



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 15, 2018

Weather Study

METEOROLOGY

ERA18LA164

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A. ACCIDENT

Location: Daytona Beach, Florida
Date: June 9, 2018
Time: 1500 eastern daylight time
1900 Coordinated Universal Time (UTC)
Aircraft: Piper PA-44-180, Registration: N21161

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 remotely 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 June 9, 2018, and are based upon the 24-hour clock, where local time is - 4 hours from 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.

The accident site was located at approximate latitude 29.2392° N, longitude 81.0789° W, at an elevation of 55 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

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

1.1 Surface Analysis Chart

The southeastern United States section of the NWS Surface Analysis Chart for 1400 EDT is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart indicated a low-pressure system at 1017-hectopascals (hPa) over the South Carolina coast near Charleston, with an associated stationary frontal boundary stretching eastward into the western Atlantic Ocean. A surface trough² stretched from the low southwestward into southern Georgia, with another trough near Jacksonville, Florida, extending southward over the accident area, and then stretched southwestward across central Florida into the eastern Gulf of Mexico. A high pressure center was located over the eastern Gulf of Mexico off Florida at 1021-hPa with a ridge extending eastward north of the accident site.

The station models around the accident site depicted air temperatures in the mid 80's degrees Fahrenheit (°F), dew point temperatures in the low 70's °F with temperature-dew point spreads of 14° F, a light and variable wind of 5 knots or less, and partly cloudy skies.

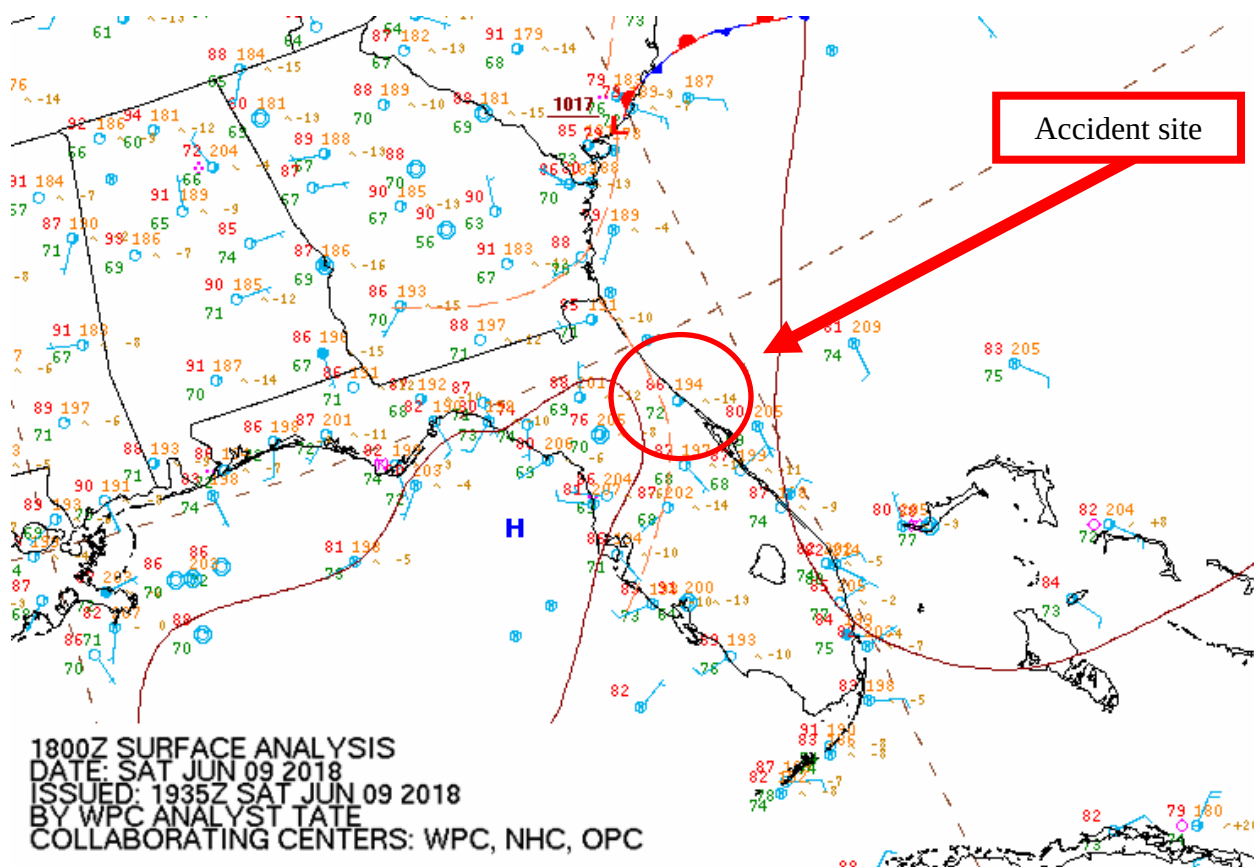


Figure 1 – NWS Surface Analysis Chart for 1400 EDT

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-hPa are presented in figures 2 through 6. There was a mid-level trough located over the accident site (figure 5) at 500-hPa. Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a south to southwest wind around 10 to 15 knots at 925- and 850-hPa that became a westerly 20 knot wind by 700-hPa (figure 4). By 300-hPa, the wind was from the south to east between 10 and 20 knots (figure 6).

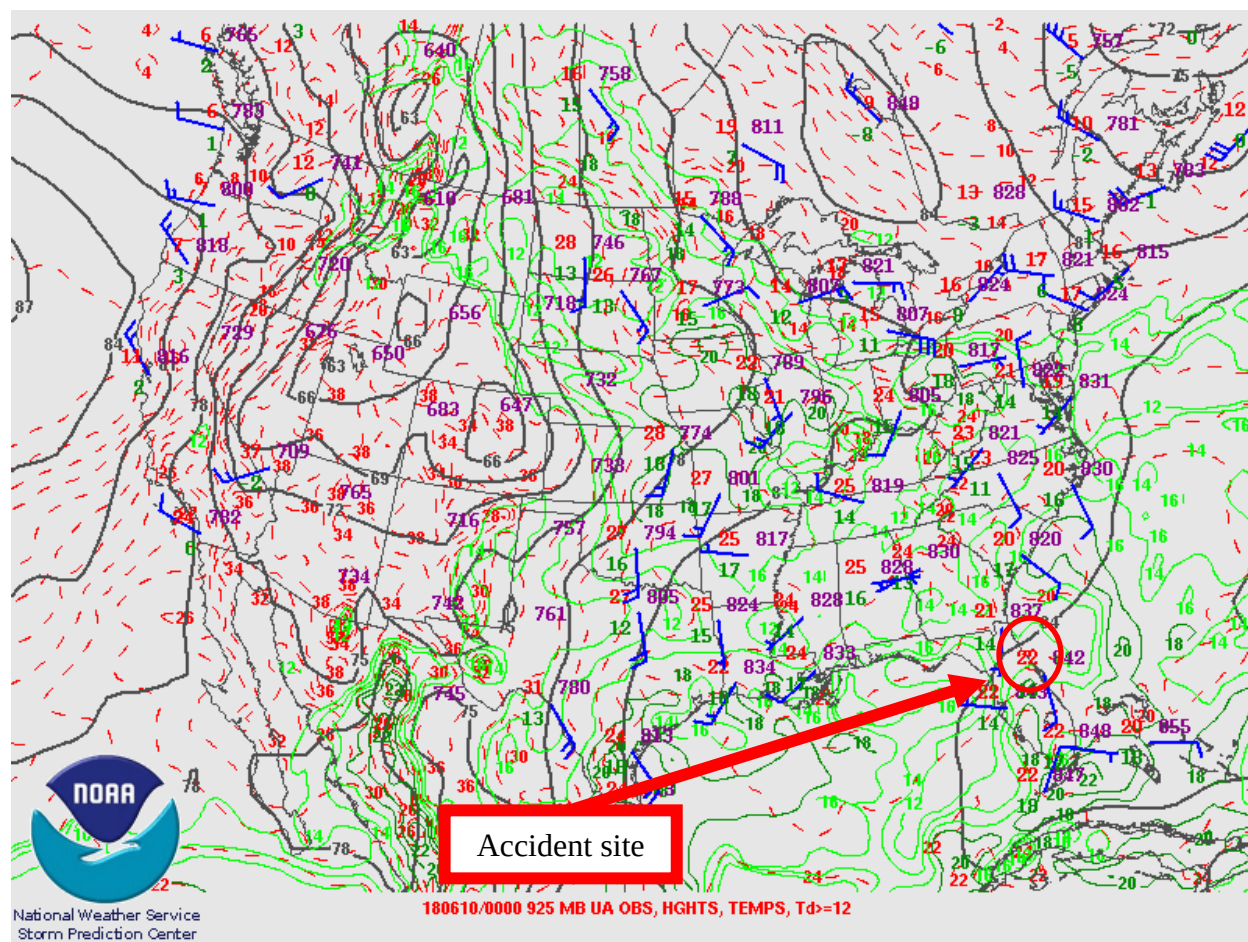


Figure 2 – 925-hPa Constant Pressure Chart for 2000 EDT

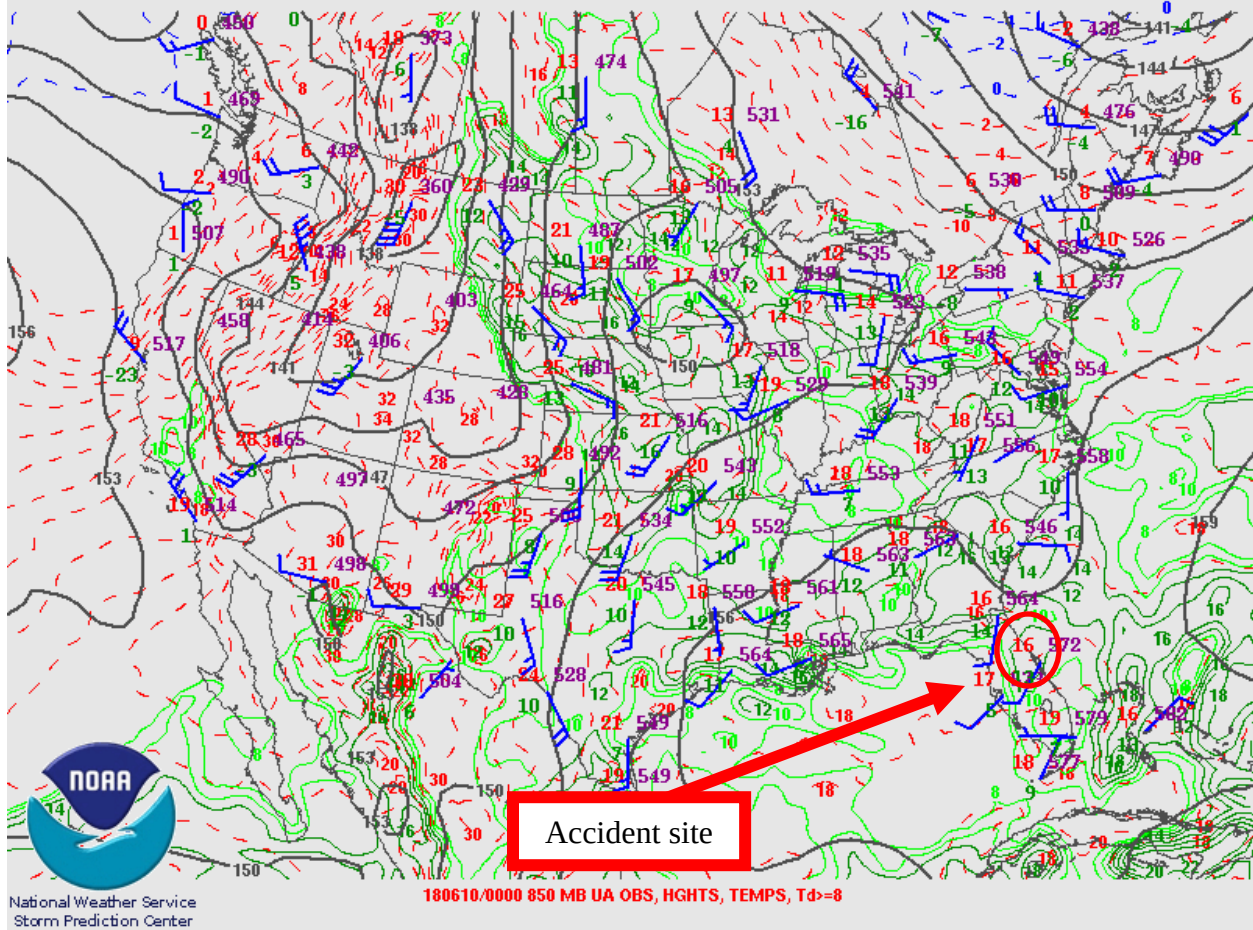


Figure 3 – 850-hPa Constant Pressure Chart for 2000 EDT

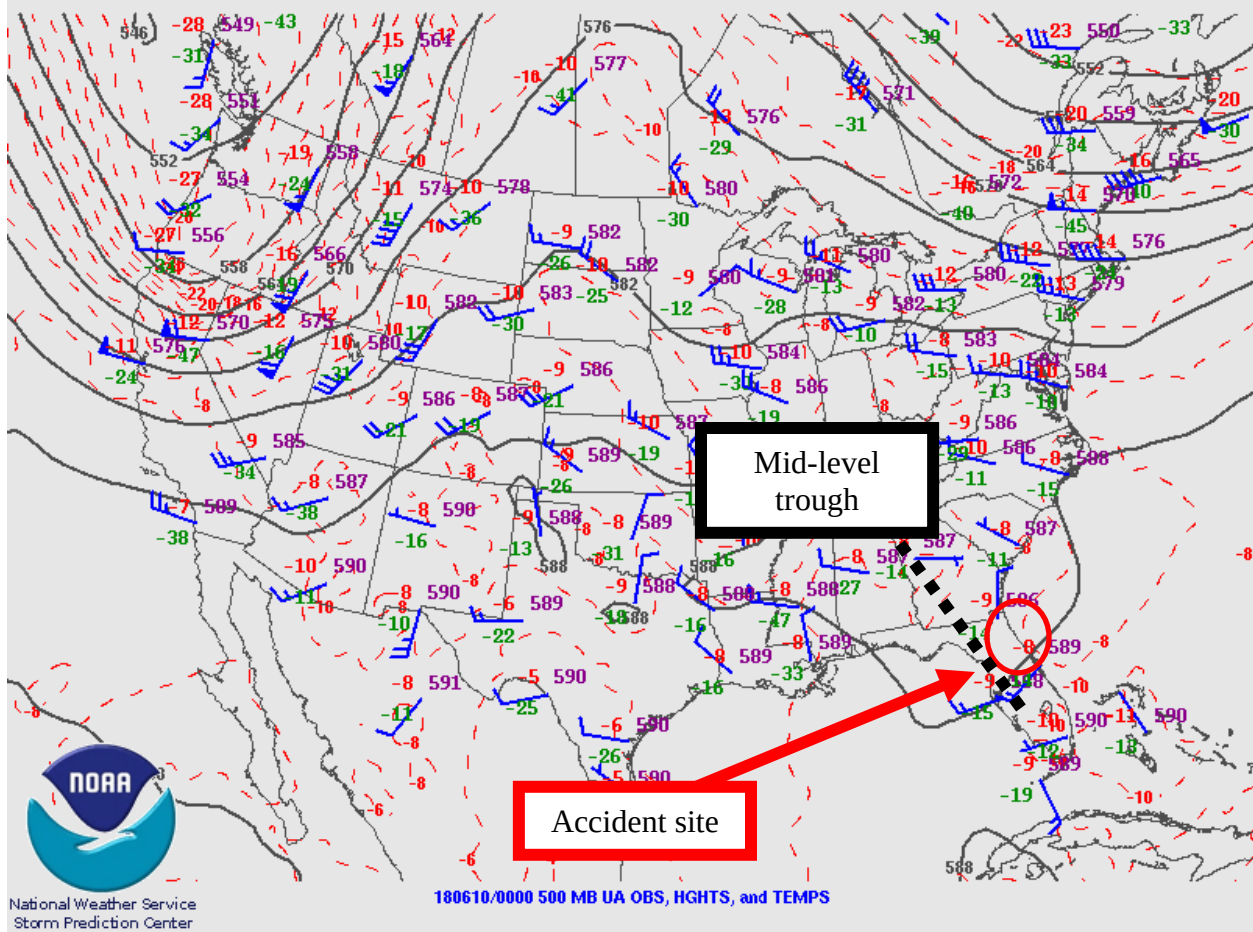


Figure 5 – 500-hPa Constant Pressure Chart for 2000 EDT

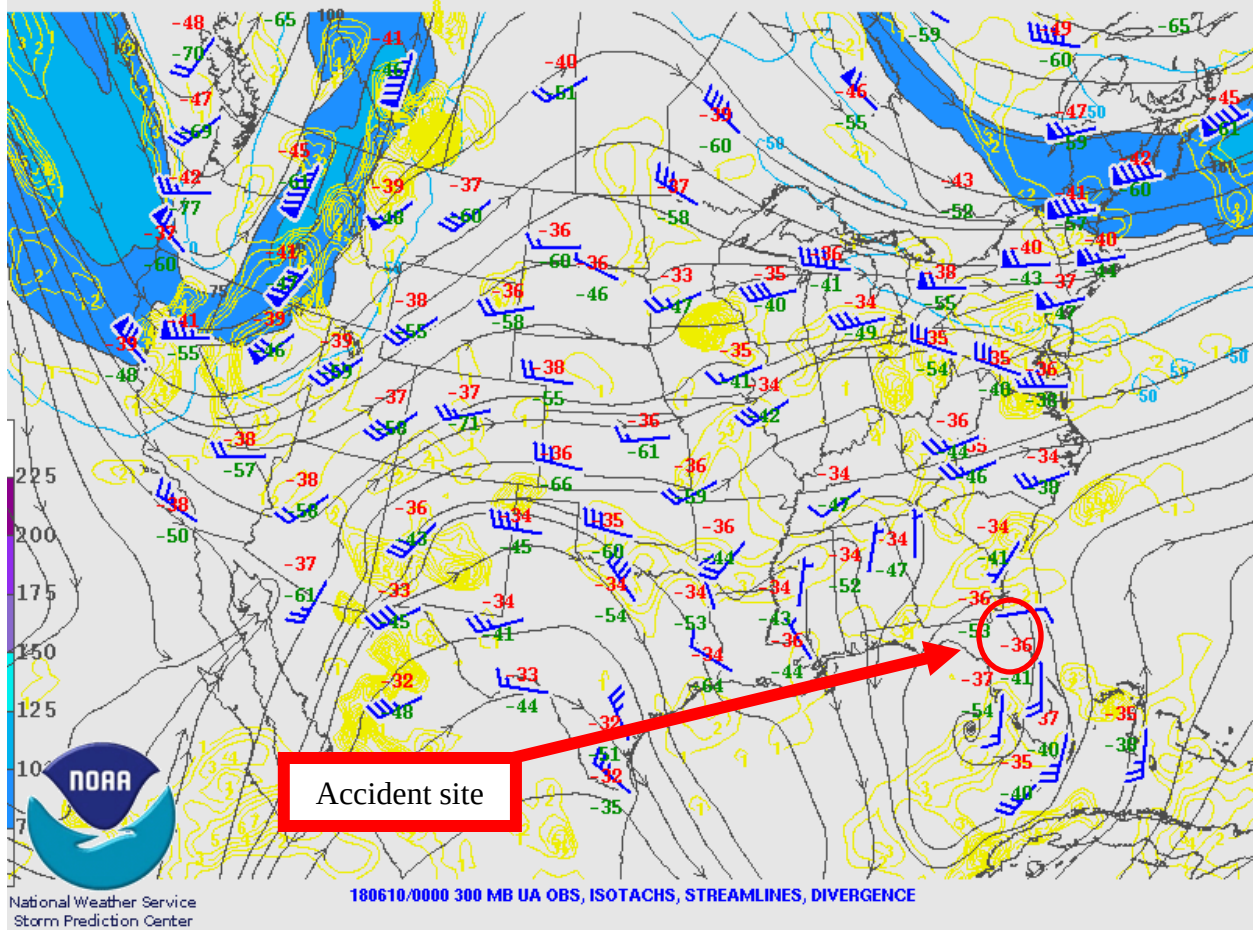


Figure 6 – 300-hPa Constant Pressure Chart for 2000 EDT

2.0 SPC Products

SPC issued the following Day 1 Convective Outlook at 1227 EDT (figure 7) with areas of general thunderstorms forecast for the accident site. SPC defines the “TSTM” area as an area that encloses where a 10% or higher probability of thunderstorms is forecast during the valid period. The SPC Day 1 Convective Outlook text follows figure 7:

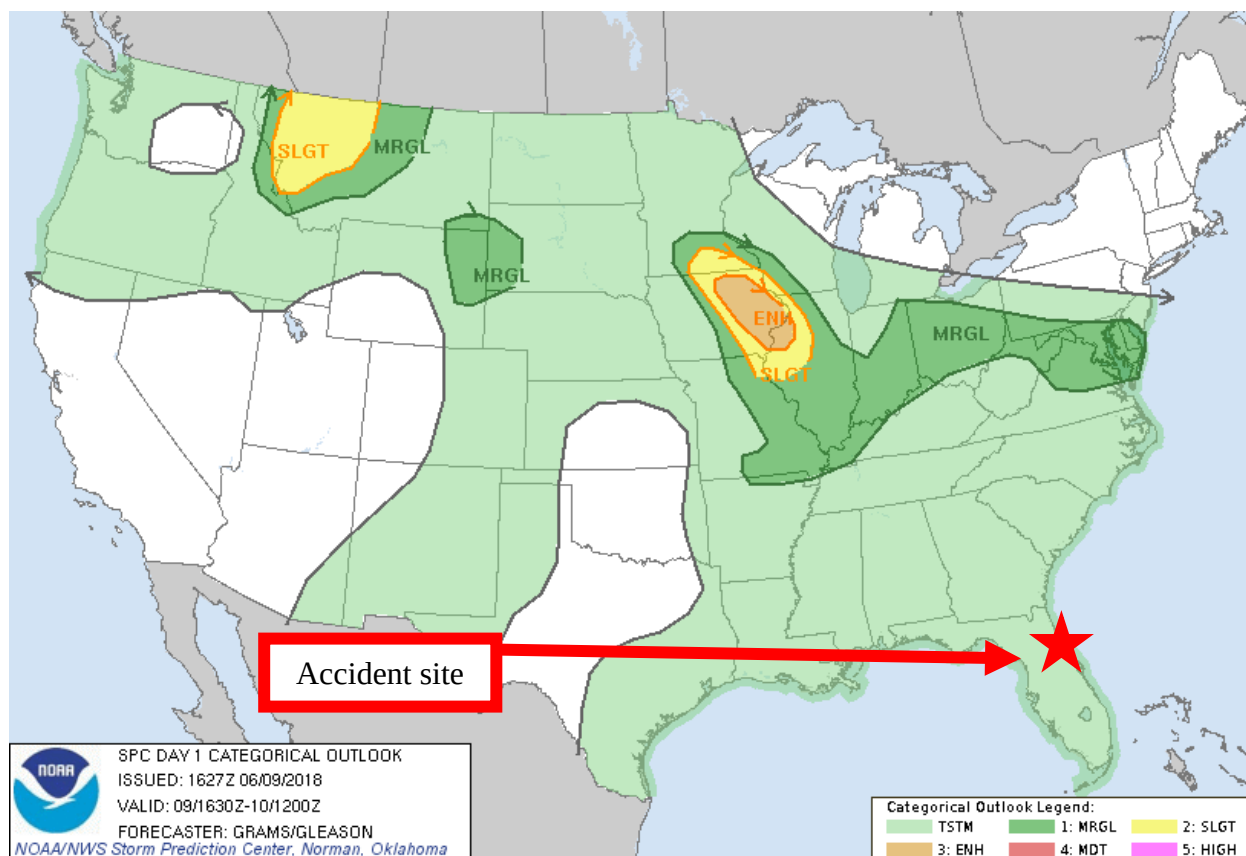


Figure 7 – SPC day 1 Convective Outlook valid at the time of the accident

SPC AC 091627

Day 1 Convective Outlook
NWS Storm Prediction Center Norman OK
1127 AM CDT Sat Jun 09 2018

Valid 091630Z - 101200Z

...THERE IS AN ENHANCED RISK OF SEVERE THUNDERSTORMS EASTERN IA AND NORTHWEST IL...

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS WESTERN MT...

...SUMMARY...

A cluster of severe storms with a few tornadoes, damaging winds, and large hail is anticipated late afternoon into tonight across eastern Iowa and vicinity. A few storms producing severe wind gusts are expected this afternoon into early evening across western Montana.

...Eastern IA vicinity...

A mesoscale setup for a few supercells capable of all hazards transitioning to a bowing MCS is expected this evening. Moderate diabatic heating is underway across much of western and central IA in between morning convection across eastern IA and southern MN. This will contribute to substantial destabilization with MLCAPE reaching 1500-3000 J/kg amid a pocket of residual upper 60s to lower

70s surface dew points. Renewed surface-based storm development is expected by late afternoon where the southern MN MCV interacts with the composite front/outflow arcing along the MN/IA border into eastern IA. Vertical shear will be enhanced within this mesoscale corridor as southeast surface winds are maintained beneath a confined swath of stronger mid-level westerlies south of the MCV. A few supercells producing large hail and tornadoes are expected through early/mid-evening. However, convection should subsequently evolve into another southeast-moving MCS across eastern IA into western IL tonight with damaging winds becoming the predominant hazard.

...Western MT...

An amplified mid-level trough over the Pacific Northwest will progress east across the northern Rockies through tonight. This trough and a strong associated cold front will begin to affect western MT this afternoon. Intense surface heating is expected ahead of the front, yielding a deeply mixed thermodynamic profile as surface dew points mix into the 40s and lower 50s. Forcing for ascent will be focused along the sharpening front and a few storms should form along it by mid-afternoon, spreading north-northeast toward the Alberta border through early evening. Severe wind gusts will be the main threat with the high-based supercells, though steep lapse rates will also support a risk of isolated large hail mainly through the late afternoon portion of the convective life cycle.

...Midwest to Mid-Atlantic...

Moderate buoyancy is expected along and south of a quasi-stationary front draped across these regions. Scattered storms will be focused this afternoon in the Mid-Atlantic portion of the boundary. Loosely organized clusters should evolve from remnant MCVs in vicinity of the front across the Midwest and OH Valley. With predominantly weak vertical shear, isolated downburst winds will be the main threat.

..Grams/Gleason.. 06/09/2018

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 2000Z

3.0 Regional Weather Radar

A regional view of the NWS national composite radar mosaic for 1455 and 1500 EDT are included as figures 8 and 9, respectively, with the approximate accident site marked by a red circle. The images depicted echoes with greater than 50 to 60 decibels (dBZ³) located over the accident site at 1455 and 1500 EDT. The closest weather radar imagery will be further documented in detail in sections 7.4 and 7.5.

³ 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.

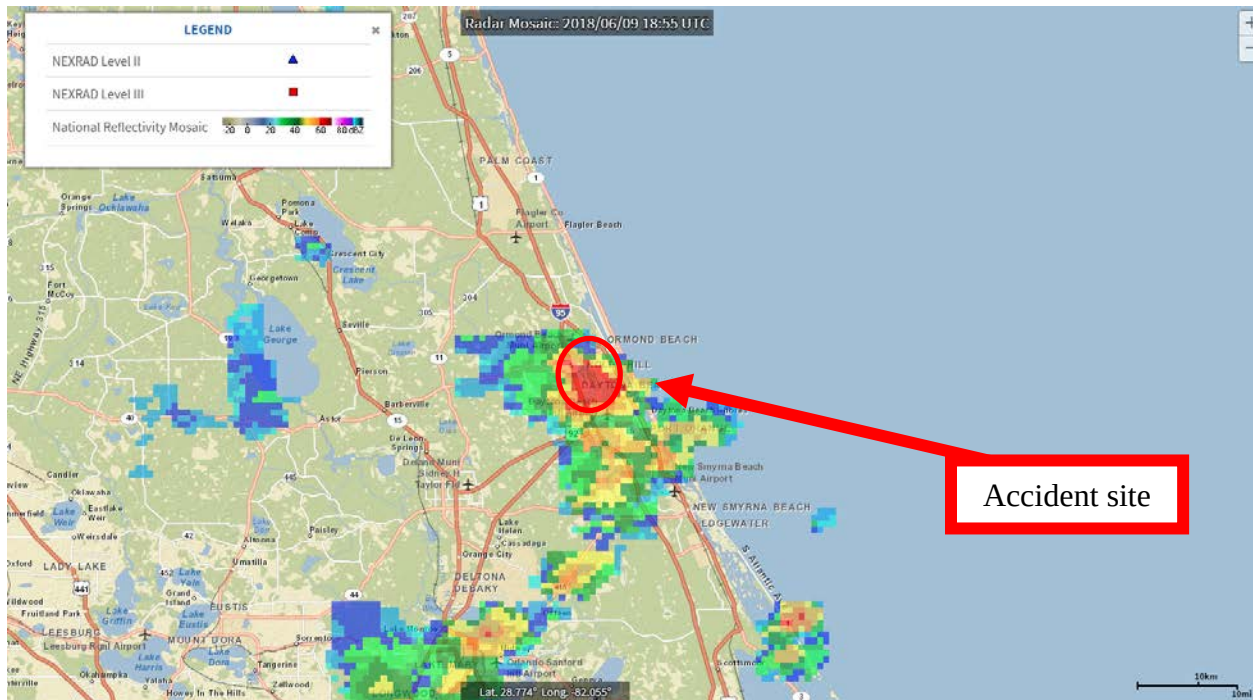


Figure 8 – Regional Composite Reflectivity image for 1455 EDT

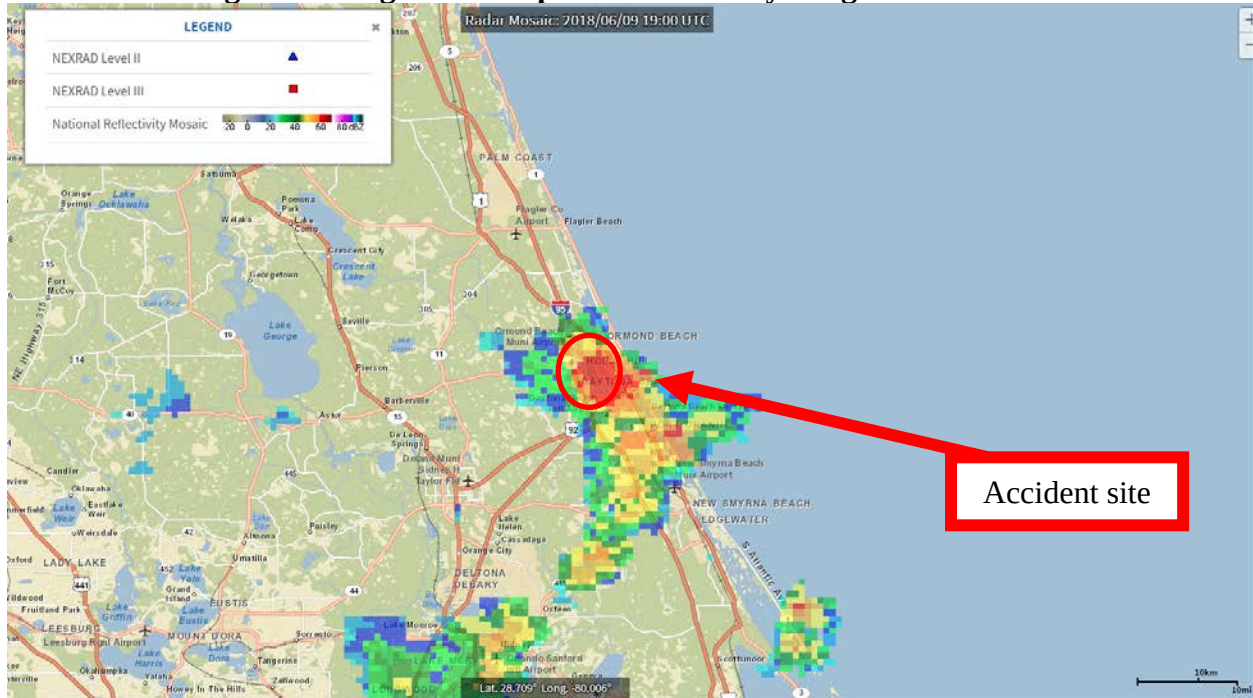


Figure 9 – Regional Composite Reflectivity image for 1500 EDT

4.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 10 is a sectional chart with the accident site and the closest weather reporting locations to the accident site noted. The magnetic variation⁴ over the area was noted at 5° West.

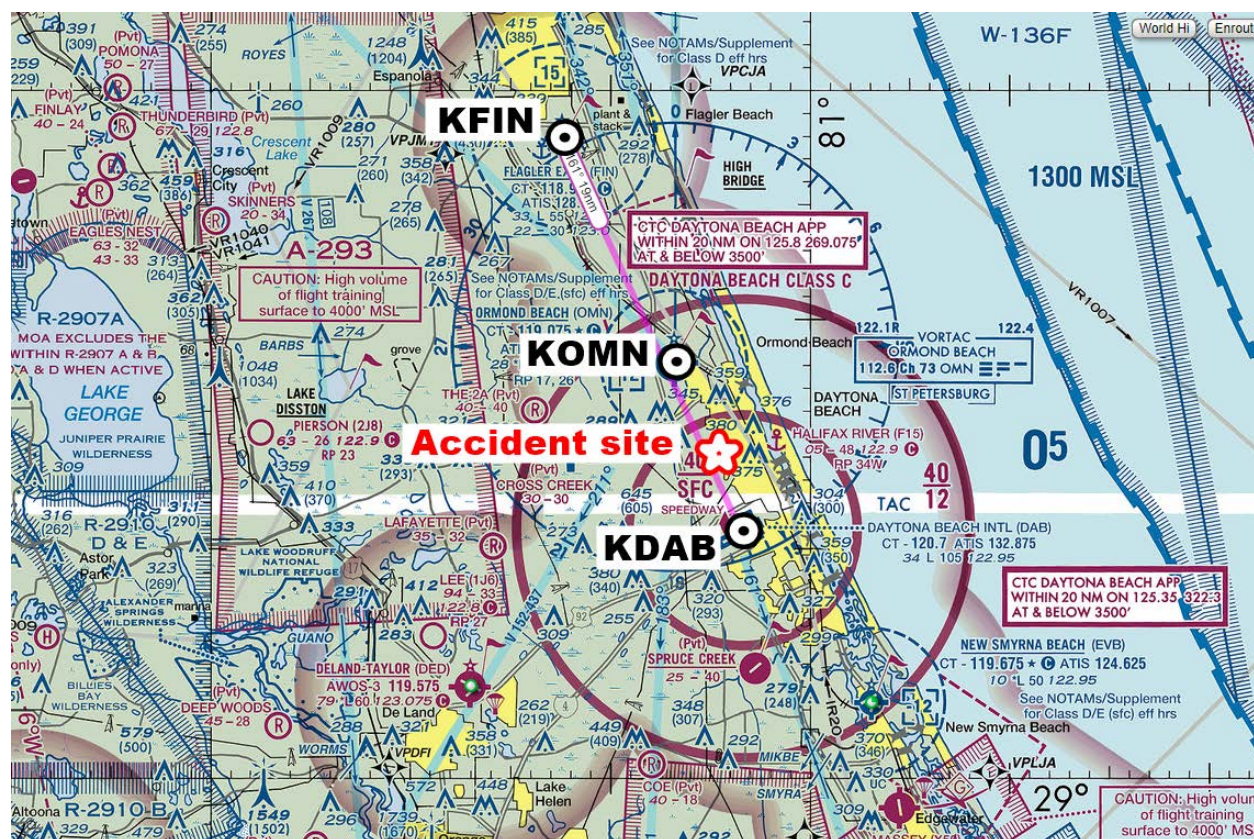


Figure 10 – Sectional chart of accident area with the location of the accident site, the closest surface observation sites, and the direct route of flight from departure to intended destination (pink line)

Daytona Beach International Airport (KDAB), Daytona Beach, Florida, was the closest official weather observation station to the accident site and the intended destination airport. KDAB had an Automated Surface Observing System (ASOS⁵) whose reports were supplemented by an official weather observer. KDAB was located 4 miles south-southeast of the accident site, at an elevation of 34 ft (figure 10). The following raw observations were disseminated during the times surrounding the accident:⁶

⁴ Magnetic variation – The angle (at a particular location) between magnetic north and true north.

⁵ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁶ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1153 EDT] METAR KDAB 091553Z 24006KT 10SM SCT028 SCT040 SCT250 29/23
A3014 RMK AO2 SLP205 T02890228 \$=

[1253 EDT] METAR KDAB 091653Z 23007KT 10SM BKN032TCU BKN250 30/23 A3013
RMK AO2 SLP201 TCU OHD-ALQDS CB DSNT N SW-W T03000228 \$=

[1353 EDT] METAR KDAB 091753Z VRB04KT 10SM BKN035TCU BKN048 BKN250
30/22A3011 RMK AO2 LTG DSNT SW SLP194 TCU OHD-ALQDS
CB DSNT SW-W T03000222 10300 20211 58014 \$=

**[1444 EDT] SPECI KDAB 091844Z VRB06KT 9SM TS SCT031CB BKN041 BKN075
BKN250 28/23 A3009 RMK AO2 LTG DSNT SW TSE43B44 FRQ
LTGICCG W-NW TS W-NW MOV E CB OHD-E-S-SW MOV E T02830233 \$=**

**[1453 EDT] METAR KDAB 091853Z 30014G19KT 9SM TS SCT025CB BKN041 BKN075
BKN250 27/22 A3009 RMK AO2 LTG DSNT SW TSE43B44 SLP188 FRQ
LTGICCG NW TS NW MOV E CB OHD-E-S-SW MOV E T02720222 \$=**

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**[1553 EDT] METAR KDAB 091953Z VRB03KT 10SM FEW025 FEW037 SCT090 BKN200
28/23 A3008 RMK AO2 LTG DSNT SE AND S RAB1856E16 TSE53
SLP186 TS MOVD E CB DSNT NE-SE-SW-W P0000 T02830228 \$=**

**[1638 EDT] SPECI KDAB 092038Z VRB05KT 10SM -TSRA FEW020CB SCT040 SCT090
BKN200 27/23 A3006 RMK AO2 LTG DSNT SE-W RAB36 TSE34B38
OCNL LTGICCG VC SE-S W-NW TS VC SE-S W-NW MOV NE CB DSNT
NW VCSH NW P0000 T02720233 \$=**

[1653 EDT] METAR KDAB 092053Z 11008KT 10SM TS FEW020CB SCT040 SCT090
BKN200 27/23 A3007 RMK AO2 LTG DSNT SE-W RAB36E45
TSE34B38 SLP180 OCNL LTGICCG VC E-SE W-NW TS VC SE-S
W-NW MOV NE CB DSNT N VCSH NW P0000 60000 T02720233 57014 \$=

[1717 EDT] SPECI KDAB 092117Z 16005KT 10SM FEW020 SCT040 SCT090 BKN200
27/23 A3006 RMK AO2 TSE17 TS DSIPTD CB DSNT SE VCSH NW
T02720228 \$=

The relevant observations in plain language were as follows:

KDAB special weather observation at 1444 EDT, wind variable at 6 knots, 9 miles visibility, thunderstorms, scattered cumulonimbus clouds at 3,100 ft above ground level (agl), broken ceiling at 4,100 ft agl, broken clouds at 7,500 ft agl, broken clouds at 25,000 ft agl, temperature of 28° Celsius (C), dew point temperature of 23° C, and an altimeter setting of 30.09 inches of mercury. Remarks: station with a precipitation discriminator, lightning distant⁷ southwest, thunderstorm ended at 1443 EDT, thunderstorm began at 1444 EDT, frequent in-cloud and cloud-to-ground lightning west through northwest, thunderstorm west through northwest moving east, cumulonimbus clouds overhead through east, south, and southwest moving east, temperature 28.3° C, dew point temperature 23.3° C, maintenance needed on the system.

KDAB weather observation at 1453 EDT, wind from 300° at 14 knots with gusts to 19 knots, 9 miles visibility, thunderstorms, scattered cumulonimbus clouds at 2,500 ft agl, broken ceiling at 4,100 ft agl, broken clouds at 7,500 ft agl, broken clouds at 25,000 ft agl, temperature of 27° C, dew point temperature of 22° C, and an altimeter setting of 30.09 inches of mercury. Remarks: station with a precipitation discriminator, lightning distant southwest, thunderstorm ended at 1443 EDT, thunderstorm began at 1444 EDT, sea level pressure 1018.8 hPa, frequent in-cloud and cloud-to-ground lightning northwest, thunderstorm northwest moving east, cumulonimbus clouds overhead through east, south, and southwest moving east, temperature 27.2° C, dew point temperature 22.2° C, maintenance needed on the system.

KDAB weather observation at 1553 EDT, wind variable at 3 knots, 10 miles visibility or greater, few clouds at 2,500 ft agl, few clouds at 3,700 ft agl, scattered clouds at 9,000 ft agl, broken ceiling at 20,000 ft agl, temperature of 28° C, dew point temperature of 23° C, and an altimeter setting of 30.08 inches of mercury. Remarks: station with a precipitation discriminator, lightning distant southeast and south, rain began 1456 EDT, rain ended at 1516 EDT, thunderstorm ended at 1553 EDT, sea level pressure 1018.6 hPa, thunderstorm moved east, cumulonimbus clouds distant northeast through southeast, southwest, and west, a trace of precipitation since 1453 EDT, temperature 28.3° C, dew point temperature 22.8° C, maintenance needed on the system.

KDAB special weather observation at 1638 EDT, wind variable at 5 knots, 10 miles visibility or greater, thunderstorm and light rain, few cumulonimbus clouds at 2,000 ft agl, scattered clouds at 4,000 ft agl, scattered clouds at 9,000 ft agl, broken ceiling at 20,000 ft agl, temperature of 27° C, dew point temperature of 23° C, and an altimeter setting of 30.06 inches of mercury. Remarks: station with a precipitation discriminator, lightning distant southeast through west, rain began at 1636 EDT, thunderstorm ended at 1634 and began at 1638 EDT, occasional in-cloud and cloud-to-ground lightning in the vicinity⁸ southeast through south and west through northwest, vicinity thunderstorm southeast through south and west through northwest moving northeast, distant cumulonimbus clouds northwest, vicinity shower northwest, a trace of precipitation since 1553 EDT, temperature 27.2° C, dew point temperature 23.3° C, maintenance needed on the system.

⁷ Distant indicated that the lightning was beyond 10 miles but less than 30 miles from the center of the airport (or airport location point, ALP).

⁸ In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

Ormond Beach Municipal Airport (KOMN) was the next closest airport to the accident site with official weather information. KOMN had an Automated Weather Observing System (AWOS⁹) whose reports were supplemented by air traffic controllers (ATC) when the KOMN ATC tower was in operation.¹⁰ KOMN was located 4 miles north-northwest of the accident site, at an elevation of 28 ft (figure 10). The following observations were disseminated during the times surrounding the accident:

[0950 EDT] METAR KOMN 091350Z 27005KT 7SM SKC 26/22 A3014=

[1050 EDT] METAR KOMN 091450Z 28005KT 7SM SCT020 27/22 A3015=

[1155 EDT] METAR KOMN 091555Z 28005KT 7SM SCT030 28/21 A3013=

[1250 EDT] METAR KOMN 091650Z 28005KT 7SM SCT030 BKN040 29/21 A3013=

[1350 EDT] METAR KOMN 091750Z 10005KT 7SM SCT030 BKN040 28/23 A3011=

[1450 EDT] METAR KOMN 091850Z 10007KT 7SM VCSH SCT030 29/23 A3009=

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[1550 EDT] METAR KOMN 091950Z 12004KT 7SM SCT030 26/23 A3008=

**[1647 EDT] METAR KOMN 092047Z 12004KT 7SM TS SCT030 29/22 A3006 RMK
TSB42 TS SW-W MOV E OCNL LTGCG SW=**

[1745 EDT] METAR KOMN 092145Z 14004KT 7SM VCSH SCT030 26/23 A3006 RMK
TS342=

[1850 EDT] METAR KOMN 092250Z 13003KT 7SM SCT030 28/23 A3005 RMK LAST=

The reports in plain language were as follows:

KOMN weather observation at 1350 EDT, wind from 100° at 5 knots, 7 miles visibility, scattered clouds at 3,000 ft agl, a broken ceiling at 4,000 ft agl, temperature of 28° C, dew point temperature of 23° C, and an altimeter setting of 30.11 inches of mercury.

KOMN weather observation at 1450 EDT, wind from 100° at 7 knots, 7 miles visibility, vicinity showers, scattered clouds at 3,000 ft agl, temperature of 29° C, dew point temperature of 23° C, and an altimeter setting of 30.09 inches of mercury.

⁹ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand feet, and altimeter setting.

¹⁰ KOMN ATC hours of operation between 0700 and 1900 EDT (in operation at the accident time).

KOMN weather observation at 1550 EDT, wind from 120° at 4 knots, 7 miles visibility, scattered clouds at 3,000 ft agl, temperature of 26° C, dew point temperature of 23° C, and an altimeter setting of 30.08 inches of mercury.

KOMN weather observation at 1647 EDT, wind from 120° at 4 knots, 7 miles visibility, thunderstorm, scattered clouds at 3,000 ft agl, temperature of 29° C, dew point temperature of 22° C, and an altimeter setting of 30.06 inches of mercury. Remarks: thunderstorm began at 1642 EDT, thunderstorm southwest through west moving east, occasional cloud-to-ground lightning southwest.

Flagler Executive Airport (KFIN) was the departure airport. KFIN had an AWOS whose reports were not supplemented. KFIN was located 15 miles north-northwest of the accident site at an elevation of 33 ft (figure 10). The following observations were disseminated during the times surrounding the accident:

[1150 EDT] METAR KFIN 091550Z 23003KT 7SM SCT032 29/21 A3013=

[1250 EDT] METAR KFIN 091650Z 26003KT 7SM SCT036 29/21 A3013=

[1350 EDT] METAR KFIN 091750Z 00000KT 7SM SCT042 29/21 A3010=

[1450 EDT] METAR KFIN 091850Z 09010KT 7SM SCT044 30/23 A3007=

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[1550 EDT] METAR KFIN 091950Z 09012KT 7SM SCT024 27/22 A3007=

[1650 EDT] METAR KFIN 092050Z 09009KT 7SM SKC 29/22 A3005=

[1750 EDT] METAR KFIN 092150Z 09010KT 7SM SKC 28/21 A3005=

[1850 EDT] METAR KFIN 092250Z VRB06KT 7SM SKC 29/21 A3005=

The reports in plain language were as follows:

KFIN weather observation at 1450 EDT, wind from 090° at 10 knots, 7 miles visibility, scattered clouds at 4,400 ft agl, temperature of 30° C, dew point temperature of 23° C, and an altimeter setting of 30.07 inches of mercury.

KFIN weather observation at 1550 EDT, wind from 090° at 12 knots, 7 miles visibility, scattered clouds at 2,400 ft agl, temperature of 27° C, dew point temperature of 22° C, and an altimeter setting of 30.07 inches of mercury.

The observations from KDAB and KOMN surrounding the accident time indicated VFR¹¹ conditions prevailing through the period; however, KDAB had a thunderstorm located over the field at the accident time with wind gusts to 19 knots, and frequent lightning with cumulonimbus clouds. No thunderstorms were reported at KFIN during the period.

5.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)¹² model sounding was created for the accident site for 1500 EDT with station elevation at sea level. The 1500 EDT HRRR sounding was plotted on a standard Skew-T Log P diagram¹³ with the derived stability parameters included in figure 11 (with data from the surface to 700-hPa, or approximately 10,000 ft msl.) This data was analyzed using the RAOB¹⁴ software package. The sounding depicted the lifted condensation level (LCL)¹⁵ at 2,648 ft agl, the level of free convection (LFC)¹⁶ at 2,898 ft agl, and the convective condensation level (CCL)¹⁷ at 3,766 ft agl. The sounding had a greater than 80% relative humidity from 4,000 ft through 10,000 ft. The freezing level was at 13,997 ft agl (msl). The precipitable water value was 2.10 inches.

¹¹ Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 6 miles visibility.

¹² The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three kilometer grids with three kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one hour period. HRRR sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

¹³ 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.

¹⁴ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹⁵ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁶ 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.

¹⁷ 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.

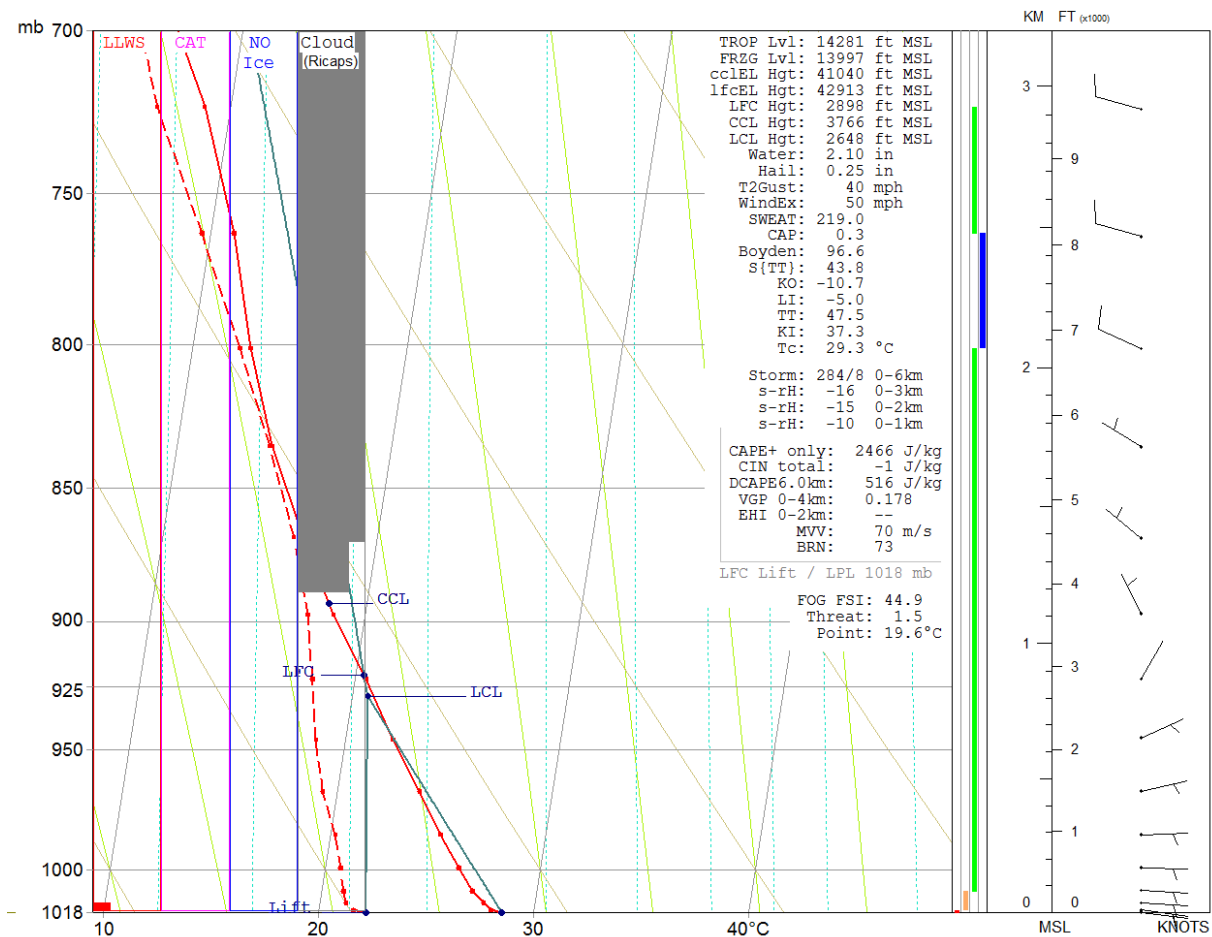


Figure 11 – 1500 EDT HRRR sounding

The 1500 EDT HRRR sounding indicated a conditionally unstable environment from the surface through 6,500 ft with 2,466 Joules/kilogram (J/kg) of CAPE¹⁸. The maximum vertical velocity (MVV) for this atmosphere was calculated as 70 meters/second (about 13,779 ft per minute).¹⁹ Downdraft CAPE (DCAPE; 6 kilometers agl)²⁰ was measured at 516 J/kg. RAOB identified the possibility of clouds above 4,000 ft through 10,000 ft. No areas of icing were indicated by RAOB for below 10,000 ft. If rain showers or thunderstorms formed the 1500 EDT HRRR sounding indicated the strongest wind speeds possible with a microburst, outflow boundary, or gust front would have been 40 mph (35 knots) as indicated by the T2Gust parameter or 50 mph (43 knots) as indicated by the WindEx parameter.

¹⁸ 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.

¹⁹ 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.

²⁰ 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 1500 EDT HRRR sounding wind profile indicated a surface wind from 098° at 4 knots with little variation in direction through 2,000 ft. The wind backed²¹ to the west between 2,000 ft and 10,000 ft with wind speeds of 10 knots or less. The mean 0 to 6 kilometer steering wind was from 255° at 11 knots, and the storm motion wind was from 284° at 8 knots. RAOB indicated no possibility of low-level wind shear or turbulence outside of convective activity.

6.0 Satellite Data

The Geostationary Operational Environmental Satellite number 16 (GOES-16) 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. The GOES-16 visible and infrared imagery (bands 2 and 13) at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period from 1300 EDT through 1700 EDT at approximately 5-minute intervals, with the closest images to the time of the accident documented.

Figures 12 and 13 present the GOES-16 visible imagery at 1452 and 1500 EDT at 3X magnification with the accident site highlighted with a red square. Inspection of the visible imagery indicated abundant cloud cover above the accident site at the accident time with cumuliform clouds growing in size above the accident site between 1452 and 1500 EDT.

Figure 14 present the GOES-16 infrared imagery at 1500 EDT 7X magnification with the accident site highlighted with a red square. The lower brightness temperatures (blue and green colors; higher cloud tops) were located just north of the accident site. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1500 EDT HRRR sounding, the approximate cloud-top heights over the accident site were 22,000 ft at 1500 EDT. The highest approximate cloud-top heights were 43,000 ft at 1500 EDT for the cumuliform cloud cover between KOMN and KDAB (blue and green colored brightness temperatures). It should be noted these figures have not been corrected for any parallax error.

²¹ A backing wind is a wind that turns counter-clockwise with height.

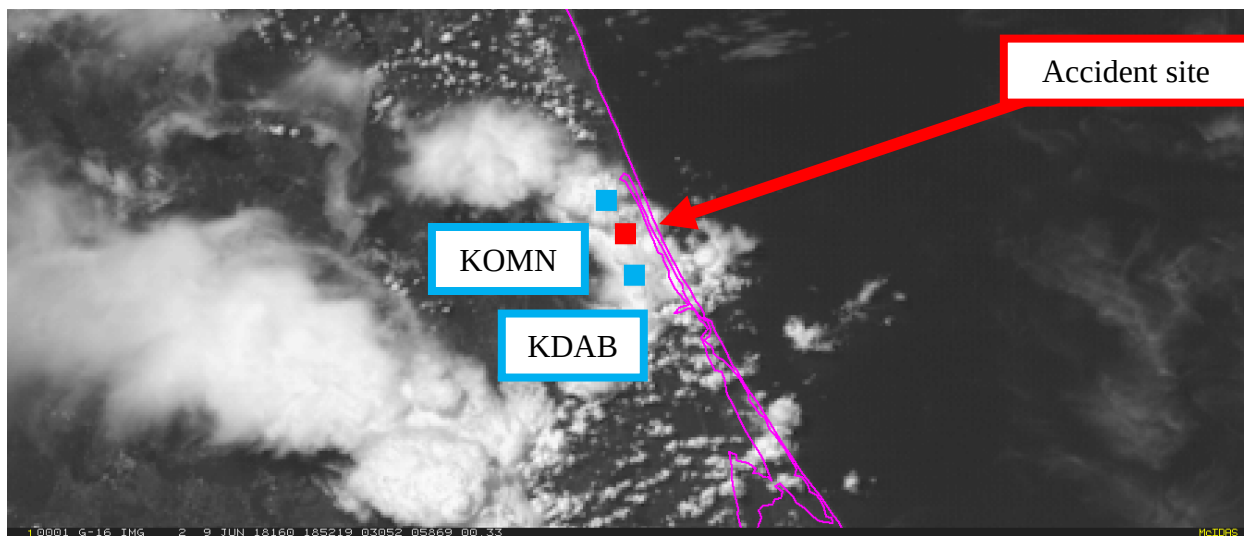


Figure 12 – GOES-16 visible image at 1452 EDT

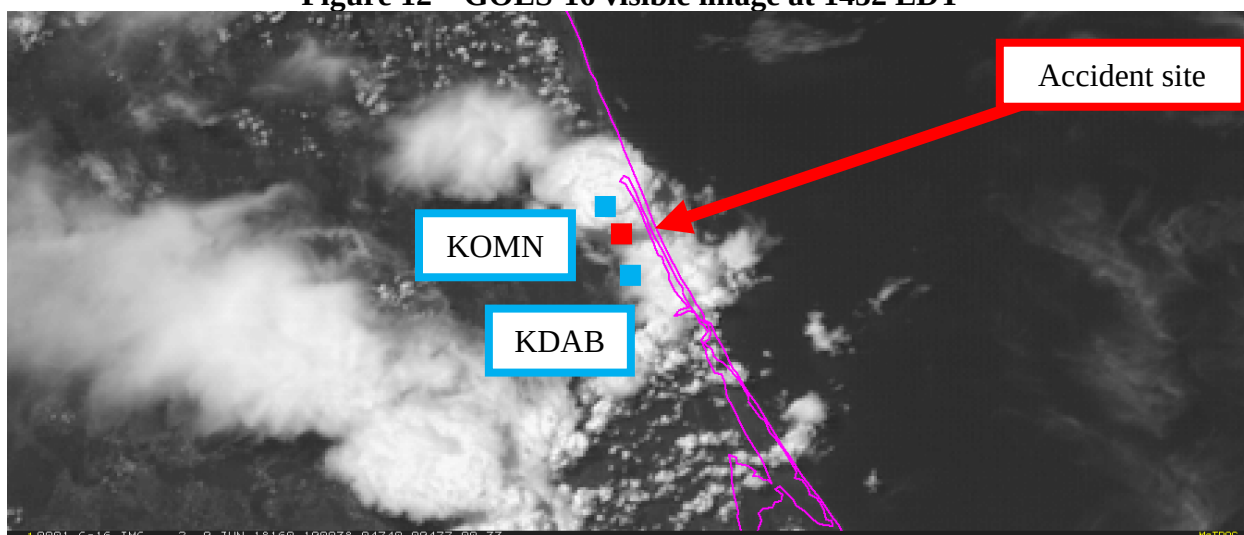


Figure 13 – GOES-16 visible image at 1500 EDT

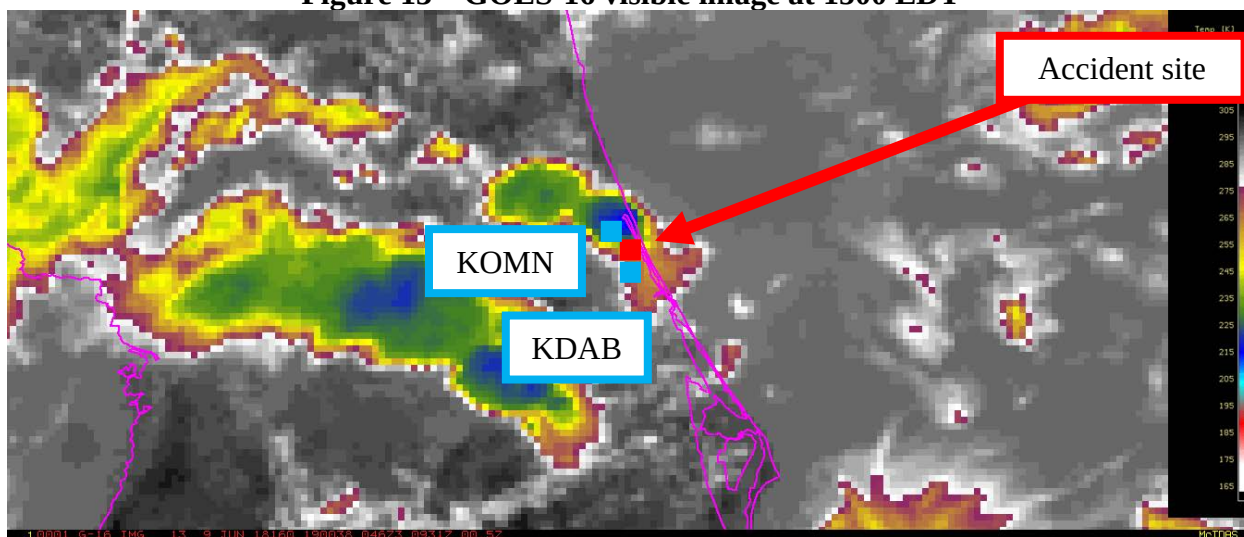


Figure 14 – GOES-16 infrared image at 1500 EDT

7.0 Radar Imagery Information

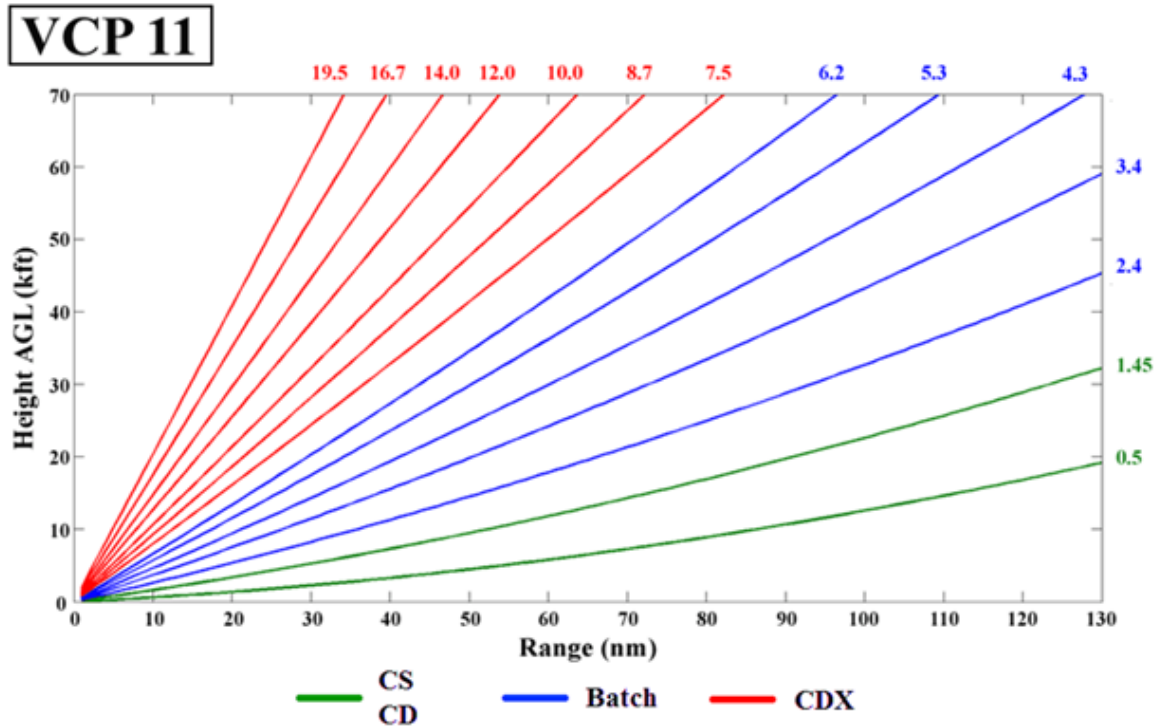
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)²² to the accident site was the Melbourne (KMLB), Florida, which was located 71 miles south-southeast of the accident site. Level II archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

7.1 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. 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° around every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 11 (VCP-11). 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 KMLB WSR-88D radar was operating in the precipitation mode VCP-11. 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.

²² 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.



VCP-11 Precipitation Mode Scan Strategy²³

7.2 Beam Height Calculation

Assuming standard refraction²⁴ of the KMLB WSR-88D radar beam, at an elevation of 149 ft and considering a beamwidth²⁵ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for the 0.5° antenna elevation over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
0.5°	7,570 ft	4,070 ft	11,070 ft

²³ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (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.

W – With range unfolding (W)

WO – Without range unfolding (WO)

²⁴ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁵ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 4,070 ft and 11,070 ft msl over the accident site and these scans are the closest altitudes to the surface and the accident aircraft's altitude before the accident occurred.

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁶ 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 dBZ, and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²⁷, "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:

²⁶ 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.

²⁷

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

- 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.

7.4 Base Reflectivity and Lightning Data

Figures 15, 16, 17, and 18 present the KMLB WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1449:56, 1453:39, 1457:22 and 1501:06 EDT, respectively, with a resolution of 0.5° X 250 m. The FAA ATC flight track of N21161 is also overlaid.²⁸ Reflectivity values between 50 and 60 dBZ were located in between the accident aircraft location at 1457:22 EDT and the accident site (figures 17 and 18) and this would correspond to very heavy rainfall and possible hail (section 7.3). The accident aircrafts flight track is observed under echoes between 1453:39 and 1457:22 EDT (figures 16 and 17) with reflectivity values between 10 to 40 dBZ, and after 1457 EDT to the time of the accident under echoes greater than 50 dBZ.

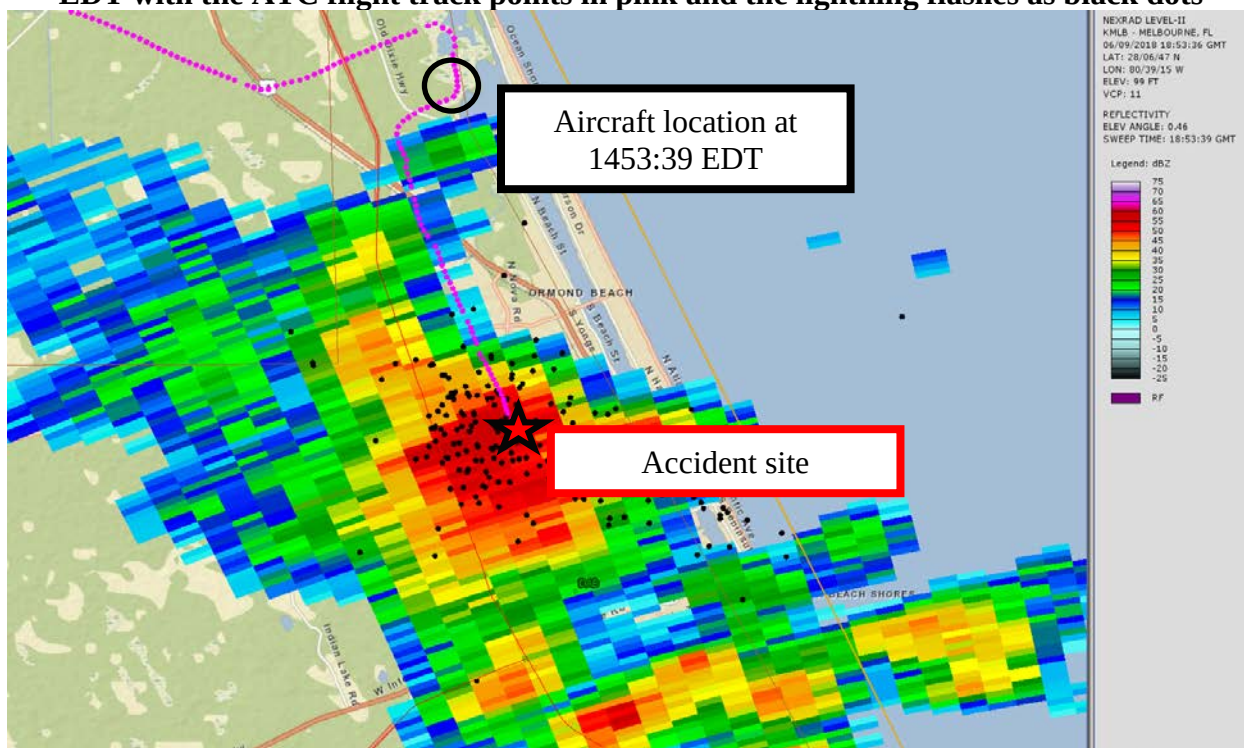
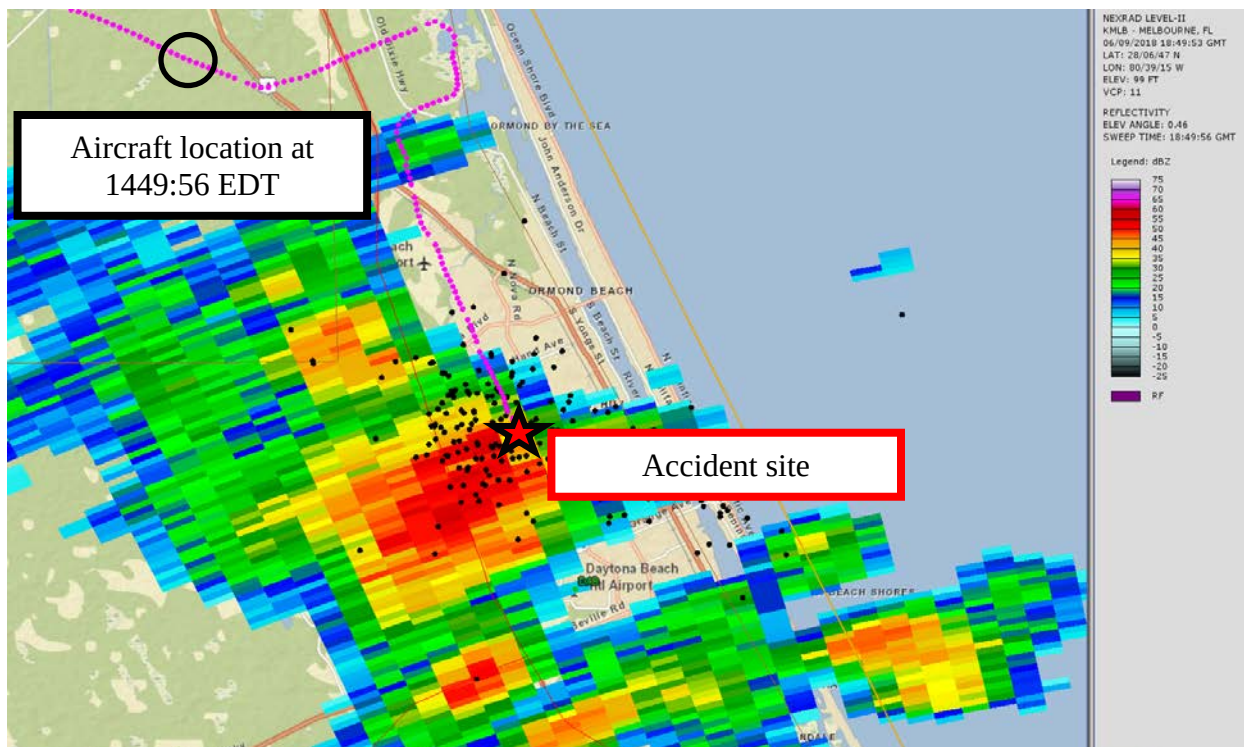
Attachment 1 is an animation of the KMLB WSR-88D 0.5 base reflectivity imagery between 1438 and 1520 EDT and depicts the area of high reflectivity or thunderstorms cell based on lightning moving to the east-northeast.

There were 255 lightning flashes²⁹ around the accident site at the accident time between 1445 and 1505 EDT (figures 15 through 18).³⁰ A closest lightning flash at 1457:40 EDT occurred within 1,000 ft of the accident flight.

²⁸ For more ATC information please see the docket for this investigation.

²⁹ Lightning Flash – This is one contiguous conducting channel and all the current strokes/pulses that flow through it. There are two types of flashes: ground flashes and cloud flashes.

³⁰ A review of Earth Networks Total Lightning network was done.



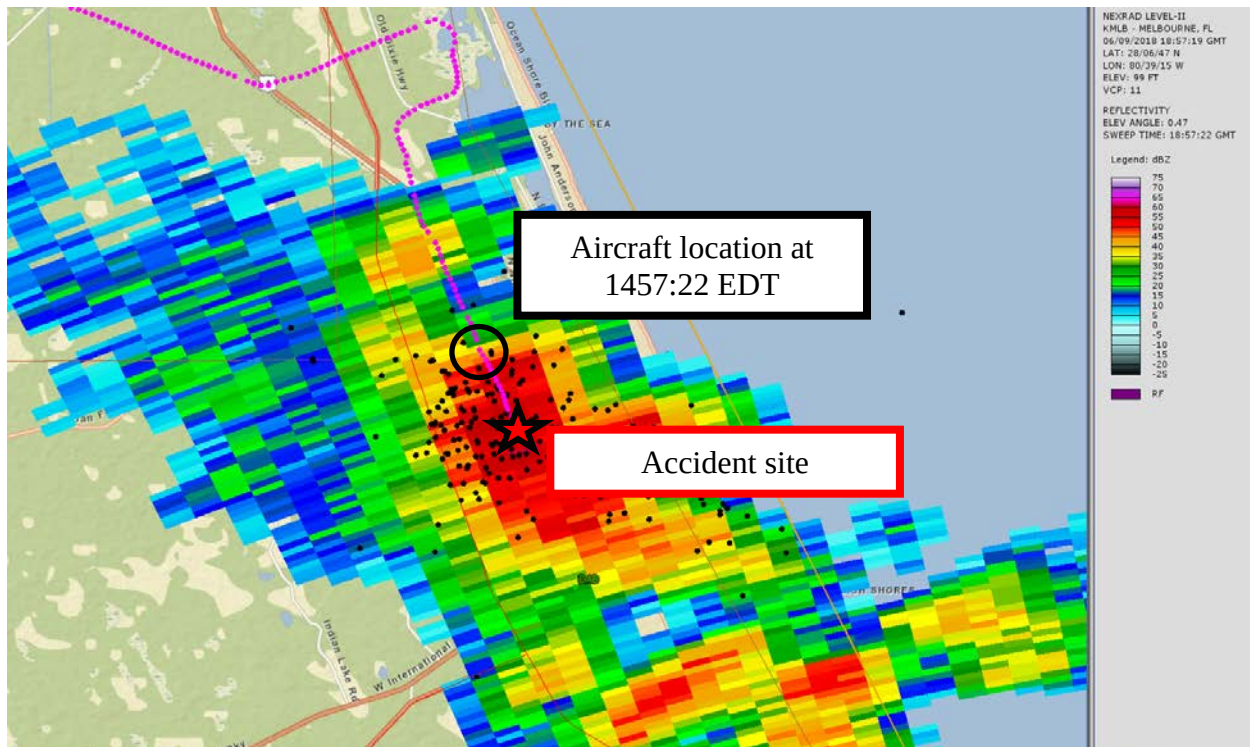


Figure 17 – KMLB WSR-88D reflectivity for the 0.5° elevation scan initiated at 1457:22 EDT with the ATC flight track points in pink and the lightning flashes as black dots

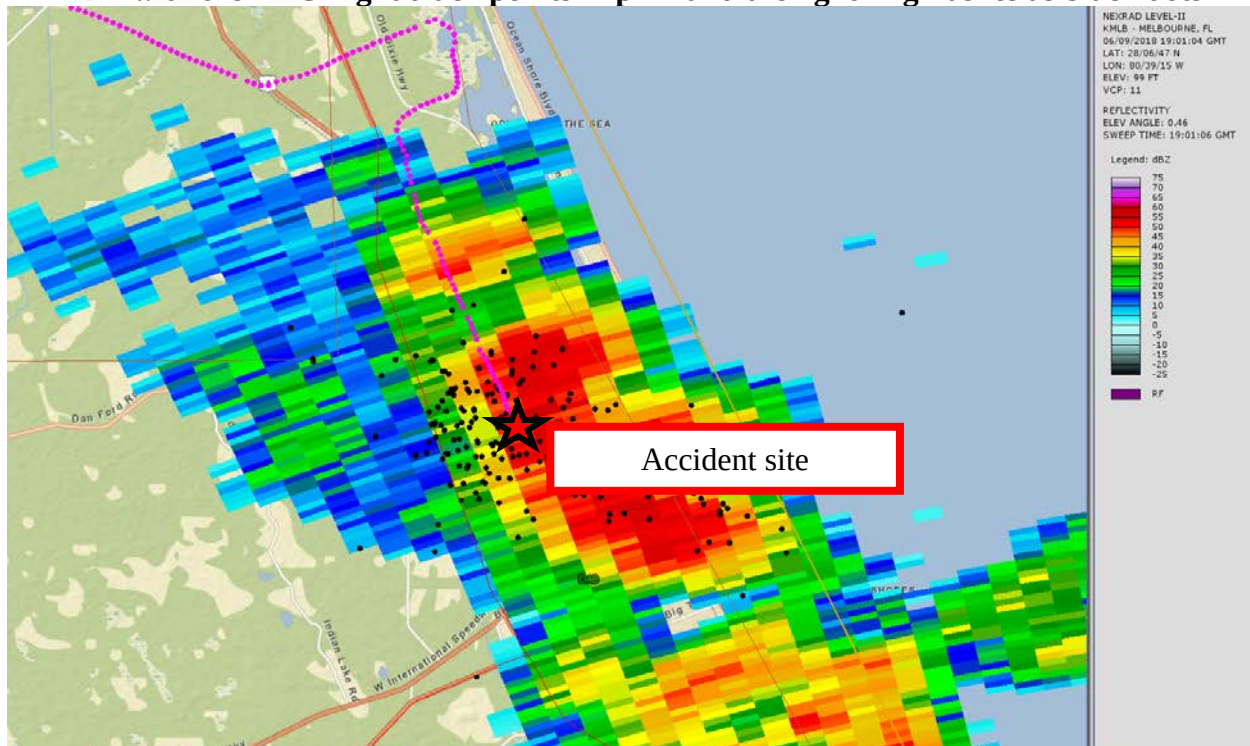


Figure 18 – KMLB WSR-88D reflectivity for the 0.5° elevation scan initiated at 1501:06 EDT with the ATC flight track points in pink and the lightning flashes as black dots

7.5 3-Dimensional Radar Reflectivity Data

Figures 19 through 22 present a 3-dimensional view of the KMLB WSR-88D base reflectivity for the elevation scans initiated at 1457 and 1501 EDT. The accident aircraft's flight track obtained from ATC was also plotted on the Google Earth image for a time comparison with the base reflectivity images. Figures 19 through 22 indicated that the accident flight flew into an area of greater than 50 dBZ reflectivity values.

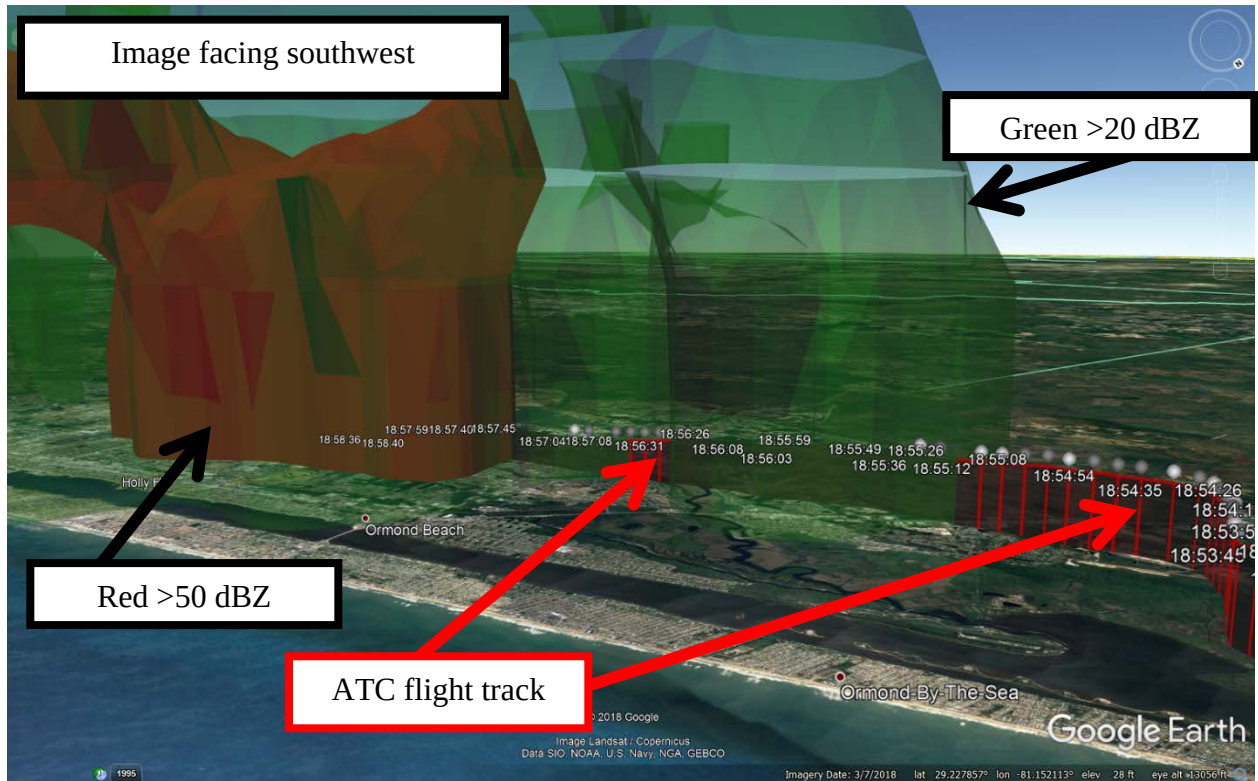


Figure 19 – 3-dimensional KMLB WSR-88D base reflectivity from the scan initiated at 1457 EDT and the ATC Flight Track (gray dots) with the image facing southwest



Figure 20 – 3-dimensional KMLB WSR-88D base reflectivity from the scan initiated at 1457 EDT and the ATC Flight Track (gray dots) with the image facing south-southwest



Figure 21 – 3-dimensional KMLB WSR-88D base reflectivity from the scan initiated at 1457 EDT and the ATC Flight Track (gray dots) with the image facing south-southeast

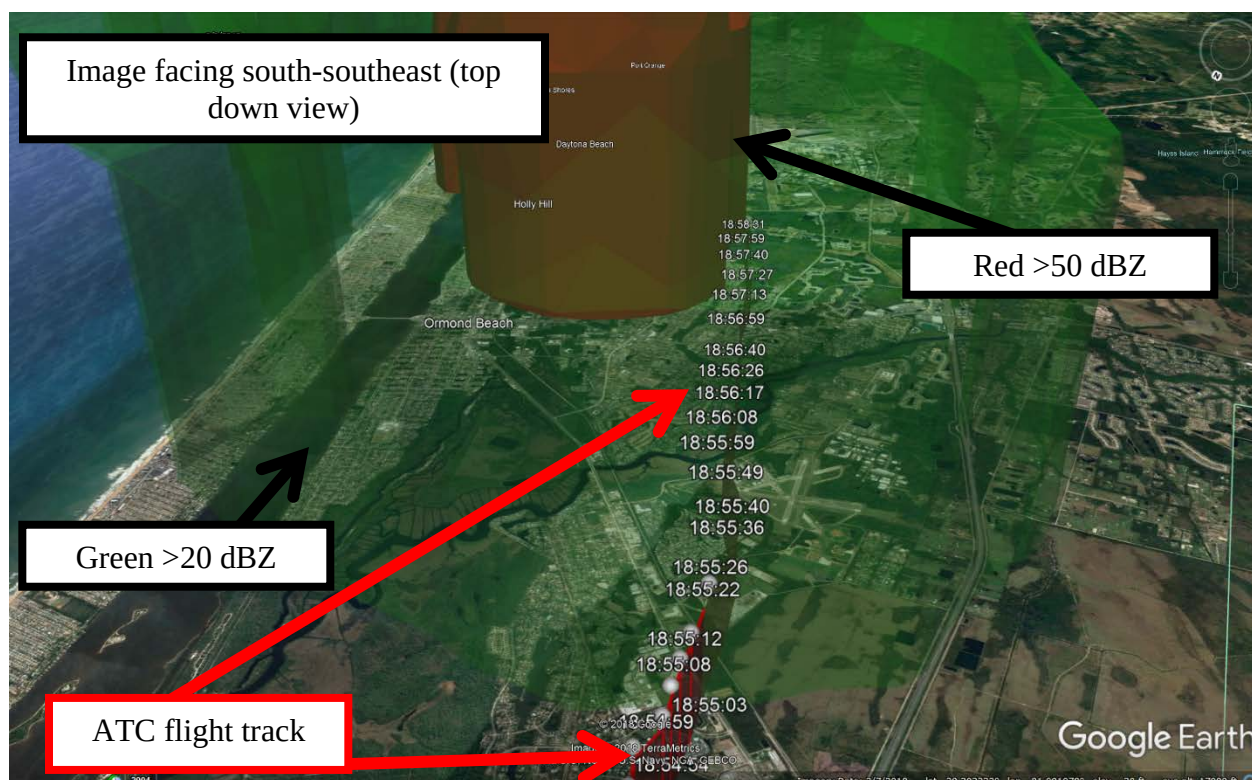


Figure 22 – 3-dimensional KMLB WSR-88D base reflectivity from the scan initiated at 1501 EDT and the ATC Flight Track (gray dots) with the image facing south-southeast

8.0 Pilot Reports³¹

All pilot reports (PIREPs) within 100 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time were reviewed. Only PIREPs for below FL200³² are provided below:

DAB UA /OV OMN21015/TM 1714/FL020/TP C172/SK 030 BKN =

DAB UA /OV OMN16010/TM 1715/FL030/TP C172/SK BKN035=

MCO UA /OV LEE200010/TM 1715/FL095/TP PA34/SK OVCUNKN-TOP125/WX +RA=

DAB UA /OV 3 WEST DAB/TM 1810/FL030/TP PA32/SK 030 SCT =

DAB UA /OV 12 WEST DAB/TM 1815/FL050/TP C182/SK 055 SCT/TB MOD=

DAB UA /OV OMN220010/TM 1907/FLDURC/TP AEST/SK VMC WEST OF DAB/RM
AIRCRAFT CLIMBING FROM 020 TO 040 REPORTED VMC CONDITIONS WEST
OF DAB=

³¹ Only pilot reports with the WMO header UBFL** identifier were considered.

³² 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.

DAB UA /OV 4 SE FIN /TM 1910/FL030/TP C172/SK IMC/RM C172 REPORTED
IMC CONDITIONS AT 030=

MCO UUA /OV MCO /TM 1923 /FL020 /TP C750 /RM LLWS +20KT 010 DURD
RWY 35R=

DAB UA /OV DAB/TM 2008/FL002/TP DA42/TB SMT =

DAB UA /OV 5 S DAB/TM 2014/FL010/TP C172/SK BASE BKN011 =

DAB UA /OV DAB/TM 2017/FL002/TP DA42/TB SMT/RM JUST FINE =

DAB UA /OV EVB/TM 2018/FL010/TP C172/WX -RA/RM RAIN LOOKS MEAN=

The decoded PIREPs in plain language from standard code and abbreviation were as follows:

Routine pilot report (UA), Daytona Beach International Airport, Florida (DAB); Over – 15 miles from Ormond Beach, Florida (OMN) VORTAC on the 210° radial; Time – 1314 EDT (1714Z); Altitude – 2,000 ft; Type aircraft – Cessna 172; Sky – Broken skies at 3,000 ft.

Routine pilot report (UA), DAB; Over – 10 miles from OMN VORTAC on the 160° radial; Time – 1315 EDT (1715Z); Altitude – 3,000 ft; Type aircraft – Cessna 172; Sky – Broken skies at 3,500 ft.

Routine pilot report (UA), Orlando International Airport, Florida (MCO); Over – 10 miles from Leesburg, Florida (LEE) NDB on the 200° radial; Time – 1315 EDT (1715Z); Altitude – 9,500 ft; Type aircraft – Piper PA-34 Seneca; Sky – Overcast skies unknown with cloud tops at 12,500 ft; Weather – Heavy rain.

Routine pilot report (UA), DAB; Over – 3 miles west of DAB; Time – 1410 EDT (1810Z); Altitude – 3,000 ft; Type aircraft – Piper PA-32; Sky – Scattered clouds at 3,000 ft.

Routine pilot report (UA), DAB; Over – 12 miles west of DAB; Time – 1415 EDT (1815Z); Altitude – 5,000 ft; Type aircraft – Cessna 182; Sky – Scattered clouds at 5,500 ft; Turbulence – Moderate.

Routine pilot report (UA), DAB; Over – 10 miles from OMN on the 220° radial; Time – 1507 EDT (1907Z); Altitude – During climb; Type aircraft – Piper Aerostar; Sky – Visual meteorological conditions (VMC) west of DAB; Remarks – Aircraft climbing from 2,000 ft to 4,000 ft reported VMC conditions west of DAB.

Routine pilot report (UA), DAB; Over – 4 miles southeast of Flagler Executive Airport (FIN); Time – 1510 EDT (1910Z); Altitude – 3,000 ft; Type aircraft – Cessna 172; Sky – Instrument Meteorological Conditions (IMC); Remarks – Cessna 172 reported IMC conditions at 3,000 ft.

Urgent pilot report (UUA), MCO; Over – MCO; Time – 1523 EDT (1923Z); Altitude – 2,000 ft; Type aircraft – Cessna Citation X; Remarks – LLWS +20 knots at 1,000 ft during descent into runway 35R.

Routine pilot report (UA), DAB; Over – DAB; Time – 1608 EDT (2008Z); Altitude – 200 ft; Type aircraft – Diamond DA42; Turbulence – Smooth.

Routine pilot report (UA), DAB; Over – 5 miles south of DAB; Time – 1614 EDT (2014Z); Altitude – 1,000 ft; Type aircraft – Cessna 172; Sky – Broken sky base at 1,100 ft.

Routine pilot report (UA), DAB; Over – DAB; Time – 1617 EDT (2017Z); Altitude – 200 ft; Type aircraft – Diamond DA42; Turbulence – Smooth; Remarks – Just fine.

Routine pilot report (UA), DAB; Over – New Smyrna Beach Municipal Airport (EVB); Time – 1618 EDT (2018Z); Altitude – 1,000 ft; Type aircraft – Cessna 172; Weather – Light rain; Remarks – Rain looks mean.

9.0 SIGMET

There was a Convective Significant Meteorological Information (SIGMET) advisory valid for the accident site at the accident time. SIGMET 49E was issued at 1455 EDT and valid through 1655 EDT and warned of a line of severe thunderstorms 20 miles wide with tops above FL450, with hail to 1 inch, and wind gusts to 50 knots possible. The SIGMET 49E was moving from 270° at 15 knots:

WSUS31 KPCI 091855
SIGE
MKCE WST 091855

CONVECTIVE SIGMET 49E
VALID UNTIL 2055Z
FL AND CSTL WTRS
FROM 10ENE OMN-10SSW ORL
LINE SEV TS 20 NM WIDE MOV FROM 27015KT. TOPS ABV FL450.
HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

OUTLOOK VALID 092055-100055
AREA 1...FROM 30ENE ORD-40W CLE-50ESE CYN-30NNE ORF-ODF-40SW
AMG-40SSE TLH-50SW SJI-50ESE BWG-40SW EKN-30S ROD-40ESE PXV-30ENE
ORD
WST ISSUANCES EXPD. REFER TO MOST RECENT ACUS01 KWNS FROM STORM
PREDICTION CENTER FOR SYNOPSIS AND METEOROLOGICAL DETAILS.

AREA 2...FROM 190ESE ECG-180SSE ILM-40E EYW-80WSW CTY-FLO-190ESE
ECG
WST ISSUANCES POSS. REFER TO MOST RECENT ACUS01 KWNS FROM STORM
PREDICTION CENTER FOR SYNOPSIS AND METEOROLOGICAL DETAILS.

There were no non-convective SIGMETs valid for the accident site at the accident time.

10.0 AIRMETS

There were no Airmen's Meteorological Information (AIRMET)s valid for the accident site at the accident time for below 10,000 ft.

11.0 CWSU Advisories

There was a Center Weather Service Unit (CWSU) Center Weather Advisory (CWA) issued at 1400 EDT valid through 1600 EDT for the accident site. CWA 302 issued by the CWSU at Jacksonville Air Route Traffic Control Center (ZJX ARTCC) warned of an area of scattered developing thunderstorms moving from 250° at 10 knots with tops to FL400. Moderate to heavy precipitation was forecast with expected gradual increase in coverage and intensity over Georgia and Florida through 1600 EDT:

FAUS23 KZJX 091800
ZJX3 CWA 091800
ZJX CWA 302 VALID UNTIL 092000
25WNW AMG-40SSE SAV-15SE OMN-35WSW ORL-70SE CEW-25WNW AMG
AREA SCT DVLPG TS MOV FM 25010KT. TOPS FL400.
MOD TO HVY PCPN. EXP GRAD INCR IN CVRG/INTST
OVR GA/FL THRU PD.
=

There was no CWSU Meteorological Impact Statement (MIS) valid at the accident site at the accident time.

12.0 Graphical Forecasts for Aviation

Due to archive and accident notification standards the archived Graphical Forecasts for Aviation (GFA) products that would have been available to the accident pilot before departure are not available for this report.

13.0 Terminal Aerodrome Forecast

KDAB had the closest NWS Terminal Aerodrome Forecast (TAF) and the TAF valid at the accident time was an amended TAF issued at 1416 EDT and was valid for a 24-hour period beginning at 1400 EDT. The 1416 EDT amended TAF for KDAB was as follows:

KDAB 091816Z 0918/1018 **VRB04KT P6SM VCTS BKN035CB**
TEMPO 0919/0921 VRB15G25KT 2SM +TSRA BKN020CB
FM092200 20004KT P6SM VCSH SCT035 BKN080
FM100200 22003KT P6SM FEW100 SCT250
FM101500 24005KT P6SM SCT025 SCT250=

Between 1400 and 1800 EDT the TAF expected a variable wind at 4 knots, greater than 6 miles visibility, vicinity thunderstorms, and a broken ceiling of cumulonimbus clouds at 3,500 ft agl. Temporary conditions between 1500 and 1700 EDT of a variable wind at 15 knots with gusts to 25 knots, 2 miles visibility, thunderstorm and heavy rain, and a broken ceiling of cumulonimbus clouds at 2,000 ft agl were forecast.

The non-amended 1323 EDT KDAB TAF was valid for a 24-hour period beginning at 1400 EDT. The 1323 EDT TAF for KDAB was as follows:

TAF KDAB 091723Z 0918/1018 24007KT P6SM BKN035
FM091900 25008KT P6SM VCTS BKN040CB
TEMPO 0920/0923 2SM +TSRA BKN020CB
FM100000 20004KT P6SM SCT035 BKN080
FM100400 22003KT P6SM FEW100 SCT250
FM101500 24005KT P6SM SCT025 SCT250=

Between 1500 and 2000 EDT the TAF expected a wind from 250° at 8 knots, greater than 6 miles visibility, vicinity thunderstorms, and a broken ceiling of cumulonimbus clouds at 4,000 ft agl. Temporary conditions between 1600 and 1900 EDT of 2 miles visibility, heavy rain and thunderstorms, and a broken ceiling of cumulonimbus clouds at 2,000 ft agl were forecast.

14.0 NWS Area Forecast Discussion

The NWS Office in Melbourne, Florida, issued the following Area Forecast Discussion (AFD) at 1012 EDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed coastal TAFs sites becoming an east to southeast wind between 7 to 11 knots into the afternoon with scattered moderate rain showers and thunderstorms with reduced ceilings and visibilities in the precipitation:

FXUS62 KMLB 091412
AFDMLB

Area Forecast Discussion
National Weather Service Melbourne FL
1010 AM EDT Sat Jun 9 2018

.DISCUSSION...

Deep mid/upr lvl trof over the Deep South/ern GOMex will maintain a steady W/SW flow thru the column over central FL while keeping the wrn flank of the Bermuda ridge weak and disorganized. RAP40 analysis shows a weak sfc/low lvl pgrad acrs the region with the H100-H70 ridge axis over the nrn Bahamas/S FL. The 09/12Z RAOBs revealed a tongue of relatively dry air over central FL with PWat values arnd 1.50" at KXMR/KTBW, increasing southward to arnd 1.75" at KMFL/KEYW, and northward to arnd 2.00" at KJAX. RAP40 analysis confirms this area of dry air with H85-H50 avg dewpoint depressions btwn 7-10C... as high as 15C over the ern GOMex.

Aloft, H30-H20 lyr dominated by a large cyclone over the ern GOMex/FL peninsula, with a pocket of surprisingly strong upr lvl divergence over the Gold Coast/Lake-O/Treasure Coast. H50 analysis reveals a cold air advection pattern with temps btwn -8C/-9C over east central FL, dropping to -9C/-10C over west central/south FL. H85-H50 lapse rates btwn 5.5-6.0C/KM.

Relatively low moisture levels will keep precip coverage AOB 50pct today, but the mid/upr lvl dynamic support will couple with the

cold/dry air to increase the potential for any storms that do dvlp. Latest sat imagery reveals minimal cloud cover over central FL, near full sun should drive sfc temps to their convective triggers by early aftn. Weak sfc/low lvl pgrad will allow both east/west coast sea breezes to dvlp by midday and push well inland...west coast breeze will be dominant once again given the W/SW steering flow. Convection will be delayed initially by the dry air, but should fire by mid aftn as the inland progress of the sea breezes concentrates the moisture over the interior.

PoP distribution from the mrng fcst package looks good as the H100-H70 mean flow supports seabreeze merger in the vcnty of a line from Lake George to Lake-K...highest PoPs east of that line. Storms will have the potential to generate strong wind gusts and small hail. Max temps near climo avgs...U80s along the coast, L90s inland.

&&

.AVIATION...Thru 10/12Z.

Sfc Winds: Thru 09/15Z...W/SW AOB 3KTS bcmg W 5-8KTS. Btwn 09/15Z-09/18Z...coastal sites bcmg E/SE 7-11KTS. Btwn 09/21Z-09/24Z...interior sites bcmg S/SE 6-10KTS. Btwn 10/00Z-10/03Z...bcmg S/SW 3-6KTS. Btwn 10/03Z-10/06Z...bcmg S/SW AOB 3KTS.

Vsbys/WX/Cigs: Btwn 09/16Z-09/20Z...N of KISM-KTIX sct MVFR shras/IFR tsras...E of KVRB-KOBE sct MVFR shras/isold IFR tsras. Btwn 09/20Z-09/24Z...N of KISM-KEVB chc MVFR shras/slgt chc IFR tsras...S of KISM-KEVB sct MVFR shras/IFR tsras/slgt chc LIFR +tsras with sfc G35-40KTS. Btwn 10/00Z-10/04Z...S of KISM-KMLB chc MVFR tsras/slgt chc IFR tsras. Aft 10/08Z...N of KEVB-KLEE areas MVFR vsbys in BR.

&&

.MARINE...

Broad area of low pres over the Deep South will keep the wrn flank of the Atlc ridge weak and disorganized, with the axis over the Nrn Bahamas/S FL. Weak sfc/bndry lyr pgrad will generate a lgt/vrbl flow thru midday. Winds bcmg a light to gentle E/SE breeze by early aftn as the east coast seas breeze dvlp. Seas AOB 2FT, mainly in a background easterly swell. Sct shras/tsras moving offshore this aftn/evng, mainly north of Sebastian Inlet.

&&

.MLB WATCHES/WARNINGS/ADVISORIES...

FL...None.
AM...None.

&&

\$\$

15.0 NWS Special Marine Warning

The NWS Office in Melbourne, Florida, issued the following Special Marine Warning (SMW) at 1454 EDT for the thunderstorm activity affecting the accident site at the accident time (sections 7.4 and 7.5). The SMW warned of wind gusts to 34 knots or greater, small hail, and that thunderstorms can cause sudden waterspouts:

WHUS52 KMLB 091854
SMWMLB
AMZ550-092100-
/O.NEW.KMLB.MA.W.0096.180609T1854Z-180609T2100Z/

BULLETIN - IMMEDIATE BROADCAST REQUESTED
Special Marine Warning
National Weather Service Melbourne FL
254 PM EDT SAT JUN 9 2018

The National Weather Service in Melbourne has issued a

* Special Marine Warning for...
Flagler Beach to Volusia-Brevard County Line 0-20 nm...

* Until 500 PM EDT.

* At 253 PM EDT, a strong thunderstorm was located near Daytona Beach, moving east at 15 knots.

HAZARD...Wind gusts 34 knots or greater and small hail.

SOURCE...Radar.

IMPACT...Expect wind gusts in excess of 34 knots...suddenly higher waves...lightning and heavy downpours. Make sure all on board are wearing life jackets. Return to safe harbor if possible.

* Locations impacted include...
Daytona Beach, Holly Hill, Ormond Beach, Daytona Beach Shores and South Daytona.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Move to safe harbor immediately as gusty winds and high waves are expected.

Thunderstorms can produce sudden waterspouts. Waterspouts can easily overturn boats and create locally hazardous seas. Seek safe harbor immediately.

&&

LAT...LON 2942 8113 2943 8110 2946 8112 2948 8075
2925 8063 2886 8037 2883 8074 2881 8077
2882 8076 2882 8081 2881 8080 2880 8089
2884 8085 2938 8113

TIME...MOT...LOC 1853Z 254DEG 16KT 2922 8105

HAIL...<.75IN
WIND...>34KTS

\$\$

16.0 Winds and Temperature Aloft Forecast

The NWS 1002 EDT Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

FBUS31 KWN0 091402
FD1US1
DATA BASED ON 091200Z
VALID 091800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

MLB 9900 2309+14 2415+08 2521+04 2522-09 2123-20 192137 182548 182157

The accident site was closest to the Melbourne, Florida, (MLB) forecast point. The 1002 EDT MLB forecast for use between 1000 and 1700 EDT indicated a calm wind at 3,000 ft, a wind from 230° at 9 knots at 6,000 ft with a temperature of 14° C, and a wind from 240° at 15 knots at 9,000 ft with a temperature of 8° C.

17.0 Pilot Weather Briefing

A search of official weather briefing sources such as contract provider Leidos weather briefings was done and the accident pilot did not request a weather briefing through Leidos. It is unknown if the accident pilot checked or received anymore weather information before or during the accident flight.

18.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on June 9, 2018, indicated the following:

SUN	
Begin civil twilight	0557 EDT
Sunrise	0624 EDT
Sun transit	1324 EDT
Accident	1500 EDT³³
Sunset	2023 EDT
End civil twilight	2050 EDT

³³ Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 – Animation of KMLB WSR-88D reflectivity for the 0.5° elevation scan initiated between 1438 and 1520 EDT

Submitted by:

Paul Suffern
Senior Meteorologist

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