



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

August 22, 2017

Group Chairman's Factual Report

METEOROLOGY

ERA17FA174

Table Of Contents

A.	ACCIDENT	3
B.	METEOROLOGIST	3
C.	DETAILS OF THE INVESTIGATION	3
D.	FACTUAL INFORMATION	3
1.0	Synoptic Situation	3
1.1	Surface Analysis Chart	4
1.2	Upper Air Charts	5
2.0	SPC Products	9
3.0	Surface Observations	9
3.1	5-Minute KCLW ASOS Observations	13
4.0	Upper Air Data	15
5.0	Satellite Data	17
6.0	Radar Imagery Information	18
6.1	Volume Scan Strategy	19
6.2	Beam Height Calculation	20
6.3	Reflectivity	20
6.4	Base Reflectivity and Lightning Data	21
7.0	Pilot Reports	23
8.0	SIGMET and CWSU Advisories	23
9.0	AIRMETs	23
10.0	Area Forecast	24
11.0	Terminal Aerodrome Forecast	25
12.0	NWS Area Forecast Discussion	26
13.0	Winds and Temperature Aloft Forecast	28
14.0	Pilot Weather Briefing	28
15.0	Witness Information	29
16.0	Astronomical Data	29
17.0	ITWS Information	29
18.0	Downburst and Microburst Information	30
E.	LIST OF ATTACHMENTS	30

A. ACCIDENT

Location: Near Clearwater, Florida
Date: May 5, 2017
Time: 1922 eastern daylight time
2322 Coordinated Universal Time (UTC)
Airplane: Cirrus SR22, N271TS

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are eastern daylight time (EDT) on May 5, 2017, 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 site was located at latitude 27.9778° N, longitude 82.7592° W, at an approximate elevation of 69 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.

1.1 Surface Analysis Chart

A section of the NWS Surface Analysis Chart for 2000 EDT is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart indicated that there was a cold frontal boundary located off the east coast of the United States and was located in between the Florida Atlantic coast and the Bahamas. To the west of the cold front and the accident site, the isobars¹ indicated a trough² of low pressure (black dashed line, figure 1) extending over Georgia and northwest Florida immediately west of the accident site. The station models around the accident site depicted air temperatures in the low 70's degrees Fahrenheit (°F), dew point temperatures in the mid 50's °F with temperature-dew point spreads of 11° F or more, a west wind of 10 to 20 knots, and cloudy skies.

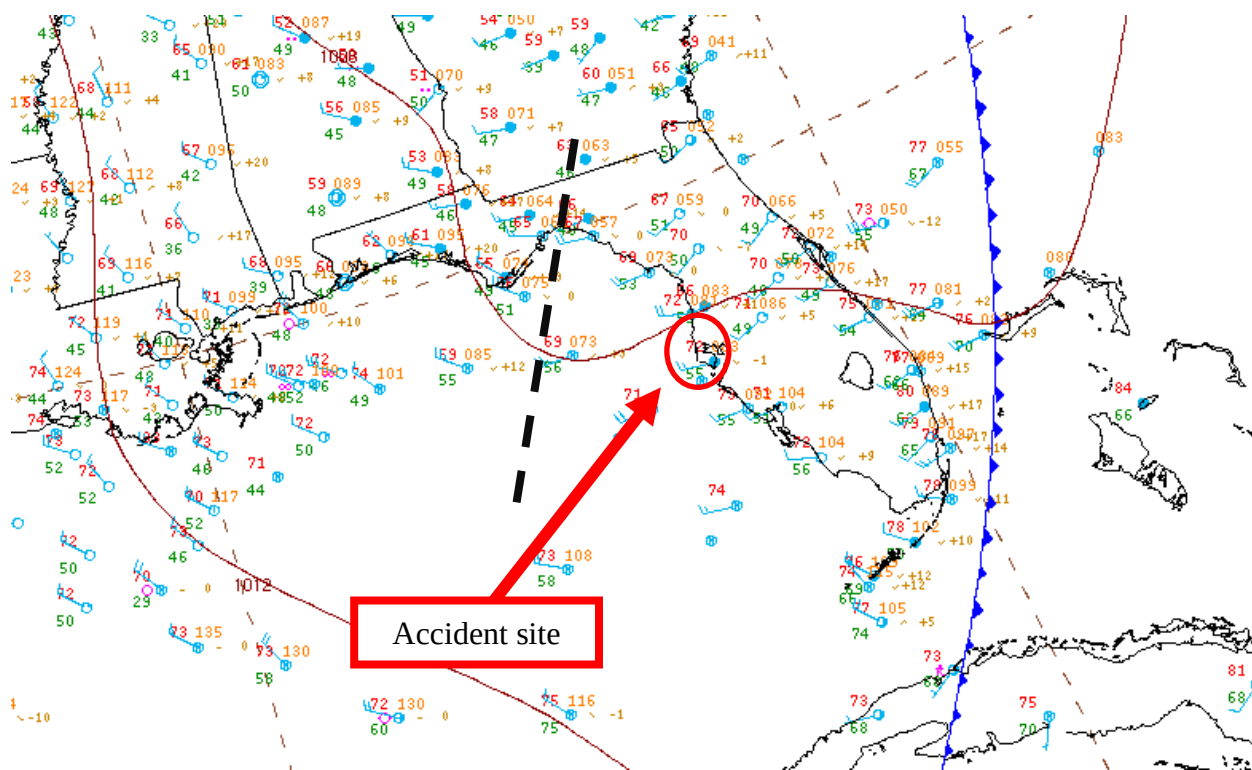


Figure 1 – NWS Surface Analysis Chart for 2000 EDT

¹ Isobar – Lines of equal pressure.

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

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 2000 EDT at 925-, 850-, 700-, 500-, and 300-hectopascals (hPa) are presented in figures 2 through 6. There was a low- and mid-level trough located just west of the accident site stretched from western North Carolina southward into the Florida Panhandle (figures 2 through 5). Troughs and surface frontal boundaries (section 1.1) can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a west wind of 20 knots at 925-hPa (figure 2) above the accident site. The wind became southwesterly by 700-hPa with a wind speed of 50 knots (figure 4). The 50-knot southwesterly wind at 700-hPa became a 90-knot southwest wind by 300-hPa (figure 6).

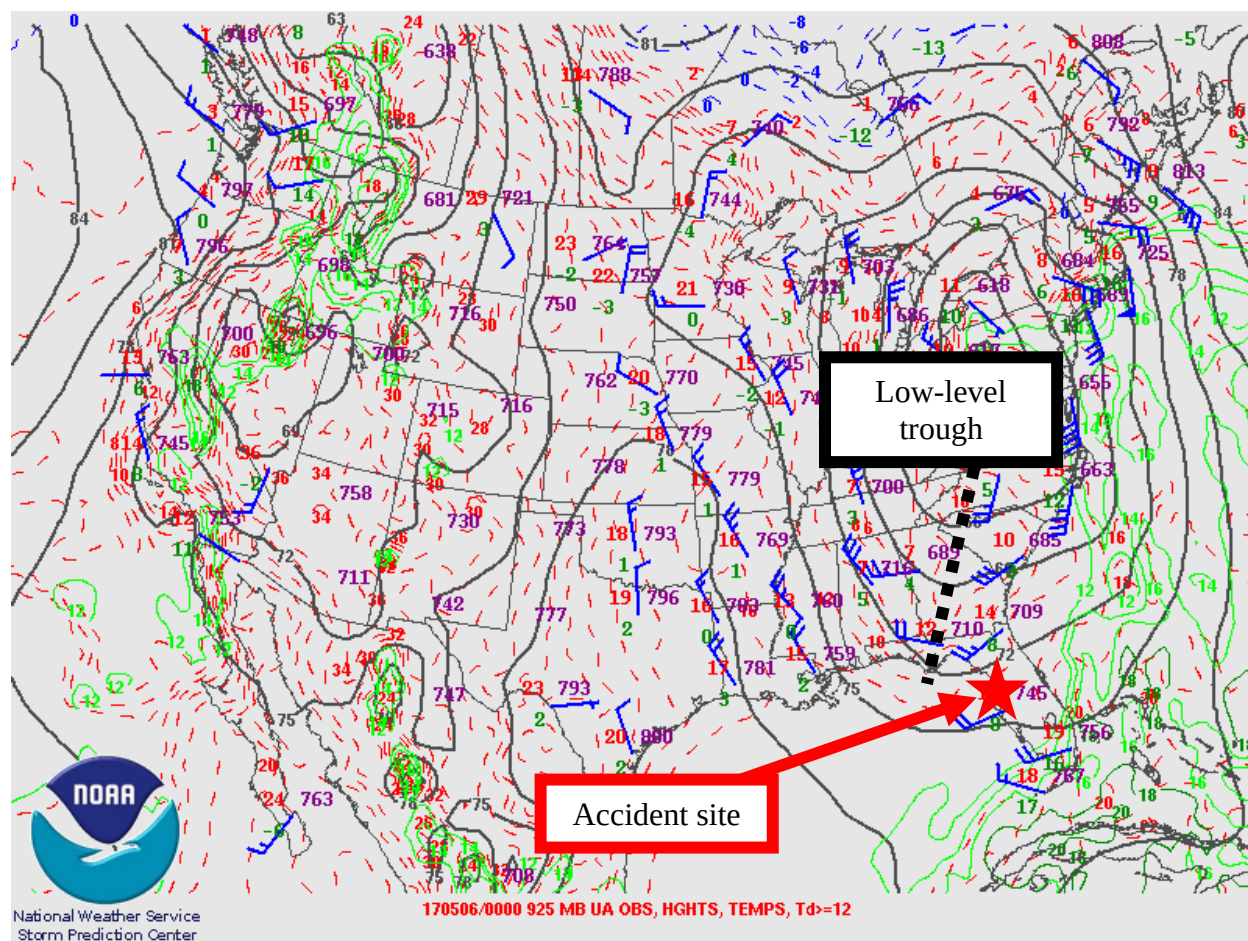


Figure 2 – 925-hPa Constant Pressure Chart for 2000 EDT

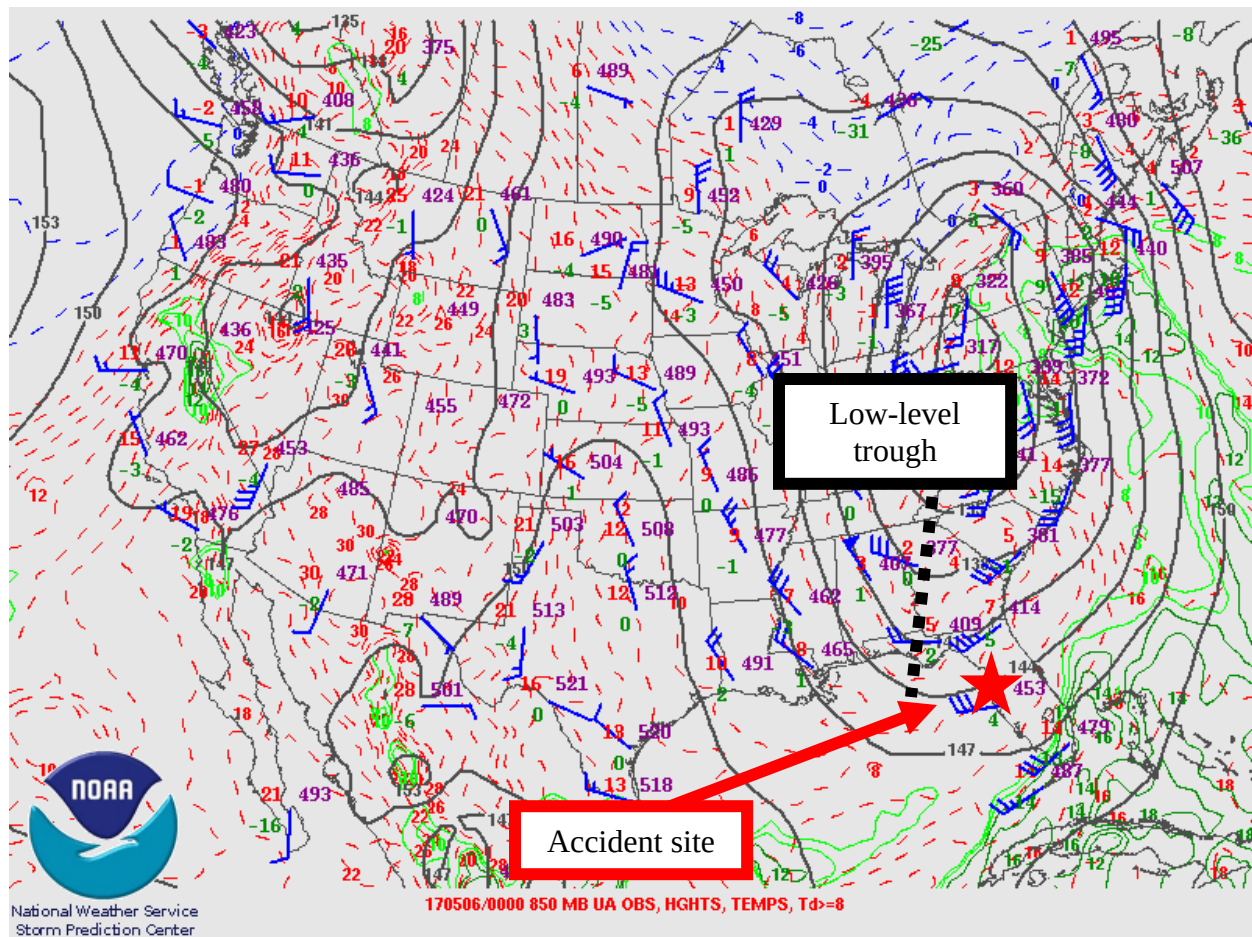


Figure 3 – 850-hPa Constant Pressure Chart for 2000 EDT

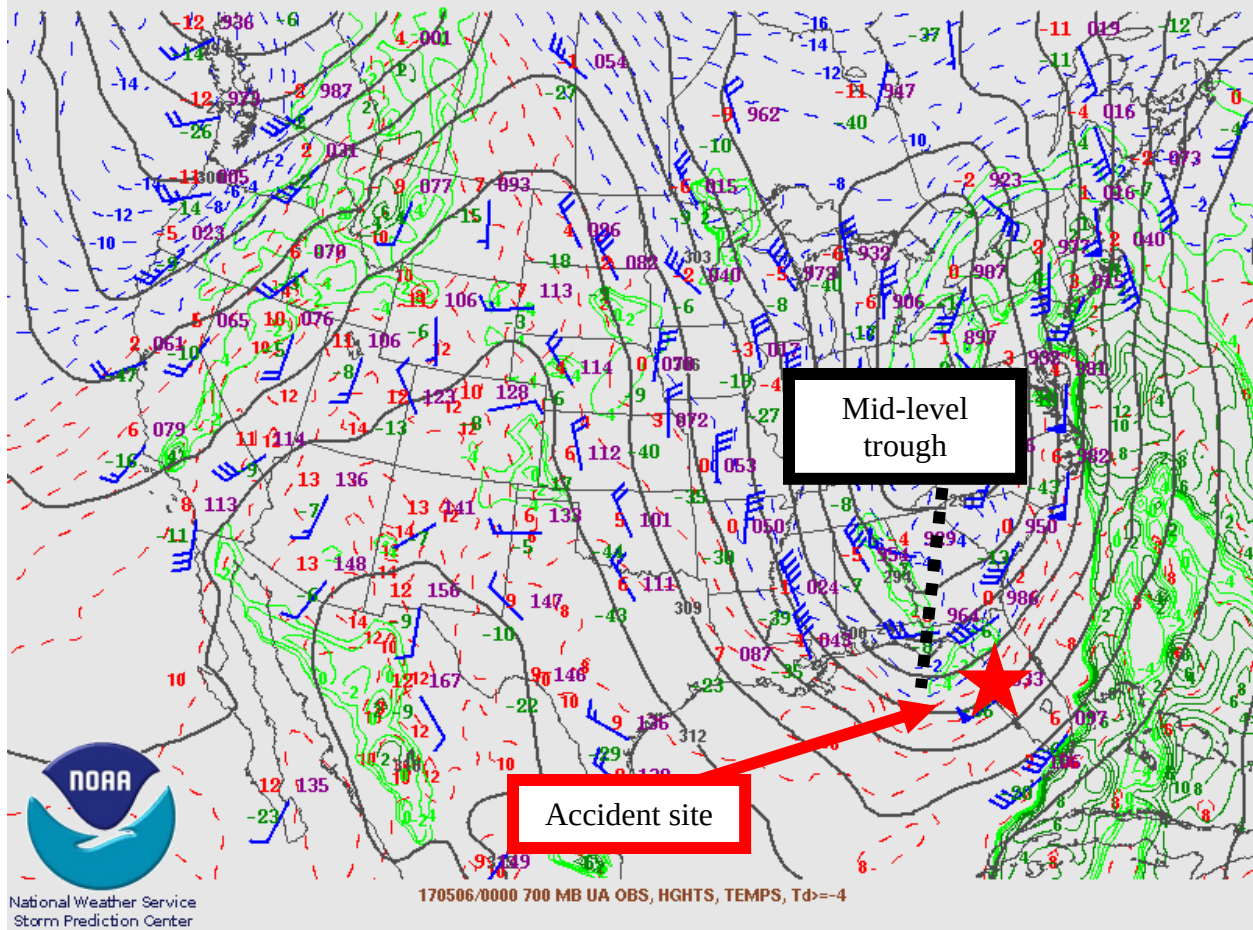


Figure 4 – 700-hPa Constant Pressure Chart for 2000 EDT

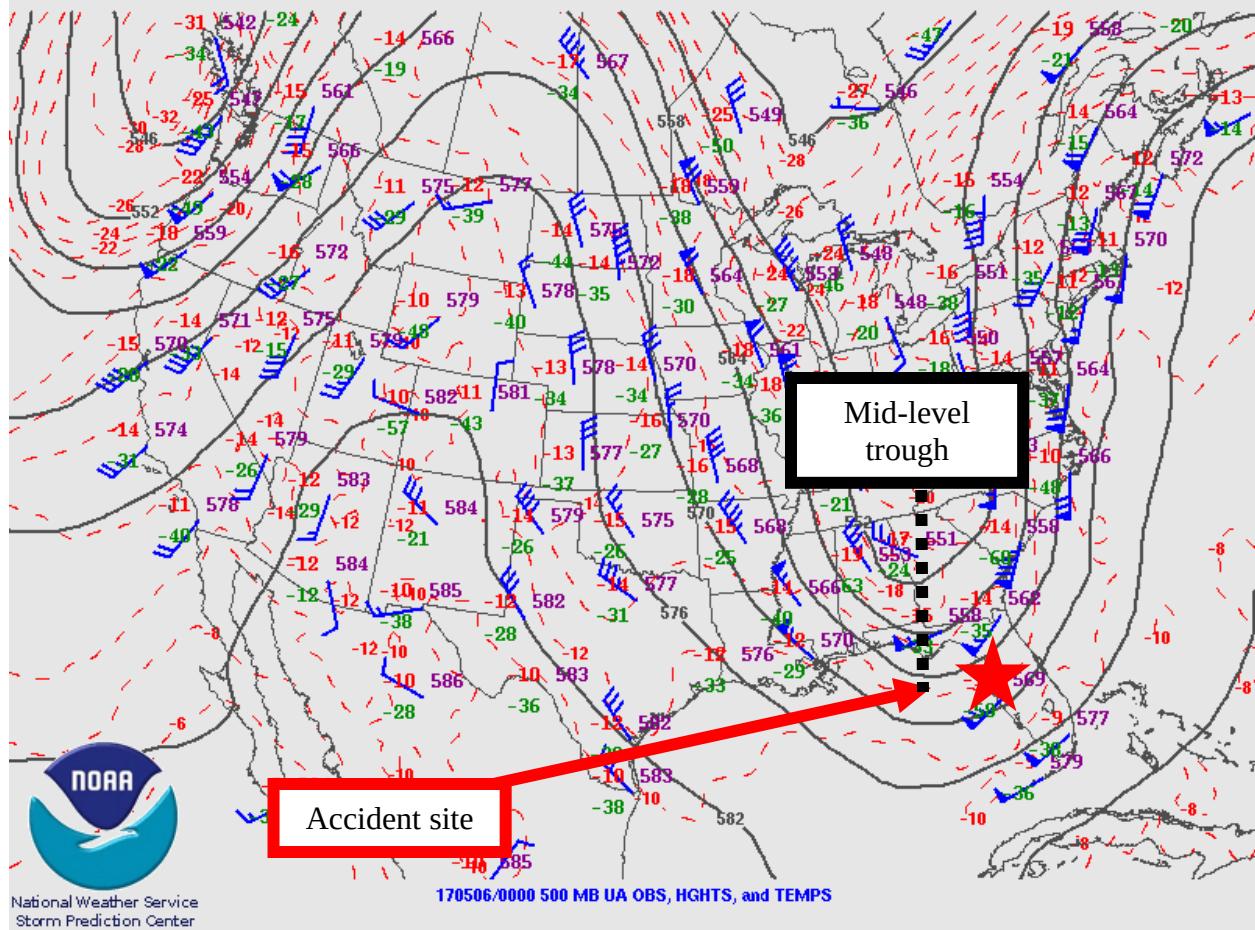


Figure 5 – 500-hPa Constant Pressure Chart for 2000 EDT

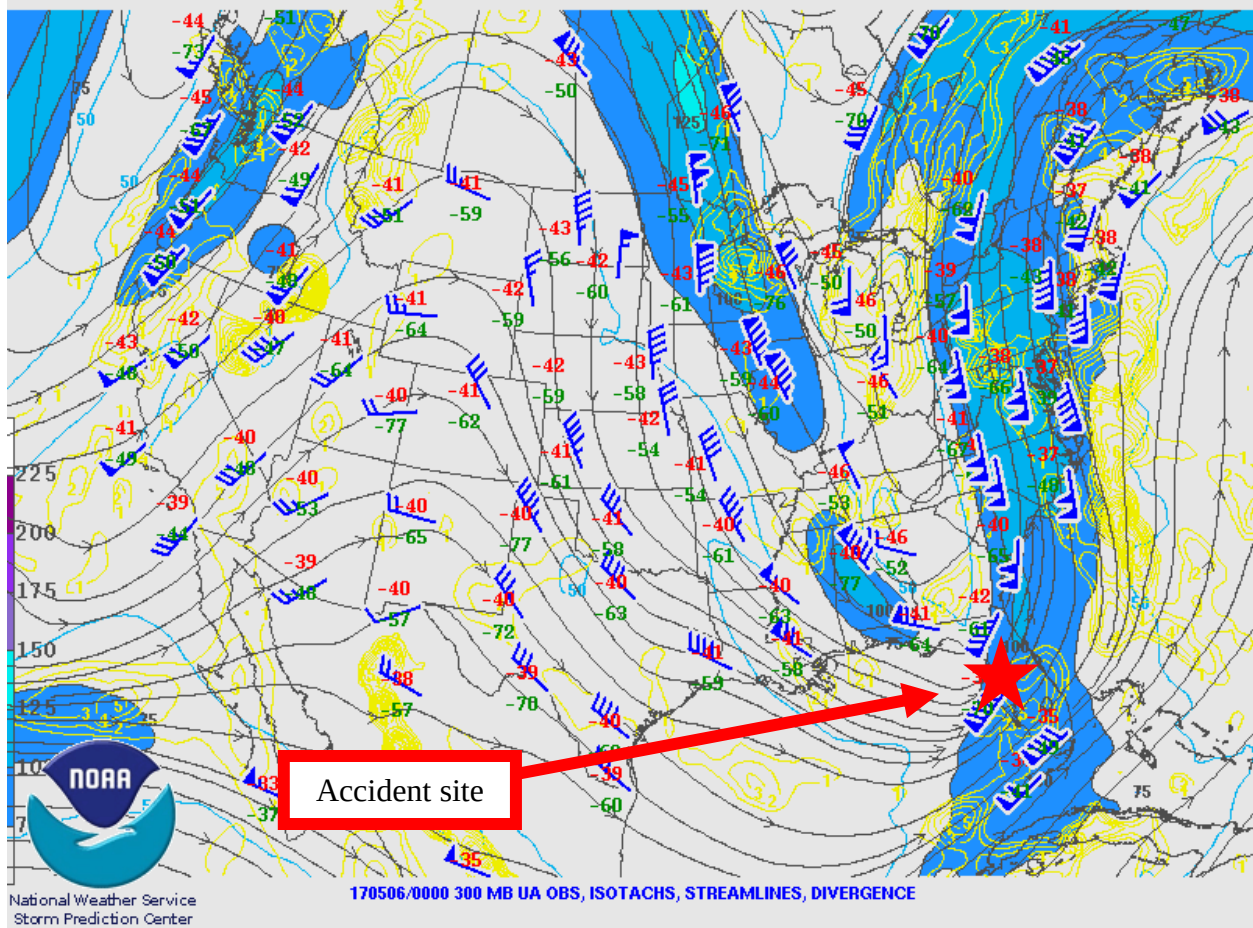


Figure 6 – 300-hPa Constant Pressure Chart for 2000 EDT

2.0 SPC Products

The NWS SPC Day 1 Convective Outlook did not forecast any thunderstorms for the accident site at the accident time.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 7 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked.

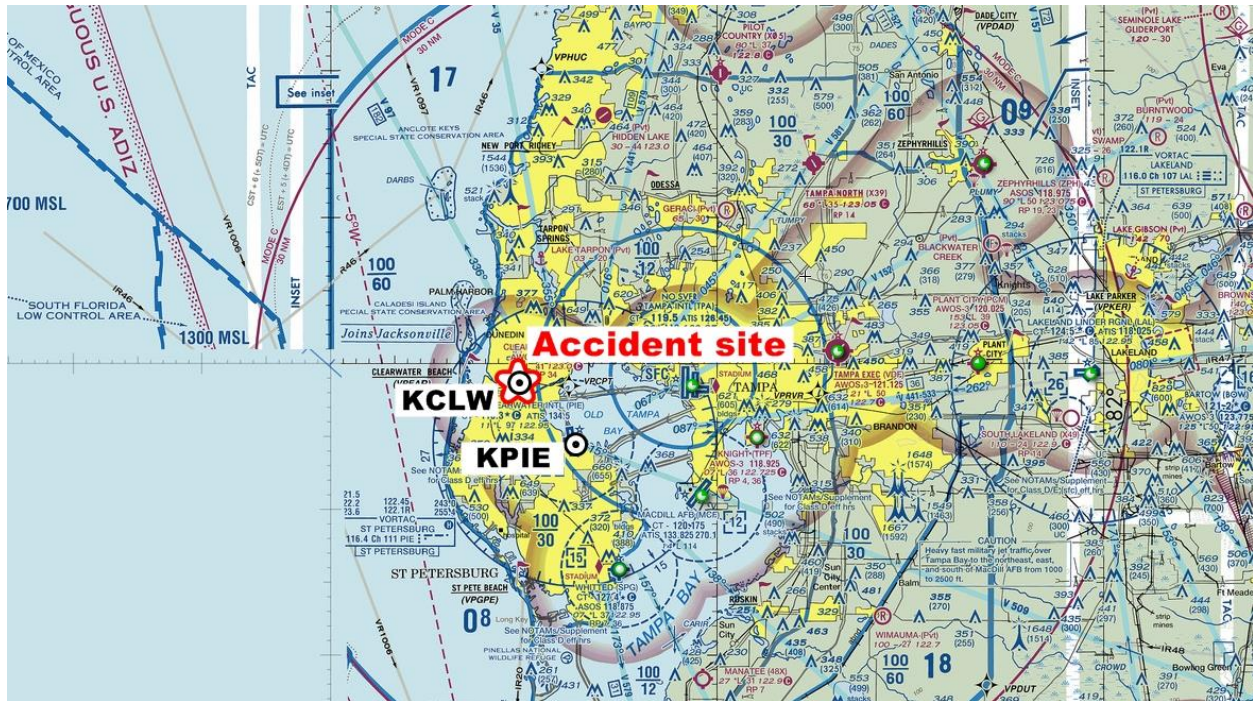


Figure 7 – Sectional chart of accident area with the location of the accident site and surface observation sites

Clearwater Air Park (KCLW) was the closest official weather station to the accident site, and was located 3 miles northeast of Clearwater, Florida. KCLW had Automated Weather Observing System (AWOS³) whose reports were not supplemented. KCLW was located within a mile of the accident site, at an elevation of 71 ft, and had a 4° westerly magnetic variation⁴ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁵

- [1715 EDT] METAR KCLW 052115Z AUTO 27013G18KT 10SM SCT044 SCT050 BKN060 22/11 A2979 RMK AO2=
- [1735 EDT] METAR KCLW 052135Z AUTO 27012G18KT 10SM SCT060 BKN070 22/11 A2978 RMK AO2=
- [1755 EDT] METAR KCLW 052155Z AUTO 28008G17KT 10SM SCT045 SCT060 SCT070 22/11 A2978 RMK AO2=
- [1815 EDT] METAR KCLW 052215Z AUTO 26011G17KT 10SM SCT047 SCT060 22/11 A2978 RMK AO2=

³ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand ft, and altimeter setting.

⁴ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2000, latest measurement taken from <http://www.airnav.com/airport/KCLW>

⁵ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1835 EDT] METAR KCLW 052235Z AUTO 27013G16KT 10SM SCT047 BKN060 BKN075
21/11 A2978 RMK AO2=

**[1855 EDT] METAR KCLW 052255Z AUTO 27014G20KT 10SM SCT047 BKN060 BKN070
21/11 A2978 RMK AO2=**

**[1915 EDT] METAR KCLW 052315Z AUTO 28010G19KT 10SM SCT045 BKN060 OVC085
21/11 A2978 RMK AO2=**

ACCIDENT TIME 1922 EDT

**[1935 EDT] METAR KCLW 052335Z AUTO 28014G23KT 10SM SCT032 BKN045 OVC060
21/12 A2979 RMK AO2=**

**[1955 EDT] METAR KCLW 052355Z AUTO 26007G16KT 10SM SCT035 BKN050 OVC095
19/15 A2979 RMK AO2=**

[2015 EDT] METAR KCLW 060015Z AUTO 28014G21KT 10SM SCT033 BKN040 BKN050
20/13 A2980 RMK AO2=

[2035 EDT] METAR KCLW 060035Z AUTO 27015G23KT 10SM SCT041 SCT047 BKN050
20/12 A2980 RMK AO2=

KCLW weather at 1855 EDT, automated, wind from 270° at 14 knots with gusts to 20 knots, 10 miles visibility, scattered clouds at 4,700 ft above ground level (agl), broken ceiling at 6,000 ft agl, broken skies at 7,000 ft agl, temperature of 21° Celsius (C), dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1915 EDT, automated, wind from 280° at 10 knots with gusts to 19 knots, 10 miles visibility, scattered clouds at 4,500 ft agl, broken ceiling at 6,000 ft agl, overcast skies at 8,500 ft agl, temperature of 21° C, dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1935 EDT, automated, wind from 280° at 14 knots with gusts to 23 knots, 10 miles visibility, scattered clouds at 3,200 ft agl, broken ceiling at 4,500 ft agl, overcast skies at 6,000 ft agl, temperature of 21° C, dew point temperature of 12° C, and an altimeter setting of 29.79 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1955 EDT, automated, wind from 260° at 7 knots with gusts to 16 knots, 10 miles visibility, scattered clouds at 3,500 ft agl, broken ceiling at 5,000 ft agl, overcast skies at 9,500 ft agl, temperature of 19° C, dew point temperature of 15° C, and an altimeter setting of 29.79 inches of mercury. Remarks, station with a precipitation discriminator.

St. Pete-Clearwater International Airport (KPIE) was the next closest official weather station to the accident site. KPIE was located 8 miles north of St. Petersburg-Clearwater, Florida. KPIE had Automated Surface Observing System (ASOS⁶) whose reports were augmented by NWS certified observers when they were logged on to the ASOS. KPIE was located 6 miles southeast of the accident site, at an elevation of 11 ft, and had a 5° westerly magnetic variation⁷ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[1353 EDT] METAR KPIE 051753Z 29012G22KT 10SM SCT045 24/11 A2983 RMK AO2 SLP101 T02390111 10239 20211 58002=
[1453 EDT] METAR KPIE 051853Z AUTO 28016G21KT 10SM SCT050 24/10 A2982 RMK AO2 SLP099 T02440100=
[1553 EDT] METAR KPIE 051953Z 27013G21KT 10SM SCT050 23/10 A2981 RMK AO2 PK WND 27026/1929 SLP094 T02330100=
[1653 EDT] METAR KPIE 052053Z 27017G23KT 10SM SCT048 BKN060 23/09 A2979 RMK AO2 PK WND 25027/2031 SLP087 T02330094 58014=
[1753 EDT] METAR KPIE 052153Z 27011G26KT 10SM SCT055 SCT070 23/09 A2978 RMK AO2 PK WND 25026/2145 SLP085 T02330094=
[1853 EDT] METAR KPIE 052253Z 25018G24KT 10SM SCT050 BKN065 23/11 A2978 RMK AO2 PK WND 27027/2201 SLP085 T02280106=

ACCIDENT TIME 1922 EDT

[1953 EDT] METAR KPIE 052353Z 27016G32KT 9SM -RA FEW047 BKN055 OVC080 21/13 A2980 RMK AO2 PK WND 26032/2347 RAB50 SLP089 P0000 60000 T02060128 10250 20206 53002=
[2053 EDT] METAR KPIE 060053Z 28011G25KT 10SM FEW043 21/11 A2981 RMK AO2 RAE18 SLP092 P0000 T02110106=
[2153 EDT] METAR KPIE 060153Z 27015KT 10SM CLR 21/08 A2982 RMK AO2 PK WND 30027/0059 SLP099 T02110078=
[2253 EDT] METAR KPIE 060253Z 26019G27KT 10SM SCT080 22/10 A2983 RMK AO2 PK WND 27027/0253 SLP101 60000 T02170100 51012=

⁶ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁷ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2010, latest measurement taken from <http://www.aimav.com/airport/KPIE>

KPIE weather at 1753 EDT, wind from 270° at 11 knots with gusts to 26 knots, 10 miles visibility, scattered clouds at 5,500 ft, scattered clouds at 7,000 ft agl, temperature of 23° C, dew point temperature of 9° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator, peak wind from 250° at 26 knots at 1745 EDT, sea level pressure 1008.5 hPa, temperature 23.3° C, dew point temperature 9.4° C.

KPIE weather at 1853 EDT, wind from 250° at 18 knots with gusts to 24 knots, 10 miles visibility, scattered clouds at 5,000 ft, broken ceiling at 6,500 ft agl, temperature of 23° C, dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator, peak wind from 270° at 27 knots at 1801 EDT, sea level pressure 1008.5 hPa, temperature 22.8° C, dew point temperature 10.6° C.

KPIE weather at 1953 EDT, wind from 270° at 16 knots with gusts to 32 knots, 9 miles visibility, light rain, few clouds at 4,700 ft agl, broken ceiling at 5,500 ft agl, overcast skies at 8,000 ft agl, temperature of 21° C, dew point temperature of 13° C, and an altimeter setting of 29.80 inches of mercury. Remarks, station with a precipitation discriminator, peak wind from 260° at 32 knots at 1947 EDT, rain began at 1950 EDT, sea level pressure 1008.9 hPa, a trace of precipitation since the last hourly observation, 6-hourly precipitation of a trace, temperature 20.6° C, dew point temperature 12.8° C, 6-hourly maximum temperature of 25.0° C, 6-hourly minimum temperature of 20.6° C, 3-hourly pressure increase of 0.2 hPa.

KPIE weather at 2053 EDT, wind from 280° at 11 knots with gusts to 25 knots, 10 miles visibility, few clouds at 4,300 ft, temperature of 21° C, dew point temperature of 11° C, and an altimeter setting of 29.81 inches of mercury. Remarks, station with a precipitation discriminator, rain ended at 2018 EDT, sea level pressure 1009.2 hPa, a trace of precipitation since the last hourly observation, temperature 21.1° C, dew point temperature 10.6° C.

The observations from KCLW and KPIE surrounding the accident time indicated gusty surface winds with VFR⁸ ceilings and visibilities as the rain showers moved from west to east across the accident area (section 6.4).

3.1 5-Minute KCLW ASOS Observations

The 5-minute KCLW ASOS observations were obtained for the period surrounding the accident and those observations are documented and summarized below:

[1900 EDT] METAR KCLW 052300Z AUTO 26006G19KT 10SM SCT047 BKN060 OVC070
21/11 A2978 RMK AO2

[1905 EDT] METAR KCLW 052305Z AUTO 27013G17KT 10SM SCT045 BKN060 OVC080
21/11 A2978 RMK AO2

[1910 EDT] METAR KCLW 052310Z AUTO 24011G19KT 10SM BKN045 BKN060
OVC080 21/11 A2978 RMK AO2

⁸ Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 ft agl and greater than 5 miles visibility.

***[1915 EDT] METAR KCLW 052315Z AUTO 28010G19KT 10SM SCT045 BKN060 OVC085
21/11 A2978 RMK AO2***

***[1920 EDT] METAR KCLW 052320Z AUTO 26011G19KT 10SM SCT047 BKN060 OVC085
21/11 A2978 RMK AO2***

ACCIDENT TIME 1922 EDT

***[1925 EDT] METAR KCLW 052325Z AUTO 26012G19KT 220V280 10SM SCT047 BKN060
OVC085 21/11 A2978 RMK AO2***

***[1930 EDT] METAR KCLW 052330Z AUTO 24016G23KT 10SM SCT045 BKN060 OVC085
21/12 A2978 RMK AO2***

***[1935 EDT] METAR KCLW 052335Z AUTO 28014G23KT 10SM SCT032 BKN045 OVC060
21/12 A2979 RMK AO2***

***[1940 EDT] METAR KCLW 052340Z AUTO 28014G23KT 7SM RA SCT032 BKN045
OVC060 20/14 A2979 RMK AO2***

***[1945 EDT] METAR KCLW 052345Z AUTO 26010G22KT 220V280 7SM -RA SCT032
BKN045 OVC060 20/15 A2979 RMK AO2***

***[1950 EDT] METAR KCLW 052350Z AUTO 26008G17KT 10SM -RA SCT042 BKN050
OVC075 19/15 A2979 RMK AO2***

***[1955 EDT] METAR KCLW 052355Z AUTO 26007G16KT 10SM SCT035 BKN050 OVC095
19/15 A2979 RMK AO2***

KCLW weather at 1915 EDT, automated, wind from 280° at 10 knots with gusts to 19 knots, 10 miles visibility, scattered clouds at 4,500 ft agl, broken ceiling at 6,000 ft agl, overcast skies at 8,500 ft agl, temperature of 21° C, dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1920 EDT, automated, wind from 260° at 11 knots with gusts to 19 knots, 10 miles visibility, scattered clouds at 4,700 ft agl, broken ceiling at 6,000 ft agl, overcast skies at 8,500 ft agl, temperature of 21° C, dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1925 EDT, automated, wind from 260° at 12 knots with gusts to 19 knots, wind direction varying between 220° and 280°, 10 miles visibility, scattered clouds at 4,700 ft agl, broken ceiling at 6,000 ft agl, overcast skies at 8,500 ft agl, temperature of 21° C, dew point temperature of 11° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

KCLW weather at 1930 EDT, automated, wind from 240° at 16 knots with gusts to 23 knots, 10 miles visibility, scattered clouds at 4,500 ft agl, broken ceiling at 6,000 ft agl, overcast skies at 8,500 ft agl, temperature of 21° C, dew point temperature of 12° C, and an altimeter setting of 29.78 inches of mercury. Remarks, station with a precipitation discriminator.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Tampa Bay, Florida, (KTBW), located 25 miles southeast of the accident site, with a site number 72210, and an elevation of 43 ft. The 2000 EDT sounding was plotted on a standard Skew-T log P diagram⁹ with the derived stability parameters included in figure 8 (with data from the surface to 600-hPa, or 14,000 ft msl.) This sounding data was analyzed using the RAOB¹⁰ software package. The sounding depicted the lifted condensation level (LCL)¹¹ at 4,985 ft msl, a convective condensation level (CCL)¹² of 5,993 ft, and a level of free convection (LFC)¹³ at 5,918 ft. The freezing level was 12,909 ft. The precipitable water value was 0.67 inches.

⁹ 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.

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

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

¹² 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.

¹³ 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.

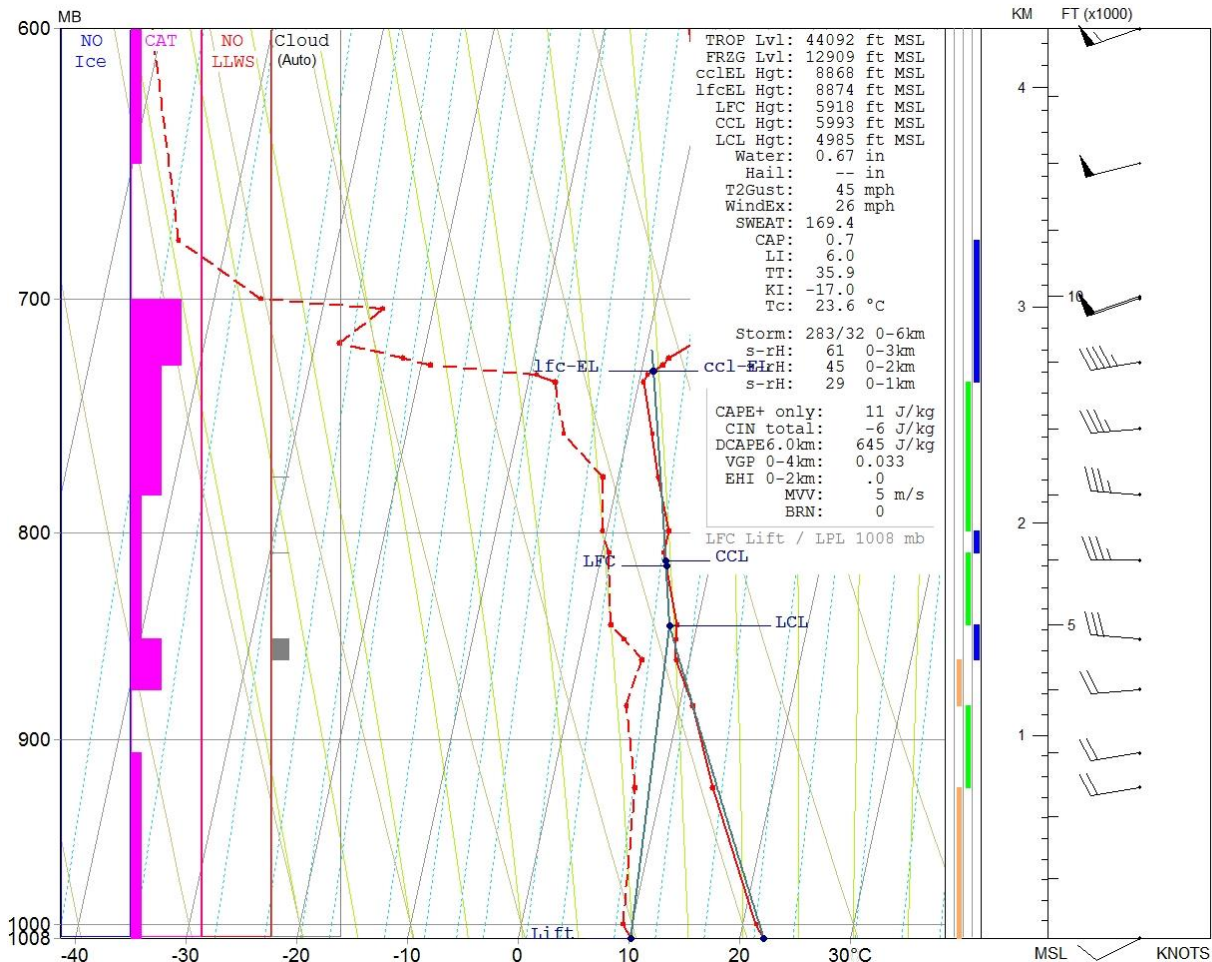


Figure 8 – 2000 EDT TBW sounding

The 2000 EDT KTBW sounding indicated a mainly conditionally unstable environment from the surface through 8,500 ft with 11 J/kg of CAPE¹⁴ from the surface. This environment would have been supportive of cloud formation and rain showers, if a lifting mechanism was in the area of the accident site at the accident time (sections 1.1 and 1.2). The maximum vertical velocity (MVV) for this atmosphere was calculated as 5 meters/second (about 984 ft per minute).¹⁵ Downdraft CAPE (DCAPE; 6 kilometers agl)¹⁶ was measured at 645 Joules/kilogram. RAOB identified the possibility of clouds starting around 5,000 ft. No areas of icing were indicated by RAOB for below 14,000 ft msl. The 2000 EDT KTBW sounding indicated the strongest wind speeds possible with any convective outflow was estimated at 45 mph (39 knots) as indicated by the T2Gust parameter.

¹⁴ 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.

¹⁵ MVV is not usually considered a realistic estimate for maximum vertical velocity in a storm. Anecdotes suggest considering a value of MVV/2, however it is not well understood when or where such a half-value should be applied.

¹⁶ The DCAPE can be used to estimate the potential strength of rain-cooled downdrafts within thunderstorm convection, and is similar to CAPE. Larger DCAPE values are associated with stronger downdrafts.

The 2000 EDT KTBW sounding wind profile indicated a surface wind from 240° at 9 knots with the wind remaining westerly through 14,000 ft. The wind speed increased to 22 knots at 2,500 ft and 35 knots by 6,000 ft. Above 6,000 ft the wind was westerly with the wind speed between 35 and 55 knots. The mean 0 to 6 kilometer or 18,000 ft was from 250° at 43 knots. RAOB did not indicate the possibility of low-level wind shear between the surface and 2,000 ft outside of rain shower or thunderstorm activity. RAOB indicated the possibility of clear-air turbulence in three layers between the surface and 14,000 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-13 bands 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1800 EDT through 2100 EDT at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 9 and 10 present the GOES-13 visible imagery from 1915 and 1930 EDT at 2X magnification with the accident site marked with a red box. The visible imagery indicated cloud cover above the accident site at the accident time with the cloud cover cumuliform in nature moving from west to east. Figure 11 presents the GOES-13 infrared imagery from 1930 EDT at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site with the lower brightness temperatures (red colors, higher cloud tops) stretched from southwest to northeast across the accident site and central Florida. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 2000 EDT KTBW sounding, the approximate cloud-top heights over the accident site were 13,000 ft at 1930 EDT. It should be noted these figures have not been corrected for any parallax error.

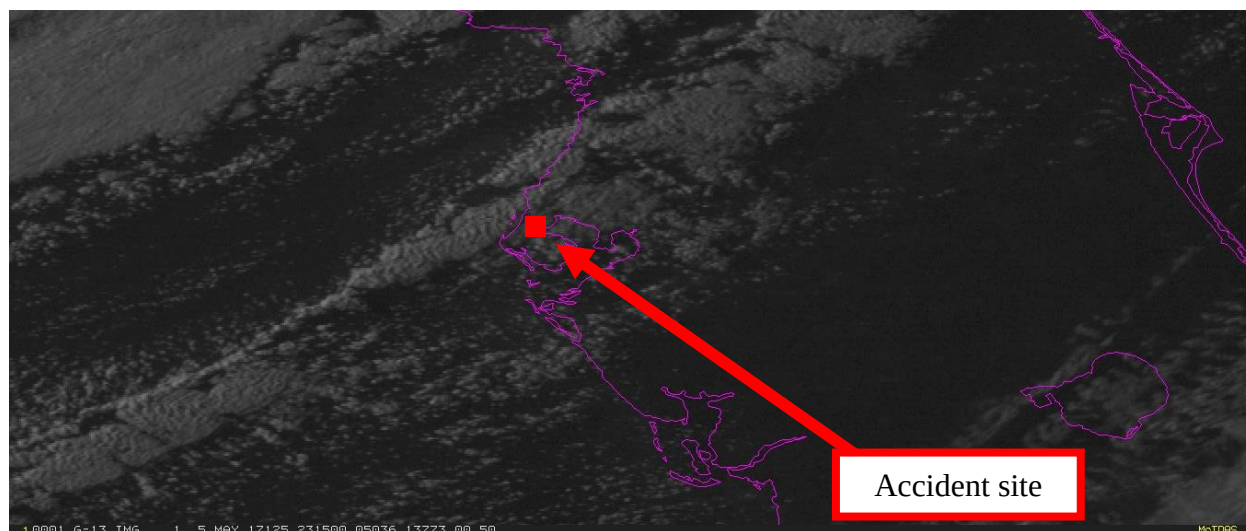


Figure 9 – GOES-13 visible image at 1915 EDT

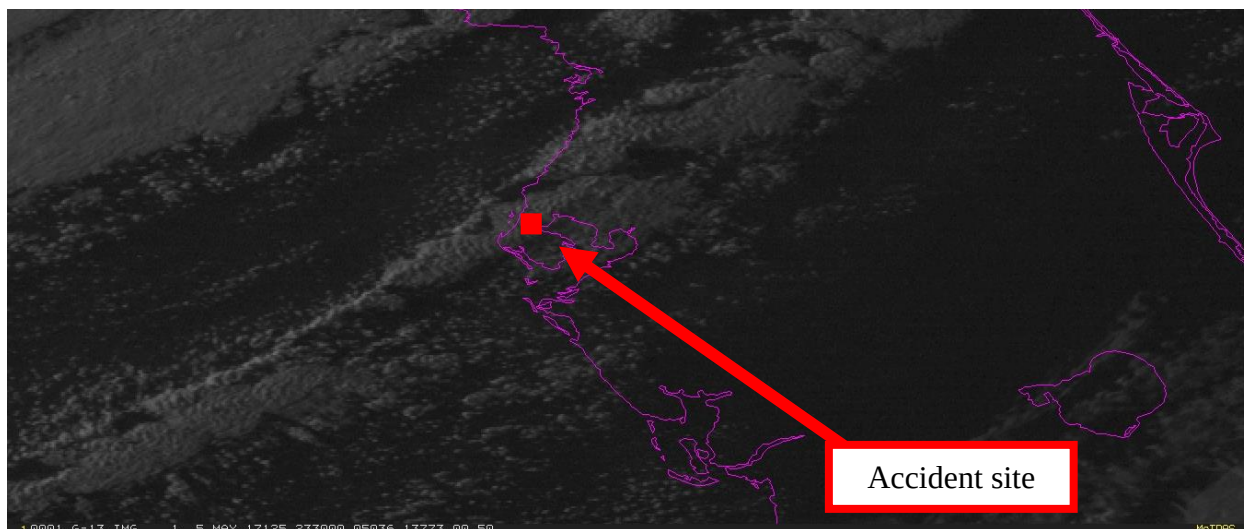


Figure 10 – GOES-13 visible image at 1930 EDT

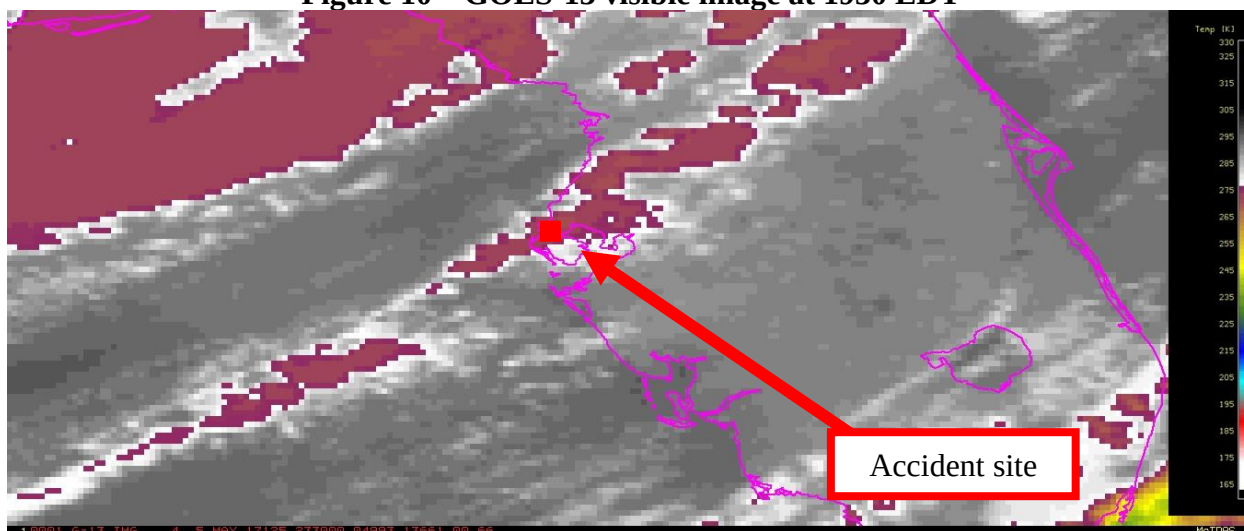


Figure 11 – GOES-13 infrared image at 1930 EDT

6.0 Radar Imagery Information

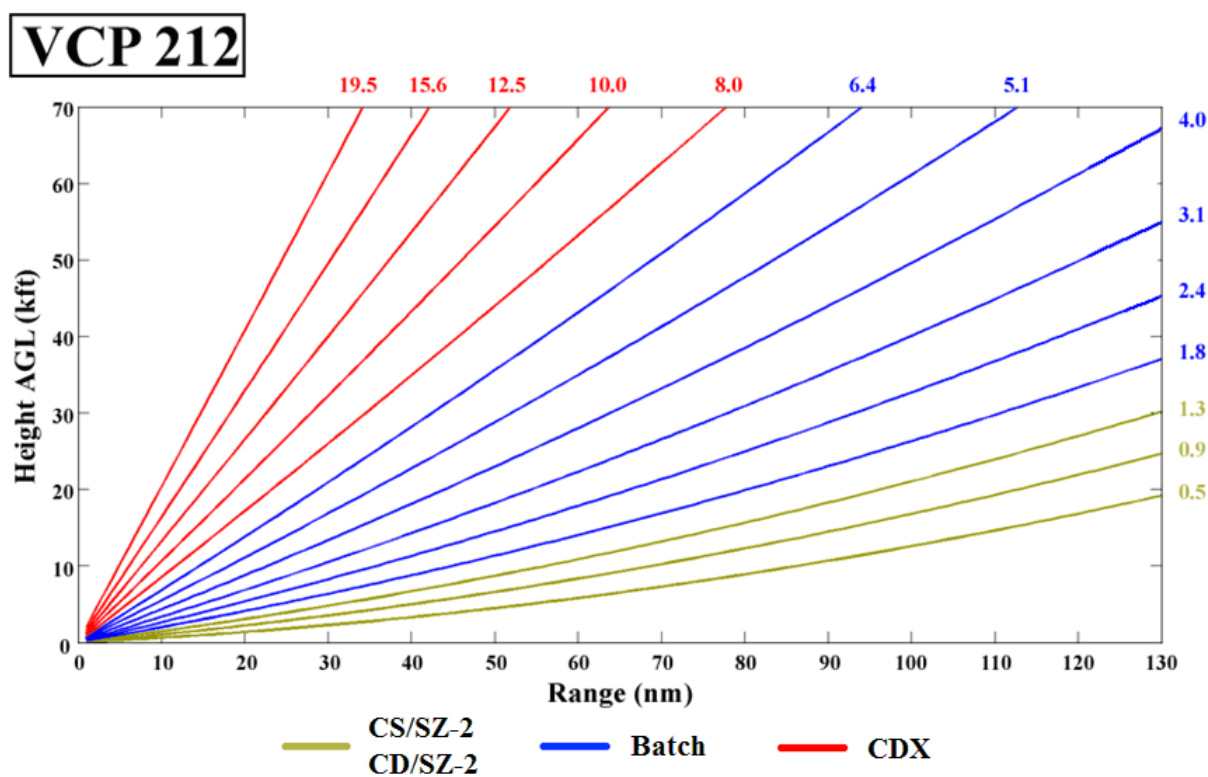
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁷ to the accident site was KTBW. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

¹⁷ 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 three 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 KTBW WSR-88D radar was operating in the 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.



VCP-212 Precipitation Mode Scan Strategy¹⁸

¹⁸ Contiguous Surveillance (CS)--The low PRF scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured.

Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values.

Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

6.2 Beam Height Calculation

Assuming standard refraction¹⁹ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width²⁰ information²¹ of the radar display over the site of the accident. The heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	1,820 ft	590 ft	3,050 ft	2,460 ft

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 590 ft and 3,050 ft msl over the accident site and these are the closest altitudes to the accident site before the accident occurred.²²

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²³ 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 (dBZ²⁴), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

W – With range unfolding (W)

WO – Without range unfolding (WO)

¹⁹ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁰ Beam width – A measure of the angular width of a radar beam.

²¹ Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.

²² For more information, please see the air traffic control (ATC) data located in the docket for this accident.

²³ 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.

²⁴ 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.

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

6.4 Base Reflectivity and Lightning Data

Figures 12 through 14 present the KTBW WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1920, 1924, and 1928 EDT with a resolution of 0.5° X 250 m. The ATC flight track is also included with the arrows pointing in the direction of travel. The accident flight track indicated that the accident flight was located in an area of 0 to 15 dBZ reflectivity values at 1920 EDT (figure 12) and ahead of a band of higher reflectivities of 40 dBZ. Between 1924 and 1928 EDT 10 to 30 dBZ reflectivity values moved over the accident site (figures 13, 14, and attachment 1), with the main band of higher reflectivities moving over the accident site after 1928 EDT. The 0 to 30 dBZ reflectivity values would correspond to light precipitation (section 6.3). There were no lightning strikes around the accident site at the accident time.²⁵ The KTBW WSR-88D base velocity data was reviewed and did not indicate any clearly defined divergence centers over the accident site.

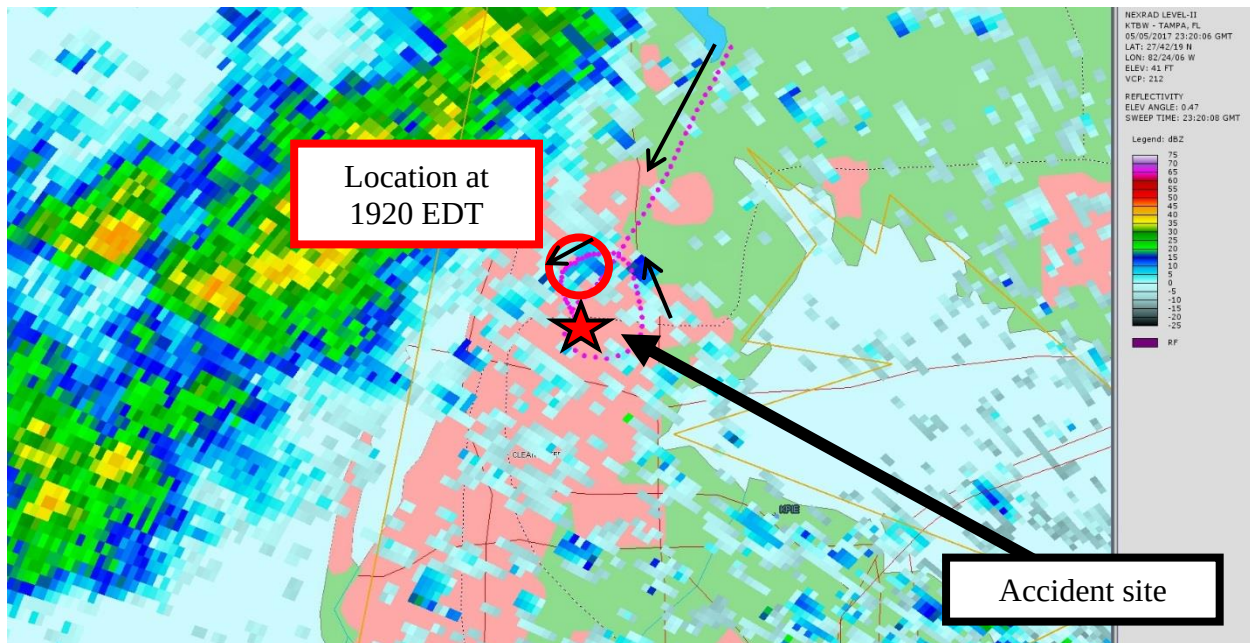


Figure 12 – KTBW WSR-88D reflectivity for the 0.5° elevation scan initiated at 1920 EDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

²⁵ A review of Earth Networks Total Lightning network was done.

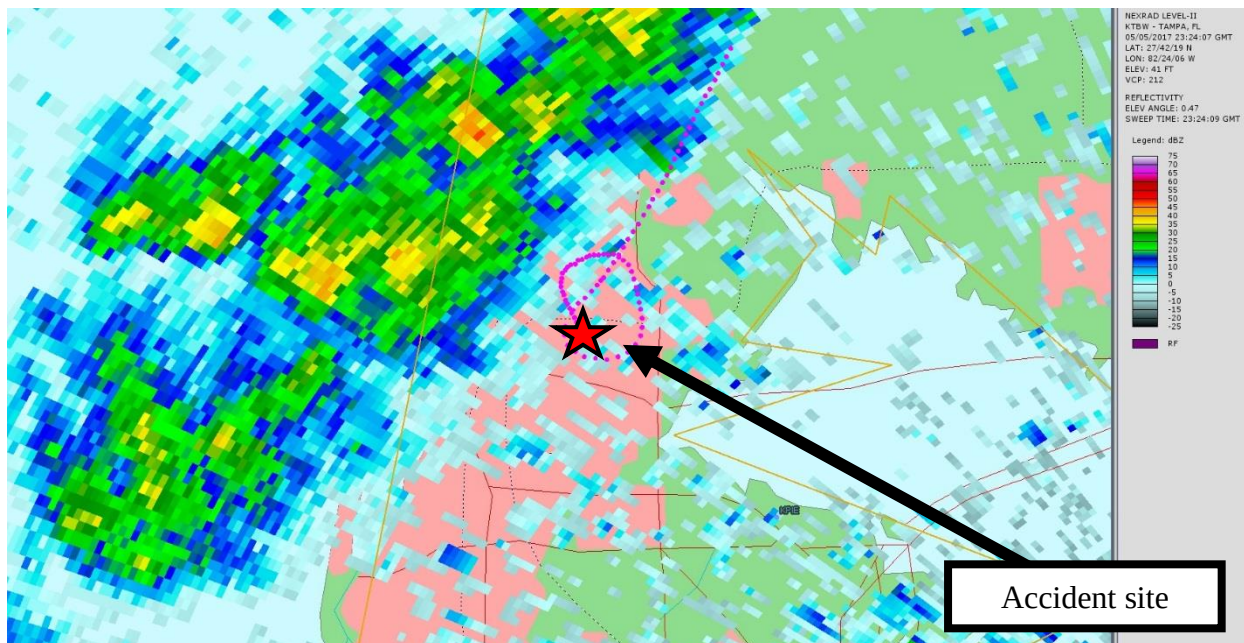


Figure 13 – KTBW WSR-88D reflectivity for the 0.5° elevation scan initiated at 1924 EDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

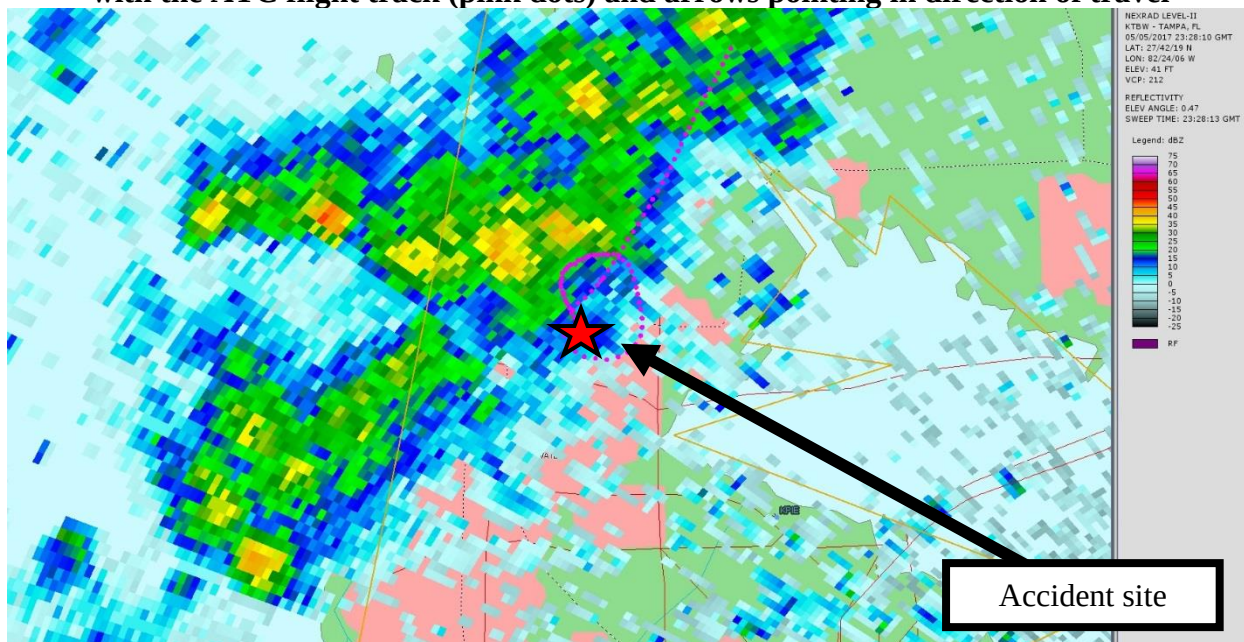


Figure 14 – KTBW WSR-88D reflectivity for the 0.5° elevation scan initiated at 1928 EDT with the ATC flight track (pink dots) and arrows pointing in direction of travel

7.0 Pilot Reports²⁶

All PIREPs close to the accident site from about two hours prior to the accident time to about two hours after the accident time were reviewed. There were no PIREPs near the accident site for below FL180²⁷ that were distributed into the national airspace.

8.0 SIGMET and CWSU Advisories

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

No Center Weather Service Unit (CWSU) Meteorological Impact Statement (MIS) or Center Weather Advisories (CWA)s were valid for the accident site at the accident.

9.0 AIRMETs

Airmen's Meteorological Information (AIRMET) advisory Tango was valid for the accident site at the accident time. AIRMET Tango was issued at 1645 EDT and advised of moderate turbulence below 12,000 ft:

117
WAUS42 KKCI 052045
WA2T
-MIAT WA 052045
AIRMET TANGO UPDT 4 FOR TURB AND STG SFC WNDS VALID UNTIL 060300
.
AIRMET TURB...NC SC GA AND CSTL WTRS
FROM 160SE SIE TO 190ESE ECG TO 130SSE ILM TO 50SW PZD TO GQO TO
HNV TO 20NE ECG TO 160SE SIE
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET TURB...SC GA FL AND CSTL WTRS
FROM 130SSE ILM TO 180E PBI TO 70ENE PBI TO 150SE MIA TO 80WSW
EYW TO 90WSW PIE TO 170SE LEV TO 130ESE LEV TO 40W CEW TO 50SW
PZD TO 130SSE ILM
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET TURB...NC SC GA FL AND CSTL WTRS
FROM 160SE SIE TO 190ESE ECG TO 130SSE ILM TO 70ENE PBI TO 50S
MIA TO 20S EYW TO 90WSW PIE TO 50SE SJI TO 40W CEW TO 50SW PZD
TO GQO TO HNV TO 30ENE ECG TO 160SE SIE
MOD TURB BLW 120. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET STG SFC WNDS...FL CSTL WTRS
FROM 50SW CEW TO 60SSW TLH TO 30W CTY TO 50SSE CTY TO 60W PIE TO
120SSE SJI TO 50SW CEW

²⁶ Only pilot reports with the WMO header UBFL** identifier were considered.

²⁷ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 21-00Z.
CONDS CONTG BYD 03Z ENDG 06-09Z.

.
AIRMET STG SFC WINDS...NC CSTL WTRS
FROM 160SE SIE TO 190ESE ECG TO 140ESE ILM TO 80ESE ECG TO 110E
ORF TO 160SE SIE
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS ENDG 21-00Z.
....

10.0 Area Forecast

The Area Forecast issued at 1345 EDT, valid at the accident time, forecasted a scattered to broken ceiling at 4,000 ft, with cloud tops at 8,000 ft, isolated light rain showers, and a west wind gusts to 25 to 30 knots:

832
FAUS42 KPCI 051745
FA2W
-MIAC FA 051745
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 061200
CLDS/WX VALID UNTIL 060600...OTLK VALID 060600-061200
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...18Z CDFNT ALG A 40W CSN-ILM-TRV-60SW EYW LN. 12Z TROF
FM SW VA ACRS WRN NC.
.
NC
MTNS...BKN050-060 TOPS 080. WDLY SCT -SHRA. BECMG 0205 BKN045
TOPS 120. WDLY SCT -SHRA. OTLK...MVFR CIG SHRA.
PIEDMONT...BKN040 TOPS 070. OTLK...VFR.
CSTL PLAINS...
N HLF...BKN015-025 TOPS 140. WDLY SCT -TSRA. CB TOPS FL400.
TIL 03Z WND S G25KT. OTLK...VFR THRUT.
S HLF...SCT-BKN035 TOPS 070. OTLK...VFR.
.
SC
NW THIRD...BKN045 TOPS 080. WDLY SCT -SHRA. 22Z OVC035. WDLY SCT
-SHRA. 04Z BKN050. OTLK...VFR.
RMNDR...BKN-SCT040-050 TOPS 060. BECMG 0305 BKN035. OTLK...MVFR
CIG WRN SXNS...VFR ERN SXNS.
.
GA
NW QTR...BKN030 OVC040 TOPS 120. WDLY SCT -SHRA. 23Z BKN035. WND
NW G25KT. OTLK...MVFR CIG WND 10Z VFR WND.
NERN QTR...BKN035 TOPS 100. WDLY SCT -SHRA. WND SW G25KT SRN
SXNS. BECMG 0003 OVC030-035. OTLK...MVFR CIG.
SW QTR...SCT025 BKN040 TOPS 090. TIL 00Z WND W G25KT. OTLK...VFR.
SE QTR...BKN-SCT045 TOPS 080. WND W G25-30KT. 00Z SCT035 BKN060.
OTLK...VFR.

.
 FL
 PNHDL...BKN040-050 TOPS 080. WND NW G25-30KT. BECMG 0003 SKC.
 OCNL SCT CI. OTLK...VFR.
NRN-CNTRL PEN...SCT-BKN040 TOPS 080. ISOL -SHRA. WND W G25-30KT.
OTLK...VFR.
 SRN PEN...SCT020 SCT-BKN050 BKN100 TOPS 140. TIL 01Z WDLY SCT
 -TSRA. CB TOPS FL400. OTLK...VFR.
 .
 CSTL WTRS
 ATLC WTRS...
 E OF AN ORF-TRV-EYW LN...SCT020 BKN040 LYRD FL200. SCT -TSRA.
 CB TOPS FL430. BECMG 2302 SCT-BKN050 TOPS 080. WND W G25KT.
 OTLK...VFR.
 RMNDR...SCT030 WND SW G25KT. BECMG 2302 BKN030 TOPS 060. WND W
 G25KT. OTLK...VFR WND.
 GULF WTRS E OF 85W...BKN030 TOPS 060. WND W 20G30KT. OTLK...VFR
 WND.

11.0 Terminal Aerodrome Forecast

KPIE was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF issued before the time of the accident but valid after the accident time was issued at 1920 EDT and was valid for a 24-hour period beginning at 2000 EDT. The 1920 EDT TAF for KPIE was as follows:

TAF KPIE 052320Z 0600/0624 **25016G25KT P6SM BKN050**
TEMPO 0600/0601 6SM SHRA
 FM060800 31012KT P6SM SCT040
 FM061300 29014G20KT P6SM FEW040=

The 1920 EDT TAF expected a wind from 250° at 16 knots with gusts to 25 knots, greater than 6 miles visibility, and a broken ceiling at 5,000 ft agl. Temporary conditions were forecast between 2000 and 2100 EDT of 6 miles visibility and moderate rain showers.

The 1333 EDT KPIE TAF was valid at the time of the accident and was valid for a 24-hour period beginning at 1400 EDT. The 1333 EDT TAF for KPIE was as follows:

TAF KPIE 051733Z 0518/0618 **29018G28KT P6SM SCT050**
 FM060800 31012KT P6SM SCT040
 FM061300 29014G20KT P6SM FEW040 SCT250=

The 1333 EDT TAF expected a wind from 290° at 18 knots with gusts to 28 knots, greater than 6 miles visibility, and scattered clouds at 5,000 ft agl.

12.0 NWS Area Forecast Discussion

The NWS Office in Tampa Bay/Ruskin, Florida, issued the following Area Forecast Discussion (AFD) at 1426 EDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed that VFR conditions were expected to continue all night with breezy/gusty west to northwest winds near the coastal TAF sites:

550
FXUS62 KTBW 051826
AFDTBW

Area Forecast Discussion
National Weather Service Tampa Bay Ruskin FL
226 PM EDT Fri May 5 2017

.SHORT TERM (This afternoon-Saturday)...

Cool early May weekend on tap as large upper low lifts northward into the Eastern Great lakes region by late Saturday. Mid to upper dry NW flow aloft for clearing skies tonight into Saturday as short wave moves into the Gulf late Saturday. At the surface, cool Canadian high pressure building into the region today-tonight to filter cool and low dewpoint airmass into the region. Strong W-NW low level flow off the Gulf for some Gulf moisture and possible stratocu to keep overnight temps from dropping much near the coast but expect morning temps generally 1-4 degrees below climate normals. But, Saturday low level flow veers more northerly with daytime temps feeling quite pleasant running 5-10 degrees below normal averages.

Also, the strong onshore winds and elevated seas moving ashore have been producing large breaking waves and dangerous rip currents for area beaches today through this evening. Expect surf heights to drop below 5 ft Saturday but still remain in the 2-4 ft range for another day of strong rip currents.

.Long Term (Saturday Night-Friday)...

A large closed low will linger across the northeast with a ridge building over the western and central Gulf of Mexico and north through the central part of the country. This set-up will keep a northwest flow aloft over Florida through mid-week. Surface high pressure will remain over the region. On Sunday, we should still be looking at very pleasant conditions, with dew points in the 50s and temperatures a bit warmer, but still in the lower to mid 80s. Monday through Wednesday will feature even warmer temperatures and rising dew points, and by Tuesday and Wednesday, we are looking at highs around 90 or even the lower 90s for some inland locations. Onshore flow will keep coastal spots a bit cooler each afternoon. No rain is in the forecast.

For Thursday and Friday, the ridge aloft will flatten as a weak shortwave pivots toward the east coast, while the surface high gets shunted eastward as an area of low pressure and a frontal boundary move into the southeast on Friday. Overall, dry and warm conditions will persist to end the week.

&&

.AVIATION...VFR conditions, all TAFs sites all night, with breezy/gusty west to northwest winds near the coast.

&&

.MARINE...

Tight gradient as strong high pressure builds into the region tonight into Saturday to keep hazardous winds and seas over the E Gulf through at least Saturday Morning and small craft should remain in port as SCAs remain posted for all waters. Buoys continue to run 8-10 ft well offshore and 6 ft nearshore with winds 20+ knots and higher gusts this afternoon. Elevated and gusty W-NW winds and seas continue tonight before slowly subsiding Saturday through the day. Winds and seas to subside further Sunday into early next week for improved marine conditions.

&&

FIRE WEATHER...Very dry conditions to settle over the region this weekend with critically low RHs possible for inland areas and Levy County Saturday then larger areas Sunday. Will have to see how last nights rainfall impacted ERCs later today to determine the need for fire weather watches or red flag warnings during the weekend.

&&

.Preliminary Point Temps/PoPs...

TPA 64 76 63 82 / 10 0 0 0
FMY 65 80 61 84 / 10 0 0 0
GIF 58 78 58 85 / 10 0 0 0
SRQ 65 75 62 79 / 10 0 0 0
BKV 57 76 54 83 / 10 0 0 0
SPG 65 75 66 79 / 10 0 0 0

&&

.TBW WATCHES/WARNINGS/ADVISORIES...

FL...High Rip Current Risk through Saturday evening for Coastal
Charlotte-Coastal Hillsborough-Coastal Lee-Coastal
Manatee-Coastal Sarasota-Pinellas.

High Surf Advisory until 10 PM EDT this evening for
Coastal Charlotte-Coastal Hillsborough-Coastal Lee-
Coastal Manatee-Coastal Sarasota-Pinellas.

Lake Wind Advisory until 8 PM EDT this evening for Coastal
Citrus-Coastal Hernando-Coastal Levy-Coastal Pasco-
Inland Citrus-Inland Hernando-Inland Levy-Inland
Pasco-Sumter.

Gulf waters...Small Craft Advisory until 10 AM EDT Saturday for

Charlotte Harbor and Pine Island Sound-Coastal waters from Bonita Beach to Englewood FL out 20 NM-Coastal waters from Englewood to Tarpon Springs FL out 20 NM-Coastal waters from Tarpon Springs to Suwannee River FL out 20 NM-Tampa Bay waters-Waters from Bonita Beach to Englewood FL out 20 to 60 NM-Waters from Englewood to Tarpon Springs FL out 20 to 60 NM-Waters from Tarpon Springs to Suwannee River FL out 20 to 60 NM.

&&

\$\$

13.0 Winds and Temperature Aloft Forecast

The NWS 1601 EDT Winds and Temperature Aloft forecast valid for the accident flight is included below:

```
631
FBUS31 KWN0 052002
FD1US1
-DATA BASED ON 051800Z
VALID 060000Z   FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT    3000    6000    9000    12000    18000    24000    30000    34000    39000

PIE 2626 2730+05 2634+03 2549+02 2650-13 2563-26 238438 239145 249953
```

The accident site was closest to the PIE forecast point. The 1601 EDT PIE forecast indicated a wind at 3,000 ft from 260° at 26 knots, a wind at 6,000 ft from 270° at 30 knots with a temperature of 5° C, and a wind at 9,000 ft from 260° at 34 knots with a temperature of 3° C.

14.0 Pilot Weather Briefing

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS), Leidos weather briefings, and Direct User Access Terminal Service (DUATS) was done. The accident pilot did not receive an official DUATS, LMFS, or Leidos weather briefing. The accident pilot did receive a weather briefing at 1012 EDT on May 5 through ForeFlight (attachments 2, 3 and 4). The weather briefing received from ForeFlight was only for a flight between Groton, Connecticut, (KGON), and Hagerstown, Maryland, (KHGR), and no ForeFlight weather briefing data was requested or received for a flight to KCLW. It is unknown if the accident pilot checked or received additional weather information before or during the accident flight.

15.0 Witness Information

An ATP rated pilot based at KCLW was landing at KCLW just ahead of the accident pilot. The ATP rated pilot stated that while landing and coming over “the numbers” on the runway that the wind became very gusty and it took him a while to get his airplane on the ground. The ATP rated pilot was concerned that he wouldn’t clear the runway before the accident airplane landed, so the ATP rated pilot got off the runway quickly and radioed the accident pilot that the winds were “snotty” on final and to be careful. The ATP rated pilot stated that the accident pilot acknowledged the radio transmission. The ATP rated pilot then taxied to his parking spot and tied down the airplane. The ATP rated pilot stated that the winds were blowing so hard by that time that he struggled to get the canopy on his airplane. It also began to rain. For more information please see attachment 5.

An employee at KCLW’s Fixed Base Operator (FBO) witnessed the accident sequence and weather conditions. The employee stated that the wind was blowing very hard at the time of the accident and the wind would gust “heavy” for about 30 seconds, then stop. Then the wind would gust “heavy” again. The employee stated that thunderstorms were moving across the airport at the time of the accident, but the employee did not see any lightning with the storms. For more information please see attachment 6.

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on May 5, 2017, indicated the following:

SUN	
Begin civil twilight	0522 EDT
Sunrise	0648 EDT
Sun transit	1327 EDT
Sunset	2008 EDT
End civil twilight	2133 EDT

17.0 ITWS Information

In response to NTSB request 17-157, the FAA provided the screen shots of the Integrated Terminal Weather System (ITWS)²⁸ Situation Display applicable to the Tampa Bay, Florida, area for the time period surrounding the accident. Images from the ITWS Situation Display for 1900 through 2000 EDT are presented in Attachment 7.

²⁸ Please see: https://www.faa.gov/air_traffic/technology/itws/ for more information.

18.0 Downburst and Microburst Information

The FAA's Advisory Circular AC 00-6B titled "Aviation Weather" issued in August 2016 is the primary basic training guide on many weather hazards, including downbursts and microbursts. In section 19.6.3, downburst and microburst are associated with rain showers and more frequently with thunderstorm activity. Downbursts create many hazards for aviation and often cause damaging wind at the surface. An exemplar diagram of a downburst from a rain shower or thunderstorm cloud base is shown in figure 15. Further information on the hazards of a downburst and microburst and the safest courses of action for pilot can be found in the FAA's AC 00-6B, the FAA's AC 00-24C, the FAA's Aeronautical Information Manual change 2 section 7-1-26 published in January 2015, and from the University Corporation for Atmospheric Research (UCAR)²⁹.

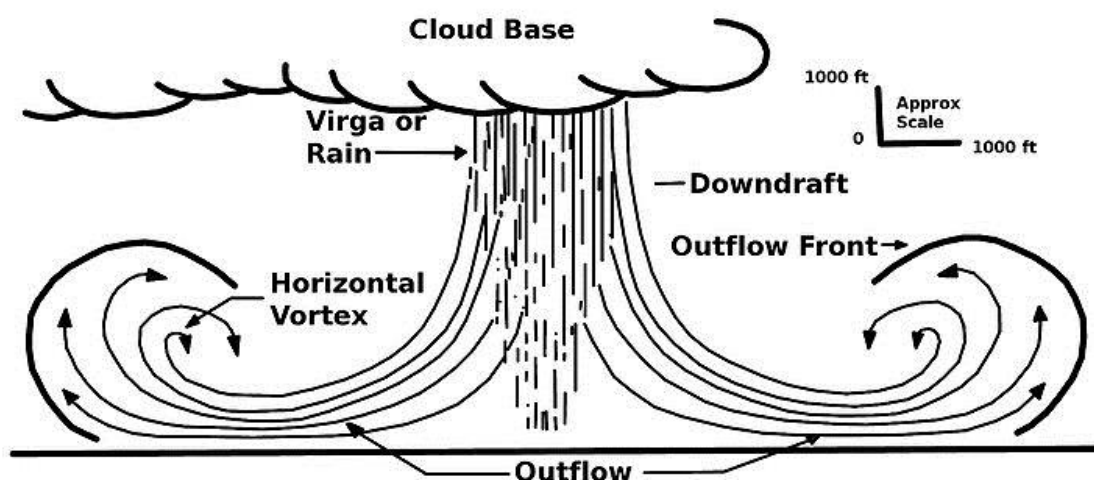


Figure 15 – Exemplar diagram of a downburst and outflow

E. LIST OF ATTACHMENTS

Attachment 1 – Animation of KTBW WSR-88D base reflectivity images for the 0.5° elevation scans initiated from 1903 to 1940 EDT

Attachment 2 – ForeFlight weather briefing package from 1012 EDT

Attachment 3 – ForeFlight/Leidos flight plan filed by accident pilot

Attachment 4 – Correspondence with ForeFlight

Attachment 5 – Record of Conversation

²⁹ UCAR's Collaboration among Education and Training Programs (COMET) Meteorology Education and Training (MetEd) module on Thunderstorm Downdrafts:
https://www.meted.ucar.edu/tropical/synoptic/local_storms/navmenu.php?tab=1&page=2.0.0&type=flash

Attachment 6 – Record of Conversation

Attachment 7 – FAA response to NTSB request 17-157 data

Submitted by:

Paul Suffern
Senior Meteorologist

THIS PAGE INTENTIONALLY BLANK