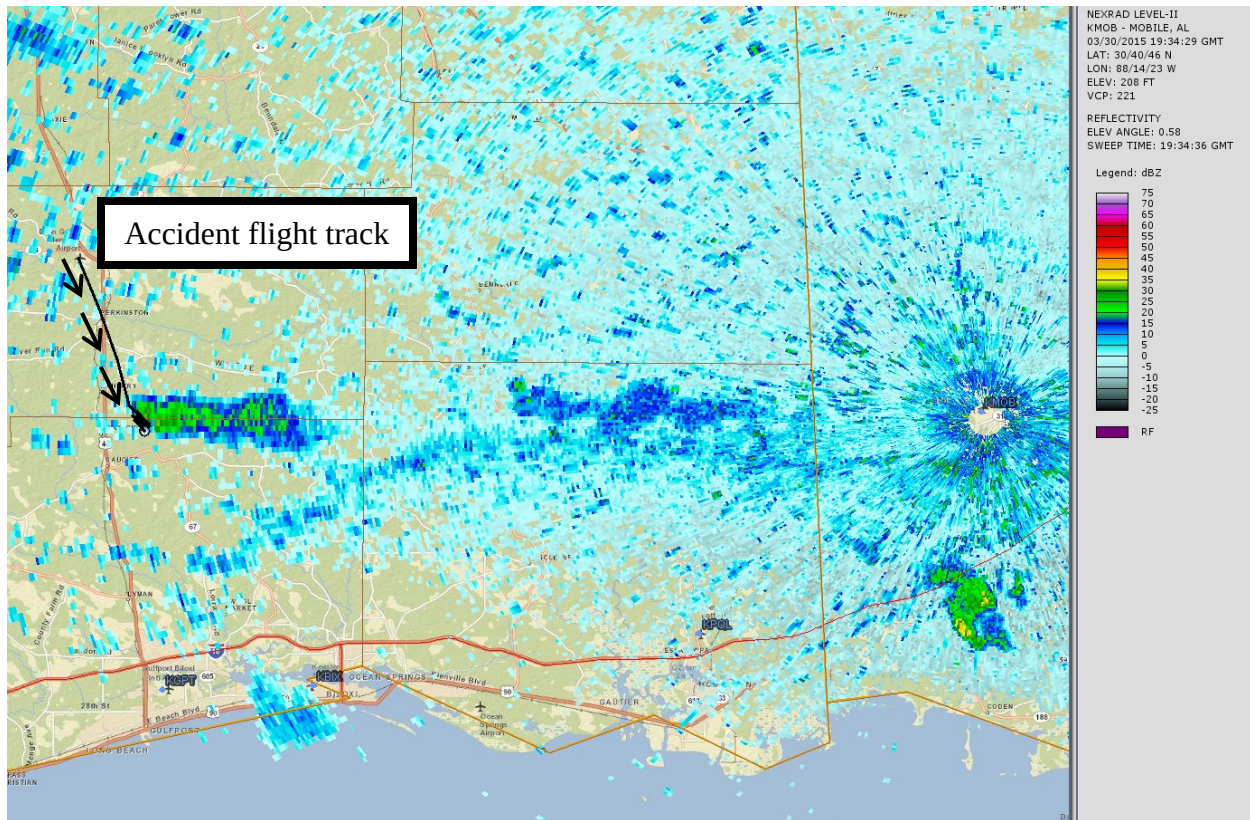


Figure 14 – KMOB WSR-88D reflectivity for the 0.5° elevation scan initiated at 1434 CDT with GPS flight track data

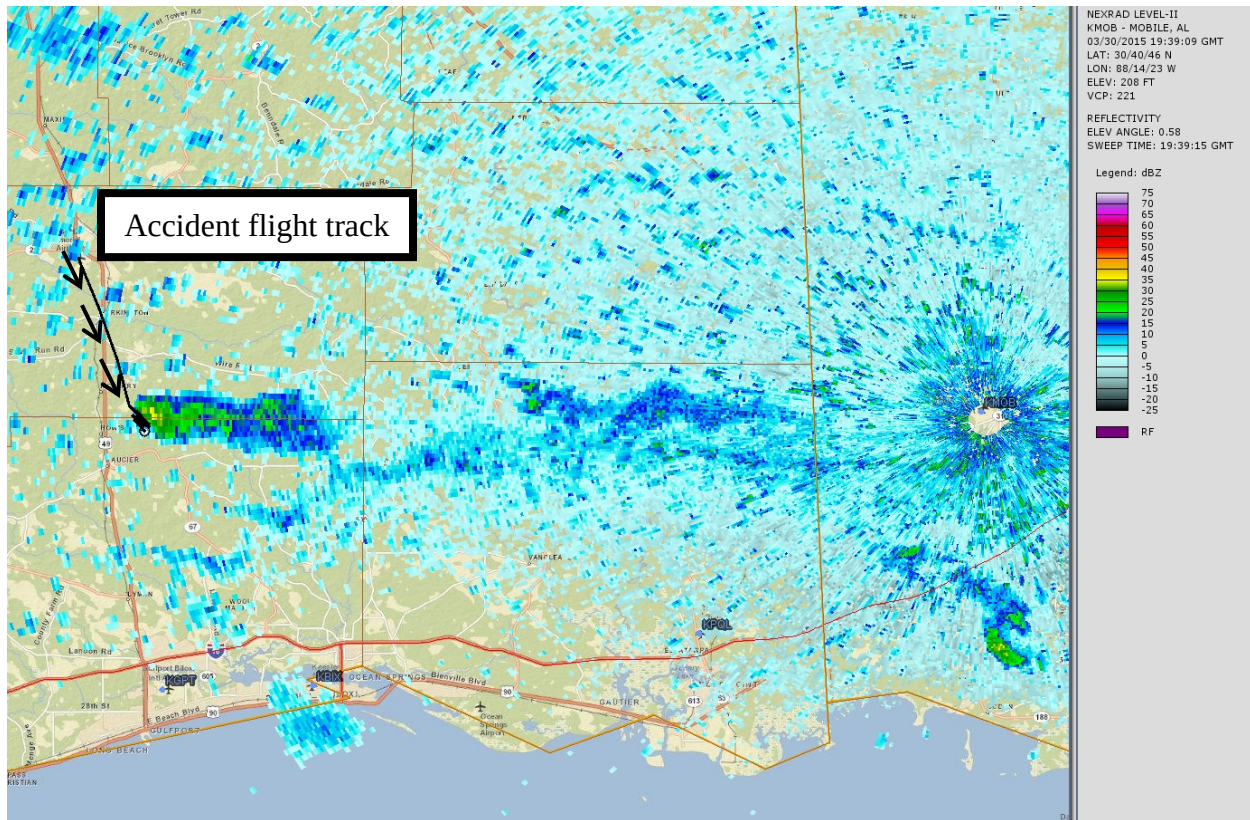


Figure 15 – KMOB WSR-88D reflectivity for the 0.5° elevation scan initiated at 1439 CDT with GPS flight track data

6.5 Dual-Polarization Weather Radar Data

The closest NWS WSR-88D with Dual-Polarization (dual-pol) technology was KMOB. Level II and III archived 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 KMOB WSR-88D also produced differential reflectivity (Zdr), correlation coefficient (CC), specific differential phase (KDP), and the hydrometeor classification algorithm (HC).

6.6 Zdr, CC, KDP, and HC¹⁹

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 return²⁰. 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 horizontal²¹. Near zero values of Zdr indicate that both the horizontal and vertical power return from within the volume scanned are of similar values, meaning the dominant hydrometeors are similar in size in both the vertical and horizontal²².

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 1²³. 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.

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 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 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.

¹⁹ Definitions for Zdr, CC, KDP, and HC adapted from training material from the NWS WDTB.

²⁰ A positive Zdr means that the dominant hydrometeors within the volume are larger in the horizontal than vertical (i.e. rain drops).

²¹ A negative Zdr correlates to vertically oriented hydrometeors, i.e. vertically oriented crystals or conical graupel.

²² A near zero Zdr is often an indication of hail or spherical rain drops.

²³ CC values greater than 1 indicate an untrustworthy signal due to low signal-to-noise ratio in areas of weak reflectivity.

6.7 Dual-Pol Imagery

Figure 16 presents the KMOB WSR-88D base reflectivity, Zdr, and CC values for the 0.5° elevation scan initiated at 1434 CDT with a resolution of 0.5° X 250 m. Figure 16 depicted very light to moderate echoes at the accident site and to the east-northeast from the accident site with 15 to 30 dBZ values. However, the Zdr values were all much greater than 1 dB with the CC values all much less than 0.80. As described in section 6.6 when the CC values are all less than 0.80, this is indicative of non-meteorological targets, including bugs, chaff, smoke, and birds. Knowing that the accident flight was there to support work on spot fires on the day of the accident, it is likely that the echoes and high base reflectivity values at the accident site and to the east-northeastward were smoke from the spot fires.

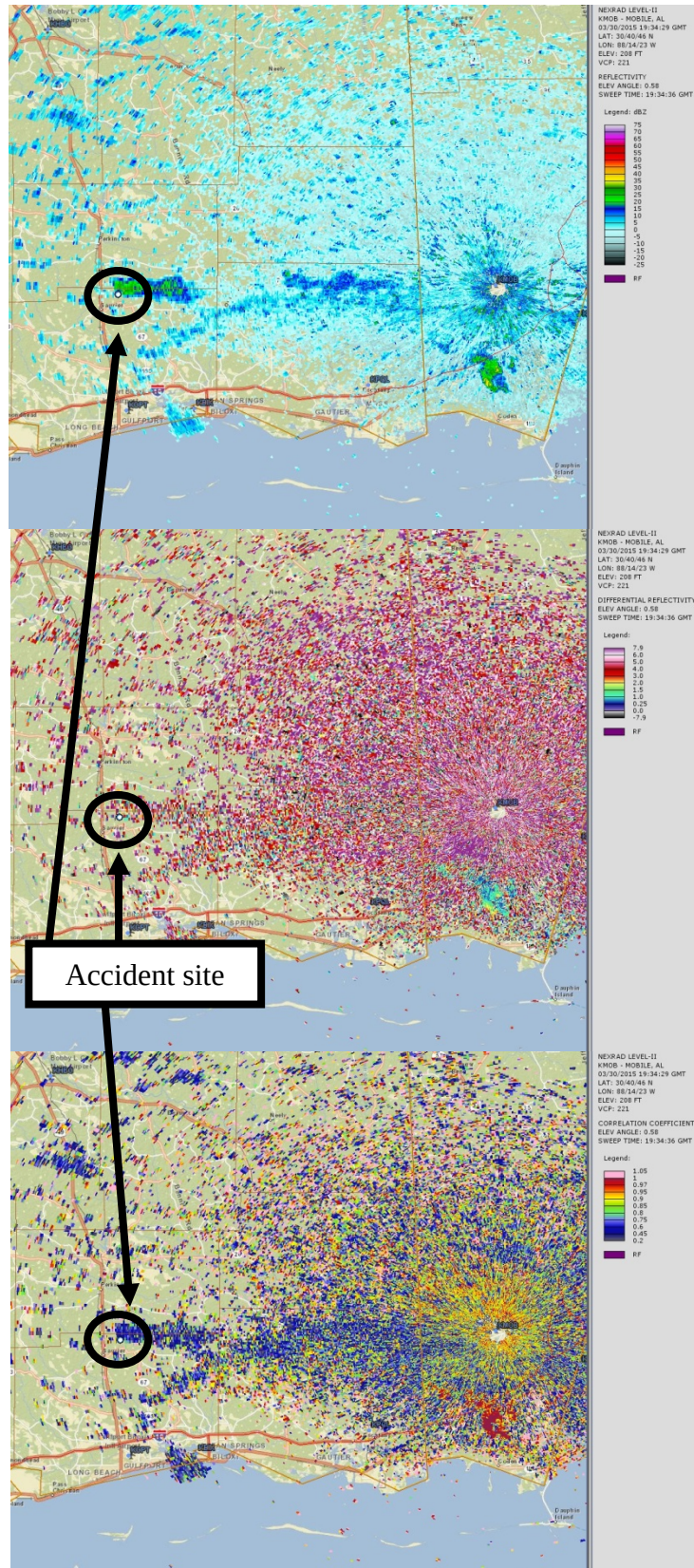


Figure 16 – KMOB WSR-88D 0.5° elevation scan for 1434 CDT (a) base reflectivity, (b) Zdr, and (c) CC

7.0 Pilot Reports

All pilot reports (PIREPs) were reviewed close to the accident site for below 15,000 feet msl from around two hours prior to the accident time to around three hours after the accident time and no PIREPs were reported.

8.0 SIGMET and CWSU Advisory

No SIGMET or meteorological impact statement (MIS) were valid for the accident site at the accident time.

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

9.0 AIRMETs

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

10.0 Area Forecast

The Area Forecast issued at 1345 CDT, valid at the accident time, forecasted a broken ceiling at 3,500 to 4,000 feet msl with cloud tops to 6,000 feet msl, and this forecast is consistent with the observations from KGPT:

FAUS44 KPCI 301845

FA4W

_DFWC FA 301845

SYNOPSIS AND VFR CLDS/WX

SYNOPSIS VALID UNTIL 311300

CLDS/WX VALID UNTIL 310700...OTLK VALID 310700-311300

OK TX AR TN LA MS AL

.

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...19Z CDFNT NJ-SE VA-ECNTRL AL-NERN LA THEN WRMFNT TO
NERN TX-LBB-NW PTNS TX PNHDL. HI PRES NRN AR. HI PRES ERN GLFMEX.
UPR LVL SHORTWAVE TROF ECNTRL NM-ELP-NRN MEX. 00Z WRMFNT FM LOW
PRES SW KS-SCNTRL OK-NERN TX. CDFNT NERN TX-SE AL-SRN SC-CSTL
WTRS. HI PRES MID TN. HI PRES NCNTRL GLFMEX. HI PRES WRN CO-SW
TX. UPR LVL SHORTWAVE TROF SE NM-FAR W TX-NRN MEX. 13Z TROF FM
LOW PRES SW KS-SW TX. WRMFNT SW KS-NERN OK-SW AL. HI PRES RDG ERN
GLFMEX-SE TX. HI PRES WRN SC.

.

OK

PNHDL...BKN CI. TIL 00Z WND SW G25KT. OTLK...VFR.

NWRN...BKN CI. OTLK...VFR.

SW...BKN CI. 23Z BKN150 TOP FL260. 06Z OCNL VIS 3-5SM BR.

OTLK...MVFR BR.

NCNTRL...SCT CI. OTLK...VFR.

SCNTRL...SCT CI. 02Z BKN160 TOP FL260. 06Z SCT025 BKN050 TOP 060.

OCNL VIS 3-5SM BR. OTLK...MVFR BR.
 NERN...SKC. 00Z BKN CI. OTLK...VFR 09Z MVFR CIG.
 SE...SKC. 06Z BKN015 OVC150 TOP FL250. OTLK...MVFR CIG.
 .
 NWRN TX
 PNHDL...BKN CI. OTLK...VFR.
 RMNDR...BKN150 TOP FL280. 00Z BKN CI. OTLK...VFR.
 .
 SWRN TX
 FAR W TX...BKN140 TOP FL280. 23Z OVC120. OTLK...VFR TSRA.
 SJT-DLF EWD...SKC. OTLK...MVFR CIG.
 RMNDR...BKN CI. 03Z OVC150 TOP FL280. OTLK...VFR.
 .
 N CNTRL TX
 WRN...BKN CI. 00Z BKN160 TOP FL260. 05Z SKC. OTLK...VFR.
 ERN...OVC025 TOP 035. 21Z BKN035 BKN160 TOP FL250. OTLK...MVFR
 CIG.
 .
 NERN TX
 BKN025 TOP 040. 06Z BKN025 OVC150 TOP FL250. OTLK...MVFR CIG 08Z
 IFR CIG BR.
 .
 SERN TX
 SCT035. 06Z OVC015-025 TOP 035. OTLK...MVFR CIG 09Z IFR CIG BR.
 .
 S CNTRL TX
 HILL COUNTRY...BKN-OVC CI. OTLK...MVFR CIG.
 MIDDLE CSTL PLAIN...SCT020 BKN035 TOP 050. 21Z SCT035. 02Z
 OVC015. 06Z OVC010-020 TOP 025. VIS 3-5SM BR. OTLK...IFR CIG BR.
 LWR CSTL PLAIN...BKN025 TOP 040. 21Z SCT030. WND SE G25KT. 01Z
 SCT015. OTLK...MVFR CIG 09Z IFR CIG.
 LWR RIO GRANDE VLY...BKN025-030 TOP 040. 20Z SCT025. TIL 00Z WND
 SE G25KT. OTLK...MVFR CIG.
 RMNDR...OVC030 TOP 045. 21Z BKN035-040 TOP 050. 05Z OVC015-020
 TOP 040. OTLK...MVFR CIG 08Z IFR CIG.
 .
 AR
 NW...SKC. 00Z BKN CI. OTLK...VFR 09Z MVFR CIG.
 SW...SKC. 05Z BKN140 TOP FL280. OTLK...VFR 08Z MVFR CIG BR.
 NERN...SKC. 05Z BKN CI. OTLK...VFR.
 SE...SCT035. 23Z SKC. 01Z SCT120. OTLK...VFR 10Z IFR BR.
 .
 LA
 NW...BKN015 TOP 030. 21Z SCT030. 05Z BKN140 TOP FL280. OTLK...VFR
 09Z MVFR CIG BR.
 NERN...BKN035 TOP 050. 22Z SCT035. OTLK...VFR 10Z IFR BR.
 CNTRL...BKN035 TOP 050. 20Z SCT035. OTLK...VFR.
 SW...BKN025 TOP 040. 20Z SCT035. 06Z SCT010. OCNL VIS 3-5SM BR.
 OTLK...MVFR BR.
 SE...BKN045 TOP 060. 00Z SKC. OTLK...VFR 08Z MVFR BR.
 .
 TN
 WRN-MIDDLE...SKC. OTLK...VFR.
 ERN...SCT060. 23Z SKC. OTLK...VFR.
 .
MS

NRN...SKC. OTLK...VFR.
 SW...BKN025 TOP 040. 20Z BKN035 TOP 050. 00Z BKN CI. OTLK...VFR
 09Z IFR BR.
SE...BKN035-040 TOP 060. 02Z SKC. OTLK...VFR 09Z MVFR BR.
 .
 AL
 NW...SKC. OTLK...VFR.
 NERN...BKN045 TOP 060. 23Z SKC. OTLK...VFR.
 SW...BKN035 OVC050 TOP 100. ISOL -SHRA/-TSRA. CB TOP FL380. 01Z
 BKN050 TOP 080. OTLK...VFR 09Z IFR CIG BR.
 SE...BKN015 OVC040 TOP FL250. WDLY SCT -SHRA/ISOL -TSRA. CB TOP
 FL400. 01Z SCT050. OTLK...MVFR BR.

11.0 Terminal Aerodrome Forecast

KGPT was the closest site with a NWS TAF. The TAF valid at the time of the accident was issued at 1236 CDT and was valid for a 24-hour period beginning at 1300 CDT. The TAF forecast for KGPT was as follows:

TAF KGPT 301736Z 3018/3118 **20008KT P6SM BKN035**
 FM310200 VRB03KT P6SM SCT250
 FM310900 VRB03KT 5SM BR SCT008
 FM311500 27004KT P6SM BKN250=

The forecast expected wind from 200° at 8 knots, greater than 6 miles visibility, and a broken ceiling at 3,500 feet agl.

12.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Mobile, Alabama, issued the following Area Forecast Discussion at 0657 CDT (closest AFD to the accident time), which discussed a cold front moving into the central and southern Mississippi and Alabama areas this afternoon through tonight bringing with it a small chance for showers and thunderstorms:

FXUS64 KMOB 301157
 AFDMOB
 AREA FORECAST DISCUSSION
 NATIONAL WEATHER SERVICE MOBILE AL
 657 AM CDT MON MAR 30 2015
 .UPDATE...A WEAKENING BAND OF SHOWERS AND ISOLATED THUNDERSTORMS IS
 MOVING INTO NORTHERN ZONES AND HAVE ADJUSTED POPS UPWARD IN THESE
 AREAS. UPDATES HAVE BEEN SENT. /13
 &&
 .PREV DISCUSSION... /ISSUED 534 AM CDT MON MAR 30 2015/
 SHORT TERM (TODAY AND TONIGHT)...**A COLD FRONT WILL MOVE INTO THE
 AREA THIS AFTERNOON AND STALL NEAR THE COAST TONIGHT.** THIS FRONT
 WILL BE RATHER WEAK DUE TO WEAK UPPER LEVEL SUPPORT...THEREFORE
 FRONTAL FORCING WILL BE WEAK. THE MAIN FORCING FOR SHOWERS AND
 THUNDERSTORMS AHEAD OF THE FRONT WILL BE FROM DIURNAL HEATING AS
 TEMPS WARM INTO THE UPPER 70S TO AROUND 80. ENOUGH INSTABILITY IS
 EXPECTED FOR SCATTERED SHOWERS AND THUNDERSTORMS DURING THE LATE

MORNING AND AFTERNOON HOURS AS THE FRONT MOVES ACROSS THE AREA. FORECAST SOUNDINGS INDICATE WILL REACH 500-700 J/KG WITH STEEP MID LEVEL LAPSE RATES AROUND 7C/KM AND WET BULB ZERO BETWEEN 8000-8500 FEET. AS A RESULT...AN ISOLATED THUNDERSTORMS COULD BECOME SEVERE THIS AFTERNOON WITH HAIL THE MAIN THREAT ALONG WITH GUSTY WINDS. THE STORM PREDICTION CENTER MAINTAINS A MARGINAL SEVERE WEATHER RISK FOR THE AREA TODAY. SHOWERS AND THUNDERSTORMS WILL DISSIPATE WITH THE LOSS OF HEATING THIS EVENING WITH DRY CONDITIONS EXPECTED OVERNIGHT. LOWS TONIGHT FALL INTO THE MID 50S INLAND TO LOW 60S ALONG THE COAST. INCREASING MOISTURE LEVELS WILL LEAD TO THE DEVELOPMENT OF PATCHY FOG LATE TONIGHT. 13/JC

(TUESDAY AND WEDNESDAY)...THE STALLED SFC FRONTAL BOUNDARY REMAINS ACROSS THE GENERAL FCST AREA TUESDAY AND WEDNESDAY...PROVIDING JUST ENOUGH OF A LOW LEVEL FOCUS TO RESULT IN SCATTERED SHOWERS AND THUNDERSTORMS EACH DAY. RAIN CHANCES HIGHEST DURING THE MORE UNSTABLE TIMES OF THE DAY (AFTERNOON HOURS TUESDAY AND WEDNESDAY) AND LESS TUESDAY NIGHT. THERE COULD BE A CONTINUED MARGINAL THREAT OF A FEW STRONG TO BRIEFLY SEVERE STORMS (ESPECIALLY ON TUESDAY) WITH LARGE HAIL REMAINING THE PRIMARY THREAT...ALTHOUGH STRONG GUSTY WINDS COULD ALSO OCCUR WITH SOME STORMS. HIGHS EACH DAY IN THE MID 70S (COASTAL) TO UPPER 70S AND LOWER 80S (INLAND). LOWS TUESDAY NIGHT IN THE UPPER 50S TO MID 60S. 12/DS

LONG TERM (THURSDAY THROUGH SUNDAY)...THURSDAY AND FRIDAY WHAT IS LEFT OF THE WEAKENING SFC BOUNDARY OVER THE SOUTHEASTERN STATES WILL LIFT BACK TO THE NORTH AS SFC HIGH PRESSURE OFF THE EASTERN SEABOARD DROPS SOUTH. WITH THIS RAIN CHANCES WILL LIKELY BE LOWER THURSDAY AND FRIDAY THAN PREVIOUSLY EXPECTED. ANOTHER FRONT WILL MOVE ACROSS THE FCST AREA ON SATURDAY BRINGING ANOTHER LOW END CHANCE FOR SHOWERS AND STORMS...BUT WILL QUICKLY MOVE THROUGH THE AREA WITH DRIER HIGH PRESSURE BUILDING IN FROM THE NORTH BY SUNDAY. HIGH TEMPERATURES IN THE UPPER 70S AND LOW 80S THURSDAY AND FRIDAY...COOLING TO THE LOW TO MID 70S MOST LOCATIONS SATURDAY AND SUNDAY IN ASSOCIATION WITH THE EXPECTED FRONTAL PASSAGE. LOW TEMPERATURES THURSDAY AND FRIDAY NIGHTS IN THE LOW TO MID 60S ACROSS THE AREA...COOLING TO THE UPPER 40S AND LOWER 50S SATURDAY NIGHT IN THE WAKE OF THE FRONT. 12/DS
AVIATION...30/12Z ISSUANCE...VFR CONDITIONS WILL PREVAIL THROUGH MUCH OF THE PERIOD. ISOLATED TO SCATTERED SHOWERS AND THUNDERSTORMS WILL DEVELOP ACROSS THE AREA LATE THIS MORNING THROUGH THE AFTERNOON AHEAD OF AN APPROACHING FRONT. MVFR/IFR CONDITIONS WILL BE POSSIBLE IN AND AROUND SHOWERS AND THUNDERSTORMS. 13/JC

MARINE....A BROAD SURFACE RIDGE OF HIGH PRESSURE WILL EXTEND FROM THE WESTERN ATLANTIC THROUGH THE NORTH CENTRAL GULF OF MEXICO THROUGH MIDWEEK. A LIGHT TO MODERATE SOUTHERLY TO SOUTHWESTERLY WIND FLOW WILL PERSIST THROUGH WEDNESDAY. ISOLATED SHOWERS OR THUNDERSTORMS WILL ALSO BE POSSIBLE MOSTLY NEAR SHORE AND OVER INLAND BAYS AND SOUNDS MONDAY THROUGH MIDWEEK. 13/JC

&&

.PRELIMINARY POINT TEMPS/POPS...

MOBILE 80 58 78 63 78 / 30 10 05 10 20
PENSACOLA 79 61 77 64 77 / 30 10 05 10 20
DESTIN 76 63 73 66 74 / 30 10 10 10 20
EVERGREEN 82 55 81 60 80 / 40 10 20 20 30
WAYNESBORO 79 55 80 59 80 / 40 10 20 20 20
CAMDEN 80 55 79 59 78 / 60 10 30 30 30
CRESTVIEW 82 55 79 62 79 / 30 10 20 20 30

&&
.MOB WATCHES/WARNINGS/ADVISORIES...
AL...NONE.
FL...NONE.
MS...NONE.
GM...NONE.
&&
\$\$

13.0 Pilot Weather Briefing

The accident pilot did not receive an official weather briefing from Lockheed Martin Flight Service. There is no record of the accident pilot receiving or retrieving any weather information before the accident flight.

14.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on March 30, 2015, indicated the following:

SUN	
Begin civil twilight	0624 CDT
Sunrise	0648 CDT
Sun transit	1301 CDT
Sunset	1914 CDT
End civil twilight	1938 CDT

F. LIST OF ATTACHMENTS

None.

Paul Suffern
NTSB, AS-30