NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 9, 2012

Group Chairman's Factual Report

METEOROLOGY

ERA12LA231

Table Of Contents

A. ACCIDENT 3
B. METEOROLOGY GROUP 3
C. SUMMARY 3
D. DETAILS OF THE INVESTIGATION 3
E. FACTUAL INFORMATION 4
1.0 Synoptic Situation 4
1.1 Surface Analysis Chart 4
1.2 Upper Air Charts 5
2.0 Storm Prediction Center Products 9
3.0 Surface Observations 13
4.0 Upper Air Data 19
5.0 Satellite Data 21
6.0 Radar Imagery Information 23
6.1 Volume Scan Strategy 24
6.2 Beam Height Calculation 25
6.3 Reflectivity 25
6.4 Radar Summary 26
6.5 Base Reflectivity 27
6.6 Lightning Data 29
6.7 Dual-Polarization Weather Radar Data 30
6.8 Volume Scan Strategy 31
6.9 Beam Height Calculation 31
6.10 Zdr, CC, and HC 31
6.11 Dual-Pol Imagery 32
7.0 Pilot Reports 47
8.0 SIGMET and CWSU Advisory 47
9.0 AIRMETs 48
10.0 Terminal Aerodrome Forecast 48
11.0 Area Forecast 48
12.0 National Weather Service Area Forecast Discussion 50
13.0 Weather Watches and Warnings 52
13.1 Storm Prediction Center Storm Reports 53
14.0 Astronomical Data 54

A. ACCIDENT

Location: Approximately 6 miles ENE of Fitzgerald, Georgia
Date: March 16, 2012
Time: approximately 1856 eastern daylight time (2256 UTC[1])
Aircraft: Firefly 8 Hot-Air-Balloon, registration: N14643

B. METEOROLOGY GROUP

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C. SUMMARY

On March 16, 2012, about 1856 eastern daylight time, a Firefly 8 hot-air balloon, N14643, was lost after it climbed into a storm that formed over Fitzgerald, Georgia. A search was conducted, and on March 20, 2012, the balloon's envelope and basket were found in wooded terrain near Fitzgerald, Georgia. The pilot, who remained in the basket, was fatally injured. Visual meteorological conditions prevailed throughout the day, as the pilot/operator conducted sport parachute flights under the provisions of 14 Code of Federal Regulations Part 91.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist was not on scene for this investigation and gathered all the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are eastern daylight time (EDT) on March 16, 2012, 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 location was located at latitude 31.74° N, longitude 83.14° W, elevation: 17,000 feet.

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

E. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) and the Ocean Prediction Center (OPC) located in Camp Springs, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC-0045G CHG 1.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 2000 EDT is provided as figure 1, with the approximate location of the accident site marked. The chart depicted a surface trough[2] north of the accident site, stretching from western South Carolina northeastward into eastern North Carolina. A surface low pressure center was located along the central North Carolina and South Carolina borders with a surface pressure of 1010-hectopascals (hPa). The station models around the accident site depicted air temperatures from the low to high 70's Fahrenheit (F), with temperature-dew point spreads of 20° F or less, variable winds around 5 knots, and partly cloudy to mostly clear skies. These air and dew point temperatures were above normal for March across southern Georgia.

[2] Trough - An elongated area of relatively low atmospheric pressure or heights.

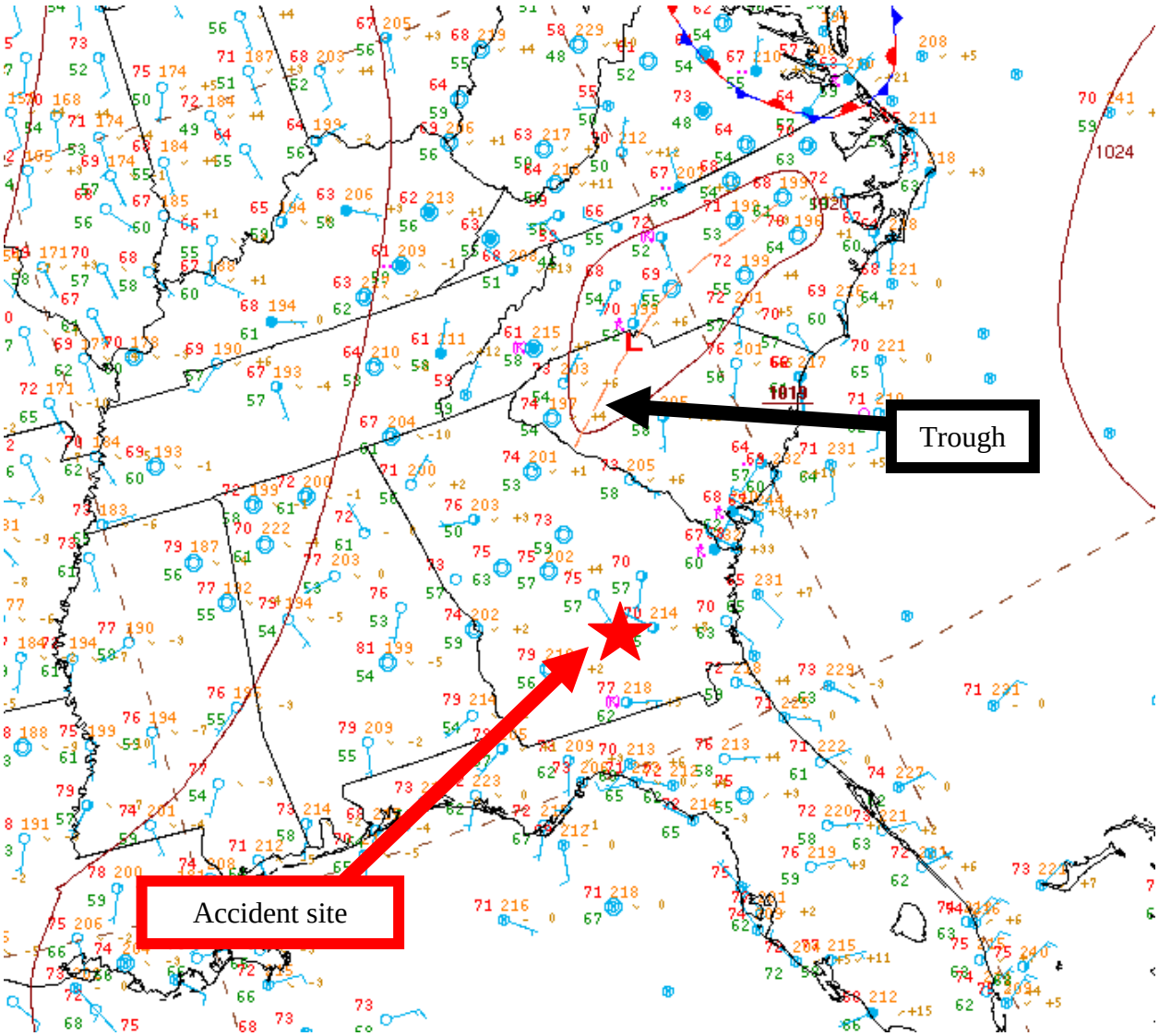


Figure 1 – NWS Surface Analysis Chart for 2000 EDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 2000 EDT are presented for 850-, 700-, 500-, and 300-hPa in figures 2 through 5. The 850-, 700-, and 500-hPa charts depicted the axis of a mid-level trough northwest of the accident site at 2000 EDT. Areas east of a mid-level trough are considered conducive for lift to help produce clouds and precipitation. Winds remained relatively light from the surface through 300-hPa.

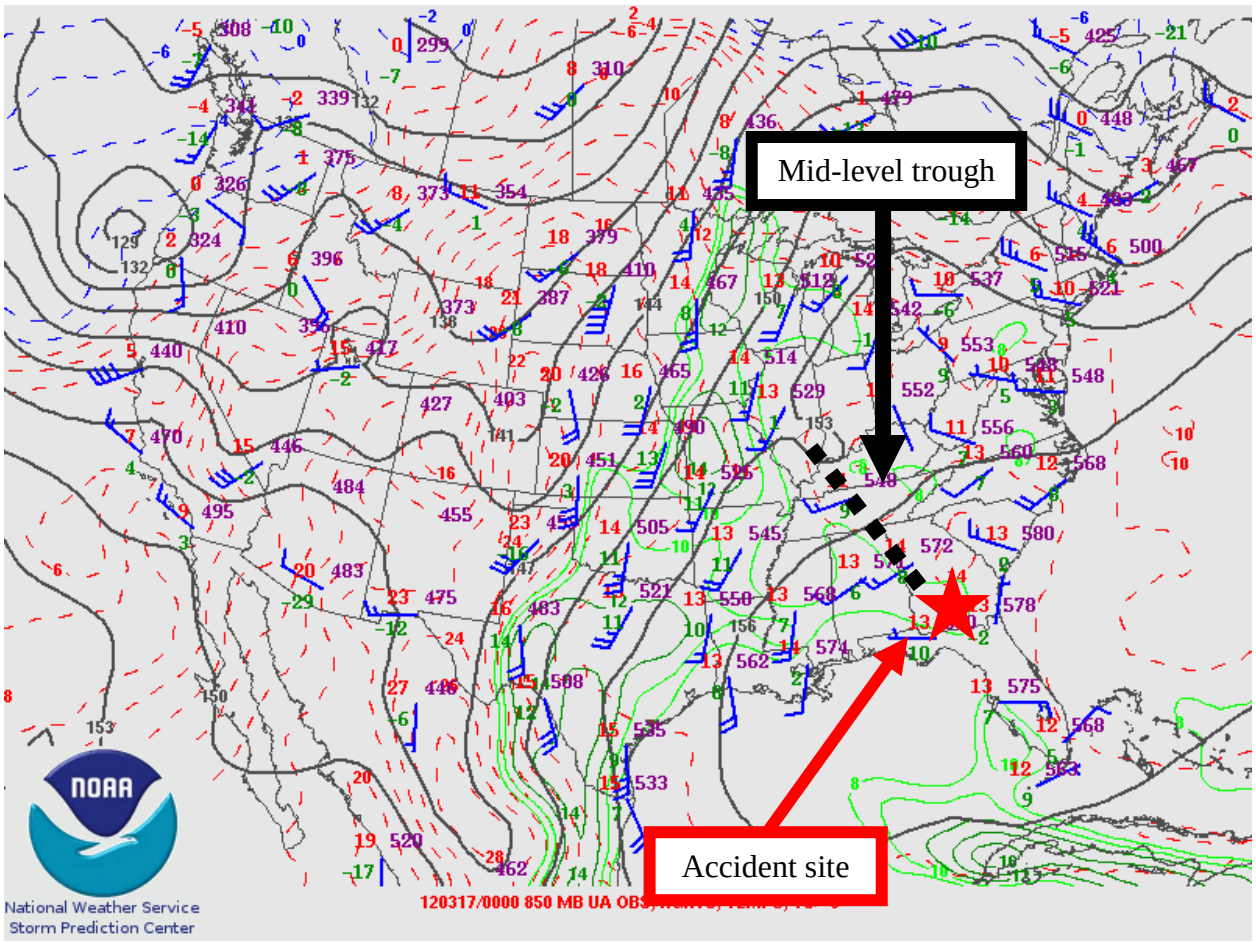


Figure 2 – 850-hPa Constant Pressure Chart for 2000 EDT

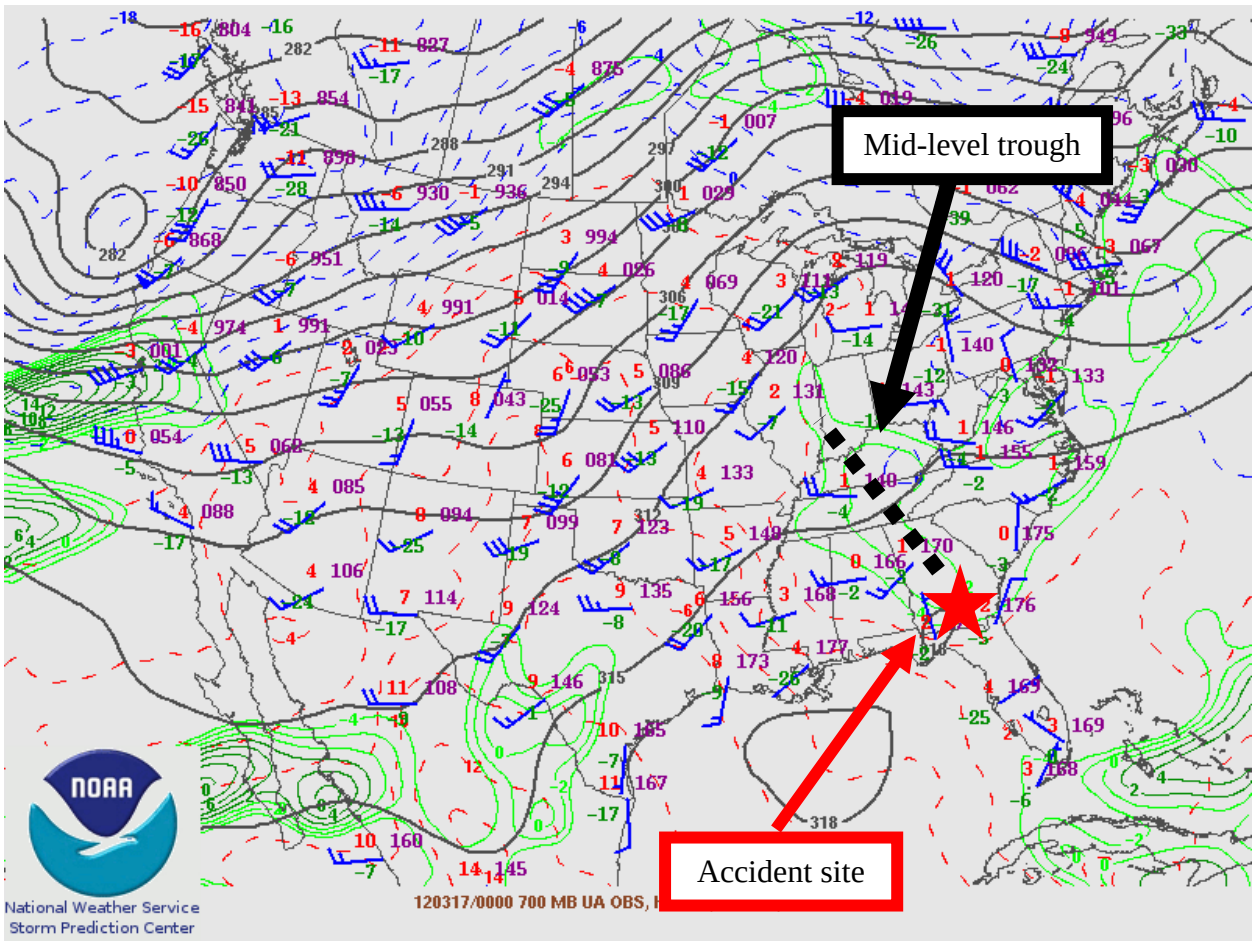


Figure 3 – 700-hPa Constant Pressure Chart for 2000 EDT

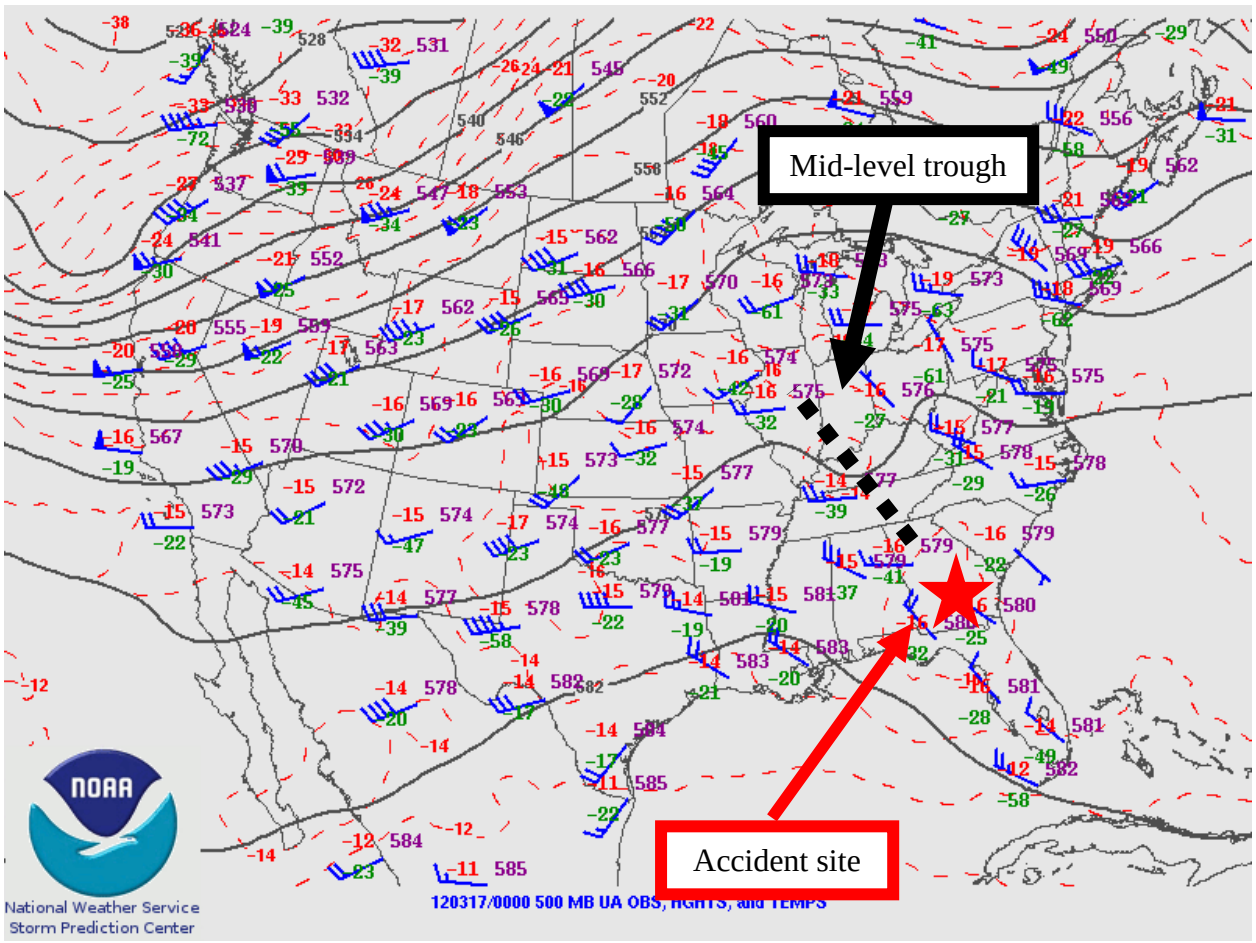


Figure 4 – 500-hPa Constant Pressure Chart for 2000 EDT

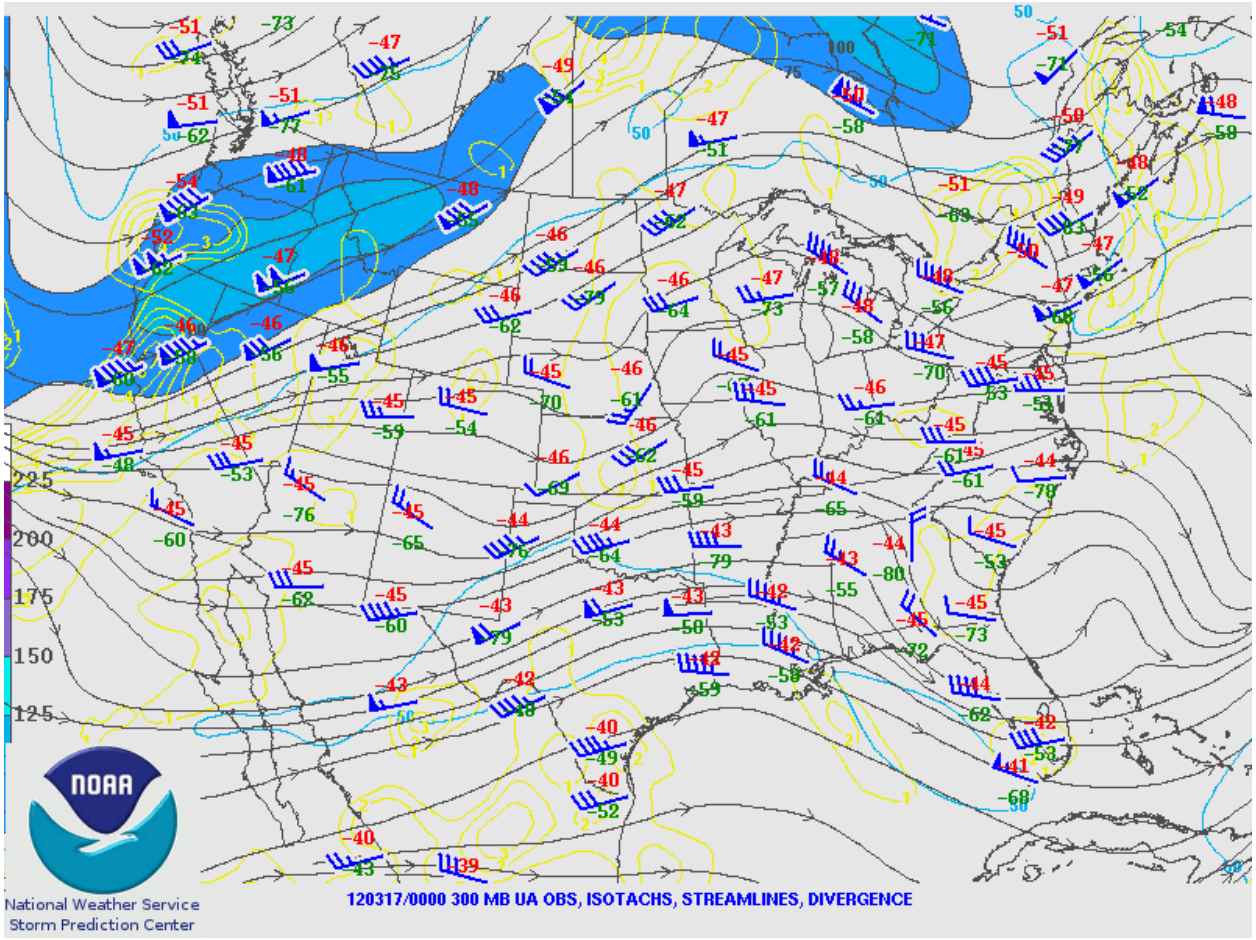


Figure 5 – 300-hPa Constant Pressure Chart for 2000 EDT

2.0 Storm Prediction Center Products

SPC issued the following day 1 Convective Outlook at 1557 EDT (figure 6) with areas of thunderstorms forecasted for the accident site with some of the thunderstorms expected to become severe [3]:

SPC AC 161957

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
0257 PM CDT FRI MAR 16 2012

VALID 162000Z - 171200Z

...THERE IS A SLGT RISK OF SVR TSTMS THIS AFTERNOON THROUGH EARLY TONIGHT FOR W TX INTO WRN OK...

...W TX INTO WRN OK THROUGH EARLY TONIGHT...

[3] The bold sections in this NWS product and the rest of products in the factual report are to highlight the individual sections that directly reference the weather conditions that are or will affect the accident location around the accident time.

REGIONAL RADAR/SATELLITE IMAGERY AND LIGHTNING DATA SHOWED AN INITIAL TSTM HAS DEVELOPED OVER SW TX /REEVES COUNTY/ ALONG THE SRN EXTENT OF THE DRY LINE...WITH ADDITIONAL CU FORMING FARTHER S OVER BREWSTER COUNTY. A MODERATELY UNSTABLE ENVIRONMENT COUPLED WITH EFFECTIVE BULK SHEAR UP TO 40 KT IS SUPPORTIVE OF SUPERCELLS. THE CATEGORICAL SLIGHT RISK/SEVERE PROBABILITIES AND FORECAST REASONING IN THE 1630Z OUTLOOK REMAIN ON TRACK AS ADDITIONAL STORM DEVELOPMENT IS EXPECTED ALONG THE FULL EXTENT OF THE DRY LINE THROUGH THE AFTERNOON. ADDITIONAL SHORT TERM INFORMATION IS AVAILABLE IN SPC MESOSCALE DISCUSSION 268.

...ERN TN/NRN-ERN AL TO SERN STATES...
THE 5 PERCENT SEVERE HAIL PROBABILITY HAS BEEN EXPANDED A LITTLE SEWD TO INCLUDE MORE OF CENTRAL/SRN SC AND SRN GA. THE CONTINUATION OF UNSEASONABLY WARM SURFACE TEMPERATURES ACROSS THIS REGION HAS WEAKENED THE LOW LEVEL INVERSION EVIDENT ON 12Z SOUNDINGS. AN UNCAPPED...MODERATELY UNSTABLE ENVIRONMENT IS SUPPORTING TSTM DEVELOPMENT ACROSS MUCH OF THIS AREA PER REGIONAL RADAR IMAGERY...BUT VERY WEAK DEEP LAYER SHEAR WILL CONTINUE TO LIMIT THE LIFESPAN OF THE UPDRAFTS. THUS...WILL MAINTAIN LOW SEVERE PROBABILITIES AS A LOCALLY STRONGER WIND GUST AND/OR ISOLATED HAIL THREAT CANNOT BE RULED OUT. ADDITIONAL DETAILS ARE AVAILABLE IN SPC MESOSCALE DISCUSSIONS 266 AND 267 FOR THIS REGION.

..PETERS.. 03/16/2012

.PREV DISCUSSION... /ISSUED 1130 AM CDT FRI MAR 16 2012/

...W TX INTO WRN OK THIS AFTERNOON INTO EARLY TONIGHT...
MORNING WATER VAPOR IMAGERY SHOWS A WEAK SRN STREAM TROUGH MOVING ENEWD OVER FAR W TX AND SRN NM...AND THIS WAVE WILL PROVIDE WEAK BACKGROUND ASCENT AND A MODEST INCREASE IN MID-UPPER SWLY FLOW OVER THE DRYLINE AND WARM SECTOR THIS AFTERNOON/EVENING. THE DRYLINE IS EXPECTED TO MIX EWD TO NEAR THE CAPROCK BY 21Z FROM THE E/SE PANHANDLE TO THE SOUTH PLAINS...AND WILL EXTEND SWD INTO THE TRANS PECOS REGION OF W TX. AS SURFACE TEMPERATURES WARM INTO THE LOW-MID 80S ALONG THE DRYLINE...CONVECTIVE INHIBITION WILL WEAKEN AND THUNDERSTORM DEVELOPMENT WILL BECOME MORE PROBABLE BY 21-00Z. GIVEN BOUNDARY LAYER DEWPOINTS NEAR 60 F TO THE E OF THE DRYLINE...MIDLEVEL LAPSE RATES NEAR 8.5 C/KM...MLCAPE OF 2500-3000 J/KG...AND A MARGINAL SUPERCELL WIND PROFILE...LARGE HAIL CAN BE EXPECTED WITH ANY SUSTAINED STORMS. THE TORNADO THREAT APPEARS TO BE SOMEWHAT MARGINAL GIVEN RELATIVELY WEAK LOW-LEVEL SHEAR IN THE WARM SECTOR /ESRH OF 50-100 M2 PER S2/. OTHERWISE...A FEW DAMAGING GUSTS WILL ALSO BE POSSIBLE LATER THIS EVENING INTO EARLY TONIGHT AS ONE OR TWO CLUSTERS OF STORMS EVOLVE FROM THE INITIAL DRYLINE CONVECTION AND SPREAD EWD INTO THE MOIST WARM SECTOR ACROSS THE LOWER PLAINS.

...TN VALLEY REGION THIS AFTERNOON...
A REMNANT MCV FROM OVERNIGHT CONVECTION WILL CONTINUE TO DRIFT EWD/ESEWD OVER WRN KY...WHILE THE OUTFLOW BOUNDARY ASSOCIATED WITH THE CONVECTIVE CLUSTER MOVES SLOWLY SWD/SEWD ACROSS MIDDLE TN AND NRN MS/AL. ADDITIONAL STORM DEVELOPMENT IS EXPECTED THIS AFTERNOON ALONG THIS OUTFLOW BOUNDARY IN A MODERATELY UNSTABLE ENVIRONMENT WITH MLCAPE OF 1500-2000 J/KG. THE INSTABILITY WILL SUPPORT STRONG

UPDRAFTS AND SOME HAIL RISK...AS WELL AS ISOLATED DOWNBURSTS WITH HEAVY PRECIPITATION LOADING. STILL...RELATIVELY WEAK VERTICAL SHEAR WILL CONTINUE TO LIMIT THE RISK FOR PERSISTENT SEVERE STORMS.

...MID MS VALLEY THIS AFTERNOON...
LOW-LEVEL WAA ON THE NW SIDE OF THE LOWER OH VALLEY MCV AND WEAK SURFACE COLD POOL WILL CONTINUE TO SUPPORT THUNDERSTORM DEVELOPMENT THROUGH THE AFTERNOON IN A N-S BAND FROM W CENTRAL IL INTO ERN MO. A COMBINATION OF MODERATE INSTABILITY FEEDING THIS CONVECTION FROM THE SW AND WEAK VERTICAL SHEAR WILL AGAIN SUPPORT MAINLY PULSE-TYPE STORMS CAPABLE OF PRODUCING ISOLATED LARGE HAIL/STRONG OUTFLOW GUSTS. FARTHER N/NW INTO IA...THERE IS LITTLE TO FOCUS STORM DEVELOPMENT THIS AFTERNOON...DESPITE A SIMILAR THERMODYNAMIC ENVIRONMENT COMPARED TO MO. THUS...WILL NOT EXTEND THE LOW HAIL/WIND PROBABILITIES INTO IA...THOUGH VERY ISOLATED STORMS COULD POSE SUCH A RISK.

...ERN NC/SE VA THIS AFTERNOON/EVENING...
A REMNANT MCV IS MOVING SLOWLY SEWD FROM WV TO VA...WHILE SURFACE HEATING AND BOUNDARY LAYER DEWPOINTS AOA 60 F WILL CONTRIBUTE TO POTENTIALLY MODERATE INSTABILITY ALONG AND E OF A DIFFUSE LEE TROUGH IN NC/VA. A FEW THUNDERSTORMS COULD DEVELOP LATER THIS AFTERNOON/EVENING AS THE MCV APPROACHES THE SURFACE TROUGH AND AREA OF STRONGER INSTABILITY...AND ISOLATED STRONG/DAMAGING OUTFLOW GUSTS WILL BE POSSIBLE.

...UPPER MI OVERNIGHT...
LOW-LEVEL MOISTURE AND STEEP MIDLEVEL LAPSE RATES WILL OVERSPREAD THE UPPER GREAT LAKES LATE TODAY THROUGH TONIGHT IN A LOW-LEVEL WAA REGIME. MODERATE ELEVATED INSTABILITY WILL DEVELOP OVER UPPER MI TONIGHT...BUT STORM DEVELOPMENT/COVERAGE IS IN QUESTION. WILL MAINTAIN THE LOW HAIL PROBABILITIES FOR NOW...BUT THIS AREA WILL BE RE-EVALUATED IN LATER UPDATES.

CLICK TO GET WUUS01 PTSDY1 PRODUCT

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

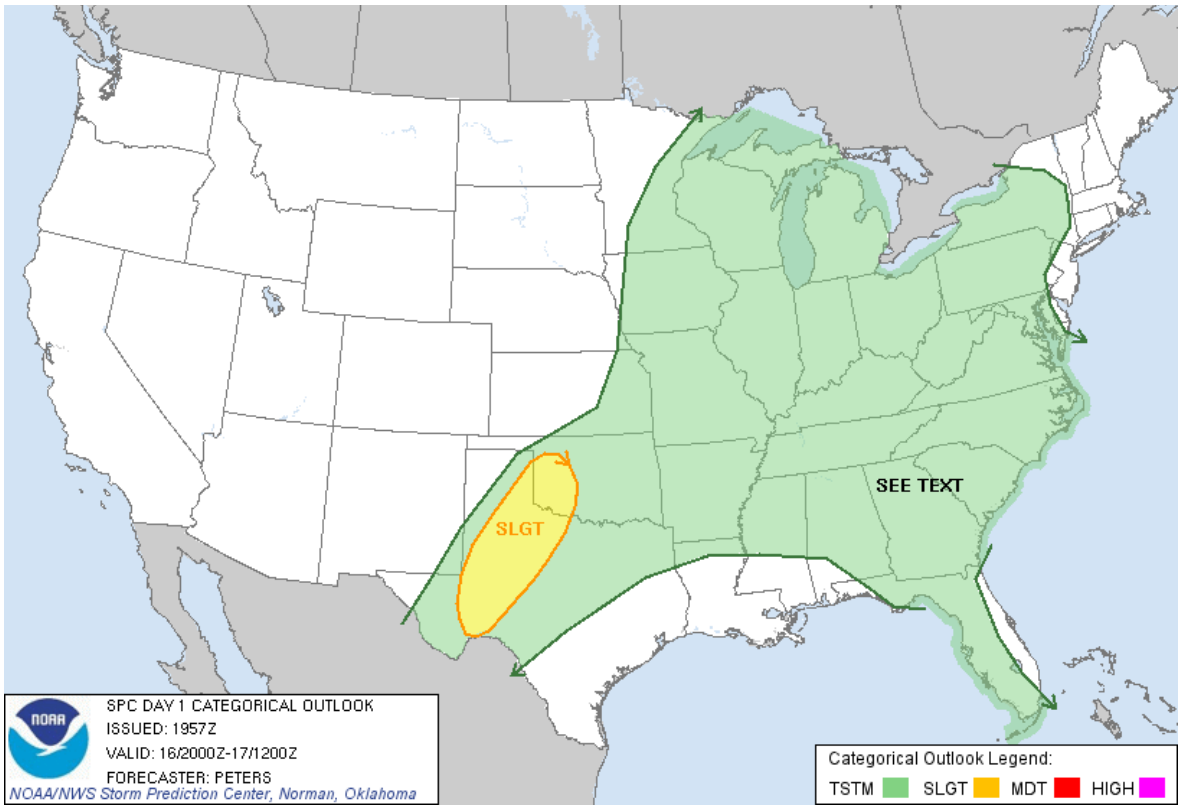


Figure 6 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

In addition, a Mesoscale Discussion (#267) was issued by the SPC at 1425 EDT with scattered thunderstorms forecasted for the accident site with marginally severe hail and gusty winds possible. A weather watch was not expected to be issued based on marginally severe weather conditions expected at the surface (figure 7):

MESOSCALE DISCUSSION 0267
NWS STORM PREDICTION CENTER NORMAN OK
0225 PM CDT FRI MAR 16 2012

AREAS AFFECTED...CNTRL/ERN GA INTO WRN SC

CONCERNING...SEVERE POTENTIAL...WATCH UNLIKELY

VALID 161925Z - 162130Z

SCATTERED THUNDERSTORMS WILL CONTINUE THROUGH THE AFTERNOON. ISOLATED INSTANCES OF MARGINALLY SEVERE HAIL AND GUSTY WINDS WILL BE POSSIBLE WITH STRONGER STORMS. A WW IS NOT EXPECTED.

TEMPERATURES HAVE WARMED INTO THE 80S THIS AFTERNOON LEADING TO A MODERATELY UNSTABLE AIR MASS WITH SBCAPE VALUES AROUND 2000-3000 J/KG. COMBINED WITH MODEST MIDLEVEL LAPSE RATES OF 6.5-7 DEG C/KM PER 12Z REGIONAL RAOBS AND 18Z MESOANALYSIS...BRIEF BUT STRONG UPDRAFTS ARE POSSIBLE. GIVEN THE LACK OF DEEP LAYER FORCING AND VERY WEAK BULK SHEAR /LESS THAN 15 KT/...ORGANIZED SEVERE STORMS ARE NOT

ANTICIPATED AND ONLY SPORADIC INSTANCES OF MARGINALLY SEVERE HAIL AND GUSTY WINDS ARE EXPECTED. THEREFORE WW IS NOT EXPECTED.

..LEITMAN.. 03/16/2012

ATTN...WFO...CHS...CAE...GSP...JAX...FFC...TAE...

LAT...LON 34028124 34258294 34188333 33958373 33228410 32598436
32128434 31958425 31398385 31198313 31208248 31278225
31678182 32468067 33228017 33758036 34028124

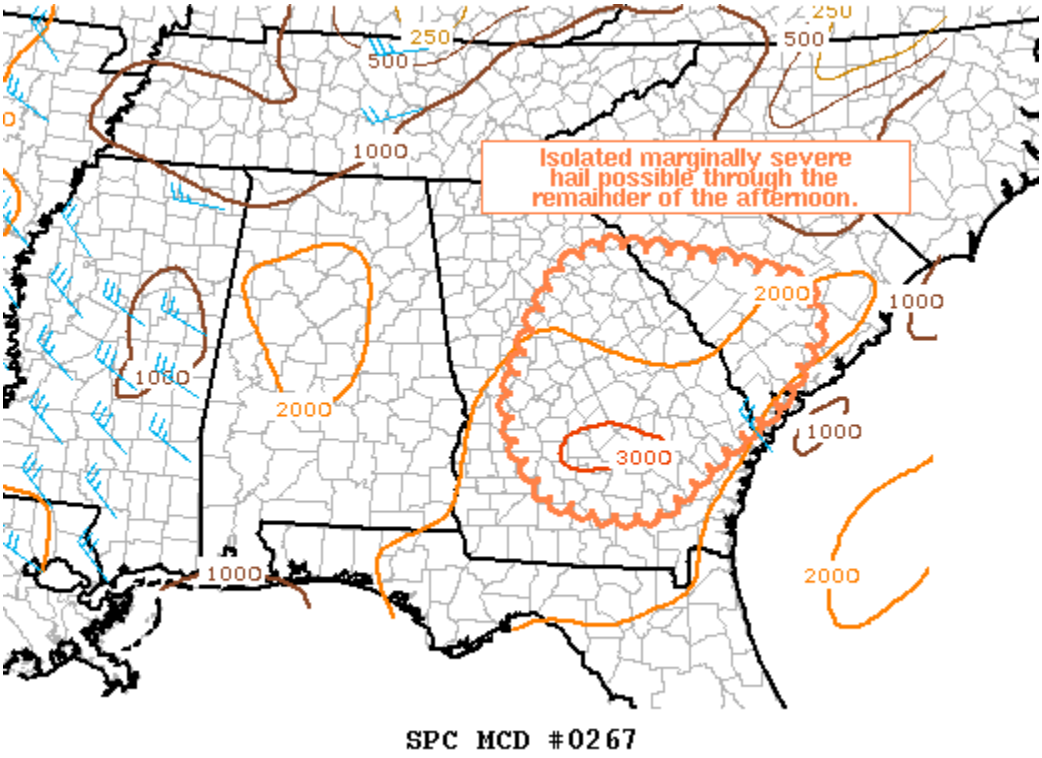


Figure 7 – Storm Prediction Center Mesoscale Discussion #267

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language.

The closest weather reporting to the accident site was from an Automated Weather Observing System (AWOS[4]) located at Fitzgerald Municipal Airport (KFZG) 2 miles southwest of Fitzgerald, Georgia, and 8 miles southwest of the accident site (figure 8). These observations were taken from automated equipment and were supplemented by a human observer. KFZG had an elevation of 365 feet, and had a 3° westerly magnetic variation[5]. The following observation was the last observation disseminated before the time of the accident (this data was received from the airport manager):

[4] 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.

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

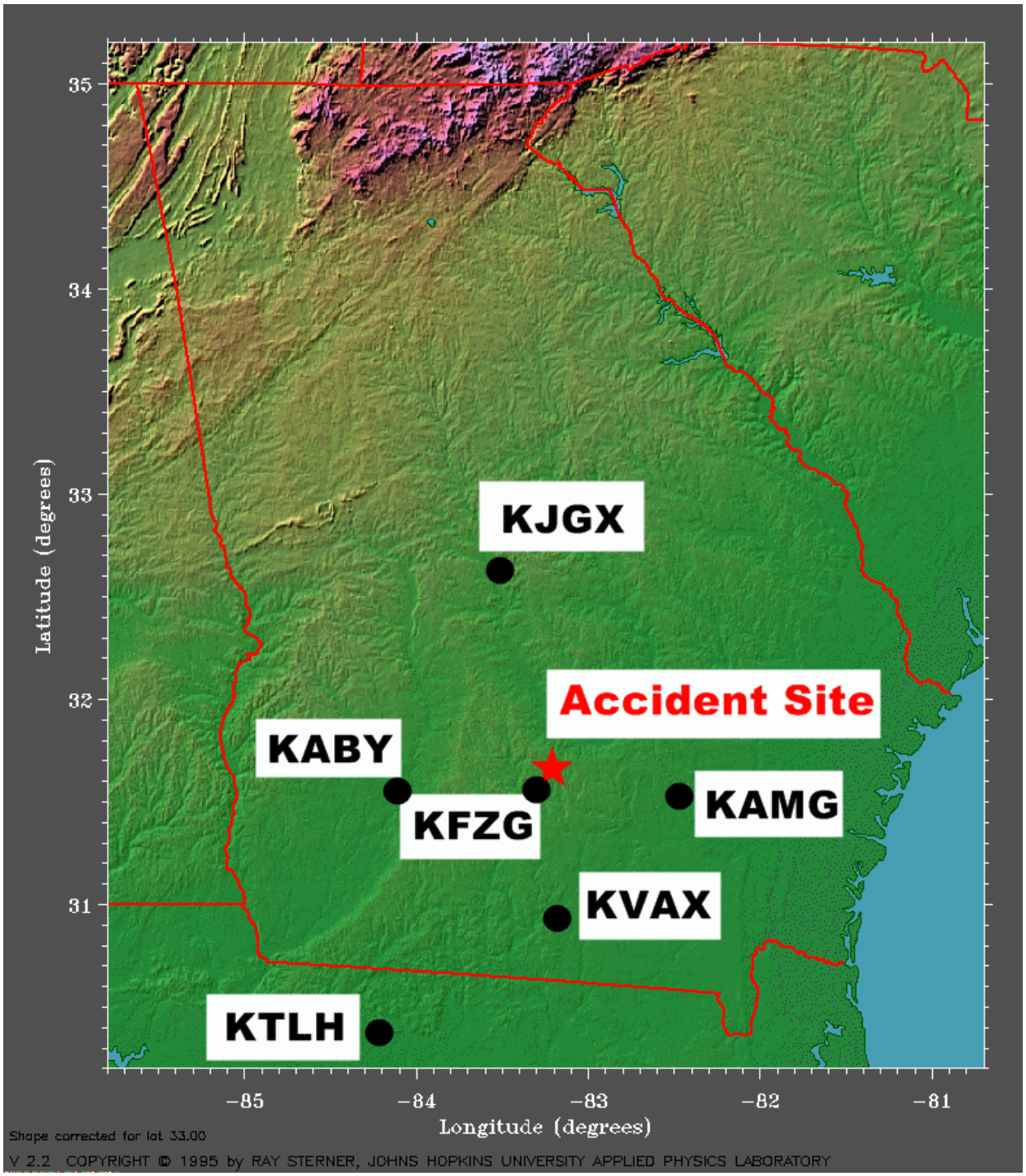


Figure 8 – Map of Georgia showing the locations of the surface observation, radar, and upper air sounding sites

[1700 EDT] KFZG 162100Z 22005KT 9SM SCT060 SCT180 29/13

KFZG weather at 1700 EDT, wind from 220° at 5 knots, 9 miles visibility, scattered clouds at 6,000 feet above ground level (agl), scattered clouds at 18,000 feet, temperature of 29° Celsius (C), dew point temperature of 13° C.

Bacon County Airport (KAMG), located 3 miles west of Alma, Georgia, had an Automated Surface Observing System (ASOS[6]) whose reports were not supplemented by a human observer (figure 8). KAMG is located 35 miles east of the accident site, at an elevation of 200 feet, and has a 5° westerly magnetic variation. The following observations were taken and disseminated during the times surrounding the accident[7]:

[1648 EDT] KAMG 162048Z AUTO 18004KT 10SM VCTS CLR 29/14 A3014 RMK AO2 LTG DSNT NW-E TSB01E43B48=

[1649 EDT] KAMG 162049Z AUTO 18005KT 10SM VCTS CLR 29/14 A3014 RMK AO2 LTG DSNT NW-E TSB01E43B48 SLP203 T02890139 56027=

[1753 EDT] KAMG 162153Z AUTO VRB03KT 10SM FEW090 SCT110 25/13 A3014 RMK AO2 LTG DSNT E AND W AND NW TSE49 SLP205 T02500128=

[1853 EDT] KAMG 162253Z AUTO 00000KT 8SM BKN110 22/17 A3014 RMK AO2 LTG DSNT W AND NW SLP205 T02170172=

ACCIDENT TIME 1856 EDT

[1937 EDT] KAMG 162337Z AUTO 14003KT 7SM VCTS -RA OVC100 21/18 A3015 RMK AO2 LTG DSNT W AND NW TSB31RAB30 P0000=

[1953 EDT] KAMG 162353Z AUTO 32006KT 9SM FEW100 BKN110 21/18 A3017 RMK AO2 LTG DSNT W AND NW TSB31E46RAB30E47 PRESRR SLP214 P0000 60000 T02110183 10294 20206 53008=

[2053 EDT] KAMG 170053Z AUTO 08006KT 10SM FEW100 SCT110 21/17 A3017 RMK AO2 LTG DSNT W SLP213 T02110172=

[2153 EDT] KAMG 170153Z AUTO 09004KT 10SM CLR 22/16 A3019 RMK AO2 SLP221 T02170161=

[2253 EDT] KAMG 170253Z AUTO 00000KT 10SM CLR 21/17 A3021 RMK AO2 LTG DSNT N SLP228 T02060167 53014=

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

[7] The bold text in the METAR coding is to highlight the text that will be typed in plain language further down in the factual report.

KAMG weather at 1753 EDT, wind variable at 3 knots, visibility 10 miles, few clouds at 9,000 feet agl, scattered clouds at 11,000 feet, temperature of 25° C, dew point temperature of 13° C, and an altimeter setting of 30.14 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant[8] east, west, and northwest, thunderstorm ended 1749 EDT, sea level pressure 1020.5 hPa, temperature 25.0° C, dew point temperature 12.8° C.

KAMG weather at 1853 EDT, wind calm, visibility 8 miles, a broken ceiling at 11,000 feet agl, temperature of 22° C, dew point temperature of 17° C, and an altimeter setting of 30.14 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant west and northwest, sea level pressure 1020.5 hPa, temperature 21.7° C, dew point temperature 17.2° C.

KAMG weather at 1937 EDT, wind from 140° at 3 knots, visibility 7 miles, vicinity[9] thunderstorms, light rain, an overcast ceiling at 10,000 feet agl, temperature of 21° C, dew point temperature of 18° C, and an altimeter setting of 30.15 inches of mercury. Remarks: automated station with a precipitation discriminator, lightning distant west and northwest, thunderstorm began at 1931 EDT, rain began at 1930 EDT, one-hourly precipitation of a trace.

The Southwest Georgia Regional Airport (KABY), located 3 miles southwest of Albany, Georgia, had an ASOS whose reports were augmented by the air traffic control tower (figure 8). KABY is located 55 miles west of the accident site, at an elevation of 196 feet, and has a 2° westerly magnetic variation. The following observations were taken and disseminated during the times surrounding the accident:

[1553 EDT] METAR KABY 161953Z 00000KT 10SM CLR 31/13 A3017 RMK AO2 SLP215 T03060133=

[1653 EDT] METAR KABY 162053Z COR 25007KT 7SM CLR 30/12 A3015 RMK AO2 SLP208 T03000122 56026=

[1753 EDT] KABY 162153Z 23007KT 8SM FEW043 30/13 A3014 RMK AO2 SLP203 T03000128=

[1853 EDT] KABY 162253Z 21004KT 10SM CLR 28/13 A3014 RMK AO2 SLP204 T02830133=

ACCIDENT TIME 1856 EDT

[1953 EDT] KABY 162353Z 00000KT 8SM CLR 26/13 A3015 RMK AO2 SLP210 T02610133 10311 20261 53002=

[8] Distant means the phenomena was detected by the automated system beyond 10 miles but less than 30 miles from the airport location point.

[9] Vicinity means the phenomena was detected by the automated system between 5 and 10 miles from the airport location point.

[2053 EDT] KABY 170053Z 00000KT 9SM CLR 23/14 A3018 RMK AO2 RAB19E52 SLP218 P0000 T02330139=

[2153 EDT] KABY 170153Z 00000KT 5SM HZ CLR 20/14 A3019 RMK AO2 LTG DSNT N SLP223 T02000144=

[2253 EDT] KABY 170253Z 20004KT 5SM HZ CLR 21/14 A3020 RMK AO2 SLP226 60000 T02060139 51016=

KABY weather at 1753 EDT, wind from 230° at 7 knots, visibility 8 miles, few clouds at 4,300 feet agl, temperature of 30° C, dew point temperature of 13° C, and an altimeter setting of 30.14 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1020.3 hPa, temperature 30.0° C, dew point temperature 12.8° C.

KABY weather at 1853 EDT, wind from 210° at 4 knots, visibility 10 miles, clear skies below 12,000 feet agl, temperature of 28° C, dew point temperature of 13° C, and an altimeter setting of 30.14 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1020.4 hPa, temperature 28.3° C, dew point temperature 13.3° C.

KABY weather at 1953 EDT, wind calm, visibility 8 miles, clear skies below 12,000 feet agl, temperature of 26° C, dew point temperature of 13° C, and an altimeter setting of 30.15 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1021.0 hPa, temperature 26.1° C, dew point temperature 13.3° C, 6-hourly maximum temperature of 31.1° C, 6-hourly minimum temperature of 26.1° C, 3-hourly pressure increase of 0.2 hPa.

4.0 Upper Air Data

The closest upper air sounding to the accident site was from Tallahassee, Florida (KTLH), which was approximately 102 miles southwest of the accident site, with a site number 72214, and a station elevation of 81 feet (figure 8). The 2000 EDT sounding from KTLH was plotted on a standard Skew-T log P diagram[10], which is presented along with the derived stability parameters in figure 9 (with data from the surface to 400-hPa, or approximately 24,000 feet msl). These data were analyzed utilizing the RAOB[11] software package. The sounding depicted a conditionally unstable vertical environment with the Lifted Condensation Level (LCL)[12] at 3,402 feet, a Convective Condensation Level (CCL)[13] at 5,958 feet, and a Level of Free Convection (LFC)[14] at 5,327 feet. The freezing level was located at 11,459 feet. The tropopause height was identified at 48,312 feet. The precipitable water value was 1.23 inches.

[10] 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.

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

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

[13] Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

[14] Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

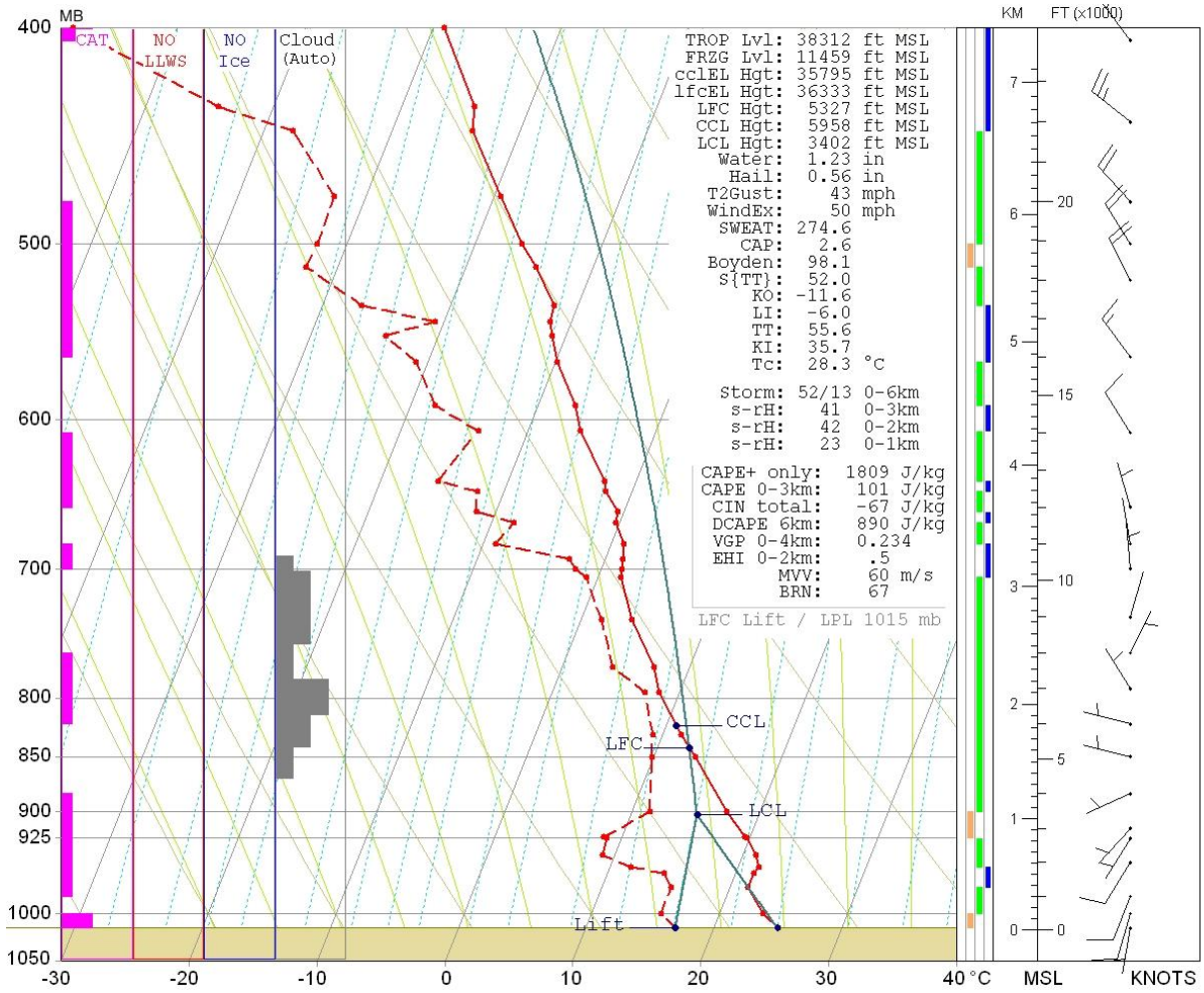


Figure 9 –KTLH 2000 EDT sounding

The sounding parameters indicated a moist and conditionally unstable environment and such conditions are considered supportive for vertical cloud formation and precipitation. This conditionally unstable environment had over 1800 J/kg of CAPE[15] and would have supported the development thunderstorm activity during the afternoon hours near the accident site. In addition the maximum vertical velocity (MVV) within an updraft was calculated to be 117 knots. No icing conditions were indicated by RAOB, however, significant icing can occur within convection. RAOB identified clouds from 5,000 feet to 11,000 feet. The Windex and T2 Gust values also supported strong outflow winds of 50 and 43 miles per hour respectively.

[15] Convective Available Potential Energy (CAPE) – CAPE is a measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed with an updraft.

The sounding wind profile indicated there was a surface wind from 190° at 7 knots, and the wind veered[16] to the north through 10,000 feet, after which the winds then backed[17] to the northwest through 24,000 feet with winds around 25 knots. RAOB did not indicate areas of low level wind shear (LLWS), but areas of clear air turbulence were indicated from the surface to 21,000 feet.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from the NCDC and processed with the NTSB's Man-computer Interactive Data Access System (McIDAS) workstation. Visible and infrared imagery (GOES-13 band 1 and 4), at wavelengths of 0.65 microns (μm) and 10.7 μm, respectively, retrieved brightness temperatures for the scene. Satellite imagery surrounding the time of the accident, from 1500 EDT through 2100 EDT at approximately 15-minute intervals, were reviewed and the closest images to the time of the accident are documented here.

Figures 10 through 13 present the GOES-13 visible imagery from 1815, 1832, 1845, and 1855 EDT, at 2X magnification with the accident site highlighted with a red square. Inspection of the visible imagery indicated that the cumuliform cloud cover was expanding over the accident site before and at the time of the accident. Figure 14 presents the GOES-13 infrared imagery from 1855 EDT at 8X magnification with the accident site highlighted with a red square. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 2000 EDT KTLH sounding, the approximate cloud-top heights over the accident site were 36,000 feet.

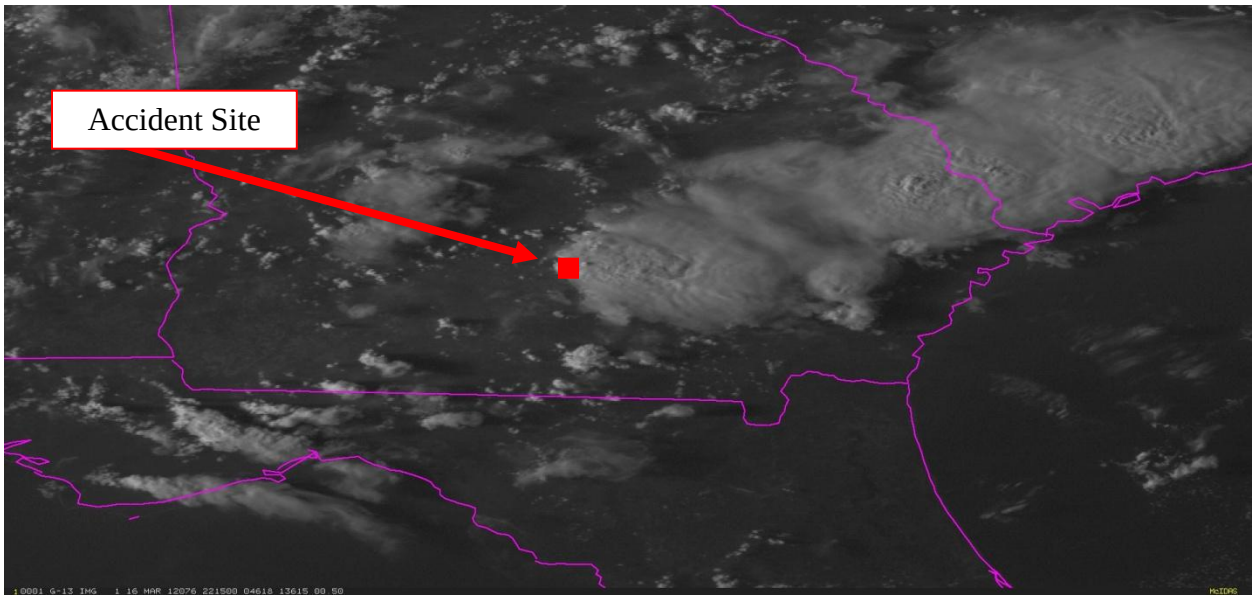


Figure 10 – GOES-13 visible image at 1815 EDT

[16] Veering wind – Wind which changes in a clockwise direction with time at a given location, or which changes direction in a clockwise sense with height.
[17] Backing wind – Wind which changes in a counter-clockwise direction with time at a given location, or which changes direction in a counter-clockwise sense with height.

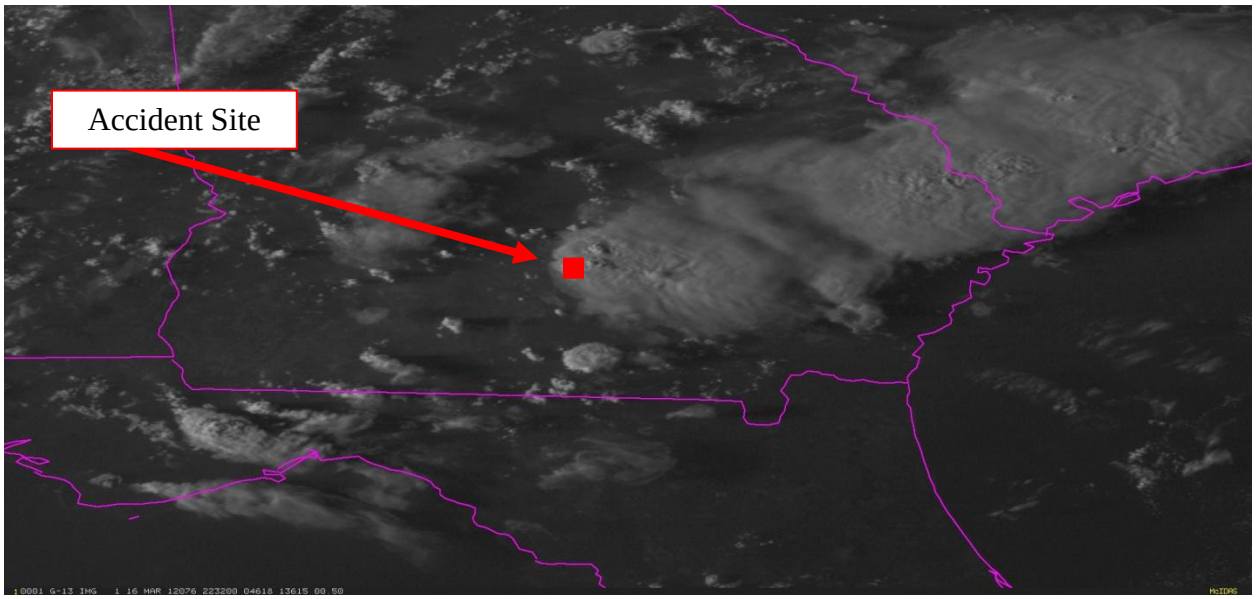


Figure 11 – GOES-13 visible image at 1832 EDT

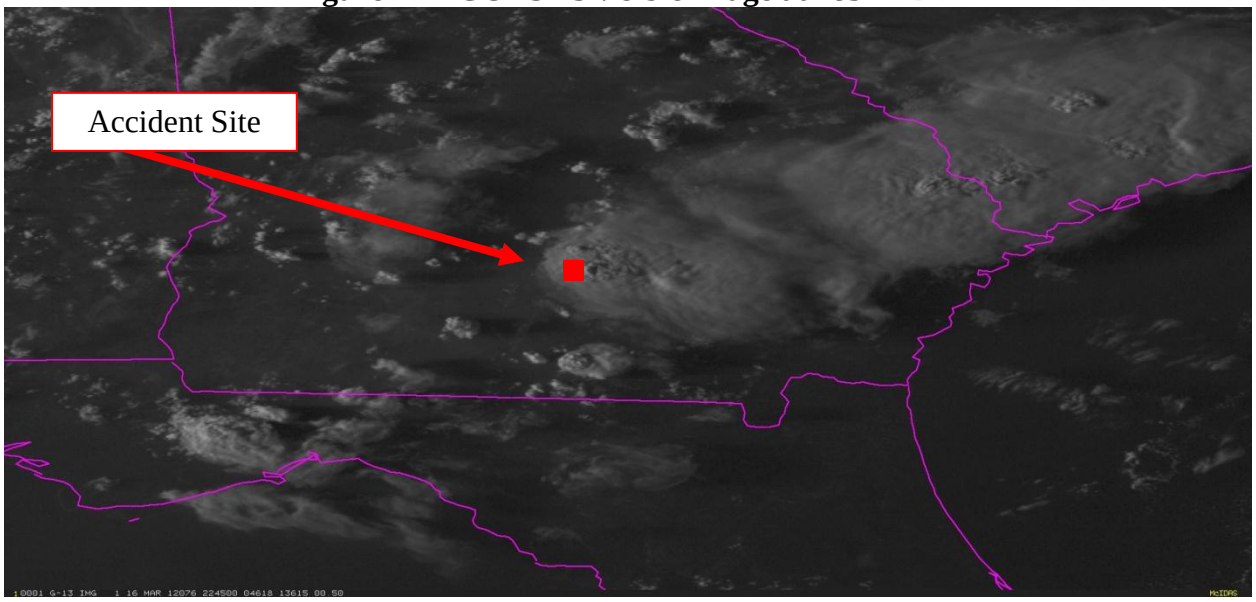


Figure 12 – GOES-13 visible image at 1845 EDT

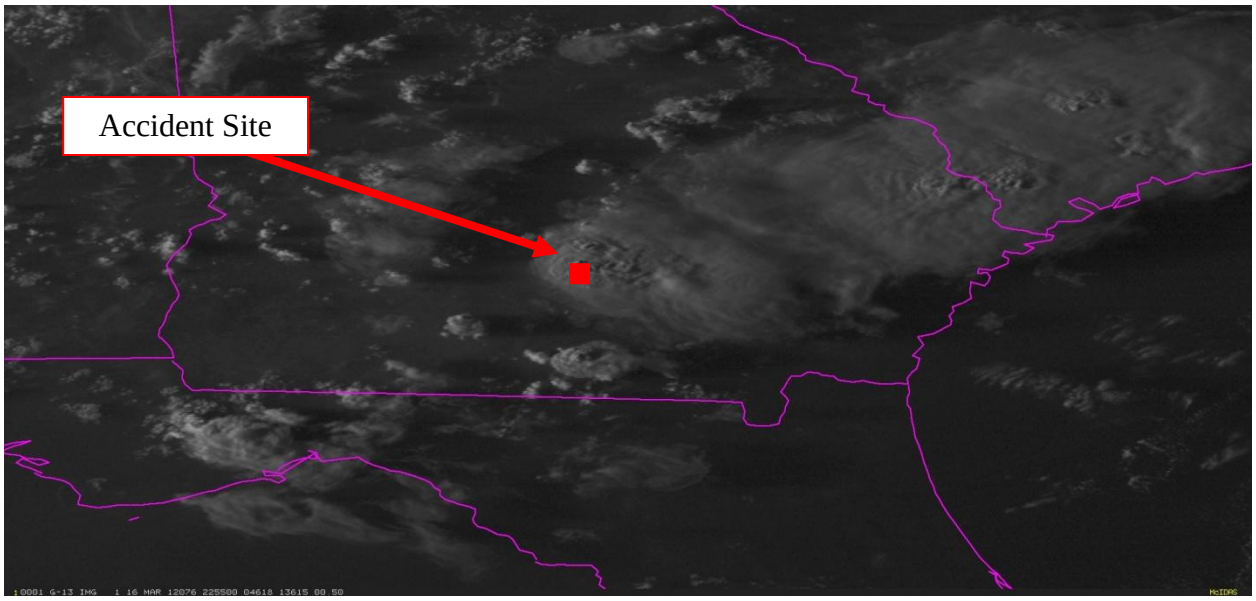


Figure 13 – GOES-13 visible image at 1855 EDT

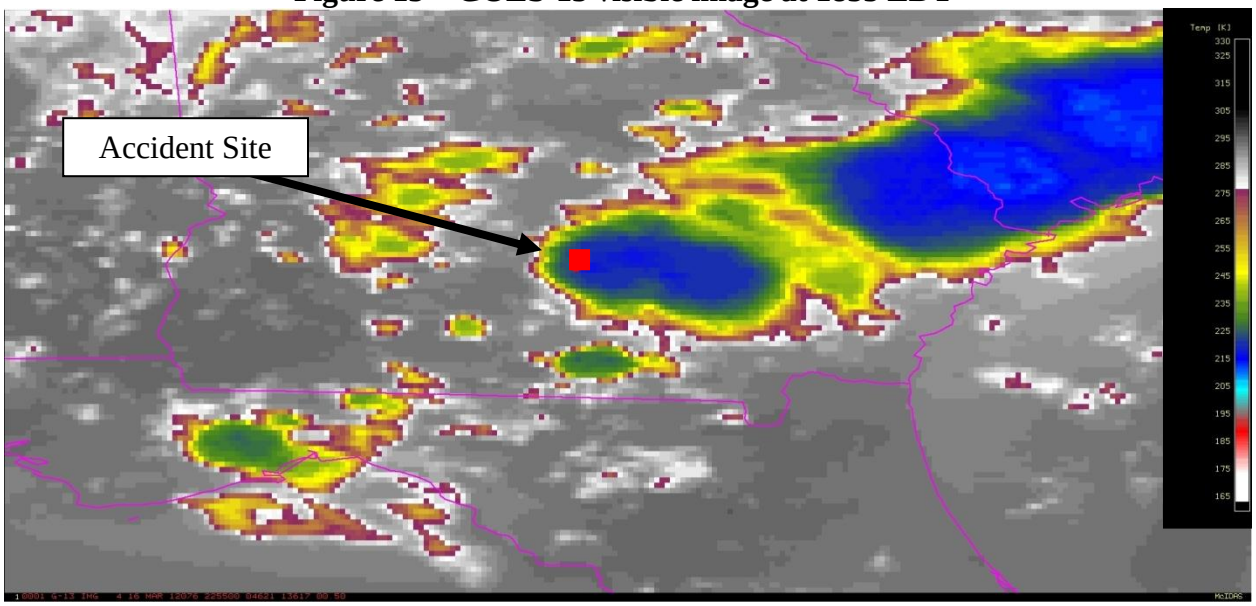


Figure 14 – GOES-13 infrared image at 1855 EDT

6.0 Radar Imagery Information

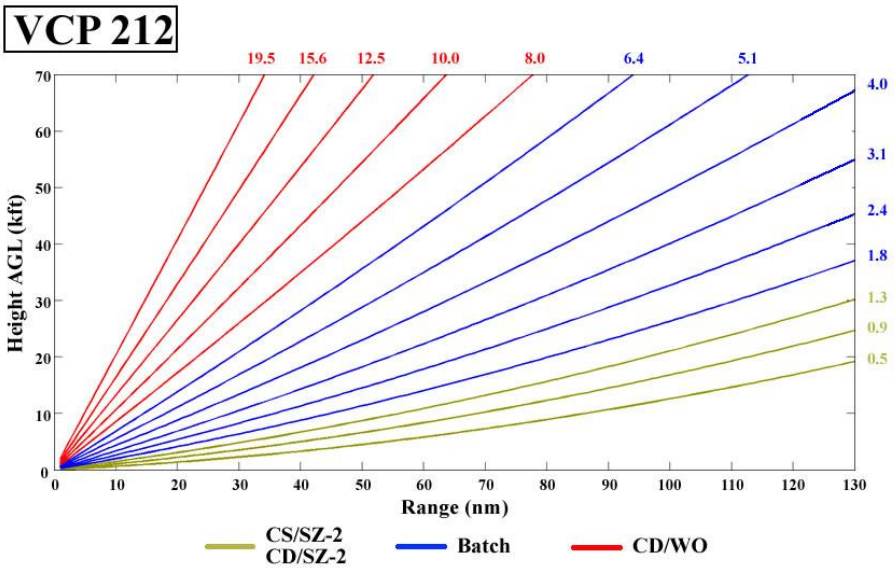
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D) was KVAX located near Moody Air Force Base, Georgia, approximately 52 miles south of the accident site at an elevation of 330 feet (figure 8). Level III archive radar data was obtained from the NCDC utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The 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 into a 0.95° beam width[18]. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

6.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the five to ten minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has two common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 212 (VCP-212). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident, the KVAX WSR-88D radar was operating in the normal precipitation mode (Mode A, VCP-212). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.



VCP-212 Precipitation Mode Scan Strategy

[18] Beam width – A measure of the angular width of a radar beam.

6.2 Beam Height Calculation

Assuming standard refraction[19] of the WSR-88D 0.95° wide radar beam, 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°	5,040 feet	2,480 feet	7,600 feet	5,130 feet
2.4°	15,480 feet	12,920 feet	18,040 feet	5,130 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 2,480 feet to 7,600 feet msl over the accident site, while the 2.4° elevation scan depicted the conditions between 12,920 feet to 18,040 feet msl over the accident site.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[20] 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 (dBZ[21]), 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.

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

[20] 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.

[21] 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.

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	

The Federal Aviation Administration (FAA) Advisory Circular AC 00-24B titled "Thunderstorms" dated January 2, 1983, also defines the echo intensity levels and potential weather phenomena associated with those levels. If the maximum VIP Level is 1 "weak" and 2 "moderate", then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very heavy" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts and turbulence.

6.4 Radar Summary

Figure 15 provides a radar summary image from 1845 EDT with reflectivity values over the southern United States, with the accident site co-located with 40 to 55 dBz values. These reflectivity values combined with the satellite imagery (figures 10 through 14) and lightning data (Section 6.6) indicated a strong thunderstorm or cluster of thunderstorms at the accident site around the accident time.

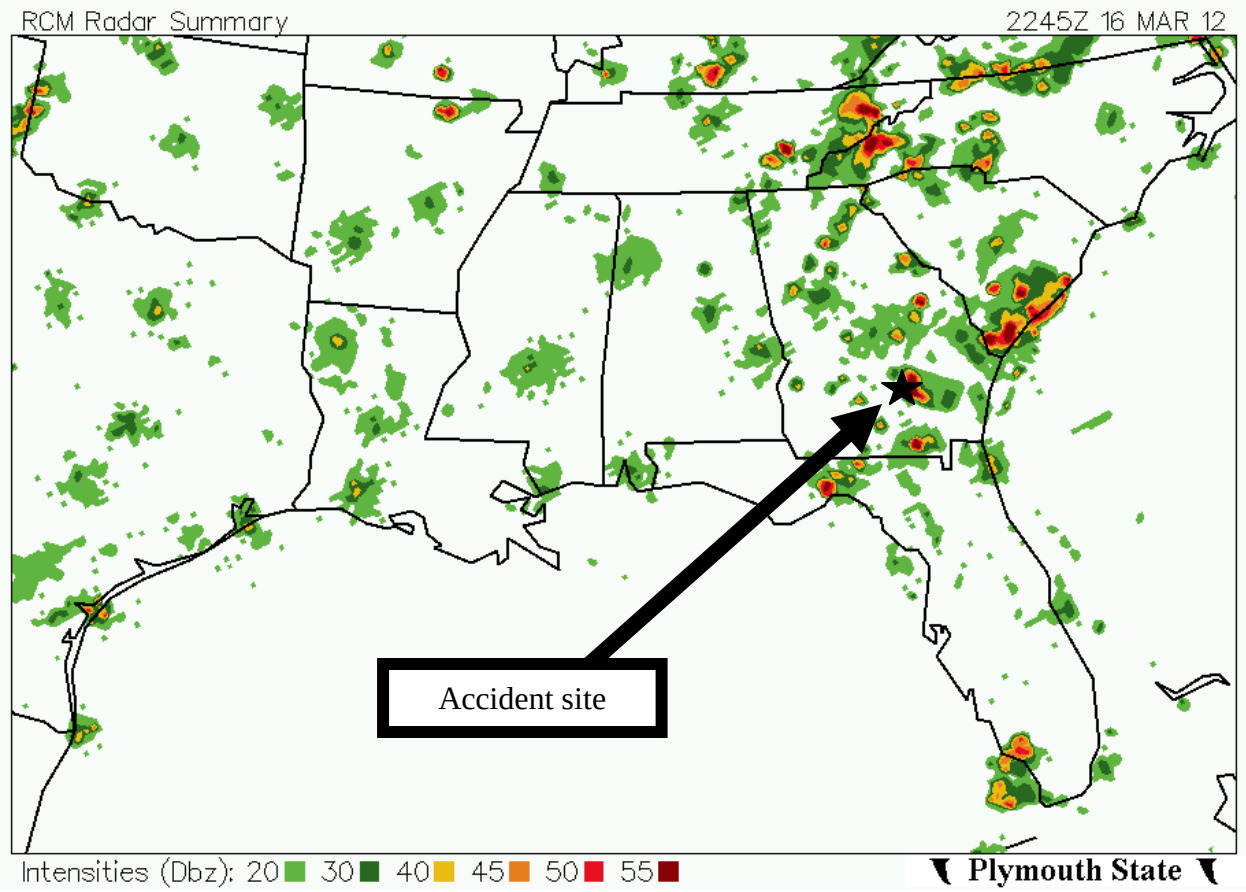


Figure 15 – Radar summary image for 1845 EDT with the accident site

6.5 Base Reflectivity

Figures 16 and 17 present the KVAX WSR-88D base reflectivity image for the 0.5° and 2.4° elevation scans initiated at 1855 EDT with a resolution of 1.0° X 250 m. Figure 16 depicted 35 to 55 dBz values at the accident site which would correspond to moderate to extreme intensity levels based on the NWS VIP scale. An outflow boundary was also present southwest of the accident site and this outflow boundary could also enhance areas of vertical motion and be a focal point for turbulence. The 2.4° elevation scan also depicted 35 to 55 dBz values 12,000 to 18,000 feet above the accident location (figure 17) and these values indicate moderate to extreme conditions where severe turbulence, lightning, large hail, and extensive wind gusts would be expected.

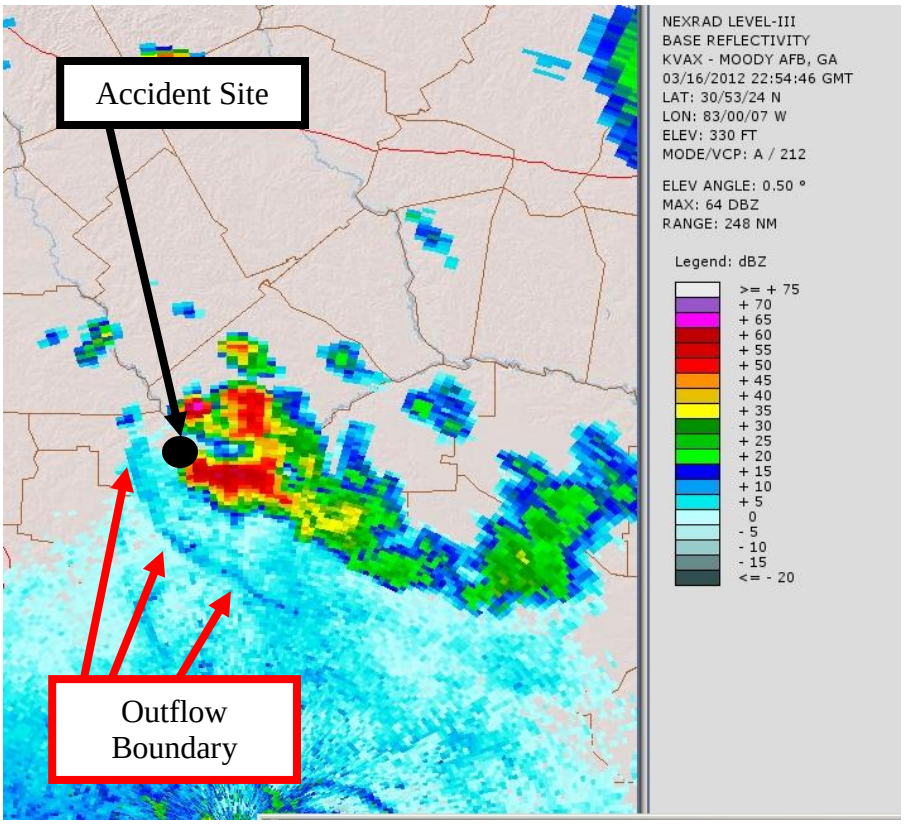


Figure 16 – KVAX WSR-88D reflectivity for the 0.5° elevation scan for 1855 EDT

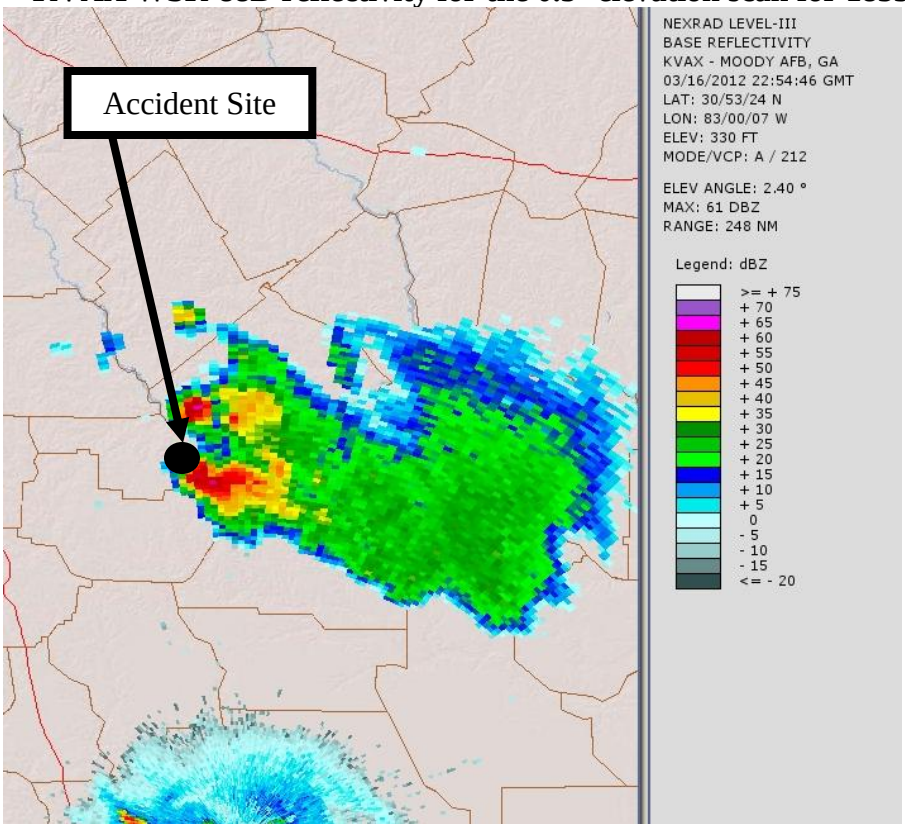


Figure 17 – KVAX WSR-88D reflectivity for the 2.4° elevation scan for 1855 EDT

6.6 Lightning Data

Lightning flash[22] data from 1841 to 1911 EDT is plotted as black dots on the 0.5° and 2.4° base reflectivity image initiated at 1855 EDT (figures 18 and 19). The images depicted a thunderstorm over the accident site at the accident time as over 1,040 lightning flashes were recorded over the 30 minute period surrounding the accident time, with over 560 lightning flashes recorded in the 15 minutes prior to the accident time.

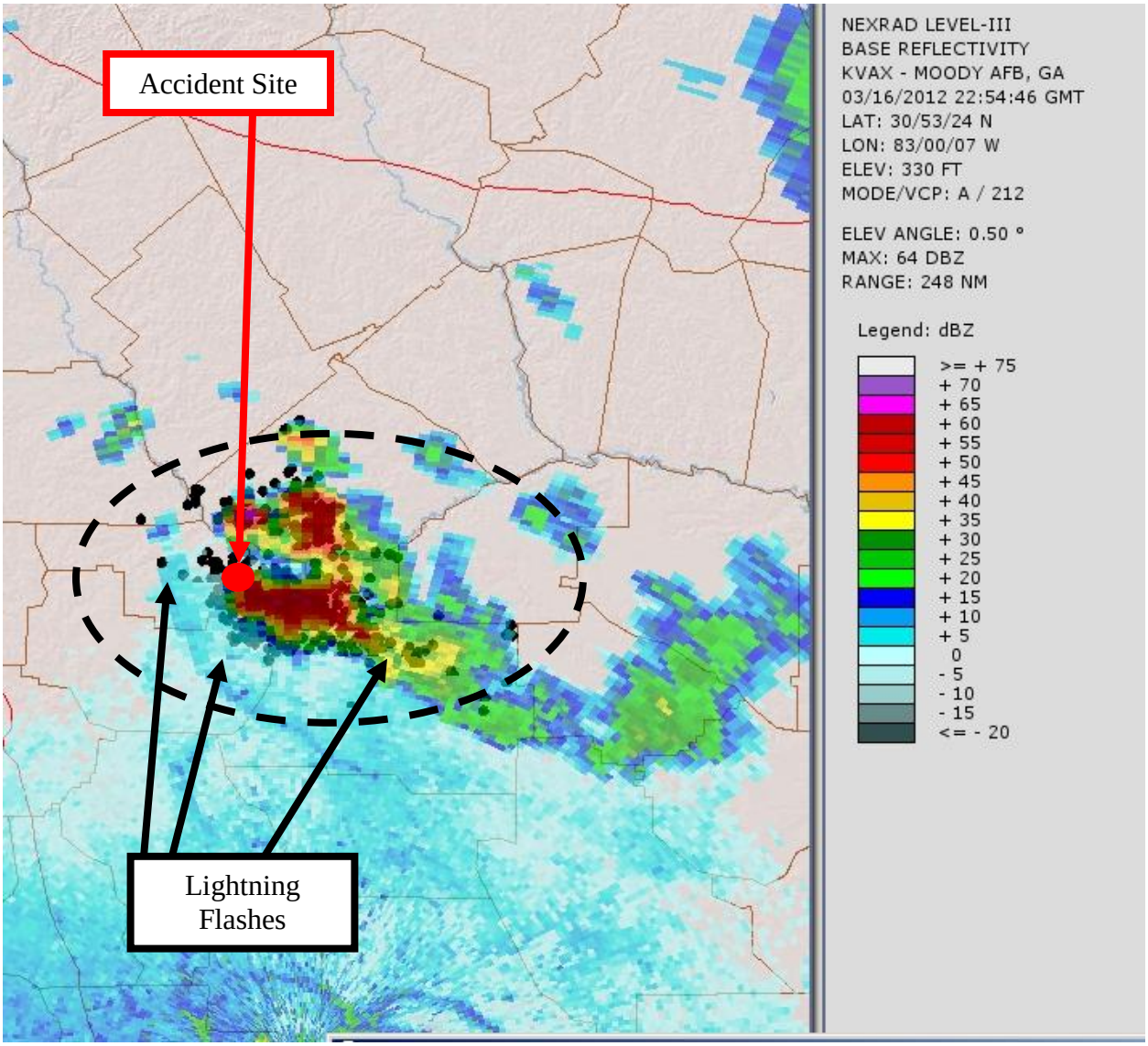


Figure 18 – KVAX WSR-88D reflectivity for the 0.5° elevation scan for 1855 EDT with the 30 minute lightning data surrounding the accident time

[22] 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.

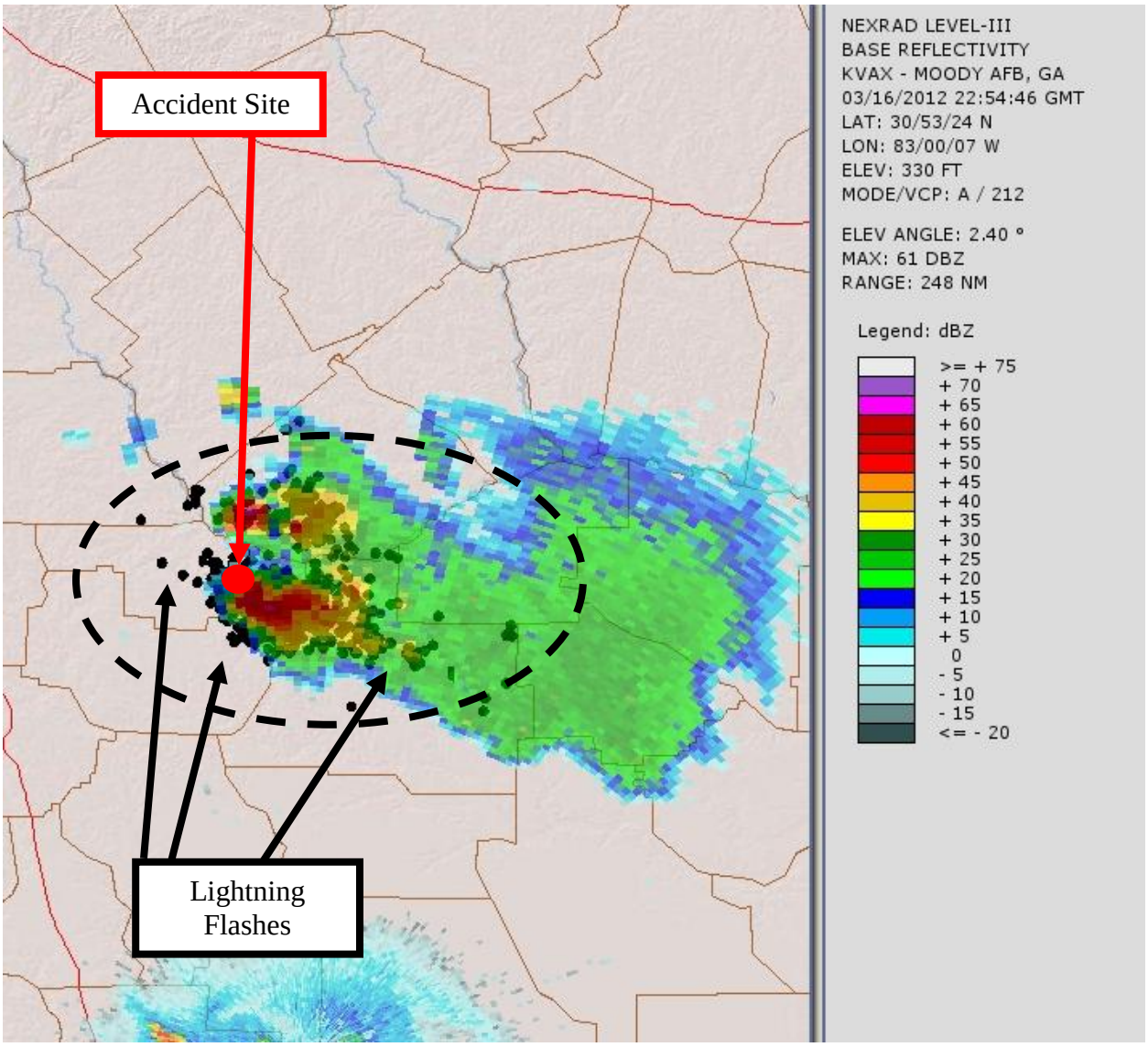


Figure 19 – KVAX WSR-88D reflectivity for the 2.4° elevation scan for 1855 EDT with the 30 minute lightning data surrounding the accident time

6.7 Dual-Polarization Weather Radar Data

The closest NWS WSR-88D with Dual-Polarization (dual-pol) technology was KJGX located near Robins Air Force Base, Georgia, approximately 57 miles north of the accident site at an elevation of 618 feet msl (figure 8). Level III archive radar data was obtained from the NCDC utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The 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 into a beam width between 0.87° and 0.96°. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width. The KJGX WSR-88D also produced: differential reflectivity (Zdr), correlation coefficient (CC), specific differential phase (Kdp), and the hydrometeor classification algorithm (HC) having been upgraded with dual-pol technology.

6.8 Volume Scan Strategy

The KJGX WSR-88D was operating in VCP-212 around the time of the accident just as KVAX was and for further information on VCP-212 see Section 6.1.

6.9 Beam Height Calculation

Assuming standard refraction of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width information[23] of the radar display over the site of the accident[24]. The heights in msl have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	6,000 feet	3,190 feet	8,810 feet	5,620 feet
1.3°	10,810 feet	8,000 feet	13,620 feet	5,620 feet
2.4°	17,440 feet	14,630 feet	20,250 feet	5,620 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 3,190 feet to 8,810 feet msl over the accident site, the 1.3° elevation scan depicted the conditions between 8,000 feet to 13,620 feet msl over the accident site, and the 2.4° elevation scan depicted the conditions between 14,630 feet to 20,250 feet msl over the accident site.

6.10 Zdr, CC, and HC[25]

Zdr is the logarithm ratio of the horizontal power return to the vertical power return. Positive values of Zdr indicate that there is more horizontal power return than vertical power return[26]. A negative value of Zdr indicates that there is more vertical power return than horizontal power return indicating that the dominant hydrometeors are larger in the vertical than in the horizontal[27]. Near zero values of Zdr indicate that both the horizontal and vertical power return

[23] Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.
[24] Calculations made using the NWS Warning Decision Training Branch (WDTB) online beamwidth calculator assuming a standard atmosphere.
[25] Definitions for Zdr, CC, Kdp, and HC adapted from training material from the NWS WDTB.
[26] A positive Zdr means that the dominant hydrometeors within the volume are larger in the horizontal than vertical (i.e. rain drops).
[27] A negative Zdr correlates to vertically oriented hydrometeors, i.e. vertically oriented crystals or conical graupel.

from with the volume scanned are of similar values, meaning the dominant hydrometeors are similar in size in both the vertical and horizontal[28].

CC is a measure of how similar the horizontal and vertical returned pulse characteristics are among all pulses in the sampled WSR-88D volume. CC provides information about the diversity of hydrometeors within the volume and the values range from 0 to 1[29]. Meteorological echoes tend to have CC values greater than 0.80, with values greater than 0.96 indicating that the meteorological targets within the volume are all very similar in size, shape, type (liquid versus solid), and orientation. CC values between 0.96 and 0.80 indicate that the meteorological targets within the volume have a higher diversity of sizes, shapes, types, and orientations as the CC trends lower. If hail is located within the volume scanned the CC values are typically between 0.80 and 0.96. Non-meteorological echoes have CC values less than 0.80 and these non-meteorological echoes can include but are not limited to bugs, chaff, smoke, and birds.

HC is a product produced by the hydrometeor classification algorithm and the HC attempts to discriminate between 10 classes of radar echoes at every 250 m range bin. HC ingests reflectivity, Zdr, CC, Kdp, and velocity, along with radially averaged and smoothed fields of reflectivity and differential phase. HC then uses the height of the melting layer (which around the accident time was around 11,000 feet msl at KTLH, figure 9) along with the previous data and assigns a radar class to each bin with a weighted value. The HC then applies a set of hard thresholds to reduce the number of clearly wrong class designations, and given the weight and likelihood of each of the 10 classes at each bin, the HC assigns the radar classification with the highest likelihood value to that particular bin.

6.11 Dual-Pol Imagery

Figure 20 presents the KJGX WSR-88D reflectivity image for the 0.5°, 1.3°, and 2.4° elevation scans initiated at 1848 EDT with a resolution of 1.0° X 250 m. It depicted 35 to 60 dBz values from 3,190 feet through 20,250 feet at the accident site indicative of a strong to extreme thunderstorm. The CC at the same elevation scans, also initiated at 1848 EDT, had values around 0.97 and 0.96 at 0.5° and 1.3°, with values around 0.99 at 2.4° (figure 21). Zdr values at 0.5° ranged from 1.50 dB to around 3.0 dB, with values ranging from 0.50 dB to 2.0 dB at 1.3°, and values around 0.0 dB at 2.4° (figure 22). With reflectivity, CC, and Zdr values in those ranges from approximately 3,000 feet to 9,000 feet a mix of rain and hail would be expected (figure 23a), between 9,000 feet and 13,500 feet a mix of dry snow, wet snow, and graupel would be expected (figure 23b), and between 14,500 feet and 20,000 feet a mix of dry snow and graupel would be expected at the accident site (figure 23c).

[28] A near zero Zdr is often an indication of hail or spherical rain drops.
[29] CC values greater than 1 indicate an untrustworthy signal due to low signal-to-noise ratio in areas of weak reflectivity.

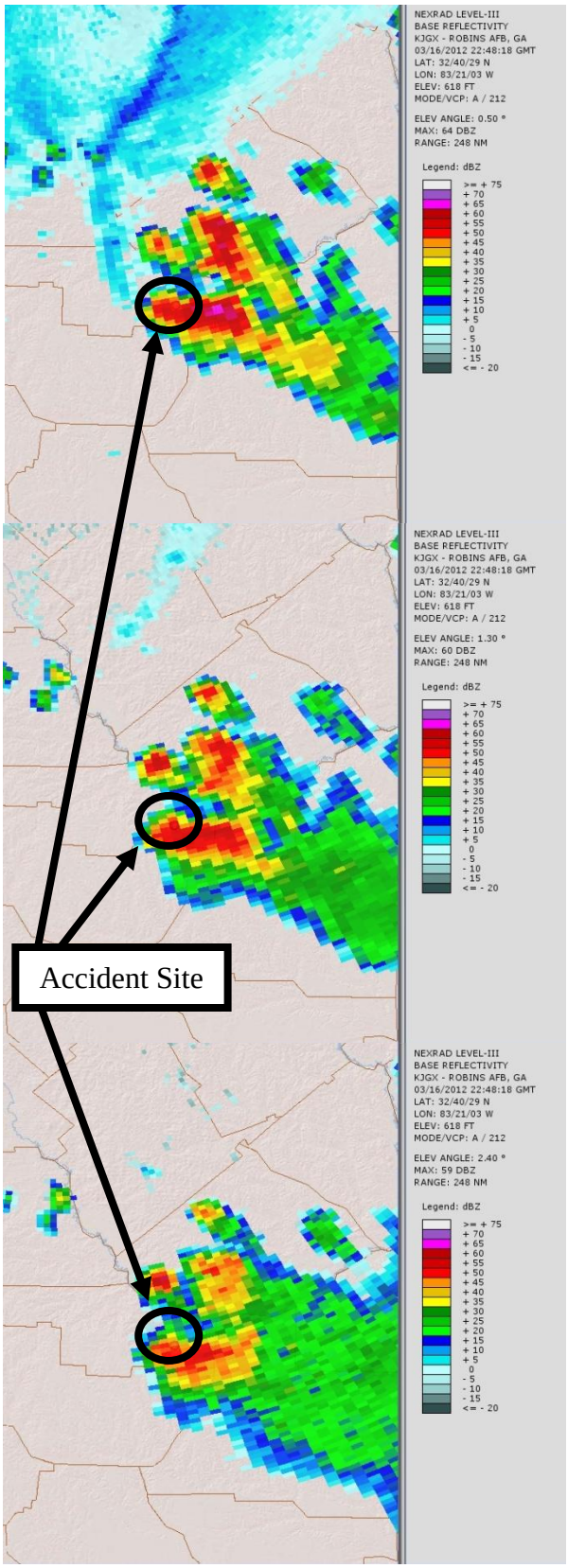


Figure 20 – KJGX WSR-88D reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1848 EDT

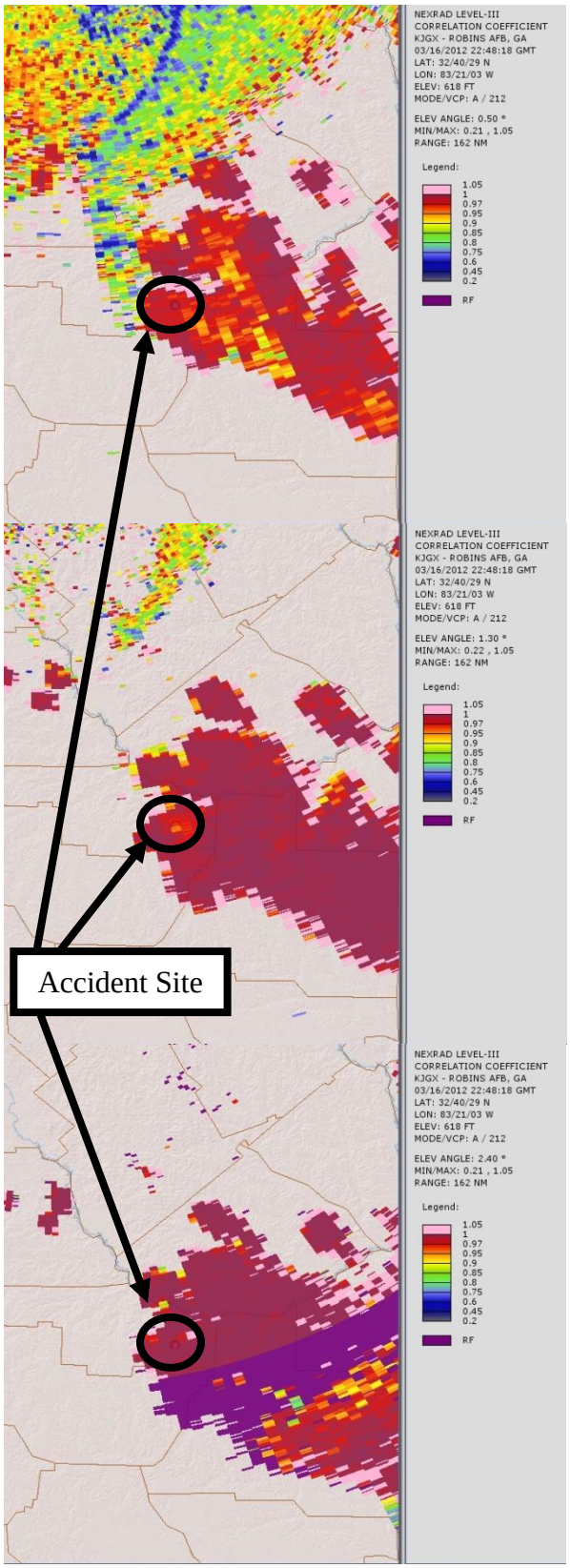


Figure 21 – KJGX WSR-88D correlation coefficient for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1848 EDT

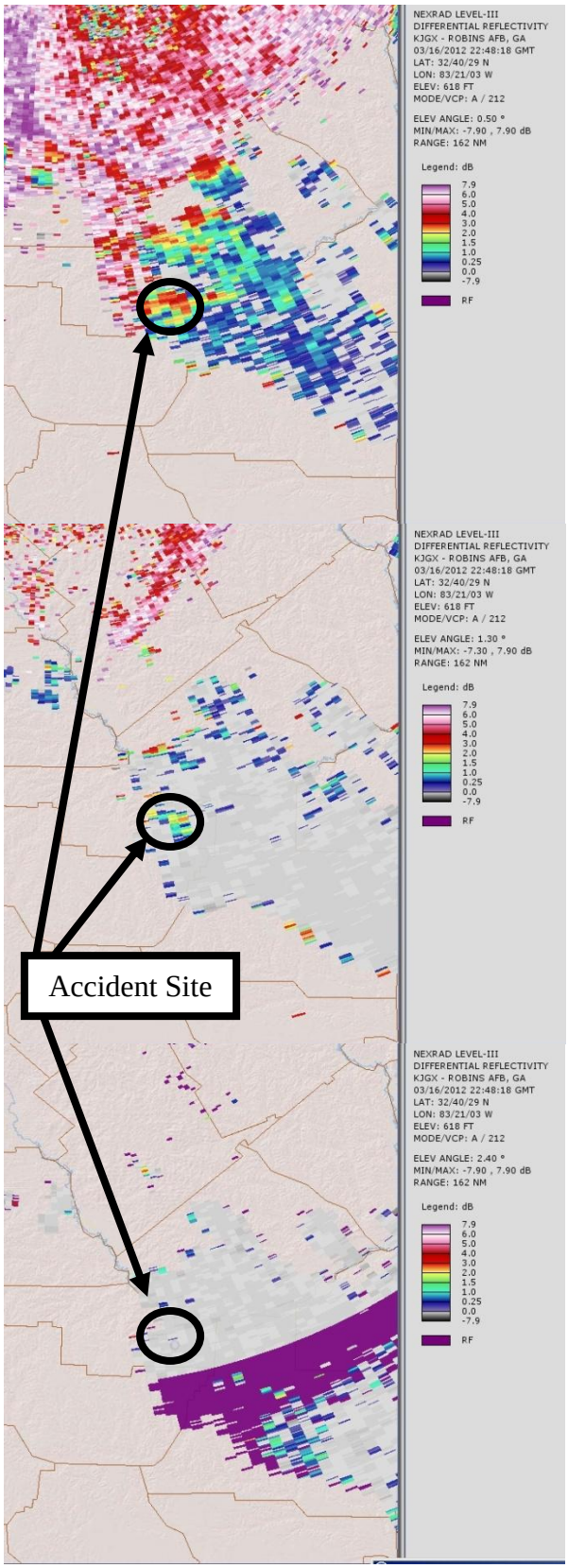


Figure 22 – KJGX WSR-88D differential reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1848 EDT

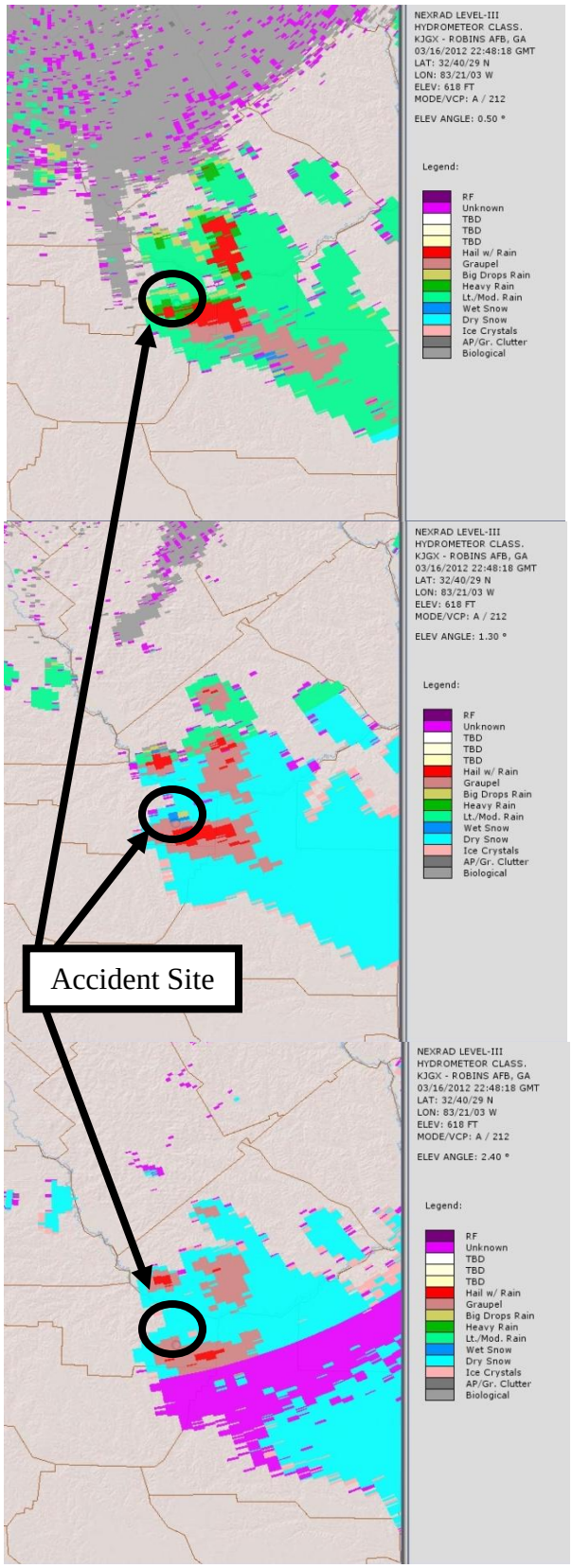


Figure 23 – KJGX WSR-88D hydrometeor classification for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1848 EDT

Figure 24 presents the KJGX WSR-88D reflectivity image for the 0.5°, 1.3°, and 2.4° elevation scans initiated at 1853 EDT. It depicted 35 to 55 dBz values from 3,190 feet through 20,250 feet at the accident site indicative of the strong to extreme thunderstorm continuing over the accident site. The CC at the same elevations scans, also initiated at 1853 EDT, had values around 0.96 and 0.97 at 0.5° and 1.3°, with values around 0.99 at 2.4° (figure 25). Zdr values at 0.5° ranged from 2.0 dB to around 3.5 dB, with values ranging from 0.50 dB to 2.0 dB at 1.3°, and values around 0.0 dB at 2.4° (figure 26). With reflectivity, CC, and Zdr values in those ranges from approximately 3,000 feet to 9,000 feet a mix of rain and hail would be expected (figure 27a), between 9,000 feet and 13,500 feet a mix of dry snow, wet snow, graupel, and hail would be expected (figure 27b), and between 14,500 feet and 20,000 feet a mix of dry snow, graupel, and hail would be expected at the accident site (figure 27c).

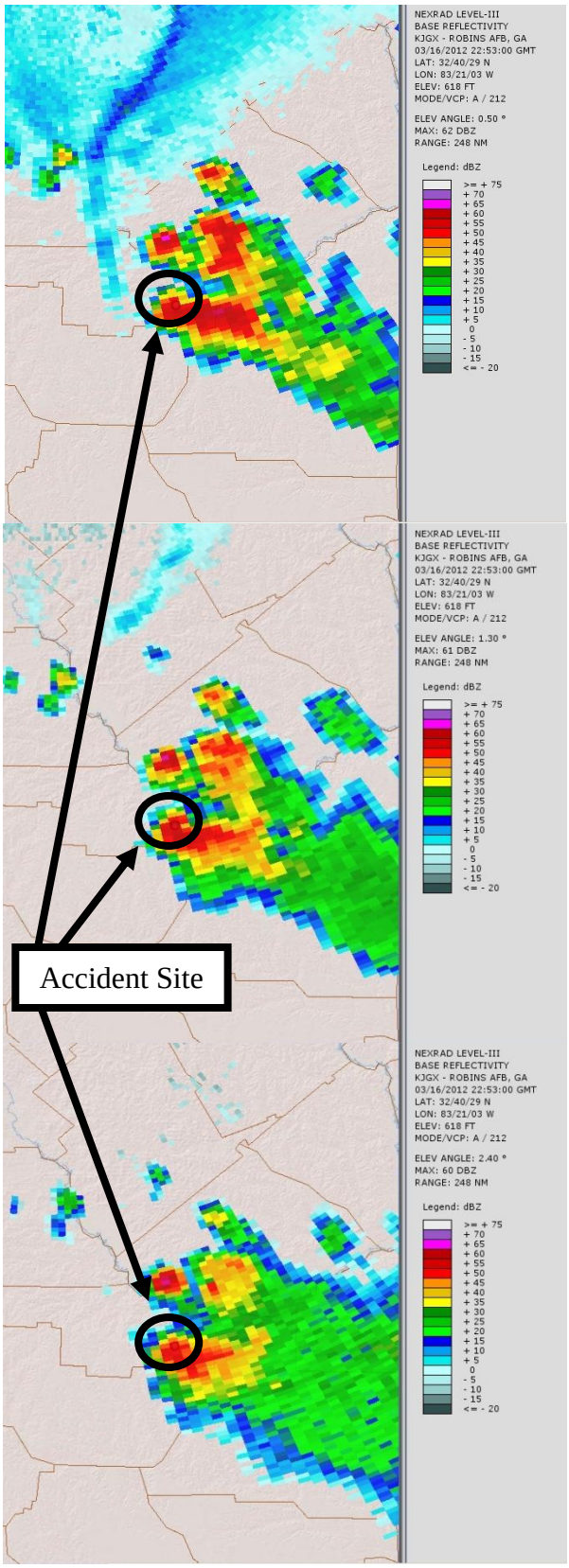


Figure 24 – KJGX WSR-88D reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1853 EDT

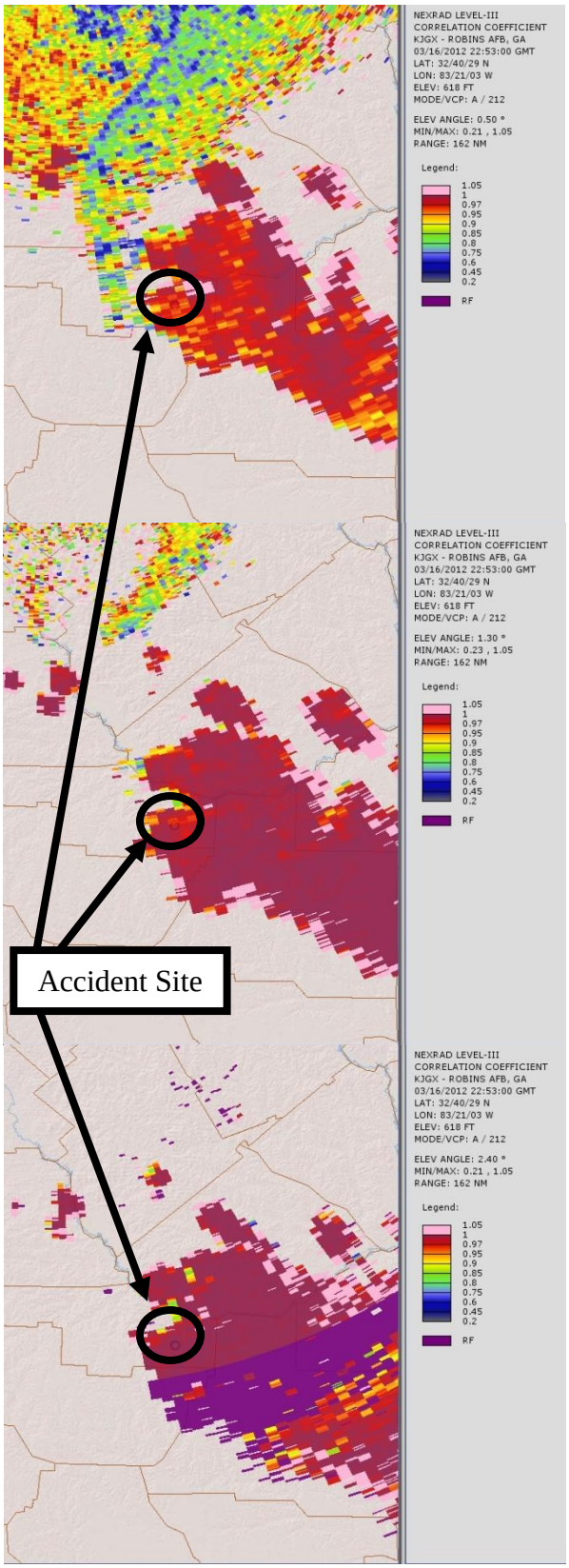


Figure 25 – KJGX WSR-88D correlation coefficient for the (a) 0.5°, (b) 1.3°, and (c) 2.4°elevation scans for 1853 EDT

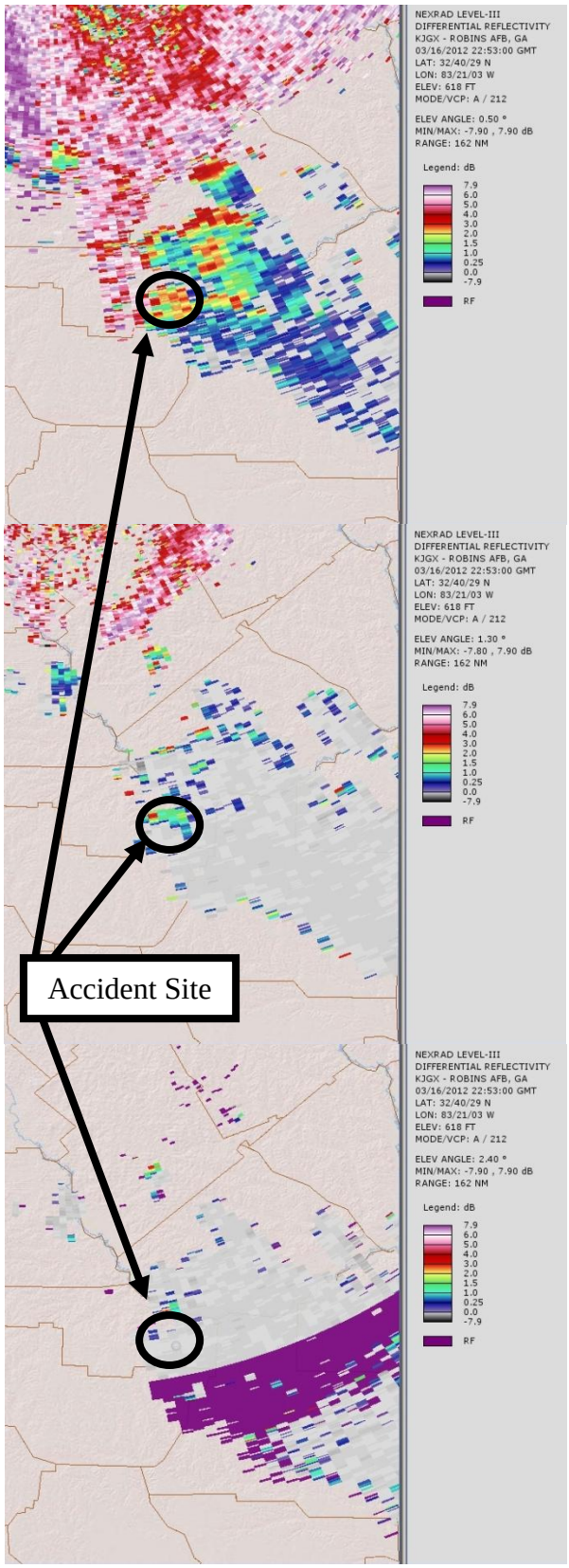


Figure 26 – KJGX WSR-88D differential reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1853 EDT

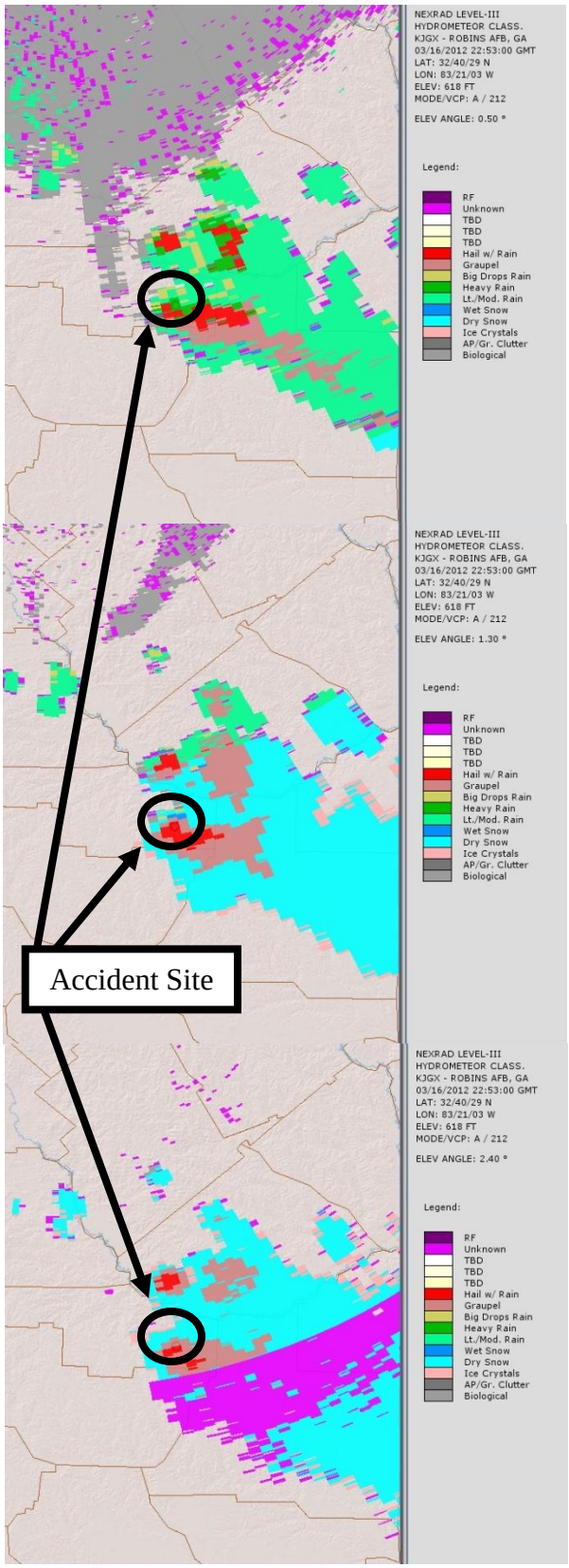


Figure 27 – KJGX WSR-88D hydrometeor classification for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1853 EDT

Figure 28 presents the KJGX WSR-88D reflectivity image for the 0.5°, 1.3°, and 2.4° elevation scans initiated at 1858 EDT. It depicted 30 to 60 dBz values from 3,190 feet through 20,250 feet at the accident site indicative of the strong to extreme thunderstorm continuing over the accident site around the accident time. The CC at the same elevations scans, also initiated at 1858 EDT, had values around 0.95 and 0.97 at 0.5° and 1.3°, with values around 0.98 at 2.4° (figure 29). Zdr values at 0.5° ranged from 1.0 dB to around 3.0 dB, with values ranging from 0.00 dB to 3.0 dB at 1.3°, and values around 0.6 dB at 2.4° (figure 30). With reflectivity, CC, and Zdr values in those ranges from approximately 3,000 feet to 9,000 feet a mix of rain and hail would be expected (figure 31a), between 9,000 feet and 13,500 feet a mix of dry snow, graupel, and hail would be expected (figure 31b), and between 14,500 feet and 20,000 feet a mix of dry snow, graupel, and hail would be expected at the accident site (figure 31c).

One area on the northwest side of the accident location had CC values around 0.92 on the 2.4° elevation scan at 1858 EDT (figure 29c) with CC values below 0.97 at both 1.3° and 0.5° (figure 29b,a). In addition, Zdr values on the 2.4° elevation scan were between 0 and 1.5 dB (figure 30c) in the area on the northwest side of the accident location with Zdr values of 3.0 dB on the 1.3° elevation scan (figure 30b). From 1848 through 1858 EDT, the Zdr values increase on the 1.3° and 2.4° elevation scans in this area on the northwest side of the accident location (figures 22b, 26b, and 30b) with the CC values decreasing from 1848 through 1858 EDT on the 2.4° elevation scan and this would be indicative of a Zdr column and the location of an updraft. A Zdr column is an area were liquid precipitation is lofted above the environmental freezing level (around 11,000 feet msl around the accident time, figure 9) by an updraft and is indicated on a WSR-88D as a local area of reflectivity values above 25 dBz, Zdr values greater than 1.5 dB, and CC values greater than 0.85. This area in the dual-pol radar imagery on the northwest side of the accident location is the same location mentioned by the accident pilot that he was ascending in an updraft with hail hitting the accident aircraft (see Interview Summaries[30]).

[30] Interview Summaries are available in the official docket for ERA12LA231.

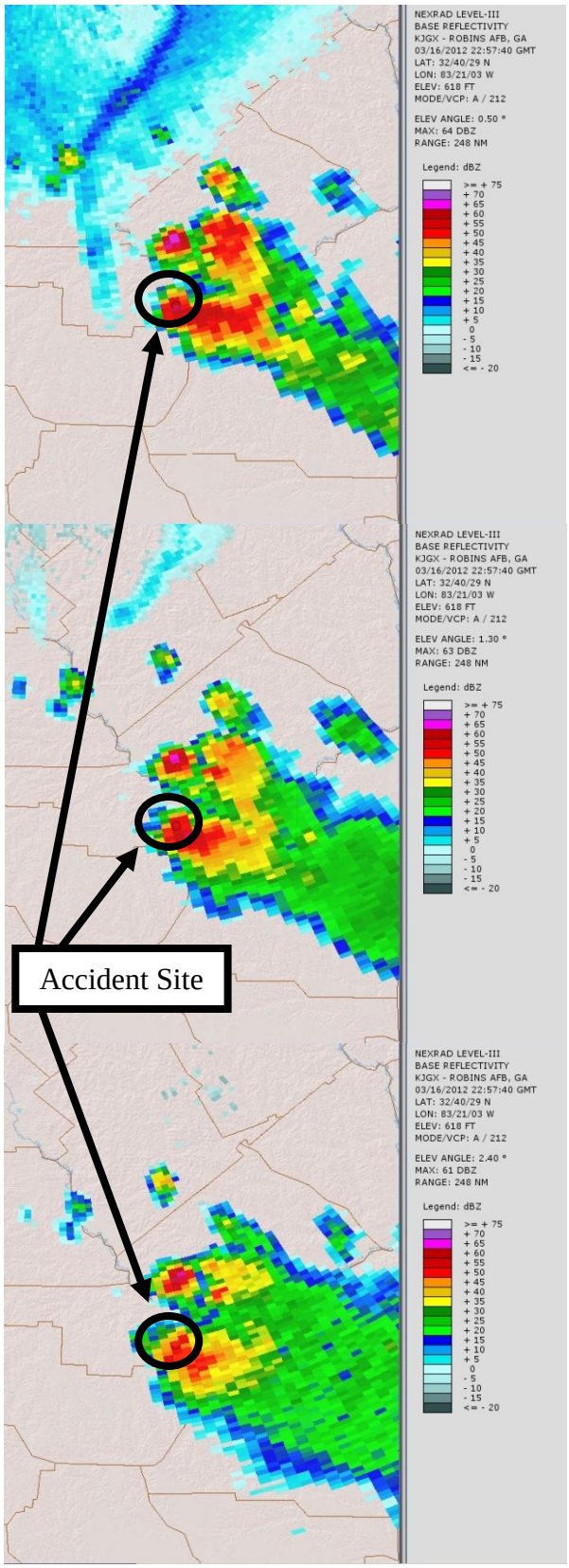


Figure 28 – KJGX WSR-88D reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1858 EDT

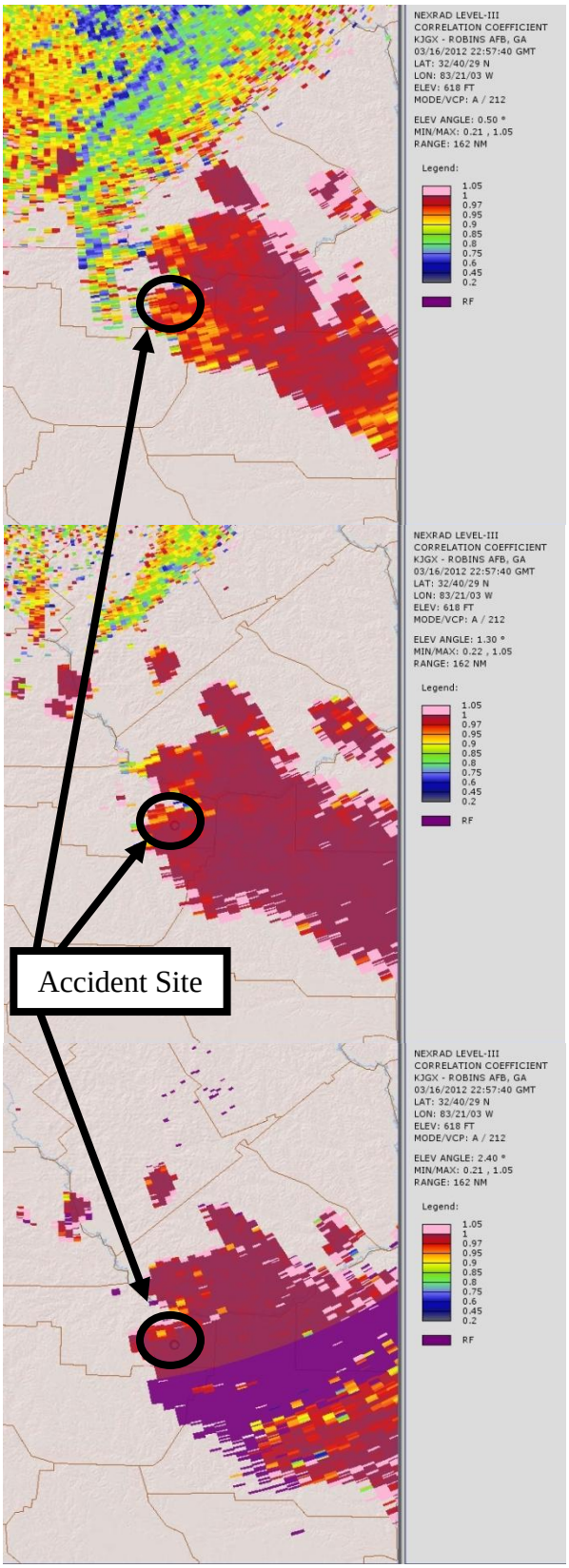


Figure 29 – KJGX WSR-88D correlation coefficient for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1858 EDT

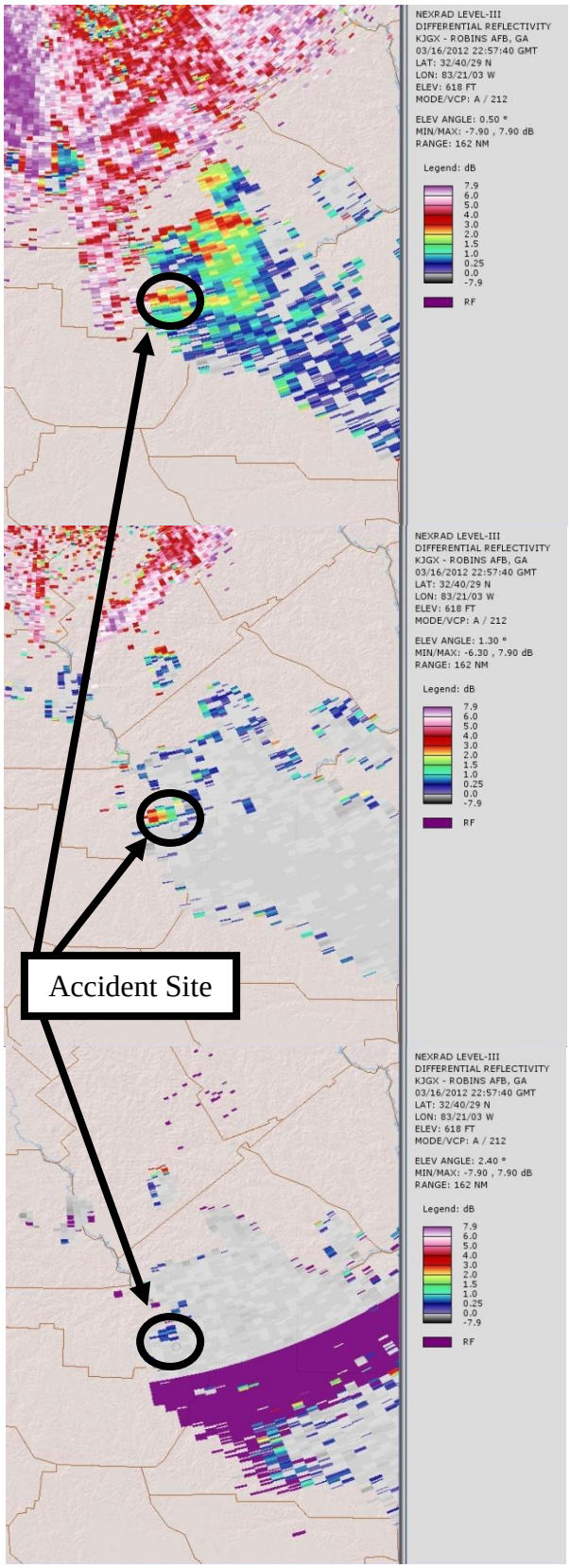


Figure 30 – KJGX WSR-88D differential reflectivity for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1858 EDT

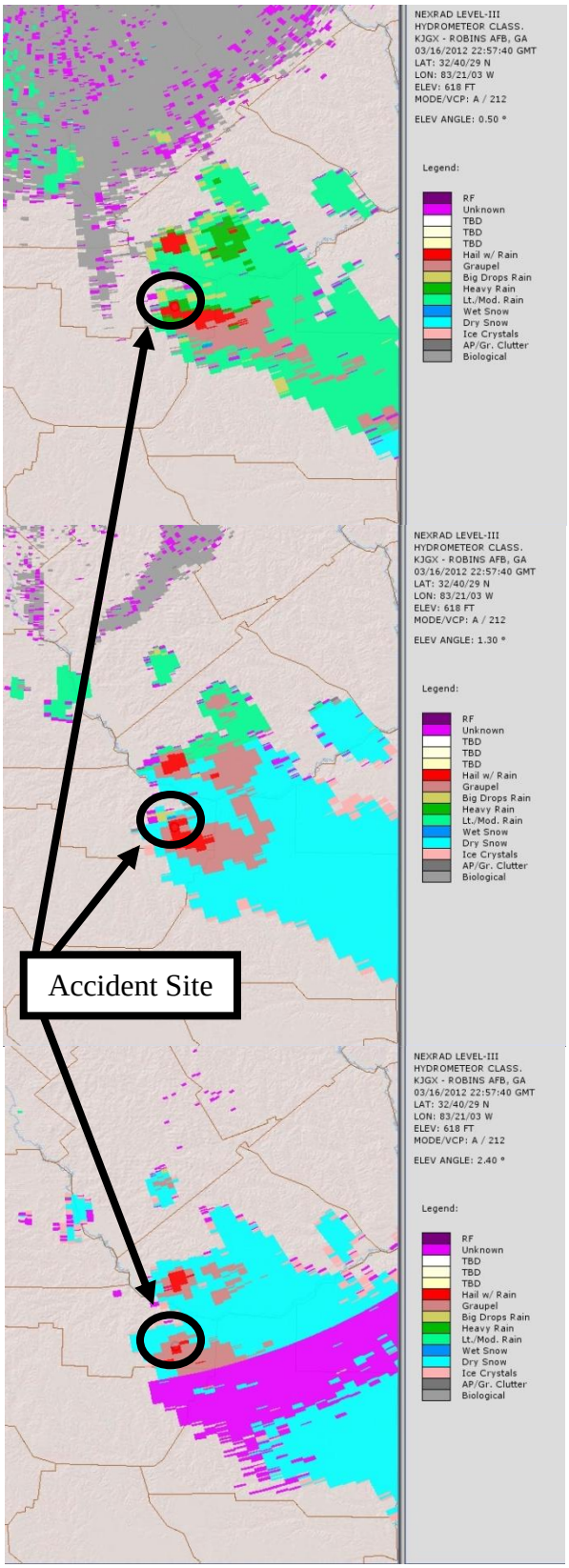


Figure 31 – KJGX WSR-88D hydrometeor classification for the (a) 0.5°, (b) 1.3°, and (c) 2.4° elevation scans for 1858 EDT

7.0 Pilot Reports

Pilot reports (PIREPs) were reviewed from six hours prior to the accident time to six hours after the accident time below 30,000 feet and no PIREPs were disseminated.

8.0 SIGMET and CWSU Advisory

SIGMET 57E was active for the accident site at the accident time warning of severe thunderstorms moving from 290° at 15 knots, with tops to FL450[31], hail to 1 inch in diameter, and wind gusts to 50 knots possible (figure 32):

WSUS31 KKCI 162255
CONVECTIVE SIGMET 57E
VALID UNTIL 0055Z
SC GA
FROM 30ESE CAE-30ENE CHS-30ESE AMG-40W AMG-30ESE CAE
AREA SEV TS MOV FROM 29015KT. TOPS TO FL450.
HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

One hour prior to issuing SIGMET 57E, SIGMET 53E was issued warning of severe thunderstorms moving from 290° at 15 knots, with tops to FL450, hail to 1 inch in diameter, and wind gusts to 50 knots possible (figure 32):

WSUS31 KKCI 162155
CONVECTIVE SIGMET 53E
VALID UNTIL 2355Z
SC GA
FROM 30ESE CAE-30NE CHS-40SSE AMG-40WNW AMG-30ESE CAE
AREA SEV TS MOV FROM 29015KT. TOPS TO FL450.
HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

No CWSU Advisory or Meteorological Impact Statement was active for the accident site at the accident time.

[31] Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. 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.

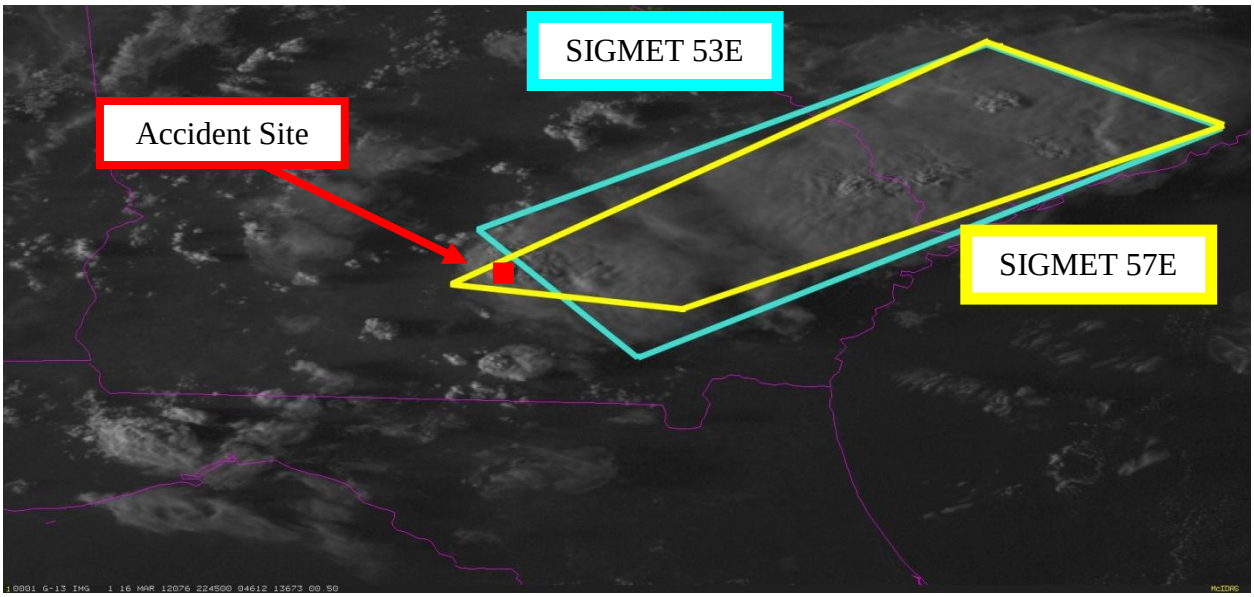


Figure 32 – GOES-13 visible satellite image from 1845 EDT with SIGMETs 53E (blue) and 57E (yellow)

9.0 AIRMETs

No AIRMETs were active for the accident site at the accident time below 30,000 feet.

10.0 Terminal Aerodrome Forecast

KABY (figure 8) was the closest site with a NWS Terminal Aerodrome Forecast (TAF[32]). The TAF valid at the time of the accident was issued at 1327 EDT and was valid for a 24-hour period beginning at 1400 EDT. The TAF forecast for KABY was as follows:

KABY 161727Z 1618/1718 24006KT P6SM SCT050CB SCT100
FM170300 00000KT P6SM SCT050
FM171500 22006KT P6SM SCT040CB=

The forecast expected wind from 240° at 6 knots, greater than 6 miles visibility, scattered cumulonimbus clouds at 5,000 feet agl, and scattered clouds at 10,000 feet.

11.0 Area Forecast

The updated Area Forecast issued at 1540 EDT forecasted an overcast ceiling at 10,000 feet msl with the clouds tops to FL200 and isolated thunderstorms with tops to FL400 for southwestern Georgia. The Area Forecast for southeastern Georgia expected scattered clouds at 5,000 feet and widely scattered thunderstorms with tops to FL400:

FAUS42 KKCI 161940 AAA 2012076 1941
FA2W

[32] Terminal Aerodrome Forecast (TAF) – These forecasts apply to a five statute mile radius from the center of the airport runway complex where the TAF is valid.

_MIAC FA 161940 AMD
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 171200
CLDS/WX VALID UNTIL 170600...OTLK VALID 170600-171200
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...WK RDG OVR FA RGN THRU PD.
.
NC
MTNS...OVC080 LYRD FL200. WDLY SCT -SHRA/-TSRA. CB TOP FL400.
00Z BKN CI. OTLK...VFR BECMG 07Z MVFR BR.
PIEDMONT...OVC060 LYRD FL200. SCT -SHRA/WDLY SCT -TSRA. CB TOP
FL400. 00Z OVC100. OTLK...VFR.
NRN CSTL PLAIN...SCT070. 22Z OVC100 TOP FL200. TIL 05Z SCT
-SHRA/ISOL -TSRA. CB TOP FL400. OTLK...VFR.
SRN CSTL PLAIN...SCT040 BKN150 TOP FL200. ISOL -SHRA/-TSRA. CB
TOP FL400. 00Z OVC100 TOP FL200. ISOL -SHRA/-TSRA. OTLK...VFR
BECMG 09Z MVFR BR.
.
SC...UPDT
MTNS...OVC070 LYRD FL200. WDLY SCT -TSRA. CB TOP FL400. 00Z BKN
CI. OTLK...VFR.
PIEDMONT...OVC050 LYRD FL200. WDLY SCT -TSRA. CB TOP FL400. 01Z
SCT100. OTLK...VFR.
CSTL PLAIN...SCT040. WDLY SCT -TSRA. CB TOP FL400. 02Z SCT060.
OTLK...VFR.
.
GA...UPDT
NRN...SCT060 BKN CI. WDLY SCT -TSRA. CB TOP FL400. 02Z SCT080.
OTLK...VFR.
SWRN...OVC100 TOP FL200. TIL 03Z ISOL -TSRA. CB TOP FL400.
OTLK...VFR.
SERN...SCT050. WDLY SCT -TSRA. CB TOP FL400. 01Z SCT060.
OTLK...VFR.
.
FL
WRN PNHDL...SKC. 03Z BKN CI. OTLK...VFR.
ERN PNHDL...OVC100 TOP FL200. ISOL -TSRA. CB TOP FL400. 02Z
SCT100. OTLK...VFR.
NRN PEN...SCT060. ISOL -TSRA. CB TOP FL400. 00Z SCT CI.
OTLK...VFR.
CNTRL PEN...SCT050. 02Z SKC. OTLK...VFR.
SWRN PEN...SCT040 SCT CI. OTLK...VFR.
SERN PEN...OVC050 LYRD FL200. ISOL -SHRA/-TSRA. CB TOP FL400.
01Z SCT100. OTLK...VFR.
KEYS...SCT020. OTLK...VFR.
.
CSTL WTRS
ATLC WTRS
NC/SC...SCT040. ISOL -TSRA. CB TOP FL400. 03Z SCT060.
OTLK...VFR.
GA/NRN FL...SKC. OTLK...VFR.

SRN FL...SCT050. ISOL -TSRA. CB TOP FL400. 01Z SCT100.
OTLK...VFR.
GULF WTRS E OF 85W...SKC. OTLK...VFR.
....

12.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Tallahassee, Florida, issued the following Area Forecast Discussion at 1428 EDT which discussed isolated showers and thunderstorms beginning to develop across central Alabama and Georgia. Isolated thunderstorms were expected to continue through the afternoon with small hail possible in the stronger storms. VMC[33] conditions were expected to continue to prevail in areas with no shower or thunderstorm activity:

AFDTAE
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TALLAHASSEE FL
228 PM EDT Fri Mar 16 2012
.SYNOPSIS...
As of 2 PM EDT, temperatures had soared into the lower to middle 80s for most locations. Subsequently, a scattered CU field has begun to develop along and north of the sea breeze fronts. **Regional radars show showers and thunderstorms beginning to develop out ahead of an MCV located across central Alabama and Georgia. Although the radar is quiet locally, still expect isolated shower and thunderstorm development later this afternoon.**
&&
.NEAR TERM (THROUGH TONIGHT)...
With favorable thermodynamics in place once again this afternoon, expect an isolated storm or two to form along the Florida panhandle and western Big Bend sea breeze fronts. **Isolated thunderstorm can also be expected later this afternoon across SE Alabama and our extreme western Georgia counties as the upper-level disturbance slides in over the region.** Later tonight, the focus will shift to the east where a stray storm or two could be possible along the intersection of the Florida east coast sea breeze and the Gulf coast sea breeze. Overall, coverage of storms is expected to be rather limited. **Like the past couple of evenings, small hail is possible with stronger storms.**
Any storms that do develop will end a few hours after sunset and overnight lows will fall into the upper 50s region-wide. Areas of fog can be expected across the panhandle of Florida late tonight, through dawn.
.SHORT TERM (SATURDAY THROUGH SUNDAY NIGHT)...
As the west coast trough shifts inland across the Great Basin, downstream heights will rise across the eastern U.S. The axis of the current broad flat upper ridge will also ever so slowly edge eastward during this time. This should shift the track of any convectively induced vort centers east as well. Mid level temps are forecast to rise a couple of degrees by Saturday afternoon to about

[33] Visual Meteorological Conditions (VMC) – Weather conditions equal to or better than specifications for Visual Flight Rules (VFR). VFR Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling above 3,000 feet agl and greater than 5 miles visibility.

-14C, so lapse rates will not be quite as steep as recent days. This trend will continue into Sunday. We therefore do not anticipate substantial convective coverage. The most favored area will include our S. Central GA zones. Will go with a 30 PoP there on Saturday and lower it to 20 for Sunday. While thermodynamic profiles will trend toward lower instability, there will still be sufficient lapse rates to allow for some hail in the more robust updrafts in pulse type storms, particularly on Saturday. Also, the storms will be slow movers and locally heavy rain will be possible. Further west and south across our AL and FL zones, the weekend will be primarily dry and warm. Temps will remain well above normal and we continue to go a few degrees above the MOS for max temps, based on recent biases. This translates to mid to upper 80s for most inland locations and upper 70s to lower 80s near the coast. Should be a great beach weekend.

.LONG TERM (MONDAY THROUGH NEXT FRIDAY)...

At the onset of the extended forecast there is excellent model agreement on an amplified synoptic flow pattern with a deep western trough and downstream eastern ridge, with the ridge axis aligned roughly over our local forecast area. The global models have been fairly consistent over the past few days worth of runs showing a cutoff low developing on Tuesday-Wednesday somewhere near the Southern Plains or Ozark region. The main question is related to the timing, and how exactly that will eventually eject to more eastern longitudes. The 16.00z operational runs of the ECMWF and GFS kick the upper level low out fast enough to push a low-level cold front into our area by Thursday or Friday. Meanwhile, the ECMWF Ensemble and GFS Ensemble both show increasing height spreads in that time frame with differing solutions amongst the various perturbed runs. Therefore, there isn't a lot of confidence in a particular cold front timing (or if one will even reach our area at all).

Still, with increasing southeast low-level flow in the latter half of the week and 0-1km mixing ratios forecast to increase from around 8 g/kg on Tuesday to 12 g/kg by Thursday, it seems like we may see increasing rain chances again regardless. PoPs were reintroduced starting on Wednesday mainly for scattered showers in the increasing WAA and moisture advection regime.

Prior to the arrival of increased low cloud cover and moisture, we should see a continuation of the warm weather from the short term period (as discussed above). 500mb heights and 1000-500mb thickness will slowly be falling from Sunday through Tuesday, and therefore it doesn't seem likely that high temperatures will be quite as warm as what we are currently experiencing this week. A blend of ECMWF and GFS MOS numbers yields 83-85F on Monday and 82-83F on Tuesday. This is similar to the previous forecast and not much different than the gridded HPC guidance.

&&

.MARINE (TONIGHT THROUGH WEDNESDAY)...

High pressure will remain in place along the northern Gulf Coast into early next week keeping winds and seas low. Winds will be primarily out of the east or southeast with sea breezes veering the winds near the coast to more directly onshore each afternoon. No headlines are expected through the weekend. The gradient will begin to tighten up a bit by Monday when we will finally begin to see a slight increase in winds and seas. A cold front is expected to approach from the west on Wednesday. Periods of exercise caution

conditions will be possible from Tuesday into Wednesday.
&&
.AVIATION (THROUGH 18Z SATURDAY)...
VFR conditions under partly cloudy skies and light winds will continue through the afternoon today. Isolated thunderstorms are possible across the local area, however impacts to any of our terminals appears low. Patchy fog is expected over the panhandle of Florida tonight, affecting KECP after 06z. VFR conditions are expected once again by mid-morning tomorrow.
&&
.FIRE WEATHER...
Although relative humidities will remain low region-wide for the next several days, RH values will remain above critical levels for Alabama and Georgia. In Florida, RH values will reach critical levels but other necessary criteria will fall short. Thus there are no fire weather concerns for the next couple of afternoons.
&&
.PRELIMINARY POINT TEMPS/POPS...
Tallahassee 59 87 57 86 55 / 20 10 0 10 0
Panama City 62 82 62 82 61 / 10 10 0 10 0
Dothan 59 88 59 88 60 / 20 10 0 10 10
Albany 59 88 60 87 58 / 20 20 10 20 10
Valdosta 60 88 59 87 57 / 20 20 20 20 10
Cross City 58 88 57 85 55 / 20 10 10 10 0
Apalachicola 62 79 61 78 60 / 10 0 0 0 0
&&
.TAE WATCHES/WARNINGS/ADVISORIES...
AL...None.
GA...None.
FL...None.
GM...None.
&&
$$

13.0 Weather Watches and Warnings

No weather watches or warnings were active for the accident site at the accident time.

A severe thunderstorm warning was issued by the National Weather Service Office in Jacksonville, Florida, for areas just east of the accident site at 1759 EDT, with the warning valid through 1845 EDT. The severe thunderstorm was capable of producing quarter size hail and damaging winds in excess of 60 mph at the surface (figure 33):

WUUS52 KJAX 162159
SVRJAX
GAC069-162245-
/O.NEW.KJAX.SV.W.0026.120316T2159Z-120316T2245Z/
BULLETIN - EAS ACTIVATION REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE JACKSONVILLE FL
559 PM EDT FRI MAR 16 2012
THE NATIONAL WEATHER SERVICE IN JACKSONVILLE HAS ISSUED A
* SEVERE THUNDERSTORM WARNING FOR...
CENTRAL COFFEE COUNTY IN SOUTHEAST GEORGIA

* UNTIL 645 PM EDT
* AT 559 PM EDT...NATIONAL WEATHER SERVICE METEOROLOGISTS WERE
  TRACKING A SEVERE THUNDERSTORM CAPABLE OF PRODUCING QUARTER SIZE
  HAIL...AND DAMAGING WINDS IN EXCESS OF 60 MPH. THIS STORM WAS
  LOCATED NEAR BROXTON...AND MOVING SOUTH AT 10 MPH.
* OTHER LOCATIONS IN THE WARNING INCLUDE BUT ARE NOT LIMITED TO
  BROXTON...AMBROSE AND DOUGLAS.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
REPORT SEVERE WEATHER OR DAMAGE TO THE NEAREST LAW ENFORCEMENT AGENCY
OR YOUR COUNTY EMERGENCY MANAGEMENT.
&&
LAT...LON 3174 8299 3164 8276 3143 8283 3144 8306
TIME...MOT...LOC 2159Z 005DEG 7KT 3164 8290
$$

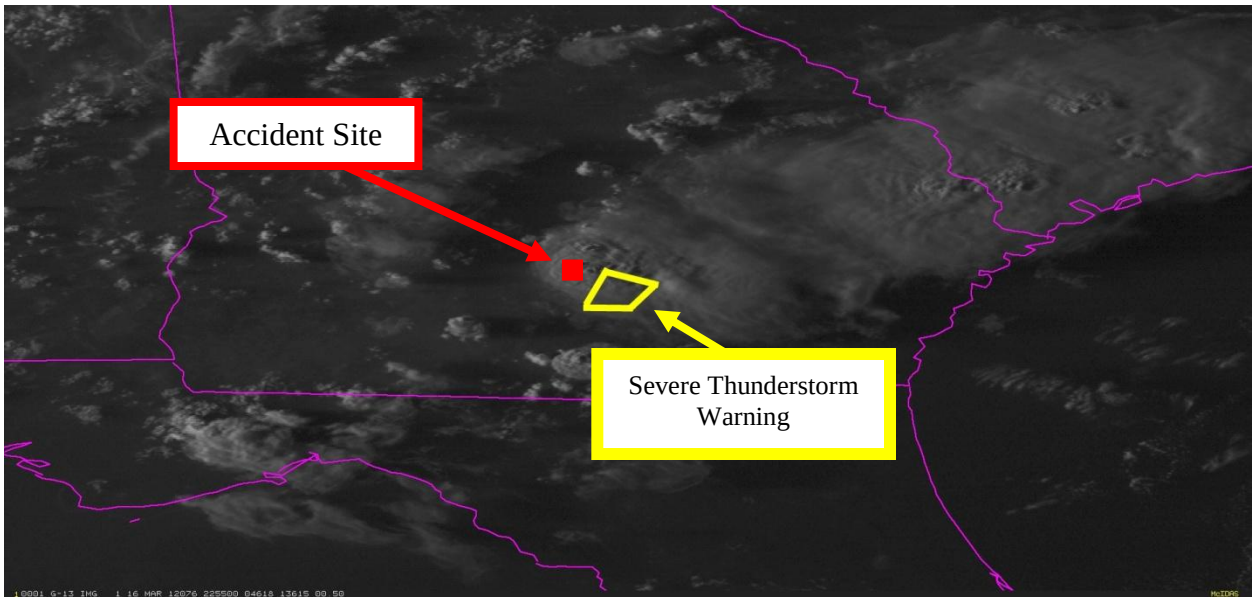


Figure 33 – GOES-13 visible satellite image from 1855 EDT with the accident site and areal extent of the severe thunderstorm warning valid until 1845 EDT

13.1 Storm Prediction Center Storm Reports

Several SPC storm reports were documented around the accident site at the accident time. At 1654 EDT, 11 miles northwest of Alma, Georgia, the Bacon County 911 Center reported hail of unknown size. At 1715 EDT, 3 miles north-northeast of West Green, Georgia, the Coffee County emergency management reported trees blown down and windows blown out at a residence due to strong thunderstorm winds. At 1810 EDT, 5 miles north-northwest of Broxton, Georgia, one inch size hail covered the yard of a residence, and 2 miles northwest of Pridgen, Georgia, quarter to dime size hail was reported. At 1944 EDT, quarter size hail and strong winds were reported in eastern Ben Hill County. Figure 34 shows the location and reports of severe weather on March 16th.

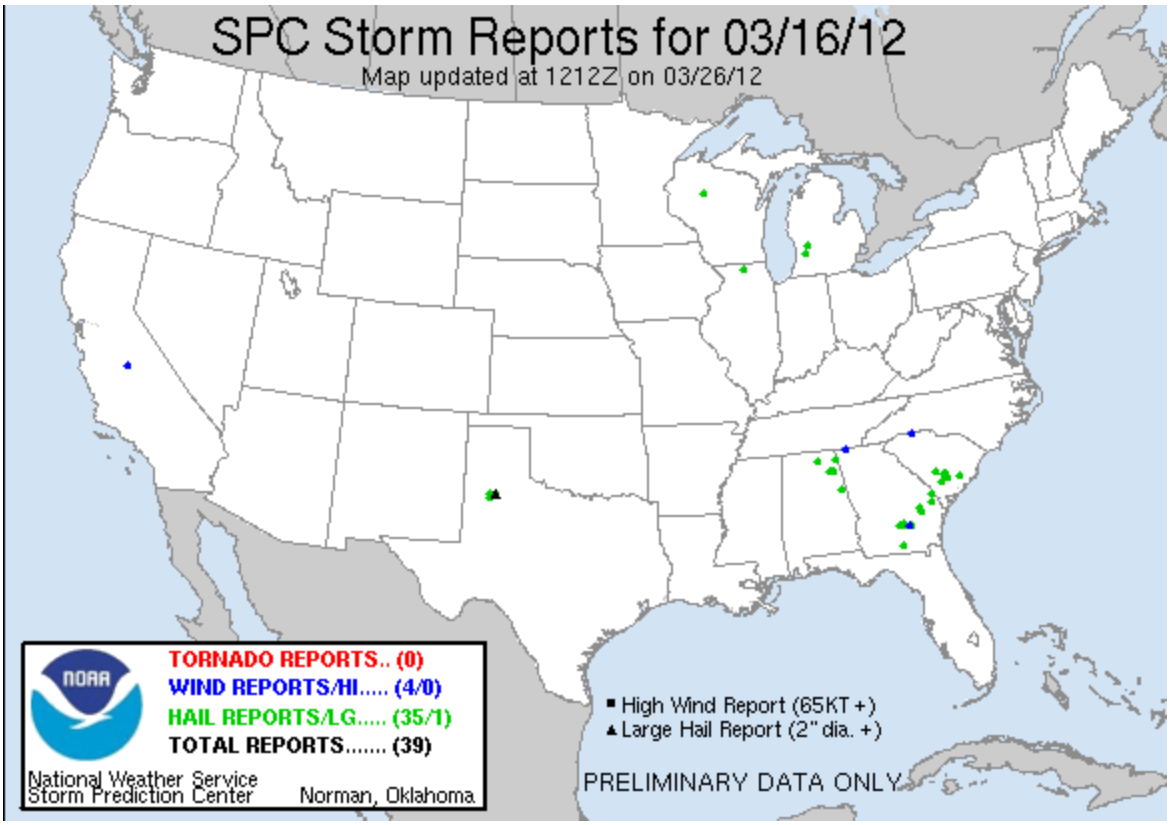


Figure 34 – Map of SPC preliminary storm reports from May 16th, 2012

14.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on March 16, 2012, indicated the following:

SUN	
Begin civil twilight	0717 EDT
Sunrise	0741 EDT
Sun transit	1341 EDT
Sunset	1942 EDT
End civil twilight	2006 EDT

Paul Suffern
NTSB, AS-30