NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 7, 2015

WEATHER STUDY

ERA15LA140

A. ACCIDENT

Location: Marco Island, Florida
Date: March 1, 2015
Time: About 1615 eastern standard time (2115 UTC[1])
Airplane: Canadair Limited CL-600-2A12 (CL-601); registration N600NP

B. METEOROLOGY GROUP

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C. SUMMARY

On March 1, 2015, about 1615 eastern standard time, a Bombardier Challenger CL-600-2A12, N600NP, registered to and operated by Six Hundred NP, LLC, experienced a landing overrun and subsequent collapse of the nose gear at the Marco Island Airport (MKY), Marco Island, Florida. Visual flight rule conditions prevailed at the time of the accident and an IFR flight plan was filed for the 14 Code of Federal Regulations (CFR) Part 91 personal flight from the Florida Keys Marathon Airport (MTH), Marathon, Florida. The airplane sustained substantial damage. The airline transportation rated pilot, co-pilot, the one flight attendant, and four passengers were not injured, while one passenger sustained serious injuries, and one passenger minor injuries. The flight originated from MTH about 1554.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) 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 and the National Climatic Data Center (NCDC). All times are eastern standard time (EST) based upon the 24 hour clock, local time +5 hours to UTC, and UTC=Z. 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. NWS airport and station identifiers use standard International Civil Aviation Organization (ICAO) 4-letter station identifiers versus International Air Transport Association (IATA) 3-letter identifiers which deletes the initial country code designator "K" for U.S. airports. Both codes are both used intermittently in this report.

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

The accident site was located at latitude 25.9950° N and longitude -81.6725° W at an elevation of approximately 5 feet.

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) 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 00-45G.

1.1 Surface Analysis Chart

A southeast section of the NWS Surface Analysis Chart for 1600 EST (2100Z) on March 1, 2015 is included in figure 1 with the approximate location of the Marco Island Airport enclosed in the red circle. The chart depicted a stationary front stretching across northern Florida and into the Gulf of Mexico and then into Louisiana. A high pressure system at 1030-hectopascals (hPa) was located over northern Georgia, and the subtropical ridge from the Azores Bermuda high pressure system extending over southern Florida. The chart depicted a weak pressure gradient over southern Florida with light easterly winds of 10 knots or less prevailing over most of the state. The weak gradient and ridge support localized sea breeze development along the coastal regions.

The station model from Naples immediately northwest of the accident site indicated a wind from the west-southwest at approximately 10 knots, broken sky cover, with a temperature of 80° Fahrenheit (F), with dew point temperature of 68° F, and a sea level pressure of 1023.0-hPa. No significant weather was depicted across the region.

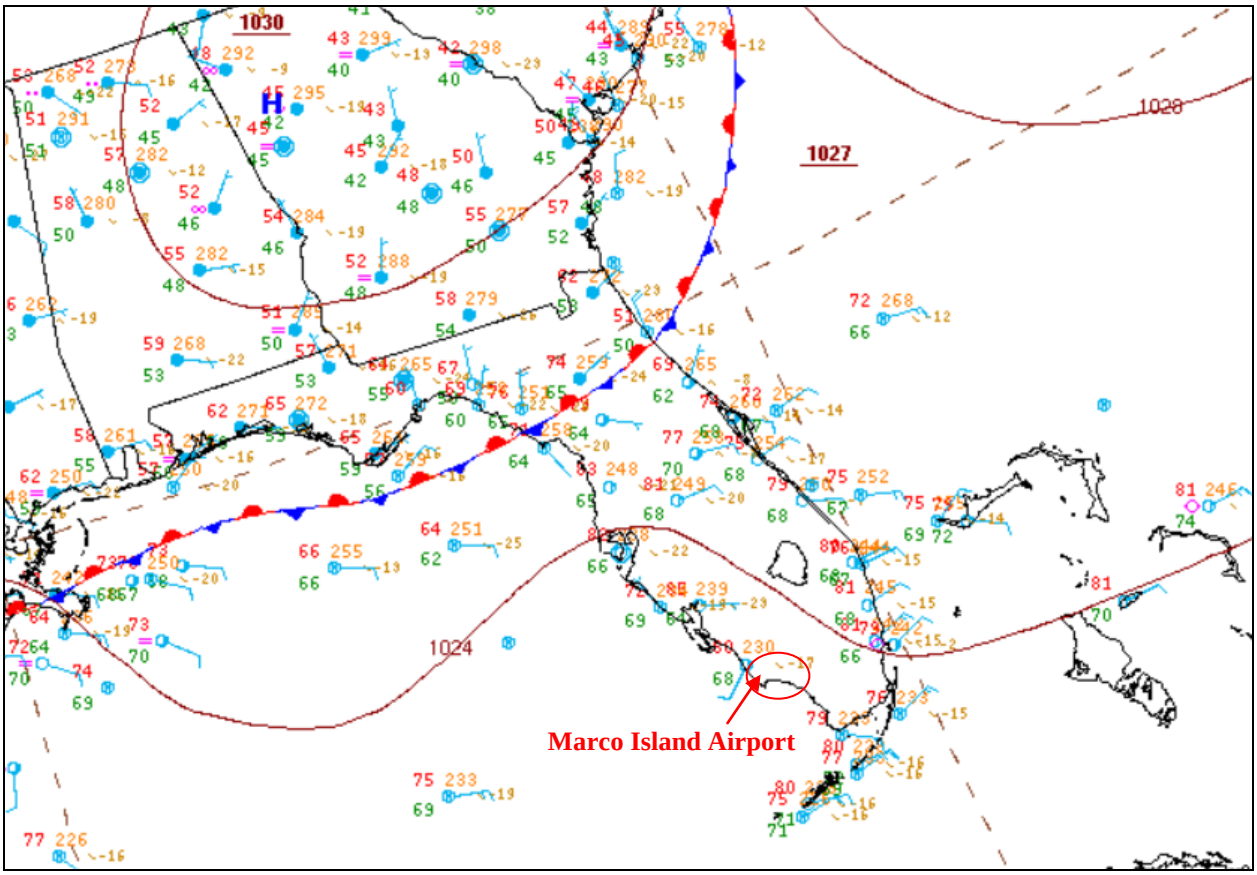

Figure 1 - NWS Surface Analysis Chart for 1600 EST

1.2 Weather Radar Mosaic

The National Center for Atmospheric Research (NCAR) - Research Application Laboratory (RAL) regional radar mosaic image for 1615 EST (2115Z) is included as figure 2, with a close up of the Marco Island Airport in figure 3. A red star has been superimposed to mark the location of the accident site. The image depicted an area of echoes over southwestern Florida in the immediate vicinity east of the Marco Island Airport and stretching southeastward parallel to the southwest Florida coast. The area of echoes was approximately 15 miles long and 5 miles wide, and observed to be moving west, or towards the Marco Island Airport.

The closest NWS weather radar will be further documented in section 5.0 of this report to review the potential for weather echoes along the flight track and/or interaction at the airport during the period.

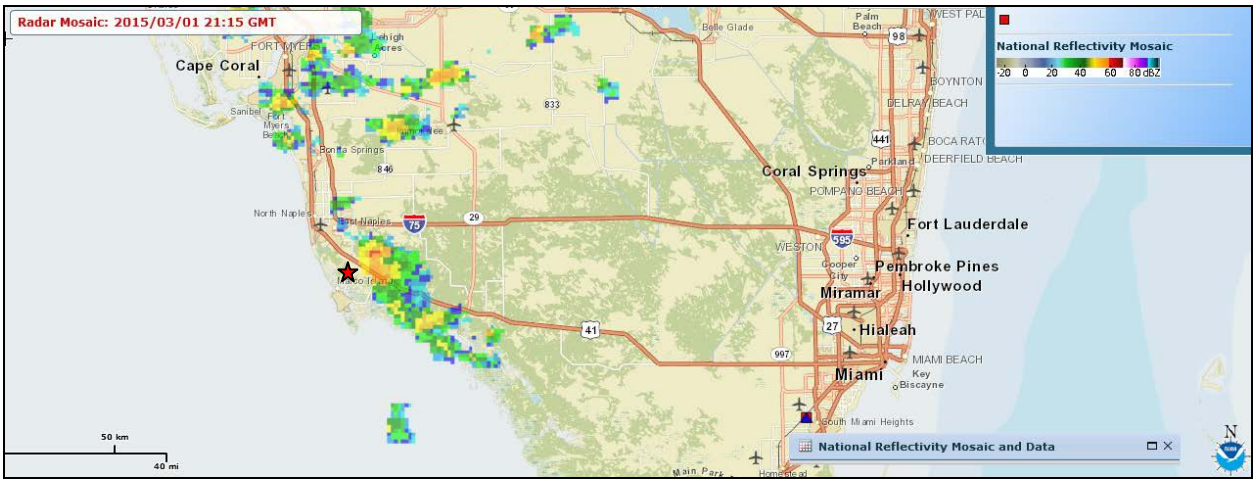

Figure 2 - NCDC regional radar mosaic image at 1615 EST

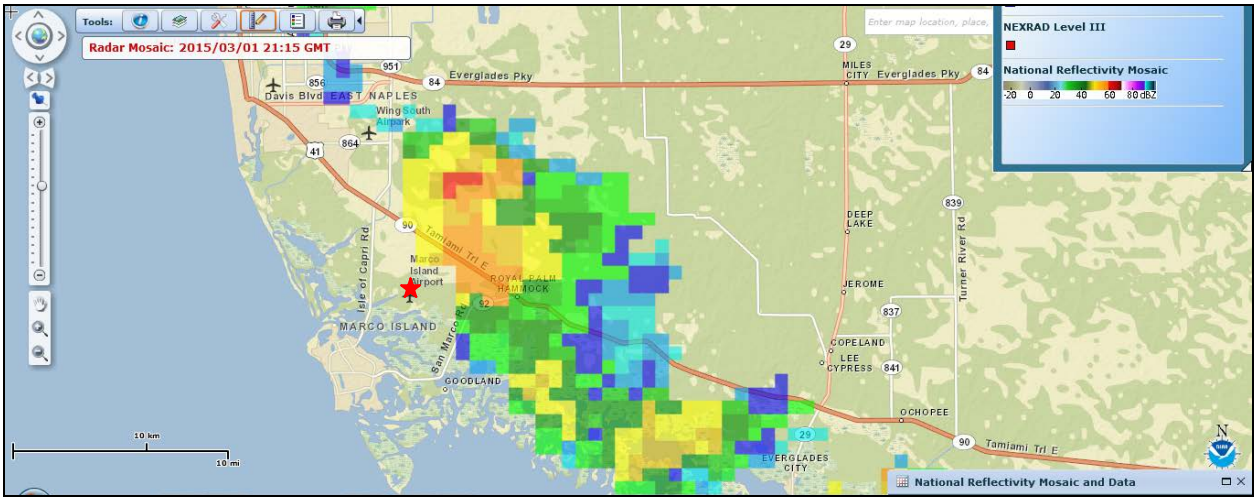

Figure 3 - Close up of the radar mosaic at 1615 EST

1.3 Convective Outlook

The NWS Storm Prediction Center's Convective Outlook mid-day forecast update issued at 1130 EST (1630Z) for the potential of organized thunderstorms during the period is included as figure 4. The chart depicted a small area of potential thunderstorm development over central and western Florida during the period, which included the Marco Island area. The outlook indicated a marginal risk or greater than 10% or higher probability of thunderstorm development over the region, with the potential for severe thunderstorms of either limited organization and longevity, or low coverage. A severe thunderstorm is defined as a thunderstorm producing surface winds of 50 knots or greater, large hail, and/or a tornado. Severe thunderstorms also imply severe-to-extreme turbulence, severe icing, and the threat of low-level wind shear and/or microburst activity.

The graphic and narrative was updated at 1450 EST (1950Z) with little or no change to the Florida forecast.

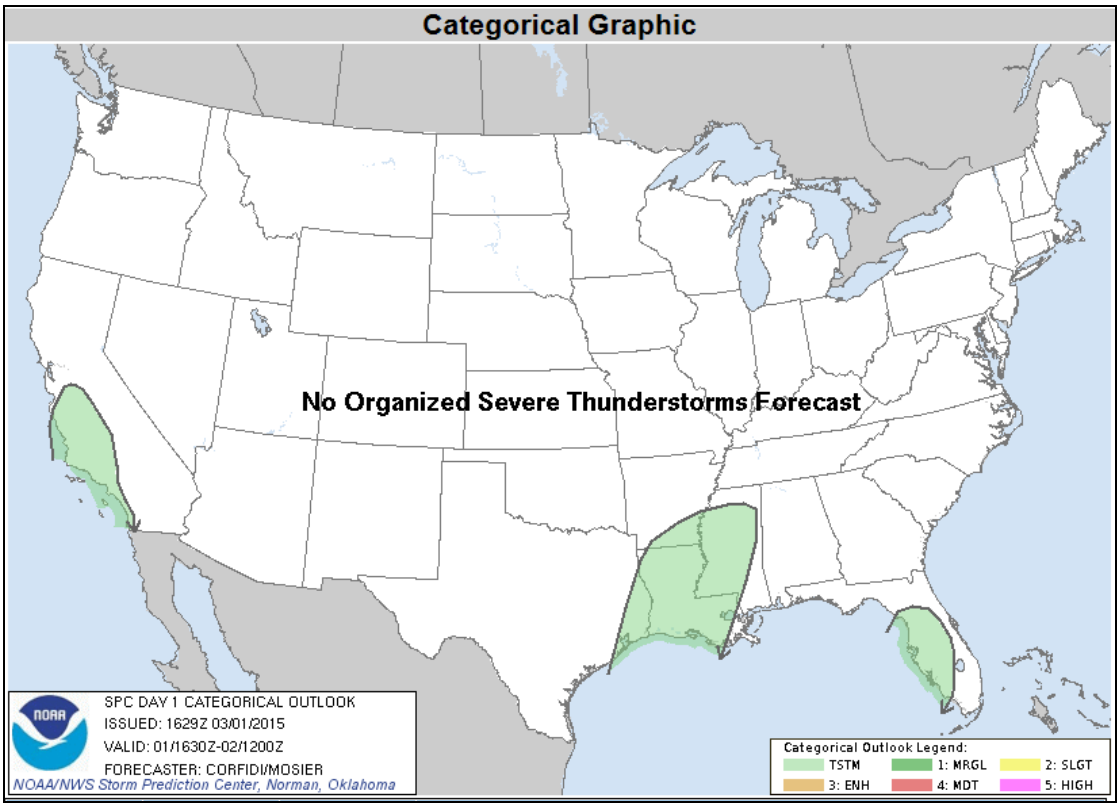

Figure 4 - NWS Storm Prediction Center's Convective Outlook

The convective outlook narrative for the Florida area that was issued with the graphic was as follows:

SPC AC 011629
DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1029 AM CST SUN MAR 01 2015

VALID 011630Z - 021200Z

...NO SVR TSTM AREAS FORECAST...

...SUMMARY...
WIDELY SCATTERED THUNDERSTORMS WILL OCCUR MAINLY TODAY OVER PARTS OF CENTRAL AND SOUTHERN CALIFORNIA...OVER SOUTHEAST TEXAS AND THE LOWER MISSISSIPPI VALLEY...AND OVER CENTRAL FLORIDA.

...SYNOPTIC SETUP...

...CNTRL FL TODAY...
MODERATE DAYTIME HEATING OF MARITIME TROPICAL AIR WITH MOIST ADIABATIC TEMPERATURE PROFILES MAY YIELD SCTD AFTN SHOWERS/TSTMS OVER PARTS OF CNTRL AND PERHAPS SRN FL. WEAK CIN AND ABSENCE OF SIGNIFICANT THERMAL ADVECTION ACROSS REGION SUGGEST THAT ACTIVITY WILL REQUIRE SOME DEGREE OF CONVERGENCE TO BE REALIZED...WITH THE LATTER LIKELY BEING MAXIMIZED NEAR INTERSECTION OF OLD W-E FRONT AND SEA-BREEZE BOUNDARIES OVER THE W CNTRL PART OF THE STATE. WHILE PW

WILL REMAIN FAIRLY HIGH...WEAK SHEAR WILL LIMIT POTENTIAL FOR ANY SUSTAINED WIND THREAT.

1.4 Prognostic Chart

The NWS 12-hour Surface Prognostic Chart current at the time of the accident is included as figure 5, and depicted the expected frontal position and forecast precipitation. The chart depicted the stationary front over northern Florida with scattered rain showers and thunderstorms over central and western Florida.

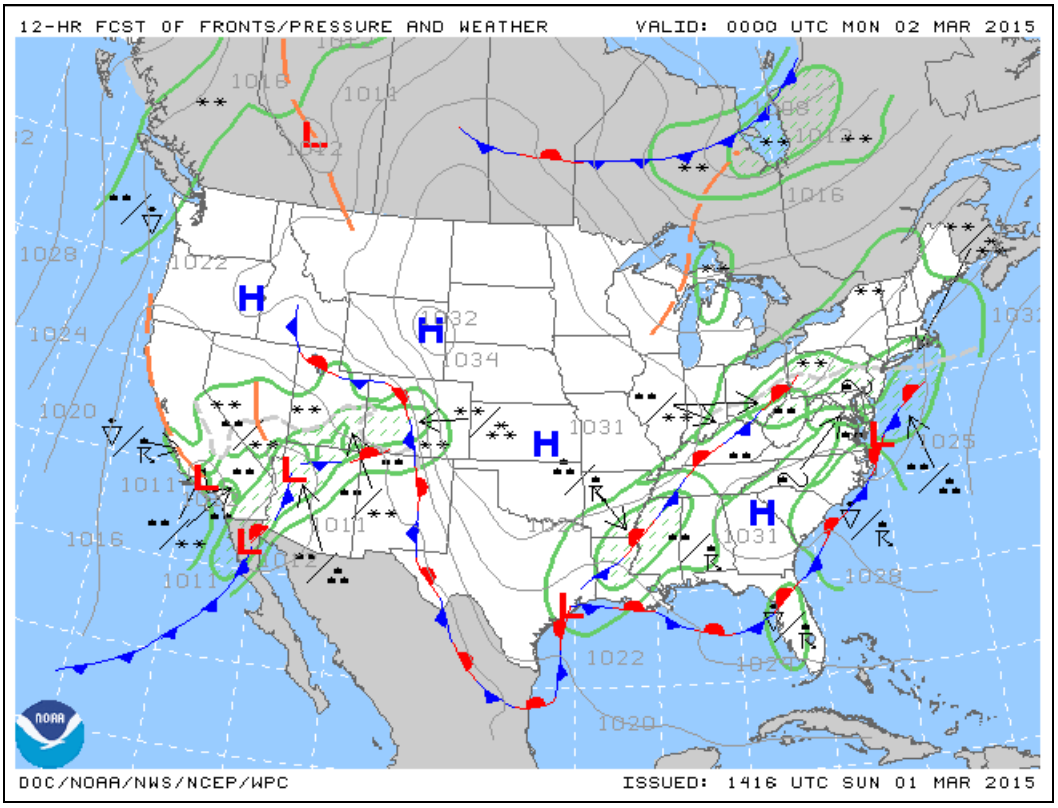

Figure 5 - NWS 12-hour Weather Prognostic Chart

2.0 Marco Island Airport Observations

The official NWS Meteorological Aerodrome Reports (METARs) and special reports (SPECIs) surrounding the period were documented for Marco Island Airport (KMKY), Marco Island, Florida. The airport had an Automated Weather Observation System (AWOS), which issued observations every 20 minutes. The airport lists an elevation of 6 feet and a magnetic variation of 3° West. The following weather conditions were reported surrounding the time of the accident, with cloud heights reported above ground level (agl) in this section.

Marco Island Airport weather at 1555 EST, automated, wind from 270° at 6 knots, visibility 10 statute miles, a few clouds at 4,800 feet agl, and a few clouds at 6,000 feet, temperature 26° Celsius (C), dew point 20° C, altimeter 30.21 inches of mercury (Hg). Remarks; automated

observation system without a precipitation discriminator, 3-hour precipitation recorded was 0.02 inches, 3-hour pressure tendency fallen 1.7-hPa.

Accident 1615 EST

Marco Island Airport weather at 1615 EST, automated, wind from 250° at 8 knots, visibility 10 miles, a few clouds at 9,000 feet agl, temperature 27° C, dew point 20° C, altimeter 30.22 inches of Hg. Remarks; automated observation system without a precipitation discriminator.

Marco Island Airport weather at 1635 EST, automated, wind from 050° at 5 knots, visibility 1 3/4 miles, scattered clouds at 1,900 feet agl, ceiling broken at 2,800 feet, overcast at 6,000 feet, temperature 24° C, dew point 21° C, altimeter 30.24 inches of Hg. Remarks; automated observation system without a precipitation discriminator, hourly precipitation 0.21 inches.

The observation at 1555 EST indicated the wind components as 1 knot tailwind and 6 knot crosswind for runway 17. At 1615 EST the component was a 1 knot headwind and 8 knot crosswind. A wind shift occurred between 1615 and 1655 EST to a northeast wind, which was likely associated with the band of showers moving across the area. The raw observations surrounding the period from 1430 through 1735 EST with referenced to UTC with the general flight categories[2] were as follows:

VFR METAR KMKY 011935Z AUTO 18008KT 10SM SCT048 SCT060 BKN095 29/19 A3022 RMK AO1=

MVFR METAR KMKY 011955Z AUTO 20003KT 5SM FEW036 SCT046 26/22 A3022 RMK AO1 P0002=

VFR METAR KMKY 012015Z AUTO 30006KT 10SM SCT050 BKN055 27/21 A3022 RMK AO1=

VFR METAR KMKY 012035Z AUTO 27005KT 10SM BKN048 BKN050 26/21 A3022 RMK AO1=

VFR METAR KMKY 012055Z AUTO 27006KT 10SM FEW048 FEW060 26/20 A3021 RMK AO1 60002 57017=

VFR METAR KMKY 012115Z AUTO 25008KT 10SM FEW090 27/20 A3022 RMK AO1=

Accident 2115Z

IFR METAR KMKY 012135Z AUTO 05005KT 1 3/4SM SCT019 BKN028 OVC060 24/21 A3024 RMK AO1

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

- Low Instrument Flight Rules (LIFR*) – ceiling or lowest layer of clouds reported as broken, overcast or the vertical visibility into a surface based obscuration below 500 feet 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 feet agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 feet agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 feet 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 feet agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

P0021=

VFR METAR KMKY 012155Z AUTO 15005KT 10SM FEW019 SCT028 BKN045 23/21 A3023 RMK AO1 P0034=

VFR METAR KMKY 012215Z AUTO 29004KT 10SM FEW047 FEW100 23/21 A3023 RMK AO1=

VFR METAR KMKY 012235Z AUTO 30003KT 10SM BKN110 23/21 A3023 RMK AO1=

The observations indicated that prior to the accident at 1455 EST the AWOS reported 0.02 inches of precipitation from the last observation, which indicated visibility of 5 miles likely with light rain at the time. The system reported from 1615 to 1635 EST a period of precipitation with 0.21 inches of precipitation, with a rate which equaled heavy rain. The total precipitation at 1655 EST was reported as 0.34 inches. The system did not detect any significant wind gusts, but did indicate a wind shift associated with the convection between 1615 and 1635, from the west to the northeast, with winds returning to the west afterwards.

3.0 Upper Air Data

The upper air sounding or rawinsonde observation (RAOB) was from the NWS Tampa Bay (KTBW) Weather Forecast Office, site number 72210, located approximately 100 miles north of the accident site at an elevation of 43 feet was documented, as it was in the same general airmass and south of the stationary front. The 1900 EST (0000Z on March 2, 2015) sounding was plotted from the surface to 500-hPa or 18,000 feet on a standard Skew-T log P diagram[3] utilizing RAOB[4] software is included as figure 9.

The sounding depicted warm moist low-level environment with the relative humidity greater than 70 percent from the surface through 10,000 feet. The lifted condensation level (LCL)[5] at 961-hPa or at 1,820 feet agl, a convective condensation level (CCL)[6] and level of free convection (LFC)[7] at 912-hPa or 3,300 feet agl. The equilibrium level (EL)[8] or expected top of convective

[3] 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.

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

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

[6] Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

[7] 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.

[8] Equilibrium Level (EL) - On a sounding, the level above the level of free convection (LFC) at which the temperature of a rising air parcel again equals the temperature of the environment. The height of the EL is the height at which thunderstorm updrafts no longer accelerate upward. Thus, to a close approximation, it represents the

clouds was at approximately 29,800 feet with the tropopause identified at 128-hPa or 49,400 feet. The freezing level was identified at approximately 14,000 feet. The wind profile indicated westerly winds below 2,000 feet, with winds shifting immediately to the east from 2,000 through 9,000 feet with speeds of 10 knots or less. The mean 0 to 6 kilometer (km) or 18,000 feet wind was from 245° at 2 knots.

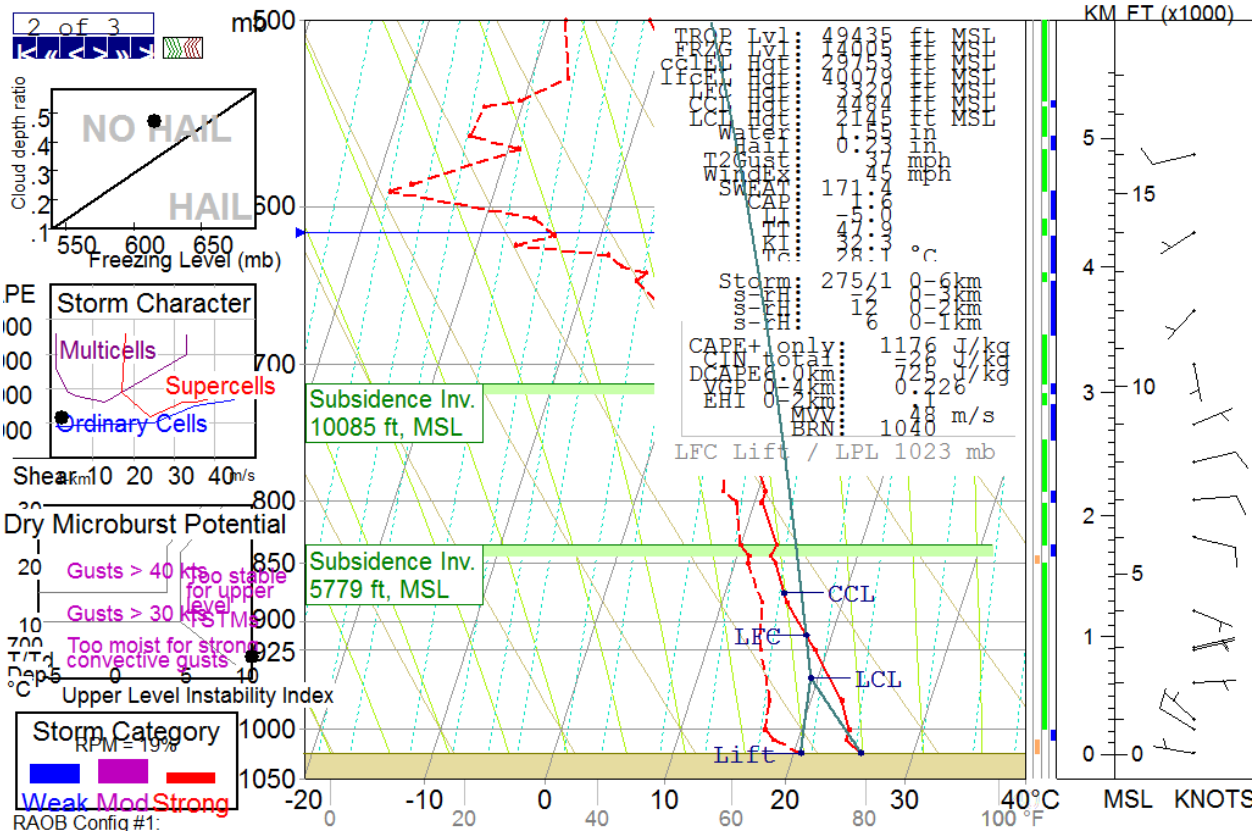

Figure 6 - Tampa sounding at 1900 EST

The stability parameters indicated a Lifted Index (LI)[9] of -5.0, a K-Index[10] of 32.2, and a Convective Available Potential Energy (CAPE)[11] of 1,150 Joules/kilogram (J/kg). The

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height of expected (or ongoing) thunderstorm tops. However, strong updrafts will continue to rise past the EL before stopping, resulting in storm tops that are higher than the EL. This process sometimes can be seen visually as an overshooting tops or anvil dome. The EL typically is higher than the tropopause, and is a more accurate reference for storm tops.

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

[10] K-Index - The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The higher the K-Index, the greater the probability of air mass type thunderstorms development.

[11] Convective Available Potential Energy (CAPE) – is a measure of the amount of energy available for convection.

maximum vertical velocity of the potential updrafts was 48 meters/second (m/s) or 96 knots. The sounding also indicated a hail potential of 1/4 inch and a precipitable water value of 1.55 inches. The microburst index or WINDEX indicated potential outflow of 39 knots. The Bulk Richardson Number (BRN)[12] was 1040 and the BRN Shear value was 1.1 (m^2/s^2), which indicated weak support for severe storms. The best category indicated a weak to moderate support for strong or severe thunderstorms.

The Tampa observed and derived sounding parameters for the 1900 EST sounding from the surface through approximately 10,000 feet are provided in Figure 7.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD/FF (deg/kts)	CAT (AF)	LLWS
43	1023	25.6	20.6	74	280/4		
412	1010	24.0	18.0	69			
698	1000	24.0	17.0	65	305/8		LIGHT
1000	990				315/4		
1513	972	22.6	16.6	69			
2000	956				85/3		
2923	925	19.0	14.5	75	75/7		
4000	890				115/7		
4228	883	15.4	13.3	87			
5287	850	13.4	11.1	86			
5483	844	12.8	11.0	89			
5779	835	13.0	10.0	82			
6000	828				105/11		
6923	801	10.6	8.5	87	85/8		
7233	792	10.6	7.1	79			
8000	770				75/8		
8610	753	7.8	5.9	88			
9000	742				65/4		
9524	728	7.0	3.3	77			
9822	720	6.2	3.4	82			

Figure 7 - Sounding parameters

The North American Mesoscale (NAM) 3-hour numerical model data was also obtained from the NOAA Air Resource Laboratory (ARL) archive site and also displayed using the RAOB software. Figure 8 is the NAM model over the accident site for forecast conditions at 1600 EST (2100Z) on March 1, 2015. The sounding depicted similar conditions as the Tampa sounding above with little variations. The sounding indicated surface conditions with a wind from 278° at 1 knot, a temperature of 25.4° C (77.7° F), dew point temperature 21.1° C (70.0° F), and sea level pressure 1024-hPa or 30.24 inches of Hg. The estimated base of the clouds or LCL was at 1,820 feet agl, with the EL or estimated tops were approximately 39,000 feet. The sounding was

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CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.

[12] Bulk Richardson Number (BRN) - is the ratio of the buoyancy (CAPE) of a lifted parcel to the vertical wind shear of the environment in which the parcel is lifted. It correlates well with observed storm type (single, multicellular, and supercells), especially for CAPEs between 1500 and 3000 J/kg. BRN's less than 45 tend to support supercell structures, with multicellular convection favored over 45. While the BRN has shown some value as a predictor of storm type, it is a poor predictor of storm rotation.

unstable with a LI of -5.0, a K-index of 23.8, and a CAPE value of 920 J/kg. The precipitable water content was 1.60 inches.

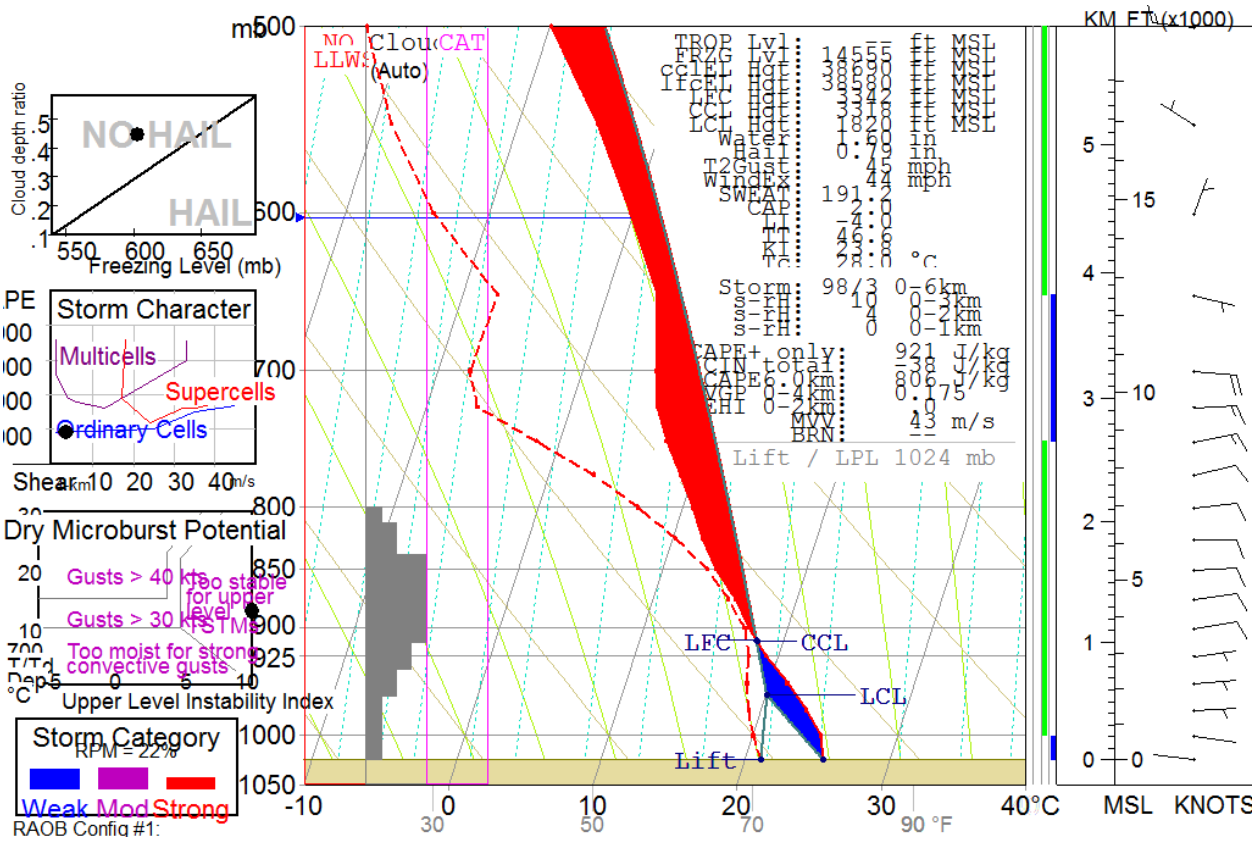

Figure 8 - North American Mesoscale (NAM) model sounding at 1600 EST

4.0 Satellite Data

The Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison (UW) in Madison, Wisconsin, and processed using the Safety Board's Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible band imagery were obtained surrounding the time of the accident. The infrared long wave imagery (band 4) at a wavelength of 10.7 microns (µm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km. The visible imagery (band 1) at a wavelength of 0.65 µm provided a resolution of 1 km.

Figure 9 is the GOES-13 infrared image at 1615 EST at 4X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops associated with deep convection and other high cirriform type clouds. The image depicted an area of low clouds with some vertical development over southwestern Florida, with no defined cumulonimbus type clouds in the vicinity of the accident site. Some enhanced clouds associated with convective clouds were identified over Alabama and southeastern Mississippi; however, no enhanced clouds were identified over Florida at the time. The radiative cloud top temperature

over the accident site was 278° Kelvin or 4.8° C, which corresponded to cloud tops near 12,000 feet based on the upper air sounding. The more vertically defined clouds immediately east of the accident site at KMKY was measured at 260° K or -13.2° C, which corresponded to cloud tops near 22,000 feet.

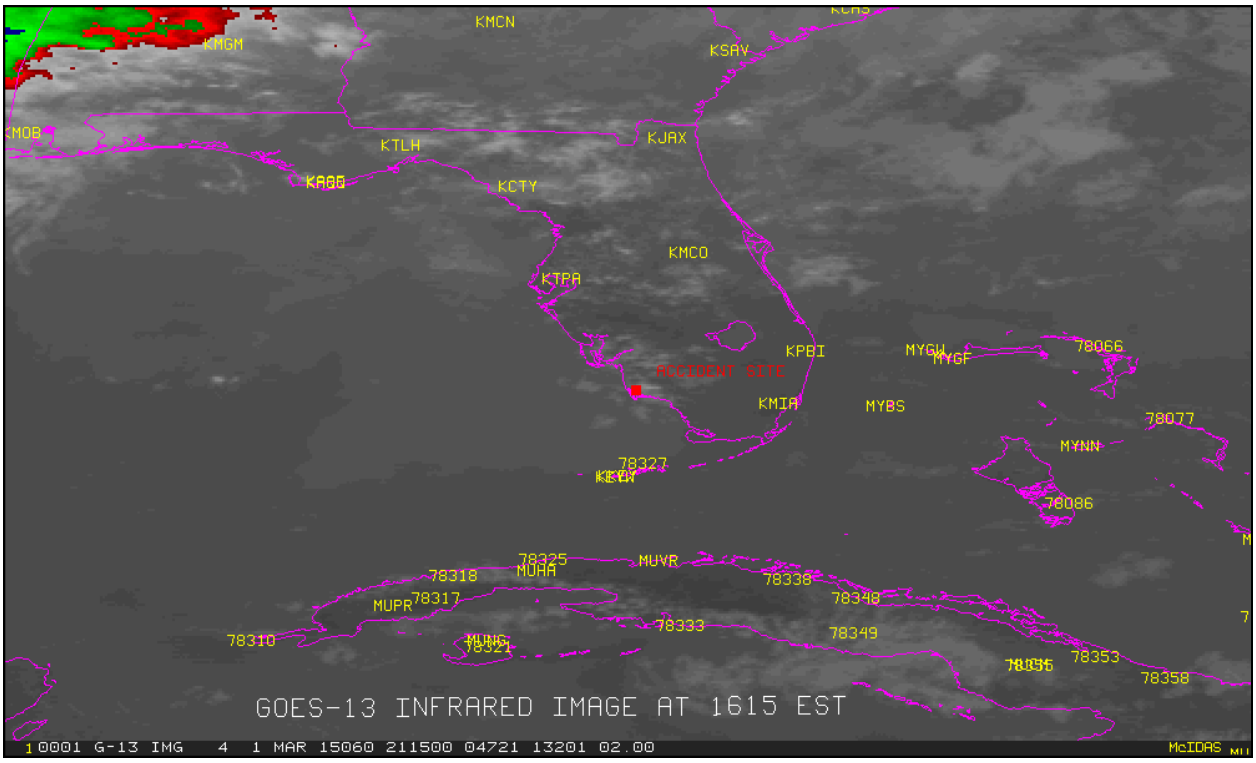

Figure 9 - GOES-13 infrared image at 1615 EST

Figures 10 and 11 are the GOES-13 visible images at 2X magnification at 1615 and 1630 EST respectively and shows a band of towering cumulus clouds immediately east and then over the airport at the time of the accident.

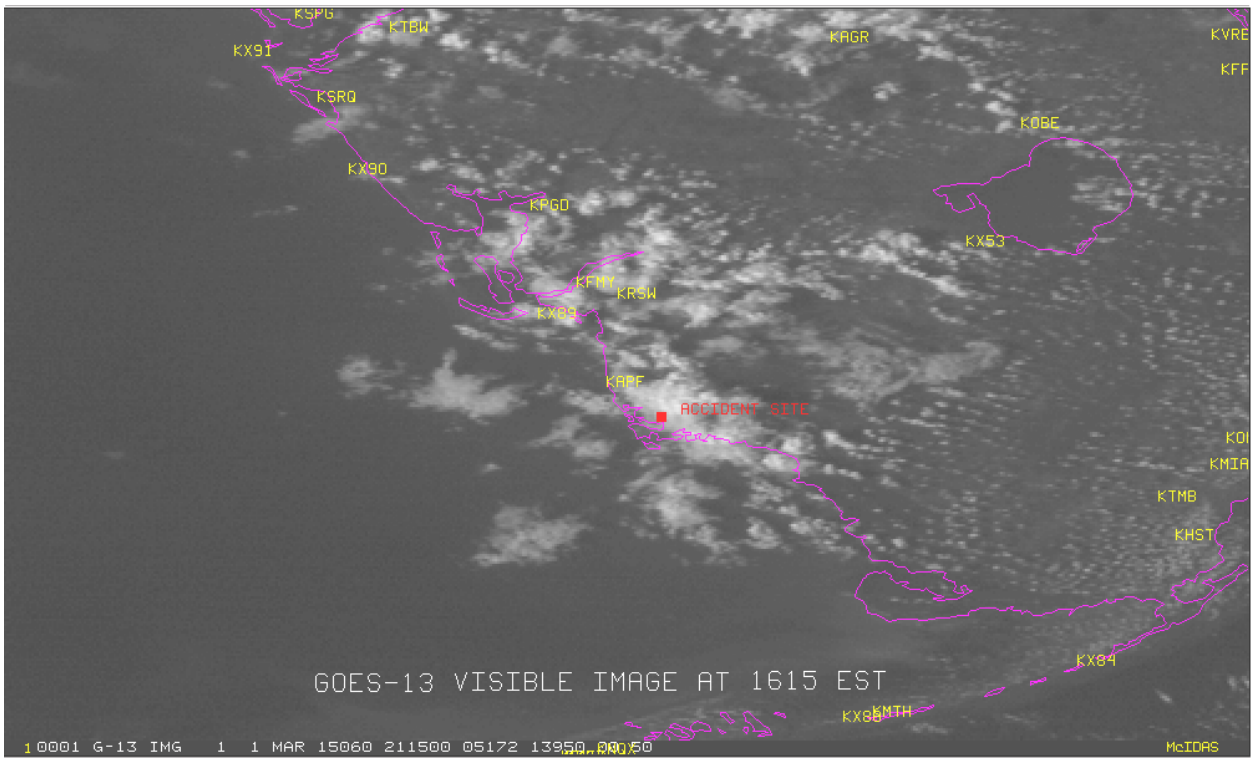

Figure 10 - GOES-13 visible image at 1615 EST

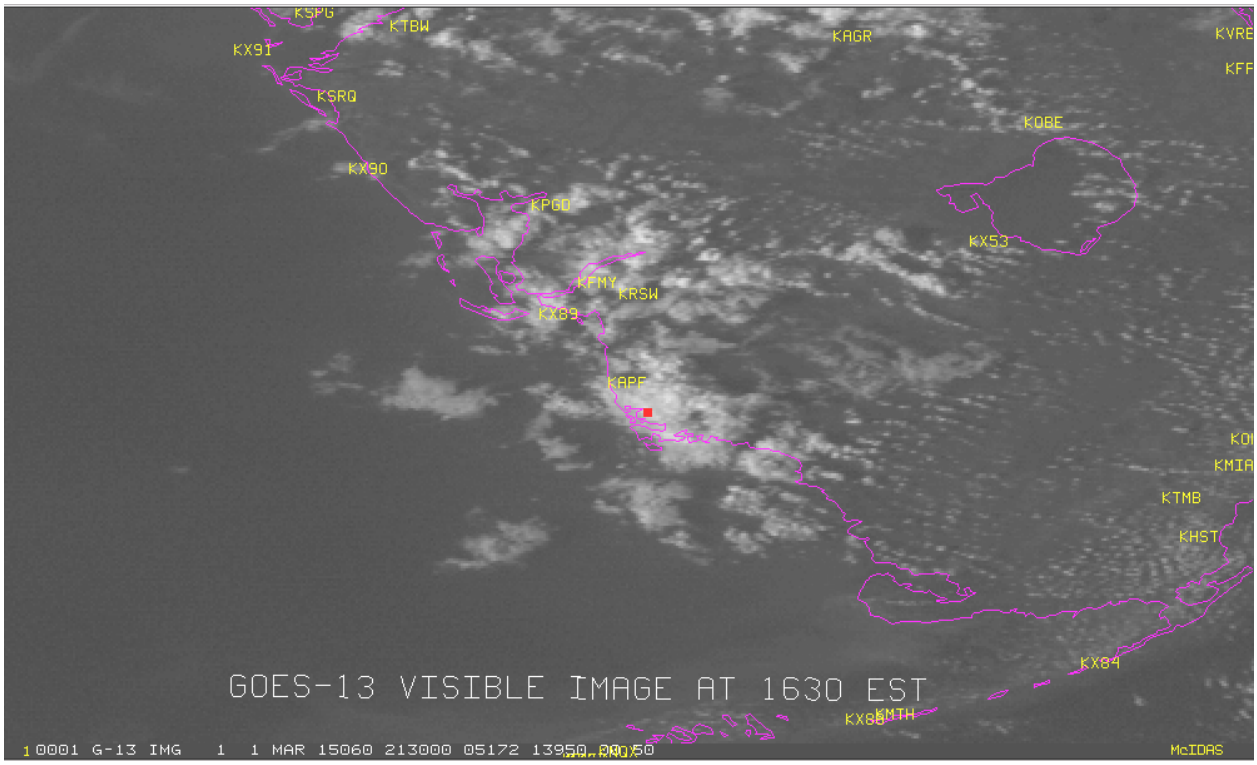

Figure 11 - GOES-13 visible image at 1630 EST

5.0 Weather Radar Information

The closest Weather Surveillance Radar-1988, Doppler (WSR-88D) to the accident site was from the NWS Miami (KAMX) located approximately 72 miles east of the accident site. The level II and III archive data was obtained from the National Climatic Data Center (NCDC) utilizing the Hierarchical Data Storage System (HDSS) 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 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 six 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 the non-severe convective mode where the radar makes 9 elevation scans from 0.50° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). 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 KAMX WSR-88D radar was operating in the precipitation mode VCP-12 where the radar makes 14 different elevation scans in 4 1/2 minutes. This mode is typically used by the NWS during periods when rapidly evolving wide spread severe convection is expected, and allows for improved low-level vertical resolution of the storms. 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.

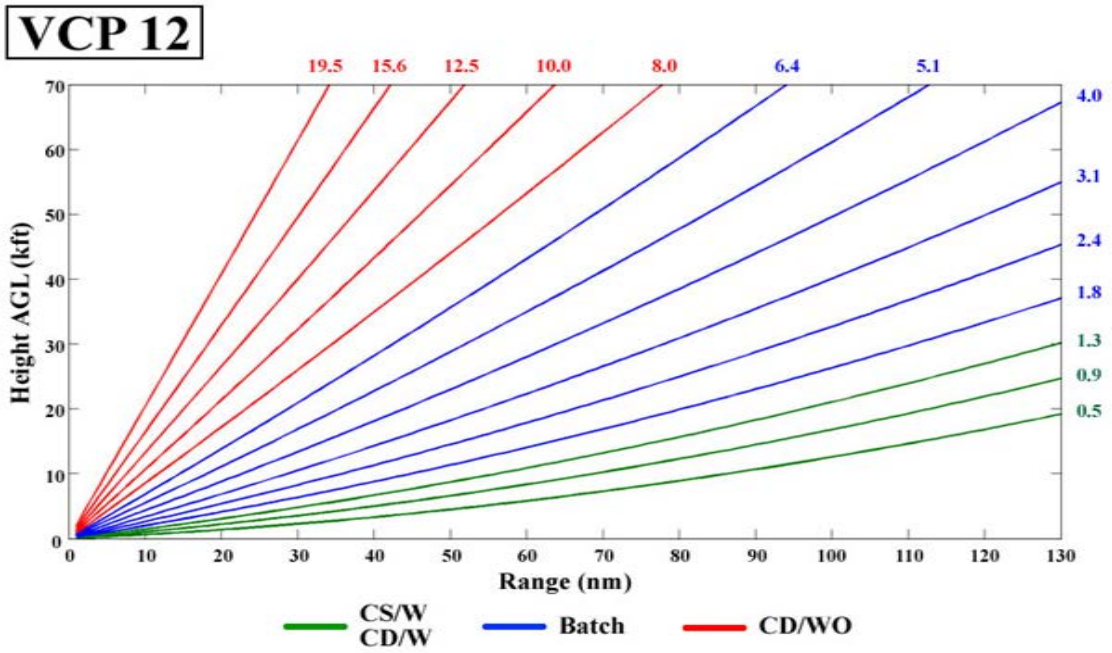

Figure 12- VCP-12 scanning mode

5.2 Beam Height Calculation

Assuming standard refraction[13] of the 0.95° radar beam of the KAMX WSR-88D with an antenna height of 111 feet and a distance of 72 miles and an azimuth of 288° from the radar, the following table shows the approximate beam height and width information 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°	7,360 feet	3,740 feet	10,990 feet	7250 feet

Based on the radar height calculations, the 0.5° elevation scan depicts the conditions encompassing the altitude between 3,740 and 10,990 feet over the accident site.

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[14] it is a function of the drop size distribution, number of particles per

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

[14] 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:

unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ[15]), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

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

Air traffic control (ATC) weather display systems also use radar weather processors with the ability to determine precipitation intensity, with controllers instructed to describe the intensity to pilots based on the following scale:

(a) "Light" (< 30 dBZ, NWS VIP level 1, not displayed)
(b) "Moderate" (30 to 40 dBZ, NWS VIP level 2)
(c) "Heavy" (> 40 to 50 dBZ, NWS VIP level 3 and 4)
(d) "Extreme" (> 50 dBZ, NWS VIP level 5 and 6)

5.4 Base Reflectivity

Figures 13 through 17 are the Miami (KAMX) WSR-88D 0.5 base reflectivity images from 1611 to 1626 EST at every 4 ½ minutes, with the flight track of N600NP overlaid. The images depict an area of echoes with maximum intensities from 45 to 50 dBZ immediately east of the

---

drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glaze ice.

[15] dBZ - 10 log Ze

Marco Island Airport as N600NP approaches from the south and flies under the leading edge of the echoes as it enters the pattern and turns final, and overruns by 1614 EST. The main area of echoes begins to move over the accident site at 1622 and 1626 EST with echoes of 35 to 40 dBZ, associated with moderate to heavy rain.

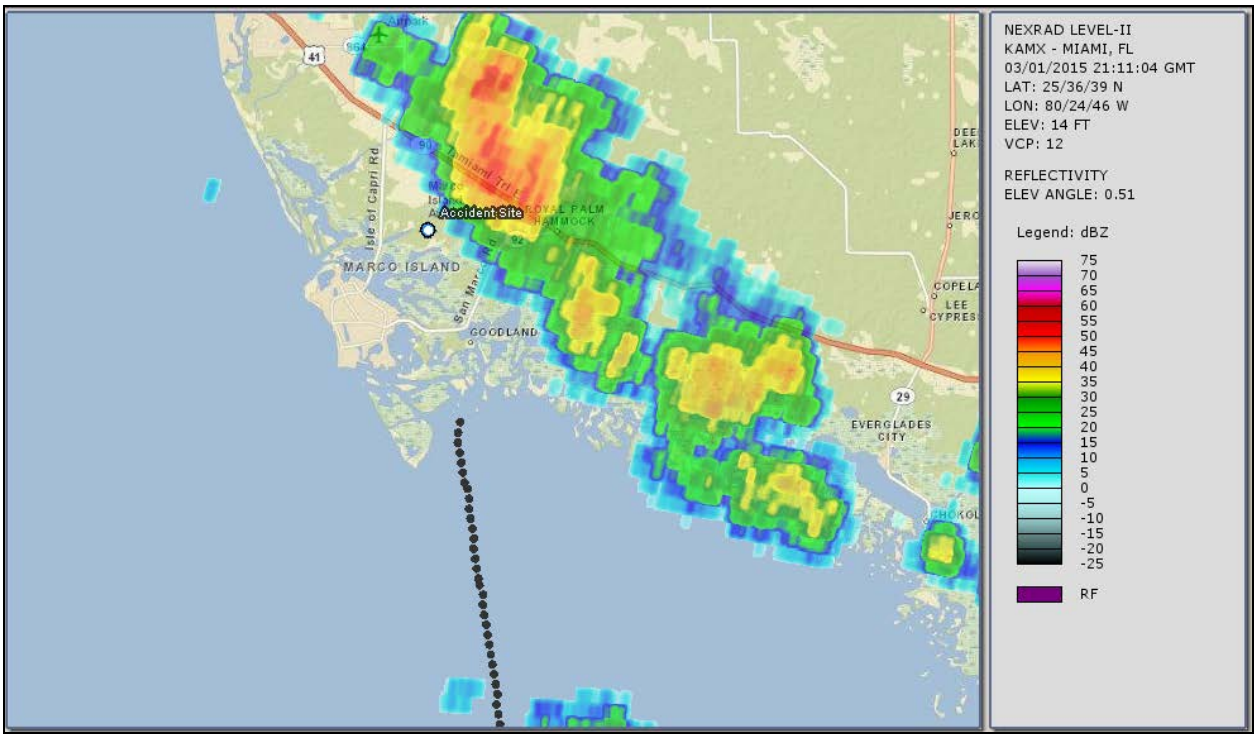

Figure 13 - Miami WSR-88D 0.5° base reflectivity display at 1611 EST

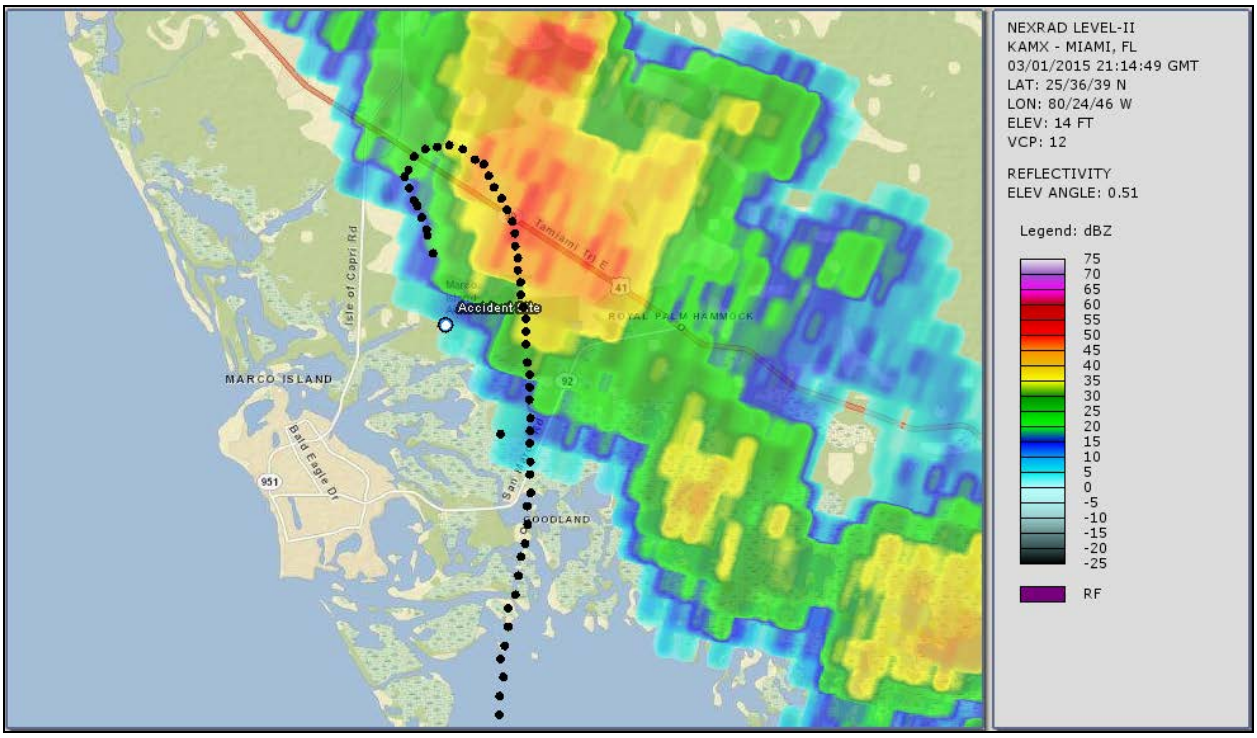

Figure 14 - Miami WSR-88D 0.5° base reflectivity image at 1614 EST

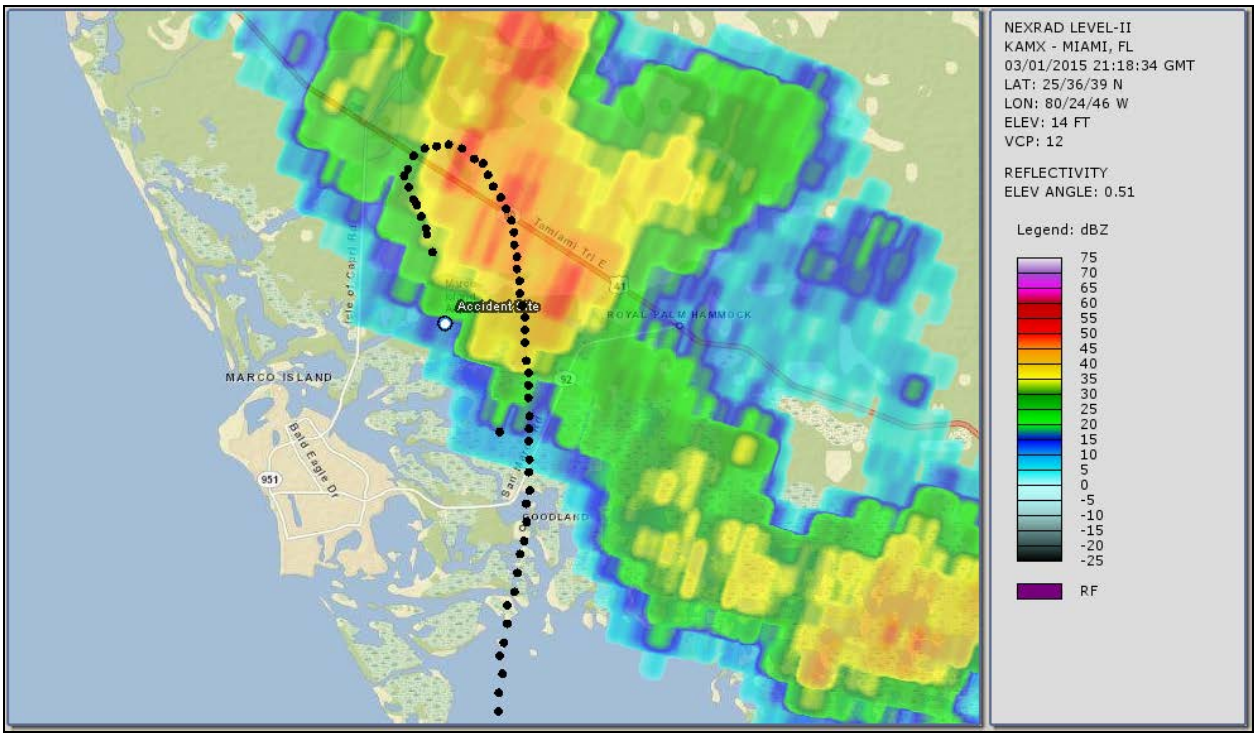

Figure 15 - Miami WSR-88D 0.5° base reflectivity image at 1618 EST

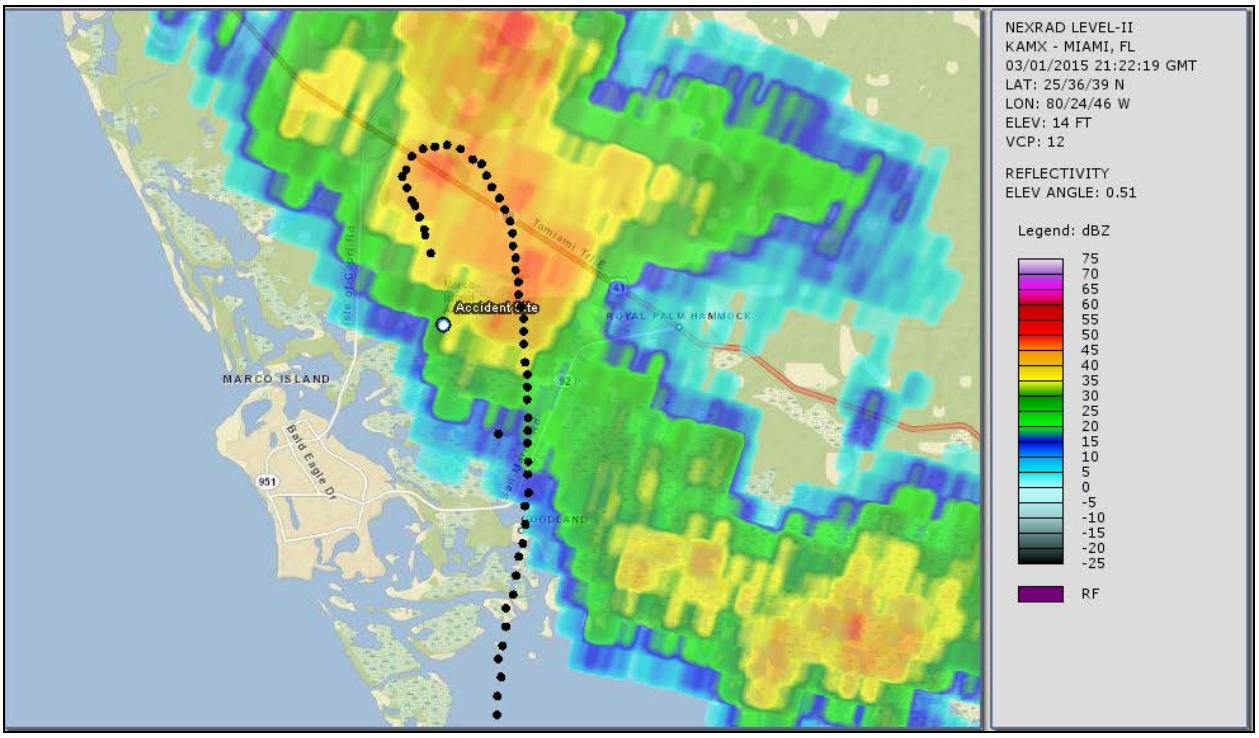

Figure 16 - Miami WSR-88D 0.5° base reflectivity image at 1622 EST

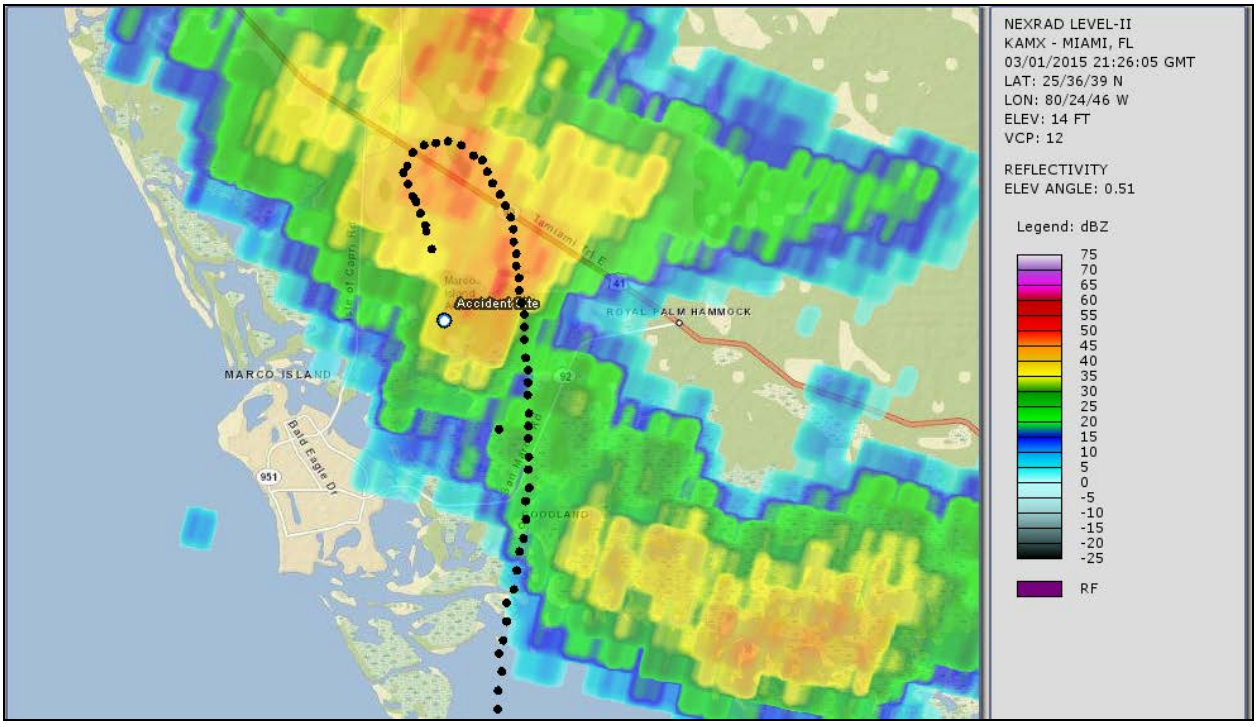

Figure 17 - Miami WSR-88D 0.5° base reflectivity image at 1626 EST

A review of the radial velocity imagery surrounding the period did not detect any strong outflows or divergent signatures with the area of echoes to suggest any strong winds, gust front, or microbursts associated with the echoes.

6.0 Lightning Data

A review of Earth Networks total lightning indicated that from 1530 through 1630 EST there was no lightning activity detected, indicating that the strong echoes were only associated with rain showers and not thunderstorms during the period.

7.0 Pilot Reports

A search of the pilot report bulletins over Florida surrounding the period indicated no relevant reports in the area surrounding the period.

8.0 Terminal Aerodrome Forecast

The NWS does not issue a Terminal Aerodrome Forecast (TAF) for Marco Island Airport. The closest NWS TAF was issued for Naples Municipal Airport (KAPF), Naples, Florida, located 10 miles northwest of KMKY at an elevation of 8 feet and a 3° W magnetic variation. The forecast current at the time prior to departure was as follows:

TAF KAPF 011723Z 0118/0218 09010KT P6SM BKN035
FM012000 23009KT P6SM VCSH BKN040
FM020100 05004KT P6SM BKN050
TEMPO 0210/0213 5SM BR
FM021400 08008KT P6SM SCT030=

The forecast was amended immediately prior to the accident at 1558 EST, expected temporary rain showers and a ceiling broken at 2,500 feet.

TAF AMD KAPF 012058Z 0121/0218 23008KT P6SM VCSH BKN080
TEMPO 0121/0122 SHRA BKN025
FM020100 05005KT P6SM BKN050
TEMPO 0210/0213 5SM BR
FM021400 08008KT P6SM SCT030=

9.0 Aviation Forecast Discussion

The NWS Miami Aviation Forecast Discussion (AFD) current for the period is included below and is intended to provide a well-reasoned discussion of the meteorological thinking which went into the preparation of the forecast products, or specifically for aviation the Naples TAF. The discussion was issued at 1559 EST and was as follows:

.AVIATION...
E-SE WIND FLOW ACROSS SOUTH FLORIDA WITH DRIER AIR COMPARED TO 24 HOURS AGO. PATTERN TODAY SIMILAR TO WHAT WE SEE IN THE SUMMER, WITH SEA BREEZE CIRCULATIONS PLAYING A MAJOR ROLE IN CLOUD

COVER/PRECIPITATION. GULF SEA BREEZE DEVELOPING BY MID AFTERNOON WILL LEAD TO SCATTERED SHRA AND EVEN ISOLATED TSRA NEAR THE WEST COAST. WENT WITH VCSH FOR KAPF AS COVERAGE OF TSRA NOT ENOUGH TO WARRANT MENTION IN TAF AT THIS TIME. THE EAST COAST WILL REMAIN MOSTLY DRY WITH ANY PROLONGED CEILINGS ABOVE 3000 FT. POSSIBLE EXCEPTION TO THIS AT KPBI WHERE A STREAMER FROM GRAND BAHAMA ISLAND MAY BRING A FEW SHOWERS TO THAT AREA LATER THIS AFTERNOON. OVERALL PATTERN PERSISTS THROUGH MONDAY. SOME OCCASIONAL LIGHT FOG AT KAPF 10Z-13Z, OTHERWISE FAIR AND VFR. /MOLLEDA
&&

10.0 Area Forecast

The NWS Area Forecast issued by the Aviation Weather Center (AWC) located in Kansas City, Missouri at 1345 EST was as follows:

FAUS42 KKCI 011845 2015060 1831
FA2W
-MIAC FA 011845
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 021300
CLDS/WX VALID UNTIL 020700...OTLK VALID 020700-021300
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...TROF OVR NC/SC/GA/NRN FL ATLC NRSHORE WTRS BY 13Z OVR NC/SC OFFSHORE WTRS. BY 06Z CDFNT WL MOV OVR WRN NC-NWRN GA BY 13Z OVR SERN VA-NWRN SC-N CNTRL GA.
.
FL
PNHDL...OVC010-020 TOP 080. VIS 3-5SM BR. TIL 21Z ISOL -SHRA. OTLK...IFR CIG BR.
NRN PEN...N HLF..OVC010 TOP 080-100. OCNL VIS 3SM BR. 01Z VIS 3SM BR. OTLK...IFR CIG BR.
S HLF..SCT020 BKN035 TOP 140. 21Z ISOL -SHRA/TSRA. CB TOP FL320. BECMG 0002 OVC010 TOP 080-100. VIS 3SM BR. OTLK...IFR CIG BR.
CNTRL PEN...BKN040 TOP 160. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL370. BECMG 0002 SCT040 SCT-BKN080 TOP 120. OCNL VIS 3SM BR. 06Z BKN010 TOP 020. VIS 3-5SM BR. OTLK...IFR CIG BR.
SRN PEN...SCT025 BKN040 TOP 100-120. WDLY SCT -SHRA. W HLF ISOL -TSRA. CB TOP FL380.
BECMG 0002 SCT020 SCT040-050.
06Z SCT010-020. W HLF OCNL VIS 3SM BR. OTLK...W HLF MVFR BR.
FL KEYS...SCT025 SCT100. 02Z SCT015. OTLK...VFR.

The forecast for southern Florida expected scattered clouds at 2,500 feet, ceiling broken at 4,000 feet with tops from 10,000 to 12,000 feet, with widely scattered light rain showers and over western Florida isolated thunderstorms and light rain. Cumulonimbus cloud tops to 38,000 feet.

11.0 In-Flight Weather Advisories

The NWS issues in-flight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). In-flight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions, which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

Surrounding the period there were no Convective SIGMETs, Severe Weather Forecast Alerts, or Center Weather Advisories issued over Florida. An AIRMET was current for sections of northern Florida, Georgia, and the Carolina's for an area of low ceilings and visibilities. The advisory did not extend over the route of flight, and is provided in figure 18. The advisories were as follows:

Convective SIGMET

MKCE WST 012055
CONVECTIVE SIGMET...NONE
OUTLOOK VALID 012255-020255
FROM 40WSW OMN-40ENE RSW-30NW RSW-PIE-50SE CTY-40WSW OMN
WST ISSUANCES POSS. REFER TO MOST RECENT ACUS01 KWNS FROM STORM PREDICTION CENTER FOR SYNOPSIS AND METEOROLOGICAL DETAILS.

AIRMET

WA2S
-MIAS WA 011445
AIRMET SIERRA UPDT 3 FOR IFR AND MTN OBSCN VALID UNTIL 012100
.
AIRMET IFR...NC SC GA FL AND CSTL WTRS
FROM 20NE ECG TO 50NE ILM TO 20WNW ILM TO 70SSE SAV TO 30S ORL TO 100SW SRQ TO 90WSW PIE TO 120ESE LEV TO 40W CEW TO 50SW PZD TO GQO TO HMV TO 20NE ECG
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
.
AIRMET MTN OBSCN...NC SC GA
FROM 40SSE PSK TO CLT TO ATL TO GQO TO HMV TO 40SSE PSK
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
....

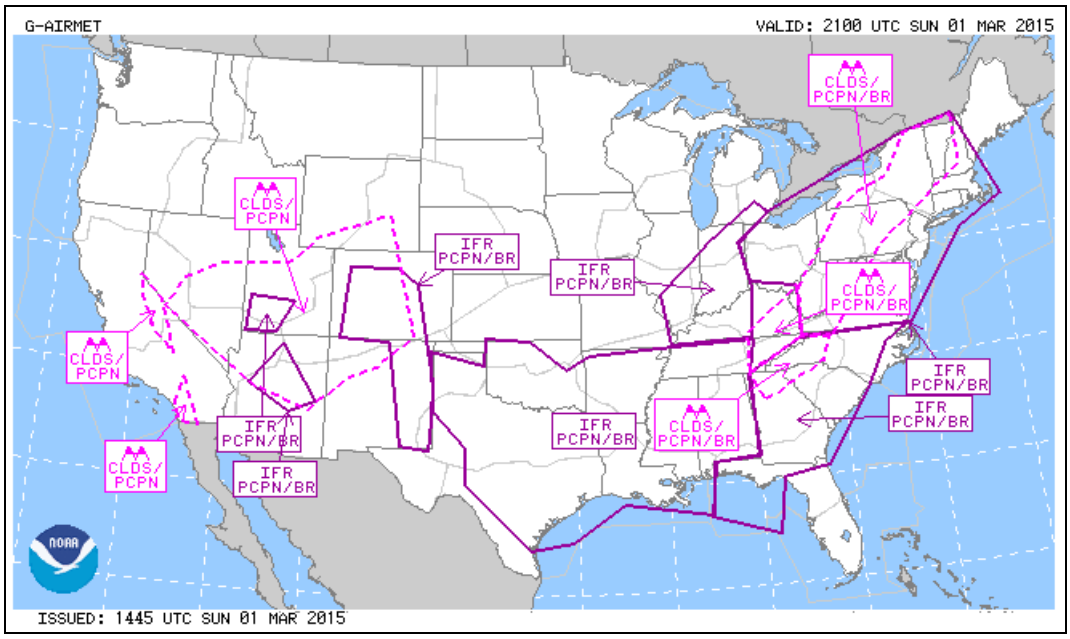

Figure 18 - G-AIRMET Sierra for IFR conditions

12.0 Winds and Temperatures Aloft Forecast

Figure 19 is the NWS Winds and Temperature Aloft (FD) bulletin was current at the time and indicated relatively light winds of less than 10 knots below 9,000 feet.

WINDS ALOFT FORECASTS

DATA BASED ON 011200Z
VALID 011800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000	45000	53000
EYW	1222	1017+13	1012+08	0508+05	2718-08	2831-19	294735	295045	295956		
MIA	1117	0906+12	0913+08	0810+04	2815-10	2831-21	295435	305445	296357	296464	285276

Submitted by:

Donald Eick
NTSB Senior Meteorologist