



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 30, 2020

Weather Study

METEOROLOGY

DCA19CA213

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A. ACCIDENT

Location: near Fort Myers, Florida
Date: September 9, 2019
Time: 1606 eastern daylight time
2006 Universal Coordinated Time (UTC)
Airplane: Spirit Airlines flight 967, Airbus A319; Registration: N515NK

B. METEOROLOGIST

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National Transportation Safety Board

C. SUMMARY

On September 6, 2019, at about 1606 eastern daylight time, a Spirit Airlines A319-132, N515NK, was on descent into Fort Myers Southwest Florida Airport (KRSW), Fort Myers, Florida, at approximately 12,000 ft when the captain gave the final arrival call to the flight attendants. Shortly thereafter, while the flight attendants were conducting final compliance checks, the aircraft encountered turbulence resulting in an injury to the ankle of one flight attendant. The flight attendant was transported to hospital after arrival for treatment. The airline reported that the flight attendant sustained a fractured ankle. The flight was operating as a 14 *Code of Federal Regulations* (CFR) part 121 flight. There were 2 flight crew, 3 flight attendants and 103 passengers on board.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are eastern daylight time (EDT) based upon the 24-hour clock, local time is -4 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The location was based on the captain's report of passing through 12,000 ft which was at approximately latitude 27.327610° N and longitude 81.5591278° W.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular “Aviation Weather Services”, AC 00-45H change 2.

1.1 Surface Analysis Chart

The southeast section of the NWS Surface Analysis Chart for 1400 EDT is included as figure 1 with the Fort Myers area noted within the red circle. The chart depicted a stationary front extending east-to-west across Georgia, Alabama, and Mississippi, with a ridge of high pressure extending over the Atlantic and across northern Florida. The location of the turbulence encounter was south of the ridge in an area of a weak pressure gradient and generally light easterly winds associated with the tropical easterly trade winds.

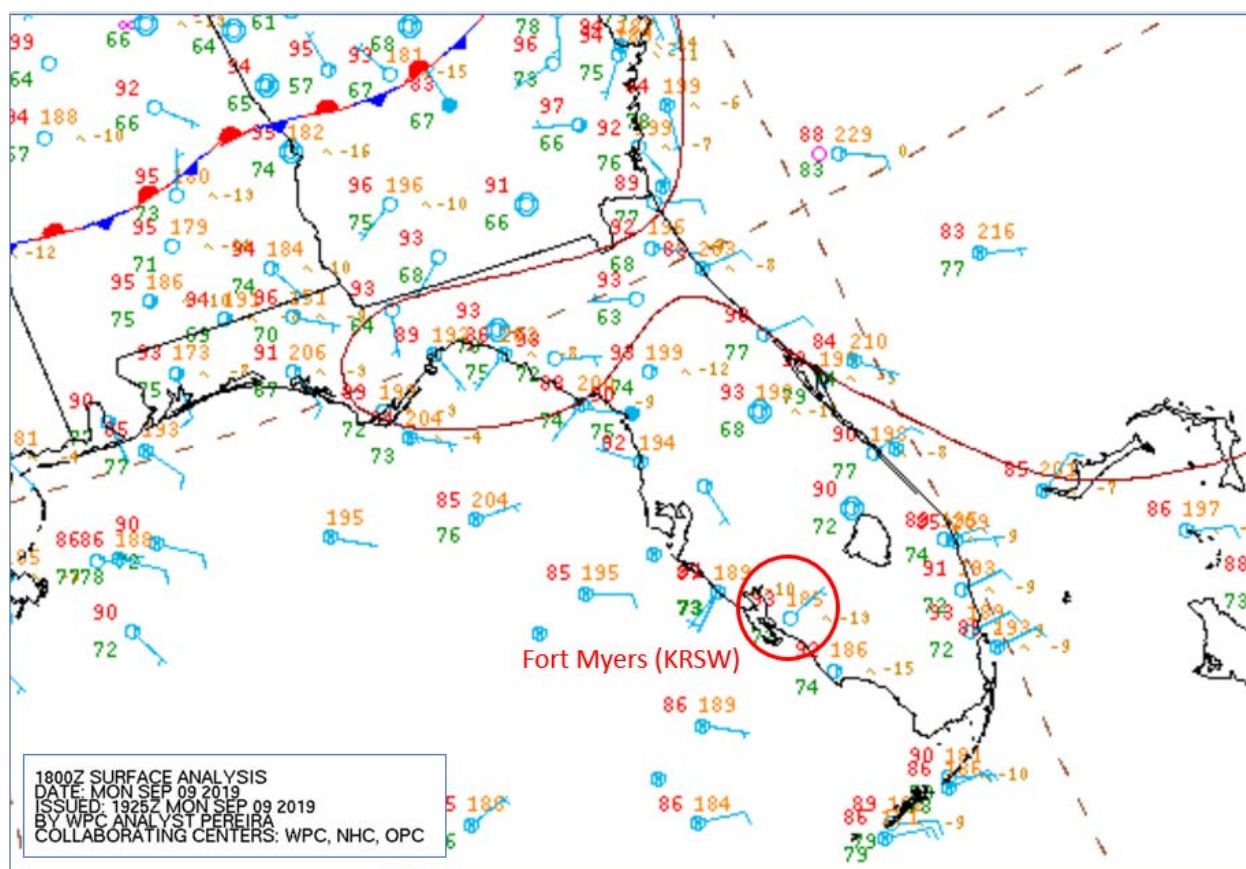


Figure 1 - Southeast section of the Surface Analysis Chart for 1400 EDT

The station model for Fort Myers, Florida, indicated a wind from the east at about 5 knots, clear skies, a temperature of 93° Fahrenheit (F), a dew point temperature of 72° F, with a sea level pressure of 1018.5-hectopascals (hPa). No significant weather was reported in the immediate vicinity of the station.

1.2 Streamline Analysis

A surface streamline analysis¹ for the southeast was obtained from archive data from Plymouth State University for 1600 EDT is included as figure 2. General convergence of the streamlines was observed over South Carolina, Georgia, Alabama, southern Mississippi, and into Louisiana and was associated with the stationary frontal boundary. Over southwest Florida a sea breeze² front was depicted from the Tampa area southward into the Fort Myers area with a localized convergence zone in the general vicinity of the turbulence location. The sea breeze convergence zone provides an additional lifting mechanism for clouds and potential precipitation formation.

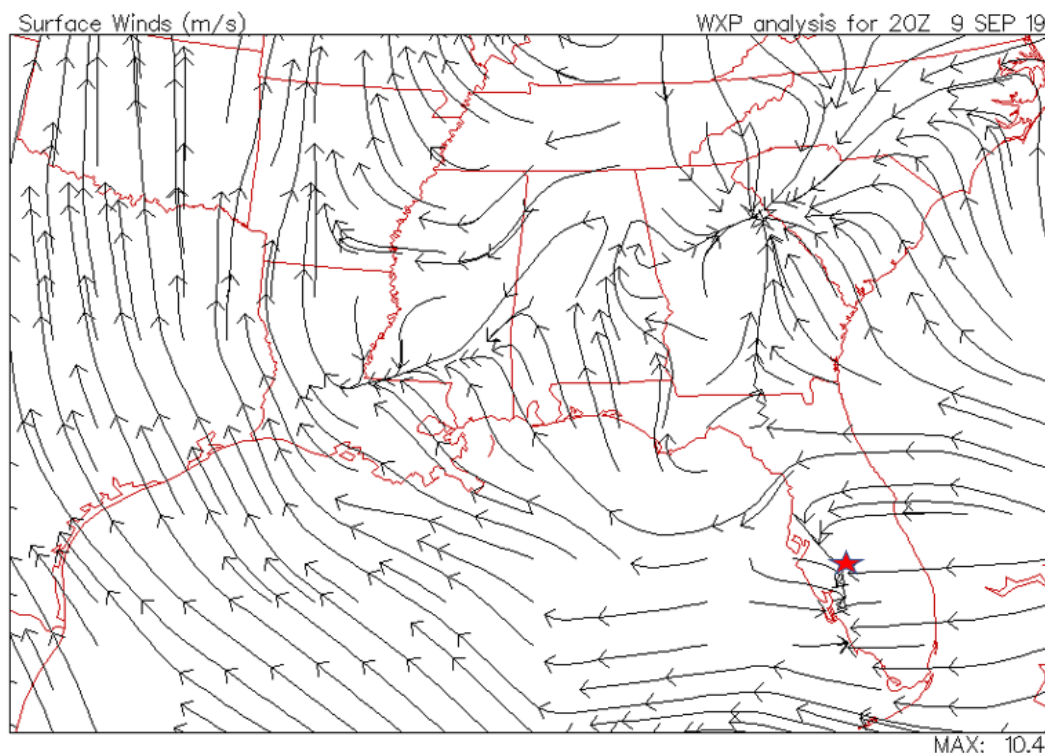


Figure 2 - Streamline analysis for 1700 EDT

1.3 National Composite Radar Mosaic

The National Composite Radar Image for 1605 EDT (2005Z) for the southeast and zoomed into the Fort Myers area are included as figures 3 and 4, respectively, with the approximate location of the turbulence encounter marked by a red star. The southeast radar composite showed numerous

¹ A streamline analysis is a depiction of the surface wind field. Streamlines are drawn parallel to the wind.

² Sea Breeze - A thermally produced wind blowing during the day from a cool ocean surface onto the adjoining warm land, caused by the difference in the rates of heating of the surfaces of the ocean and of the land.

echoes associated with thunderstorms and heavy rain in the general vicinity of the stationary fronts position (shown in figure 1) over southern Georgia, with only a few scattered areas of echoes over western Florida.

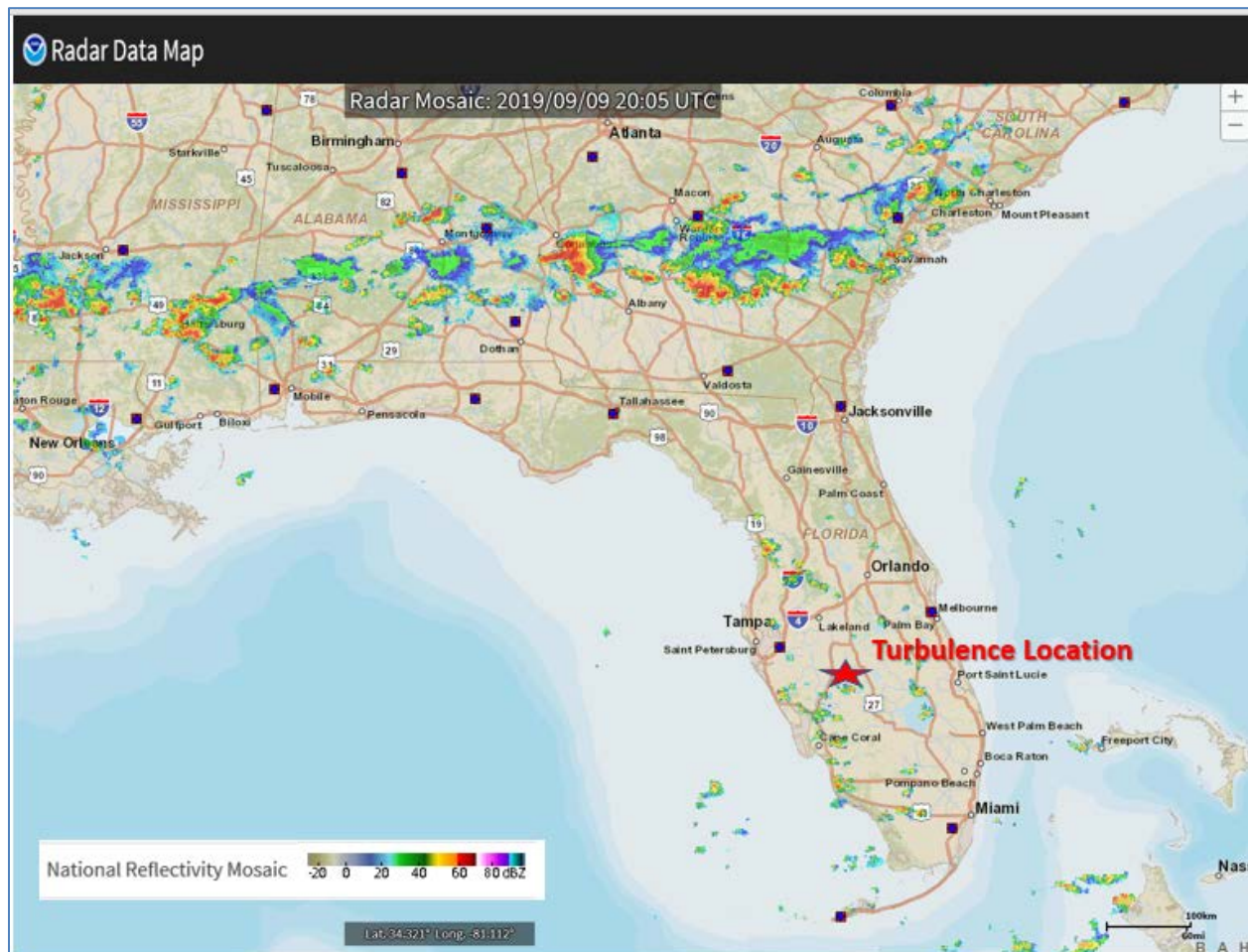


Figure 3 - Southeast section of the National Composite Radar Mosaic for 1605 EDT

The National Composite Radar Mosaic zoomed into the Fort Myers area for the same period depicted several scattered echoes over the area with two echoes approximately 10 miles south of the turbulence location, and another area immediately north of the Fort Myers Airport (KRSW).

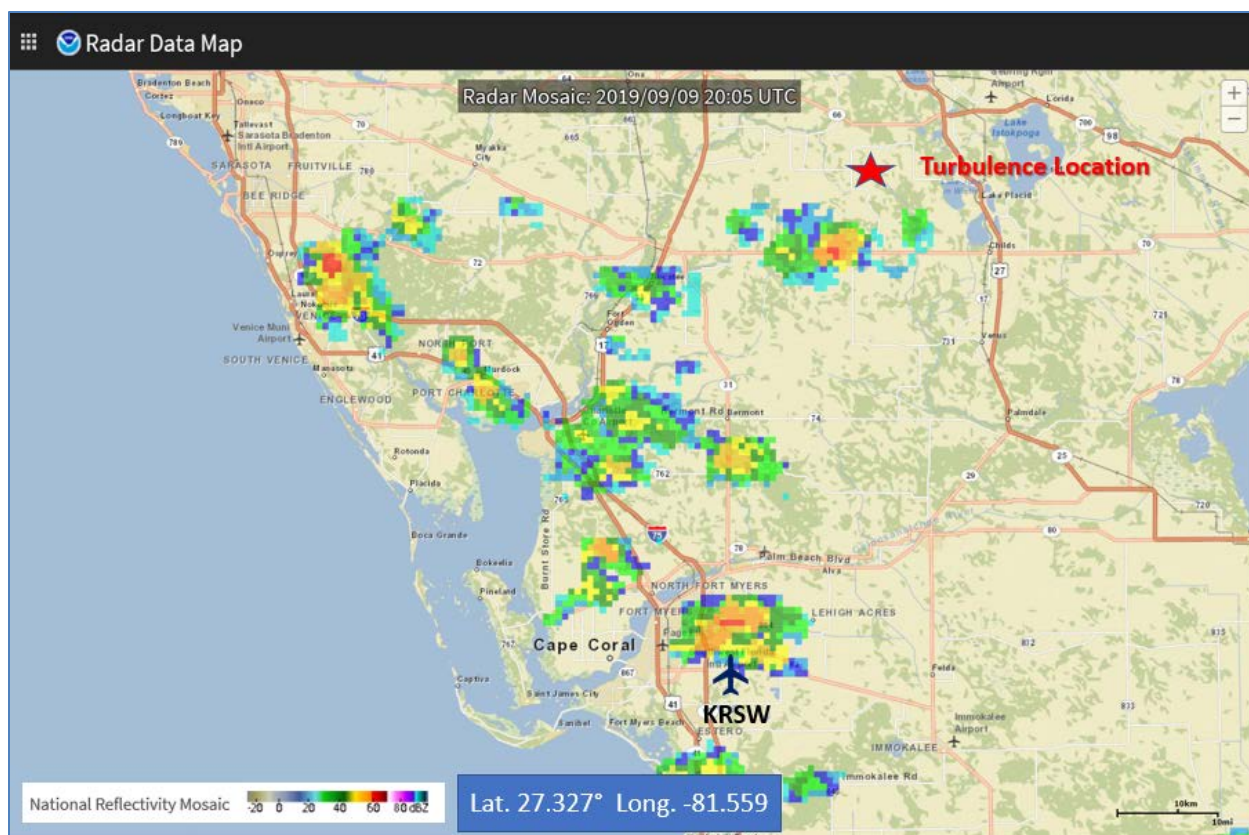


Figure 4 - Close up view of the National Composite Radar Mosaic for 1605 EDT over the Fort Myers area

Based on the existence of echoes near the turbulence location the closest weather surveillance radar will be documented in section 5.0 of this report.

1.4 Convective Outlook

The NWS Storm Prediction Center's (SPC) Day 1 Convective Outlook current for the period was issued at 1230 EDT and is included as figure 5. The intent of the chart is to identify to users like NWS forecasters, emergency managers, media, and pilots where the NWS SPC expects organized thunderstorms and severe thunderstorms³ to form. The outlook expected the highest category as a slight risk of severe thunderstorms over Iowa, Minnesota, and western Wisconsin, with general airmass type thunderstorms for the southeast and Florida. The narrative convective outlook bulletin issued with the chart did not mention any details of the potential for thunderstorms over Florida, and thus has not been included in this report.

³ A severe thunderstorm is one that produces a tornado, large hail over 1.0 inch in diameter, or outflow winds greater than 50 knots. While all thunderstorms imply the likelihood of severe turbulence, a severe thunderstorm implies a high likelihood of severe to extreme turbulence, wind shear, and a high probability of encountering hail.

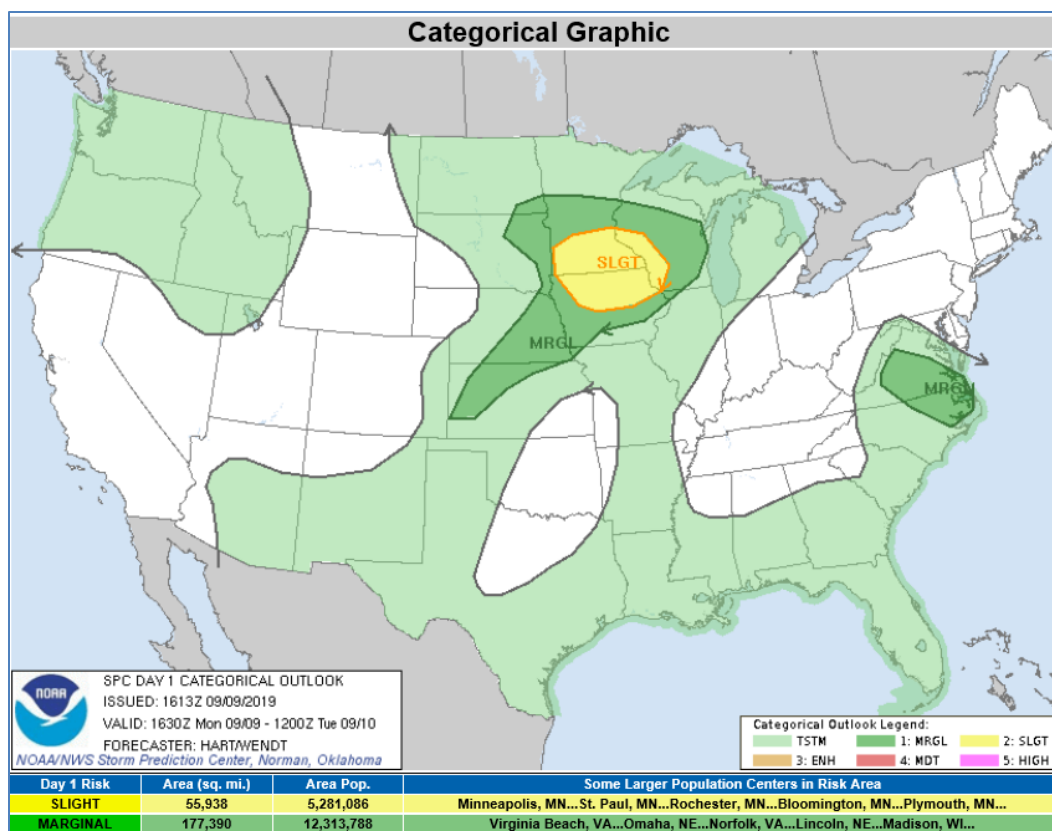
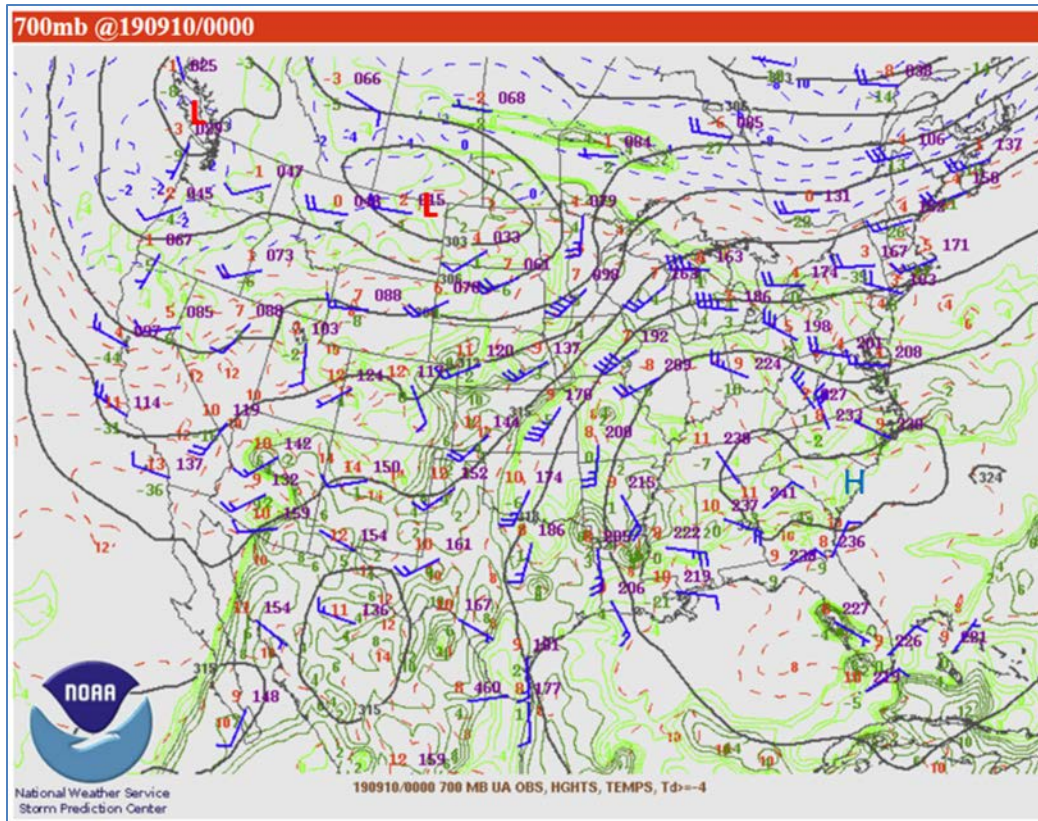


Figure 5 - Convective Outlook issued at 1230 EDT for thunderstorms

1.5 Constant Pressure Chart

The NWS SPC Constant Pressure Chart for 2000 EDT for 700-hPa or most representative of the conditions near the turbulence encounter is included as figure 6 and depicting the conditions at approximately 10,000 ft. The pressure systems have been annotated to the chart for reference. The chart depicted contour lines, isotherms or lines of equal temperature, and areas of high moisture concentrations (green lines) with dew point temperatures greater than -4° Celsius (C), and plotted stations wind barbs providing wind direction and speed.

The 2000 EDT chart depicted a high pressure system centered over South Carolina and Georgia, with a predominately easterly wind flow over Florida. The station model for Tampa however, indicated a wind from the southeast at 5 knots with a temperature of 6° C, and a temperature-dew point spread of 4° C. An area of high moisture was concentrated over southwestern Florida in the vicinity of Tampa and further south over extreme southwestern Florida coastal area.



1.6 12-hour Surface Prognostic Chart

The NWS 12-hour Surface Prognostic Chart that was issued at approximately 1100 EDT depicting the primary synoptic features, pressure systems and fronts, and expected precipitation is included as figure 7. The chart depicted the stationary front across South Carolina, Georgia, Alabama, into northern Mississippi. Scattered thunderstorms were predicted along and south of the stationary front, with more numerous activity over Alabama and Mississippi. An area of thunderstorms was also expected over western Florida and into the Gulf of Mexico and included the turbulence location and the Fort Myers area. The probability of precipitation was a “chance” or less than 65% probability of measurable rain over 0.01 inches at the valid time.

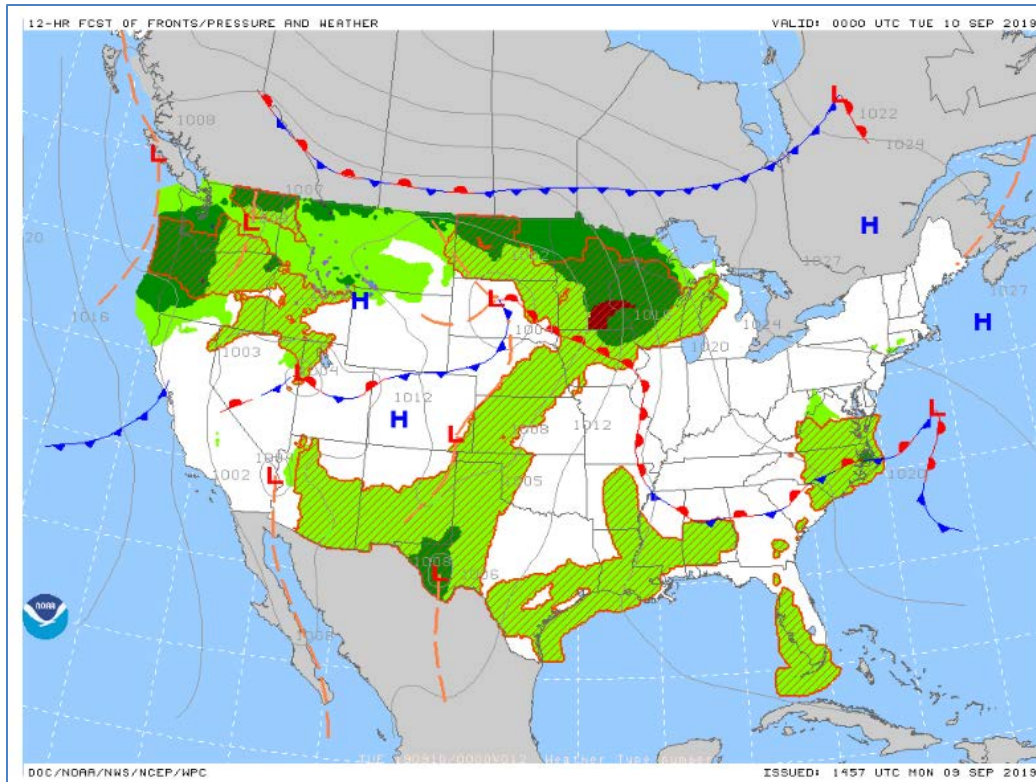


Figure 7 - NWS 12-hour Surface Prognostic Chart valid for 2000 EDT

2.0 Observations

The official observations issued surrounding the accident site were documented using standard meteorological aerodrome reports (METARs) and specials (SPECI). Cloud heights are reported above ground level (agl) in the following section, and the magnetic variation was estimated at 6° west based on the latest sectional chart for the area.

2.1 Fort Myers, Florida

The destination was Southwest Florida International Airport (KRSW), Fort Myers, Florida, located 49 miles south-southwest of the turbulence location at an elevation of 30 ft. The airport had an Automated Surface Observation System (ASOS), which was augmented by air traffic control personnel. The following conditions were reported at the approximate time of the accident.

Special weather observation for KRSW at 1605 EDT, wind from 080° at 7 knots, visibility 10 miles or more, thunderstorms in the vicinity⁴, sky clear below 12,000 ft agl, temperature 35° C, dew point temperature 22° C, altimeter 30.04 inches of mercury (Hg). Remarks: automated station with a precipitation discriminator, lightning distant south, temperature 35.0° C, dew point 22.2° C.

⁴ Vicinity is defined as between 5 and 10 statute miles from the station.

The general flight categories⁵ and raw observations from approximately 1353 through 1915 EDT surrounding the accident were as follows, the observation and accident time are included in bold italic print.

VFR *METAR KRSW 091753Z 14005KT 10SM CLR 33/22 A3008 RMK AO2 SLP183 60000 T03330222 10339 20261 58013=*

VFR *METAR KRSW 091853Z 07007KT 10SM BKN047 34/23 A3006 RMK AO2 SLP178 T03440233=*

VFR *METAR KRSW 091953Z AUTO 11004KT 10SM CLR 34/23 A3004 RMK AO2 SLP171 T03440233=*

VFR ***SPECI KRSW 092005Z 08007KT 10SM VCTS CLR 35/22 A3004 RMK AO2 LTG DSNT S T03500222=***

Accident time 2006Z

VFR *SPECI KRSW 092020Z 08006KT 10SM CLR 35/23 A3004 RMK AO2 LTG DSNT S T03500228=*

VFR *METAR KRSW 092053Z 02006KT 10SM SCT050 SCT070 OVC110 32/23 A3003 RMK AO2 LTG DSNT S AND W SLP165 T03220228 57018=*

VFR *METAR KRSW 092153Z 03003KT 10SM VCTS FEW055 BKN110 31/26 A3003 RMK AO2 LTG DSNT ALQDS RAB2058E24 SLP167 P0001 T03060261=*

VFR *SPECI KRSW 092202Z 00000KT 10SM SCT055 BKN120 30/27 A3003 RMK AO2 LTG DSNT SE AND SW AND NW T03000267=*

VFR *METAR KRSW 092253Z 23009KT 10SM VCTS BKN050 BKN065 29/24 A3005 RMK AO2 LTG DSNT S SLP174 T02940239=*

VFR *SPECI KRSW 092307Z 25007KT 10SM BKN046 BKN055 28/23 A3006 RMK AO2 LTG DSNT ALQDS T02830228=*

VFR *SPECI KRSW 092314Z 22006KT 10SM TS BKN047 OVC060 28/23 A3006 RMK AO2 LTG DSNT ALQDS TSB08 T02830233=*

A review of the observations indicated that scattered thunderstorms were reported in the vicinity of the airport from 1605 through 1908 EDT when a thunderstorm was reported over the airport, with light rain being recorded between 1658 and 1724 EDT with 0.01 inches of precipitation recorded. The high temperature of 35.0° C (95° F) was reached at the time of the turbulence encounter.

⁵ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories based on weather conditions reported:

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

- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.

- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.

- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

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

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

2.2 Sebring, Florida

The closest weather reporting facility to the accident site was from Sebring Regional Airport (KSEF), Sebring, Florida, located about 13 miles east-northeast of the turbulence location, at an elevation of 62 ft. The airport had an Automated Weather Observation System (AWOS), which was not augmented and issued observations every 20-minutes. The following conditions were reported at the approximate time of the accident:

KSEF weather observation at 1555 EDT, automated, wind from 120° at 3 knots, visibility 10 miles or more, scattered clouds at 5,000 ft agl, scattered at 6,500 ft, temperature 34° C, dew point 22° C, altimeter 30.07 inches of Hg. Remarks: automated station with a precipitation discriminator, temperature 34.0° C, dew point 22.4° C.

KSEF weather observation at 1615 EDT, automated, wind from 100° at 5 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 35° C, dew point 22° C, altimeter 30.06 inches of Hg. Remarks: automated station with a precipitation discriminator, temperature 34.5° C, dew point 22.2° C.

KSEF weather observation at 1635 EDT, automated, wind from 130° at 4 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 35° C, dew point 22° C, altimeter 30.06 inches of Hg. Remarks: automated station with a precipitation discriminator, lightning distant southwest, temperature 34.6° C, dew point 21.7° C.

The general flight category and raw observations issued between 1355 through 1915 EDT were as follows:

VFR METAR KSEF 091755Z AUTO 00000KT 10SM SCT110 33/24 A3011 RMK AO2 T03350238 10339 20255

VFR METAR KSEF 091815Z AUTO 07008KT 10SM SCT110 33/24 A3010 RMK AO2 T03300237

VFR METAR KSEF 091835Z AUTO 10003KT 10SM SCT040 34/23 A3009 RMK AO2 T03370230

VFR METAR KSEF 091855Z AUTO 07005KT 10SM SCT044 34/23 A3008 RMK AO2 T03390226

VFR METAR KSEF 091915Z AUTO 08007KT 10SM SCT044 SCT050 BKN100 34/23 A3008 RMK AO2
T03450226

VFR METAR KSEF 091935Z AUTO 11006KT 10SM SCT050 SCT065 BKN100 33/22 A3007 RMK AO2
T03340222

VFR METAR KSEF 091955Z AUTO 12003KT 10SM SCT050 SCT065 34/22 A3007 RMK AO2 T03400224

Accident 2006Z

VFR METAR KSEF 092015Z AUTO 10005KT 10SM CLR 35/22 A3006 RMK AO2 T03450222

VFR METAR KSEF 092035Z AUTO 13004KT 10SM CLR 35/22 A3006 RMK AO2 LTG DSNT SW T03460217

MVFR METAR KSEF 092055Z AUTO 11007KT 5SM HZ SCT055 35/21 A3005 RMK AO2 T03460213

VFR METAR KSEF 092115Z AUTO 09010KT 10SM SCT055 35/22 A3005 RMK AO2 LTG DSNT S T03470217

VFR METAR KSEF 092135Z AUTO 08011KT 10SM SCT055 SCT080 32/24 A3005 RMK AO2 LTG DSNT E THRU SW T03200242

VFR METAR KSEF 092155Z AUTO 12012KT 10SM SCT055 32/24 A3007 RMK AO2 LTG DSNT SE AND SW T03170237

VFR METAR KSEF 092215Z AUTO 10014G18KT 10SM BKN055 30/23 A3007 RMK AO2 T03030229

VFR METAR KSEF 092235Z AUTO 10010KT 10SM BKN055 30/23 A3008 RMK AO2 LTG DSNT S T02960231

VFR METAR KSEF 092255Z AUTO 10011KT 10SM SCT050 BKN055 BKN075 29/24 A3008 RMK AO2 LTG DSNT S T02940235

VFR METAR KSEF 092315Z AUTO 10010KT 10SM SCT050 SCT060 SCT070 29/24 A3009 RMK AO2 LTG DSNT SW T02900236

The observations for KSEF indicated VFR conditions prevailing during the period with lightning reported in the distance surrounding the station from the southwest, south, east, southeast through southwest during the period from 1635 through 1915 EDT. No thunderstorm or precipitation was recorded at the station during the period.

3.0 Sounding

To determine the vertical structure and state of the atmosphere near the accident site the closest NWS upper air site from the Tampa Bay (KTBW) Weather Forecast Office (WFO), site #72210, located in Ruskin, Florida, approximately 50 miles west-northwest of the turbulence location was documented. The NWS KTBW 2000 EDT (0000Z on September 10, 2019) sounding was obtained from archive data from the University of Wyoming website and plotted on a standard Skew T log P diagram⁶ using the complete Rawinsonde Observation RAOB program software⁷ from the surface to 450-hPa or about 21,000 ft and is included as figure 8.

The KTBW 2000 EDT sounding indicated a near surface temperature of 32° C (90° F), a dew point of 22° C (72° F), with a relative humidity of 56%, and a precipitable water content of 1.87 inches. The lifted condensation level (LCL)⁸ was identified at about 4,200 ft agl, with the level of free convection (LFC)⁹ at about 4,870 ft agl, and the convective condensation level (CCL)¹⁰ at 5,130 ft agl. The freezing level was at about 15,790 ft. The sounding support multiple layers of clouds, with the first broken layer of clouds near 5,000 ft agl, a second broken layer near 8,500 ft

⁶ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

⁷ RAOB software – The complete RAWinsonde OBServation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data

⁸ Lifted Condensation Level - the level at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

⁹ Level of Free Convection- 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.

¹⁰ Convective Condensation Level- 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.

agl where the relative humidity exceeded 90%, and with high cirriform clouds near 26,000 ft with humidity over 80%. Several temperature inversions were noted (green shading) at 6,310 ft, at 8,370 ft, and with a defined inversion due to subsidence between 10,500 ft and 12,446 ft. The atmosphere was characterized as unstable based on the Lifted Index¹¹ of -5.0 and the Convective Available Potential Energy (CAPE)¹² value of 1,982 Joules/kilogram, which support updrafts with maximum vertical velocities of 63 meters/second or about 120 knots. The lack of strong vertical wind shear favored scattered ordinary single cell non-severe thunderstorm development, with the K-Index¹³ of 32.0 providing a probability near 60% of development. At 12,000 ft the layer was considered stable based on the inversion, with the layer underneath the inversion autoconvective or very unstable due to a rapid cooling of the layer.

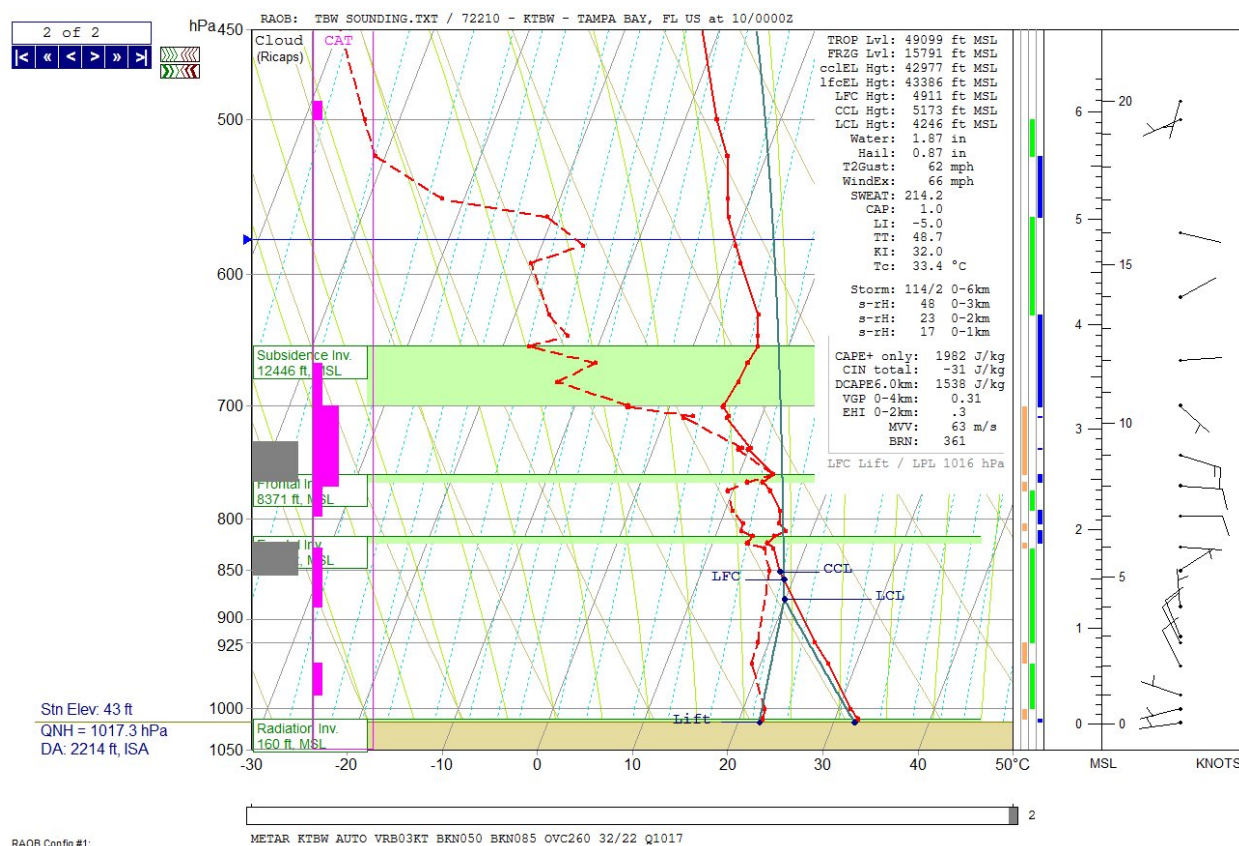


Figure 8 - KTBW sounding at 2000 EDT

¹¹ Lifted Index - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or 18,000 ft and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

¹² Convective Available Potential Energy (CAPE) - A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather. Observed values in thunderstorm environments often may exceed 1000 joules per kilogram (J/kg), and in extreme cases may exceed 5000 J/kg.

¹³ K-Index - A measure of the thunderstorm potential based on vertical temperature lapse rate, moisture content of the lower atmosphere, and the vertical extent of the moist layer.

The sounding wind profile on the right side of the sounding indicated light westerly winds near the surface which veered to the north through 5,000 ft and then shifting to the east above that level from approximately 6,000 ft through 18,000 ft, and the shifted to the southwest with height. The wind at 12,000 ft was from about 085° at 1 knot, with the mean 0 to 6 kilometer or 18,000 ft wind from 084° at 2 knots. The strongest low-level wind was identified at 7,000 ft from 110° at 17 knots, and the strongest wind at altitude was at 34,900 ft from 075° at 23 knots.

Figure 9 is the KTBW observed height, pressure (Pres), temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and wind speed (DD/FF), and RAOB derived CAT potential. At 12,000 ft the sounding did not indicate any potential CAT, however the sounding did not consider turbulence related to convection.

Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)
43	1016	32.2	22.2	56	260 / 3	
160	1012	32.4	22.4	56		
513	1000	31.2	22.2	59	255 / 4	
1000	984				290 / 5	LGT
2079	948	27.0	19.0	62	335 / 8	
2791	925	24.8	18.8	69	335 / 8	
3000	918				340 / 8	
4000	887				355 / 7	LGT
5206	850	18.2	17.1	93	55 / 2	LGT
5944	828	16.6	15.7	94	95 / 7	
6114	823	15.8	13.7	87		
6353	816	16.2	13.9	86		
6525	811	17.2	12.5	74		
6768	804	16.2	12.4	78		
7000	797				90 / 8	
7189	792	15.8	10.8	72		
7829	774	14.0	9.5	74		LGT
8000	769				95 / 12	
8117	766	12.8	11.2	90		
8371	759	13.6	13.6	100		MDT
9000	742				110 / 17	
9182	737	10.0	8.9	93		
9219	736	10.2	9.3	94		
10196	710	6.4	1.9	73		
10234	709	6.6	2.8	77		
10539	701	5.6	-4.4	49		MDT
10577	700	5.6	-4.4	49	135 / 5	
11316	681	6.2	-12.8	24		LGT
11915	666	6.4	-9.6	31	85 / 1	
12446	653	6.8	-17.2	16		
12778	645	6.4	-13.6	22		
13453	629	5.6	-16.4	19		
14000	616				60 / 2	
15067	592	1.6	-20.4	18		
15607	580	0.4	-15.6	29		
16000	571				105 / 2	
16480	561	-1.5	-20.5	22		
17044	549	-2.3	-32.3	8		
18352	522	-4.1	-41.1	4		

Figure 9 - KTBW sounding parameters through 18,000 ft

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) imagery 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 (McIDAS) software. The infrared long wave and visible imagery were obtained surrounding the time of the accident, with the images closest to the time of the accident documented below. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The visible (band 2) at a wavelength of 0.64 μm images at a resolution of 0.5 km.

Figure 10 is the GOES-16 infrared image for 1606 EDT at normal magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder clouds typically associated with deep convection. A band of cumulonimbus clouds extended from Louisiana eastward across southern Mississippi, Alabama, Georgia, and South Carolina, with several scattered smaller cumulus congestus type clouds over western Florida.

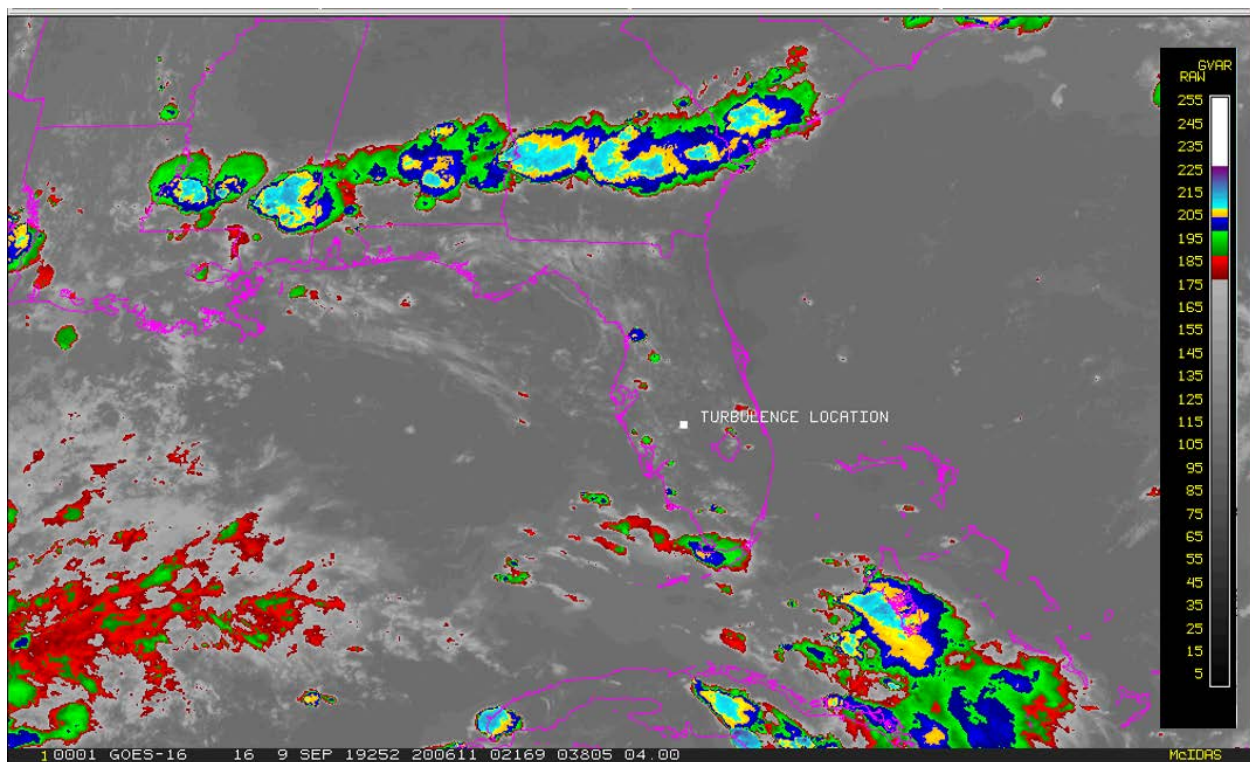


Figure 10 - GOES-16 visible satellite image for 1606 EDT

Figure 11 is a closeup of the GOES-16 infrared image at 2X magnification for 1606 EDT centered over the turbulence location. The radiative cloud top temperature over the turbulence location was 275 Kelvin or 1.8°C , which corresponded to cloud tops near 15,000 ft based on the KTBW 2000 EDT sounding. The enhanced area immediately southwest of the turbulence location had a radiative cloud top temperature of -36°C , which corresponded to cloud tops near 34,000 ft.

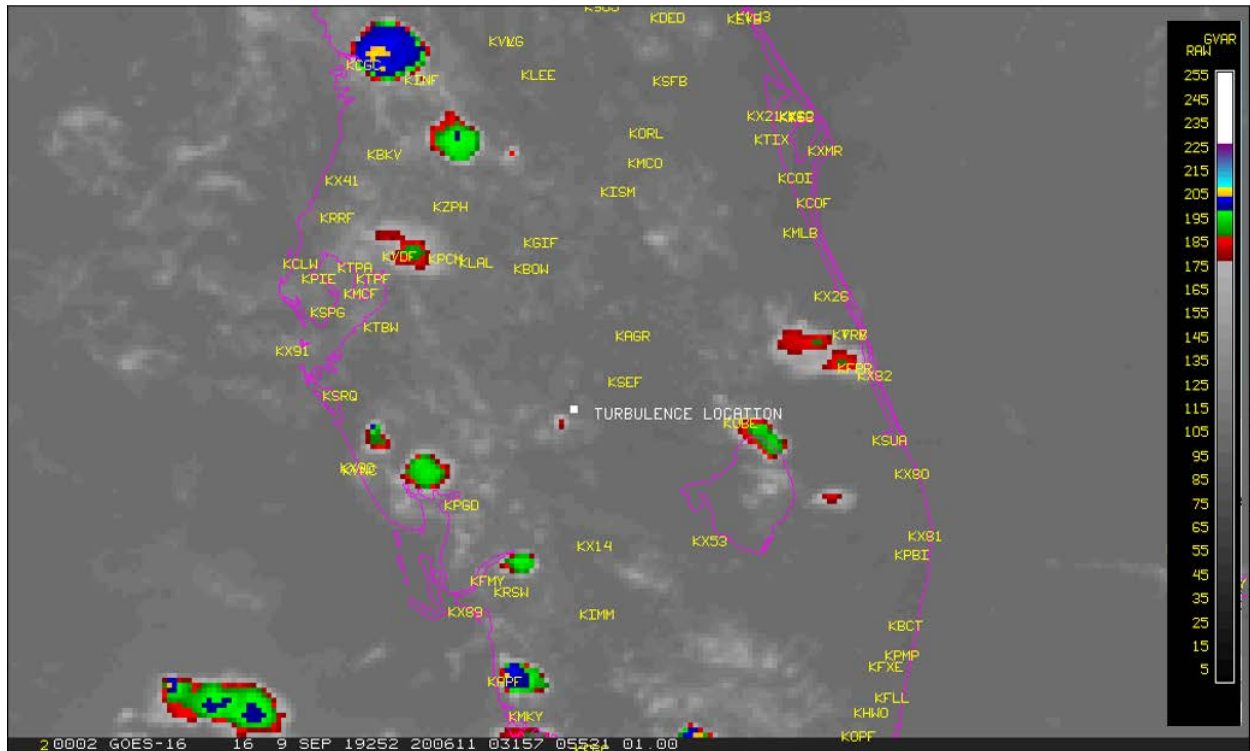


Figure 11 - GOES-16 infrared image at 2X magnification over the turbulence location for 1606 EDT

Figure 12 is the GOES-16 visible image for 1606 EDT centered over the turbulence location at 2X magnification. The image depicted areas of scattered cumulus to cumulus congestus type clouds.

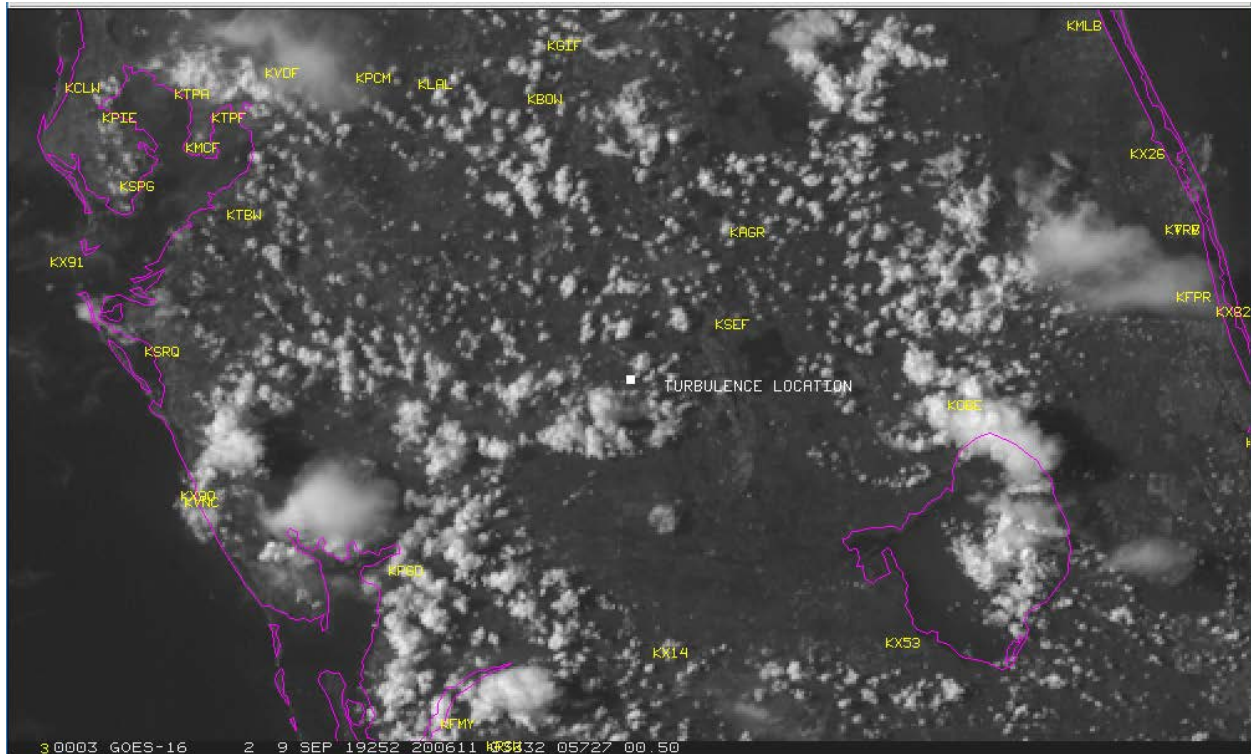


Figure 12 - GOES-16 visible image at 1606 EDT at 2x magnification

5.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar 1988 Doppler (WSR-88D) was located approximately 50 miles west-northwest of the turbulence site at KTBW. The level II archive data was obtained from the NCEI using the Hierarchical Data Storage System and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

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

5.1 Volume Scanning Strategies

During the period the KTBW WSR-88D was operating in the precipitation mode volume scan pattern 215 (VCP-215), where the radar makes 15 different elevation scans in 6 minutes. Figure 13 is a depiction of this scanning strategy and the various elevation scans by height and distance.

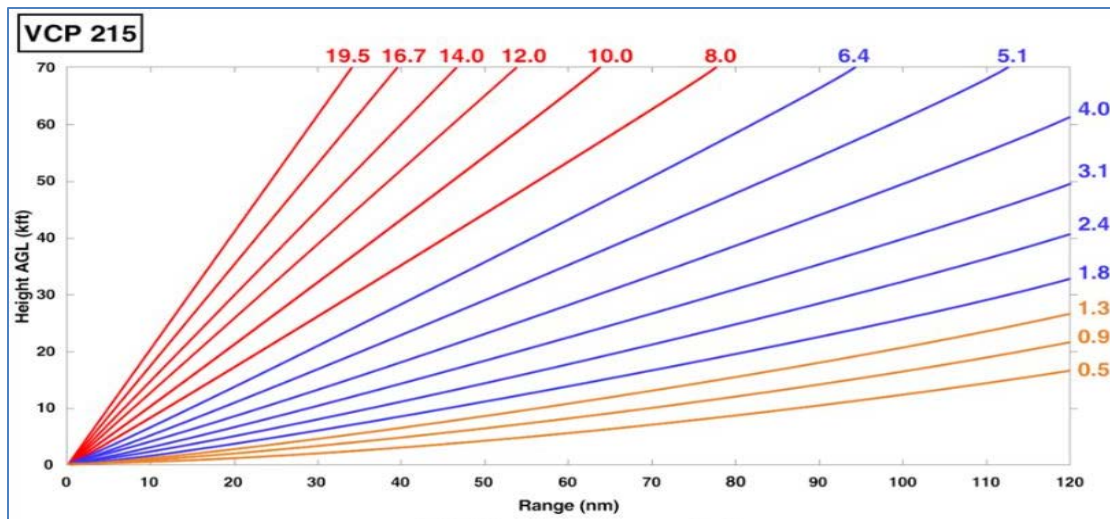


Figure 13 - VCP-215 scanning strategy elevation scans

Based on the KTBW WSR-88D antenna height of 122 ft and a distance of 50 miles from the turbulence location to the radar and assuming standard refraction¹⁴, the 1.8° elevation beam was scanning the altitudes from approximately 8,800 ft to 13,840 ft, with the center of the beam at 11,320 ft at the turbulence location.

5.1 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors, 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 (dBZ¹⁵) and is a general measure of echo intensity. Figure 14 relates the NWS former video integrator and processor (VIP) intensity levels (1-6) versus the WSR-88D's display levels (0-15), precipitation mode reflectivity in decibels (DBZ), and rainfall rates.

¹⁴ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁵ dBZ - $10 \log Z_e$

NWS VIP/DBZ CONVERSION TABLE

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

Figure 14 - NWS VIP/DBZ levels of the WSR-88D

The FAA has taken the previous NWS VIP levels 1 to 6 intensity levels and has redefined the intensity levels for pilots in Advisory Circular AC 00-24C - “Thunderstorm”. That AC further defines echoes less than 30 dBZ as “light” in intensity, “moderate” echoes at 30-40 dBZ, “heavy” with echoes of >40-50 dBZ, and “extreme” intensity echoes greater than 50 dBZ. These are the new standard radio phraseology terms used by air traffic controllers to describe weather conditions to pilots, which are also referenced in the Airmen’s Information Manual (AIM) section 7-1-14 (a) as shown in figure 15.

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

Figure 15 - Reflectivity ranges and intensity terminology

5.2 Base Reflectivity Imagery

Figure 16 is the NWS KTBW WSR-88D 1.80° base reflectivity image for 1601 EDT with the flight track of the accident airplane overlaid in magenta. The image depicts several echoes immediately south of the turbulence location, with other scattered echoes along the west coast of Florida and immediately north of KRSW. Figure 17 is a close up of the NWS KTBW WSR-88D 1.80° base reflectivity image at 1607 EDT, with the flight path over echoes of 5 to 10 dBZ. The

flight path was approximately 4 miles west of an echo with reflectivity near 50 dBZ or extreme intensity, which was slowly moving westward.

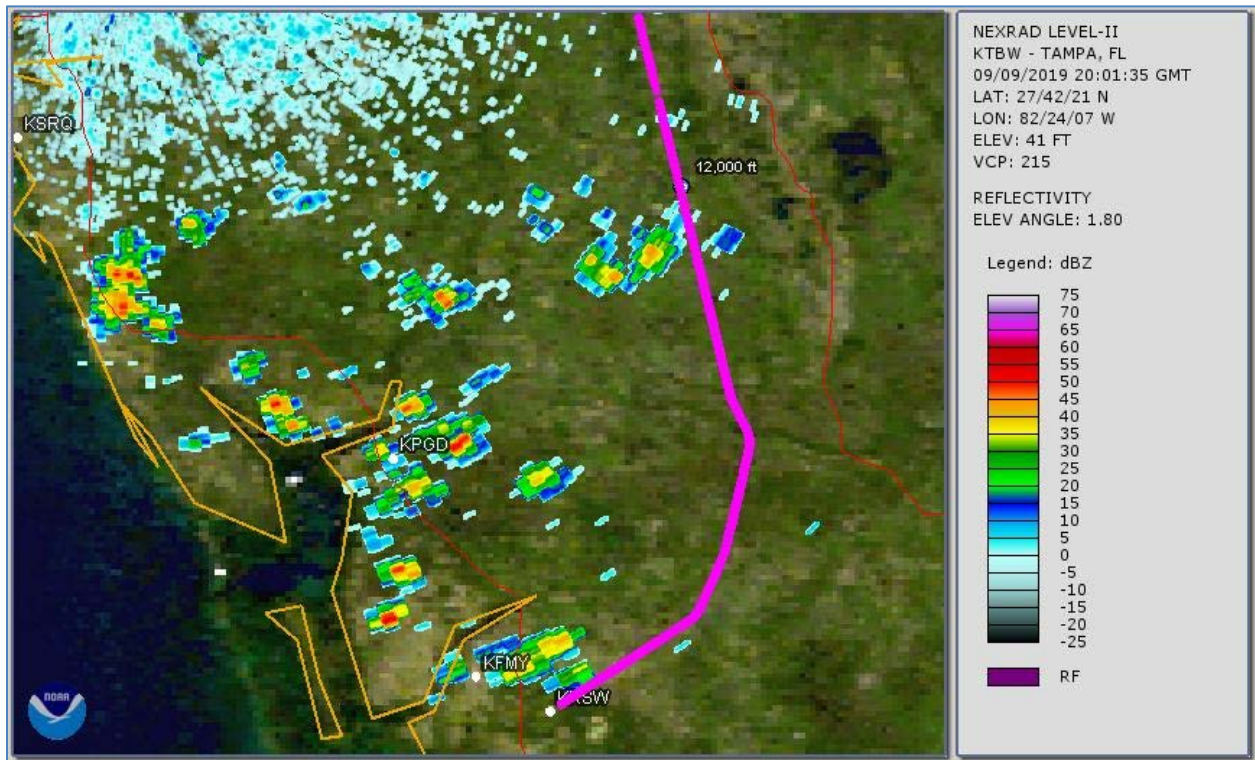


Figure 16 - NWS KTBW WSR-88D 1.80° base reflectivity image with the flight path overlaid for 1601 EDT

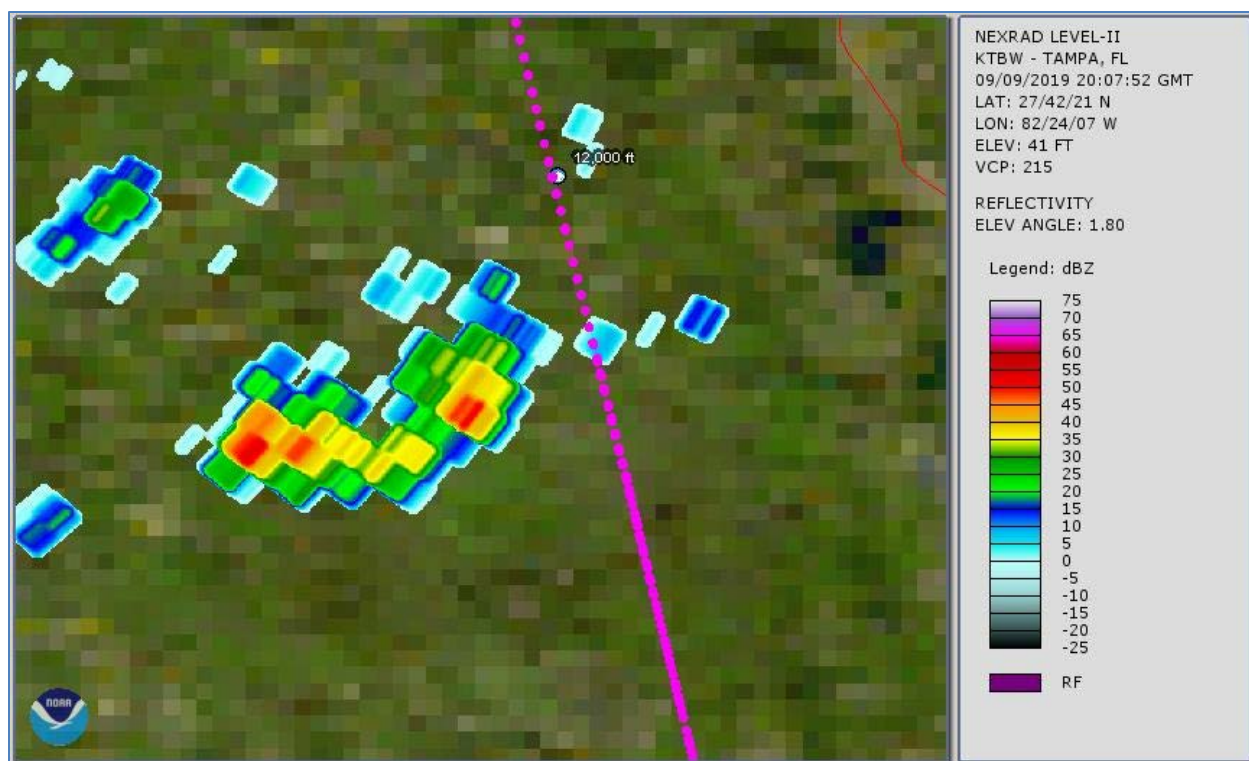


Figure 17 – Enlarge view of the NWS KTBW WSR-88D 1.80° base reflectivity image for 1607 EDT

6.0 Pilot Reports

A search of the NWS data base provided only the following pilot reports (PIREPs) within approximately 100 miles and within 4 hours prior to 2 hours after the accident. The reports are provided in standard code and abbreviations and followed by a decoded report in plain language. The reports were as follows:

*CTY UA /OV CTY169016/TM 1605/FL060/TP SR22/TB NEG/RM AEROVIE / DURD CTY SK/CU BLDG 4000
TOPS 9000*

Cross City Airport (CTY) routine pilot report (UA); Over – Cross City VORTAC¹⁶ 169° azimuth at 16 miles; Time – 1205 EDT; Altitude – 6,000 ft; Type aircraft – Cirrus SR22; Turbulence – negative; Remarks – entered through Aerovie¹⁷ during descent into CTY, cumulus clouds building bases 4,000 ft with tops to 9,000 ft.

*BKV UA /OV PIE353032 /TM 1625 /FL040 /TP SR22 /WX FV99SM /WV 16907KT /TB NEG /RM AEROVIE
DURD FRM N SK/SKC OVER GULF WATERS*

Brooksville-Tampa Bay Regional Airport (BKV) routine pilot report (UA); Over – St. Petersburg (PIE) VORTAC 353° azimuth at 32 miles; Time – 1225 EDT; Altitude – 4,000 ft; Type aircraft – Cirrus SR22; Weather – flight visibility unrestricted at 99 miles; Turbulence – negative; Wind – 169° at 7 knots; Remarks

¹⁶ A VORTAC is a radio-based navigational aid for aircraft pilots consisting of a co-located VHF omnidirectional range (VOR) beacon and a tactical air navigation system (TACAN) beacon.

¹⁷ Aerovie electric flight bag (EFB) PIREP submission

– entered through Aerovie during descent from the north; Sky cover – skies clear over the Gulf of Mexico waters.

TPA UA /OV OLENE/TM 1820/FL120/TP B717/TB MOD BTW 120 AND 090 DURD

Tampa International Airport (TPA) routine pilot report (UA); Over – OLENE intersection; Time – 1420 EDT; Altitude -12,000 ft; Type aircraft – Boeing 727; Turbulence – moderate between 12,000 and 9,000 ft during descent.

42J UA /OV GNV090012 /TM 1851 /FL035 /TP C172 /SK SCT045 /WX FV99SM /TA 21

Keystone Airpark (42J), Keystone Heights, FL, routine pilot report (UA); Over – Gators VORTAC (GNV), Gainesville; Time – 1451 EDT; Altitude – 3,500 ft; Type aircraft – Cessna 172 Sky Hawk; Sky cover – scattered clouds at 4,500 ft; Weather – flight visibility unrestricted at 99 miles; Temperature – 21° C.

GNV UA /OV KGNV /TM 2025 /FL030 /TP C172 /TB NEG BLO 030 /RM DURC

Gainesville Regional Airport (GNV), Gainesville, FL, routine pilot report (UA); Over – KGNV; Time – 1625 EDT; Altitude – 3,000 ft; Type aircraft – Cessna 172 Sky Hawk; Turbulence – negative below 3,000 ft; Remarks – during climb.

7.0 NWS Forecasts

7.1 Terminal Aerodrome Forecasts

The NWS KTBW WFO was responsible for the issuance of the Terminal Aerodrome Forecast (TAF) for KRSW. A TAF is a concise statement of the expected meteorological conditions at an airport during a specified period (usually 24 hours). TAFs are valid for a 5 mile radius around an airport's center point. The forecasts issued surrounding the period relevant to the preflight planning and the time of the accident was as follows.

*TAF KRSW 091720Z 0918/1018 12006KT P6SM SCT040 SCT060
FM092000 08008KT P6SM VCTS SCT045CB BKN060
FM100000 08005KT P6SM VCTS SCT050CB BKN100
FM100300 09004KT P6SM FEW050 SCT100 SCT250
FM101400 09010KT P6SM FEW025 SCT250*

The KRSW forecast valid from 1600 through 2000 EDT expected a wind from 080° at 8 knots, visibility 6 miles or more, thunderstorms in the vicinity, scattered clouds at 4,500 ft agl in cumulonimbus clouds, ceiling broken at 6,000 ft.

7.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each weather service forecast office (WFO) to describe the short term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation related issues that cannot be encoded into the TAF. The discussion also gives some reasoning behind the forecast. These are generated roughly every 6 hours and correspond to

the release of the latest TAFs for that office. The NWS KTBW AFD issued at about 1320 EDT was as follows, with the long term and marine weather sections excluded.

*FXUS62 KTBW 091721
AFDTBW
Area Forecast Discussion
National Weather Service Tampa Bay Ruskin FL
121 PM EDT Mon Sep 9 2019*

.AVIATION...

Brief MVFR/IFR conditions from scattered SHRA/TSRA may impact the terminals between 20-02Z and have handled with VCTS for now, otherwise VFR will prevail during the next 24 hours. Light southeast winds will prevail except becoming west-northwest from KSRQ north to KTPA and KPIE as the sea breeze component develops with higher gusts near TSRA. Winds will become east and diminish to 5 knots or less after 02Z tonight.

.Prev Discussion... /issued 921 AM EDT Mon Sep 9 2019/

UPDATE...

High pressure from the western Atlantic extending northwest across the northern peninsula is supporting a light east-southeast wind flow across the forecast area early this morning. 12Z Raob data shows that moisture has increased across the forecast area with a PW of 1.65 inches which is up over a half of an inch from yesterday at this time. This increase in moisture combined with daytime heating should support scattered diurnal shower/storm development along the sea breezes from late morning and into the afternoon with a southeast steering flow albeit weak favoring highest convective coverage and pops focusing along the I-75 corridor during the late afternoon and early evening hours where the east and west sea breeze merger should occur. Temperatures today will climb to around 90 to the lower 90s along the coast, and mid 90s inland. Ongoing forecast is on track with no changes or updates required at this time.

.TBW WATCHES/WARNINGS/ADVISORIES...

FL...None.

Gulf waters...None.

AVIATION...57/McMichael

7.3 Winds and Temperature Aloft Forecast

The NWS NCEP Winds and Temperature Aloft Forecast¹⁸ issued during the period was valid for 2000 EDT and was for use between 1600 and 2300 EDT, the forecast winds over Florida were as follows:

WINDS ALOFT FORECASTS

DATA BASED ON 091800Z

VALID 100000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

<i>FT</i>	<i>3000</i>	<i>6000</i>	<i>9000</i>	<i>12000</i>	<i>18000</i>	<i>24000</i>	<i>30000</i>	<i>34000</i>	<i>39000</i>
<i>TLH</i>	<i>9900</i>	<i>1310+18</i>	<i>0912+13</i>	<i>0811+07</i>	<i>9900-06</i>	<i>3507-18</i>	<i>291234</i>	<i>292044</i>	<i>291755</i>
<i>PFN</i>	<i>1208</i>	<i>1116+19</i>	<i>1019+14</i>	<i>1009+07</i>	<i>9900-06</i>	<i>3105-18</i>	<i>291034</i>	<i>271544</i>	<i>291255</i>
<i>PIE</i>	<i>0212</i>	<i>0209+17</i>	<i>0707+11</i>	<i>0507+07</i>	<i>9900-06</i>	<i>1707-18</i>	<i>270733</i>	<i>310943</i>	<i>990055</i>
<i>MLB</i>	<i>1114</i>	<i>0306+17</i>	<i>0509+11</i>	<i>0305+07</i>	<i>0305-05</i>	<i>0706-18</i>	<i>341634</i>	<i>312044</i>	<i>311955</i>
<i>MIA</i>	<i>1016</i>	<i>0813+18</i>	<i>0810+12</i>	<i>9900+07</i>	<i>3606-06</i>	<i>0511-18</i>	<i>342333</i>	<i>332643</i>	<i>303054</i>

¹⁸ Bulletin FBUS31 KWN0 with only the forecast below 39,000 ft included.

The St. Petersburg (PIE) forecast was the closest to the turbulence location, the forecast for 12,000 ft was for wind from 050° at 7 knots with a temperature of 7° C.

7.4 Graphic Turbulence Guidance

The current NWS Graphic Turbulence Guidance (GTG) numerical model, version 3.0, presently in operation use from the AWC website provides analysis and prediction of clear air turbulence (CAT) and mountain wave activity. The current GTG model did not depict any CAT over Florida surrounding the period.

The National Center for Atmospheric Research (NCAR) was contacted and requested to run the newer GTG-N or “Nowcast” model, which incorporates in situ EDR measurements, turbulence reports, radar reflectivity, NEXRAD Turbulence Detection Algorithm (NTDA), and the Rapid Refresh (RAP) model that is updated every 15-minutes, and specifically addresses convectively induced turbulence. This newer version 4.0 was being run in an experimental mode and was not available to the flight crew in this case. A review of the GTG-N indicated that from 1545 through 1615 EDT an area of convectively induced turbulence was depicted over the site. Figure 18 is the GTG-N for 1600 EDT for 12,000 ft, which depicted EDR values of 0.20 to 0.30 over the turbulence location, with an area of 0.30 to 0.40 immediately southwest and south.

Attachment 1 is the NCAR GTG-N images from 10,000 ft through 14,000 ft at 1545, 1600, and 1615 EDT.

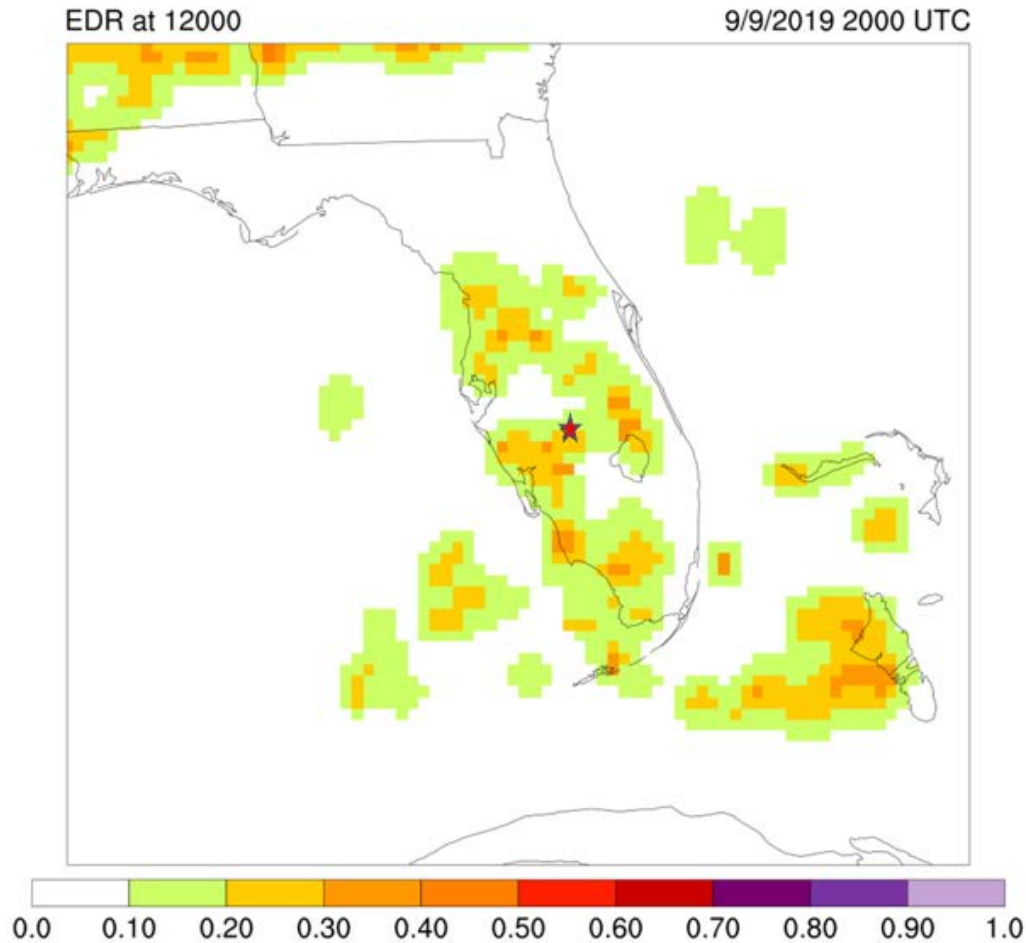


Figure 18 - GTG-N at 1600 EDT for 12,000 ft with eddy dissipation rate (EDR)

8.0 NWS Inflight Weather Advisories

Inflight Aviation Weather Advisories are forecasts to advise en route aircraft of development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) associated with FAA ARTCCs. There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the Airmen's Meteorological Information (AIRMET), and the Center Weather Advisory (CWA). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot and/or aircraft dispatcher in a Part 121 operation to evaluate on the basis of experience and the operational limits of the aircraft. The following advisories were current during the period.

During the period there were no Convective SIGMETs, SIGMETs, or AIRMETs issued by the NWS AWC current over Florida related to any organized convection, turbulence, icing, or IFR conditions. The Miami (KZMA) CWSU issued the following CWA for the area of heavy

precipitation and thunderstorms over southern Florida and the Gulf of Mexico during the period. Figure 19 is the CWA over the GOES-16 visible satellite image for 1456 EDT.

*FAUS24 KZMA 091853
ZMA4 CWA 091853
ZMA CWA 401 VALID UNTIL 092005
FROM 80SW SRQ-30SSE MIA-85W EYW-80SW SRQ
AREA OF TS WITH MOD-HVY PCPN MOV FROM 13005KT. MAX TOPS TO FL450.
EXP LTL CHG THRU PD.
LL*

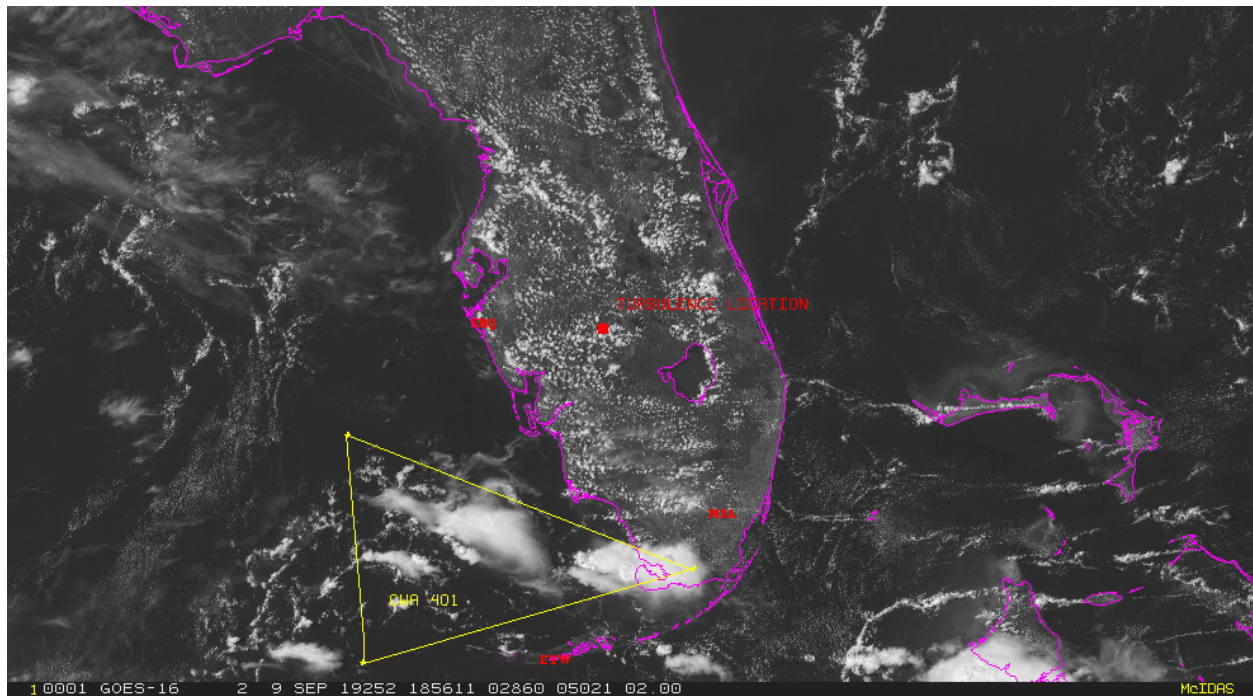


Figure 19 - CWA #401 for area of heavy precipitation and thunderstorms valid from 1453 through 1605 EDT

F. Attachments

Attachment 1 – NCAR Graphic Turbulence Guidance – Nowcast (GTG-N)

Submitted by:

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