NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

September 26, 2019

Factual Report

METEOROLOGY

DCA19MA086

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A. ACCIDENT

Location: Trinity Bay, Texas
Date: February 23, 2019
Time: 1239 central standard time (1839 UTC)[1]
Airplane: Boeing 767-375BCF; N1217A

B. METEOROLOGIST

Mike Richards
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On February 23, 2019, at 1239 central standard time (CST), Atlas Air flight 3591, a Boeing 767-375BCF, N1217A, entered a rapid descent from 6,000 ft and impacted a marshy bay area about 40 miles southeast of George Bush Intercontinental Airport (IAH), Houston, Texas. The two pilots and one nonrevenue jumpseat pilot were fatally injured. The airplane was destroyed and highly fragmented. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 121 domestic cargo flight, which originated from Miami International Airport, Miami, Florida, and was destined for IAH.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorology Group Chairman for this investigation traveled to Houston and Anahuac, Texas, on the morning following the accident. Meteorological information for this investigation was gathered on site as well as remotely. Unless otherwise noted, all times are for February 23, 2019, directions are referenced to true north, distances are in nautical miles and heights are above mean sea level (msl).

Coordinates used for the accident location: 29.76416667° north latitude, 94.71383333° west longitude, elevation of about 2 feet.

[1] UTC – abbreviation for Coordinated Universal Time

E. WEATHER INFORMATION

1.0 Synoptic Conditions

The southcentral portion of the National Weather Service (NWS) Surface Analysis Chart for 1200 CST is presented in figure 1. This figure identifies a generally northeast- to southwest-oriented cold front stretching from Arkansas through far southern Texas and extending almost directly over the accident site. This cold front was identified as advancing to the southeast and in the immediate vicinity west of the accident site. Temperatures ahead of the cold front in the warm-air side of the front across Texas and the Gulf of Mexico were generally in the mid-70s degrees Fahrenheit (°F), with temperatures behind the cold front in Texas generally in the mid-60s to low-70s °F. Surface wind ahead of the front were generally southerly to southwesterly, and were generally westerly to southwesterly behind the front in Texas. Station models depicted cloudy conditions along and ahead of the front near the accident location. Haze was depicted near the accident location.

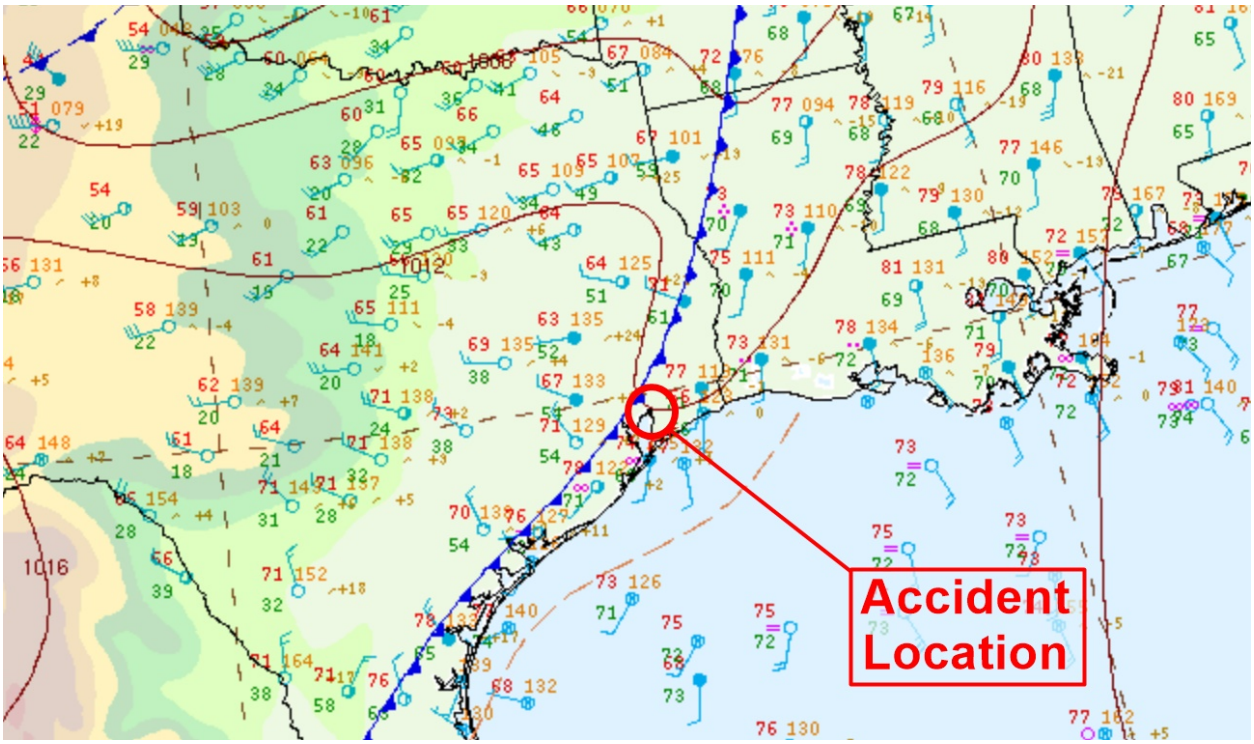

Figure 1 - NWS Surface Analysis Chart for 1200 CST.

2.0 Surface Observations

An Automated Surface Observing System (ASOS) was located at William P Hobby Airport (HOU)[2] in Houston, Texas, and was located about 35 miles west of the accident location at an elevation of about 45 feet. Longline-disseminated[3] human-augmented reports from KHOU at times surrounding the accident time are presented here.

[1053 CST] METAR KHOU 231653Z 21009G15KT 7SM SCT011 BKN016 BKN024 BKN250 24/21 A2988 RMK AO2 RAB1556E08 SLP122 P0000 T02440211=

[1153 CST] METAR KHOU 231753Z 31015G25KT 10SM -RA FEW018 BKN025 BKN036 21/15 A2990 RMK AO2 PK WND 28034/1742 WSHFT 1737 RAB23 SLP128 FROPA VCSH NE P0002 60002 T02110150 10256 20211 53009=

[1200 CST] SPECI KHOU 231800Z 31013G21KT 10SM SCT021 SCT028 BKN039 BKN250 21/15 A2989 RMK AO2 WSHFT 1740 RAE1754 VCSH NE-SE P0000 T02110150=

[1653 CST] METAR KHOU 231853Z 32014G19KT 10SM BKN250 23/13 A2990 RMK AO2 WSHFT 1740 RAE1754 SLP128 VCSH NE-SE P0000 T02280128=

At 1153 CST, KHOU reported a wind from 310° at 15 knots with gusts to 25 knots, visibility of 10 statute miles or greater, light rain, few clouds at 1,800 feet above ground level (agl), ceiling broken at 2,500 feet agl, broken clouds at 3,600 feet agl, temperature 21° Celsius (C) and dew point temperature 15°C, altimeter setting of 29.90 inches of mercury; remarks: station with a precipitation discriminator, peak wind from 280° of 34 knots occurred at 1142 CST, wind shift occurred at 1137 CST, rain began at 1123 CST, sea-level pressure of 1012.8 hectopascals (hPa),, frontal passage, moderate rain showers in the vicinity to the northeast[4], 0.02 inches of liquid equivalent precipitation since 1053 CST, temperature of 21.1°C and dew point temperature of 15.0°C, six-hour maximum temperature 25.6°C, six-hour minimum temperature 21.1°C, three-hour pressure increase of 0.9 hPa.

[2] This report uses the 3-digit International Air Transport Association format for airport identification, which does not use the geographic designating digit (e.g., "K" for stations in the continental U.S. and "P" for U.S. stations in Alaska and the Pacific region) as found in the 4-digit International Civil Aviation Organization (ICAO) identifier format. Weather observations from airports in this report are referenced by their reporting station's identifier (using ICAO format that includes the geographic designating digit), not by the airport at which the reporting station is located.

[3] "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases (effectively, the whole world) and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline-dissemination of weather observations is the primary vehicle through which the general global public has access to surface weather observations, particularly outside of the aviation community.

[4] "In the vicinity" refers to within 5-10 statute miles of the aerodrome.

An ASOS was located at IAH and was located about 41 miles west-northwest of the accident location at an elevation of about 95 feet. Longline-disseminated human-augmented reports from KIAH at times surrounding the accident time are presented here.

[1053 CST] METAR KIAH 231653Z 27010G15KT 5SM BR SCT015 BKN018 BKN029 24/22 A2988 RMK AO2 SLP119 VCSH S-SW T02440217=

[1113 CST] SPECI KIAH 231713Z 32018G24KT 8SM BR SCT016 BKN020 BKN029 19/12 A2991 RMK AO2 PK WND 33029/1701 WSHFT 1653 RAB01E13 VCSH SE-S P0000 T01940122=

[1145 CST] SPECI KIAH 231745Z 32009KT 9SM FEW020 SCT033 BKN060 20/12 A2992 RMK AO2 PK WND 33029/1701 WSHFT 1653 RAB01E13 P0000 T02000117=

[1153 CST] METAR KIAH 231753Z 32014G19KT 9SM FEW020 SCT033 BKN060 21/12 A2992 RMK AO2 PK WND 33029/1701 WSHFT 1653 RAB01E13 SLP131 P0000 60000 T02110122 10261 20189 53015=

[1202 CST] SPECI KIAH 231802Z 32015G24KT 10SM FEW035 SCT060 BKN080 BKN250 22/12 A2992 RMK AO2 T02220117=

[1253 CST] METAR KIAH 231853Z 32011G19KT 10SM SCT035 BKN080 BKN250 21/12 A2991 RMK AO2 SLP129 T02110117=

At 1113 CST, KIAH reported a wind from 320° at 18 knots with gusts to 24 knots, visibility of 8 statute miles, mist, scattered clouds at 1,600 agl, ceiling broken at 2,000 feet agl, broken clouds at 2,900 feet agl, temperature 19°C and dew point temperature 12°C, altimeter setting of 29.91 inches of mercury; remarks: station with a precipitation discriminator, peak wind from 330° at 29 knots occurred at 1101 CST, wind shift occurred at 1053 CST, rain began at 1101 CST and ended at 1113 CST, moderate rain showers in the vicinity to the southeast through south, trace amount of liquid equivalent precipitation since 1053 CST, temperature of 19.4°C and dew point temperature of 12.2°C.

An Automated Weather Observing System (AWOS) was located at Beaumont Municipal Airport (BMT) in Beaumont, Texas, and was located about 36 miles northeast of the accident location at an elevation of about 30 feet. Longline-disseminated automated reports from KBMT at times surrounding the accident time are presented here.

[1155 CST] METAR KBMT 231755Z AUTO 23010KT 10SM BKN014 OVC020 25/21 A2990 RMK AO2 T02500212 10257 20220=

[1215 CST] METAR KBMT 231815Z AUTO 21014KT 10SM BKN016 OVC023 26/21 A2988 RMK AO2 T02630213=

[1235 CST] METAR KBMT 231835Z AUTO 22014KT 10SM BKN016 BKN023 OVC028 26/21 A2988 RMK AO2 T02640210=

[1255 CST] METAR KBMT 231855Z AUTO 32014G26KT 10SM BKN020 OVC026 20/10 A2991 RMK AO2 T01990098=

[1315 CST] METAR KBMT 231915Z AUTO 32011KT 10SM SCT024 OVC032 21/10 A2990 RMK AO2 T02070100=

[1335 CST] METAR KBMT 231935Z AUTO 32008KT 10SM SCT030 SCT036 SCT042 22/10 A2988 RMK AO2 T02210099=

At 1235 CST, KBMT reported a wind from 220° at 14 knots, visibility of 10 statute miles or greater, ceiling broken at 1,600 feet agl, broken clouds at 2,300 feet agl, overcast clouds at 2,800 feet agl, temperature 26°C and dew point temperature 21°C, altimeter setting of 29.88 inches of mercury; remarks: station with a precipitation discriminator, temperature of 26.4°C and dew point temperature of 21.0°C.

At 1255 CST, KBMT reported a wind from 320° at 14 knots with gusts to 26 knots, visibility of 10 statute miles or greater, ceiling broken at 2,000 feet agl, overcast clouds at 2,600 feet agl, temperature 20°C and dew point temperature 10°C, altimeter setting of 29.91 inches of mercury; remarks: station with a precipitation discriminator, temperature of 19.9°C and dew point temperature of 9.8°C.

An ASOS was located at Jack Brooks Regional Airport (BPT) in Beaumont/ Port Arthur, Texas, and was located about 44 miles east-northeast of the accident location at an elevation of about 15 feet. Longline-disseminated automated reports from KBPT at times surrounding the accident time are presented here.

[1153 CST] METAR KBPT 231753Z 20011G19KT 9SM BKN007 OVC031 25/22 A2988 RMK AO2 SLP119 60000 T02500217 10261 20222 58001=

[1253 CST] METAR KBPT 231853Z 21012G20KT 7SM BKN007 OVC031 26/22 A2987 RMK AO2 RAB16E27 SLP113 P0000 T02560217=

[1258 CST] SPECI KBPT 231858Z 22015G20KT 8SM BKN014 BKN022 OVC031 26/22 A2987 RMK AO2 T02610217=

[1331 CST] SPECI KBPT 231931Z 32011KT 10SM -RA SCT014 OVC024 21/12 A2987 RMK AO2 WSHFT 1911 RAB27 P0000 T02060117=

At 1258 CST, KBPT reported a wind from 220° at 15 knots with gusts to 20 knots, visibility of 8 statute miles, ceiling broken at 1,400 feet agl, broken clouds at 2,200 feet agl, overcast clouds at 3,100 feet agl, temperature 26°C and dew point temperature 22°C, altimeter setting of 29.87 inches of mercury; remarks: station with a precipitation discriminator, temperature of 26.1°C and dew point temperature of 21.7°C.

At 1331 CST, KBPT reported a wind from 320° at 11 knots, visibility of 10 statute miles or greater, light rain, scattered clouds at 1,400 feet agl, ceiling overcast at 2,400 feet agl, temperature 21°C and dew point temperature 12°C, altimeter setting of 29.87 inches of mercury; remarks: station with a precipitation discriminator, wind shift at 1311 CST, rain began at 1327 CST, temperature of 20.6°C and dew point temperature of 11.7°C.

Data from a private weather station ("Dutton Lake") of unknown type located about 7 miles west-northwest of the accident site at an elevation of about 25 feet was provided by the NWS. Calibration, maintenance and siting standards of this equipment, as well as the overall quality of the data, are not known. Reporting of certain parameters[5] from Dutton Lake (rounded to nearest whole numbers) during the times surrounding the accident time are presented here (time in CST). Temperature is in °F, relative humidity is in percentages, wind magnitudes are in knots (converted from miles-per-hour and rounded to nearest whole number) and barometric pressure is in hPa.

Time	Temp	RH	W_Mag	W_Dir	G_Mag	Pres
1114	75	99	3	247°	5	1009.1
1143	75	88	3	219°	5	1009.1
1205	75	80	4	258°	7	1009.1
1220	75	65	5	219°	7	1010.2
1235	70	68	3	039°	5	1010.5
1250	66	74	3	044°	10	1010.2

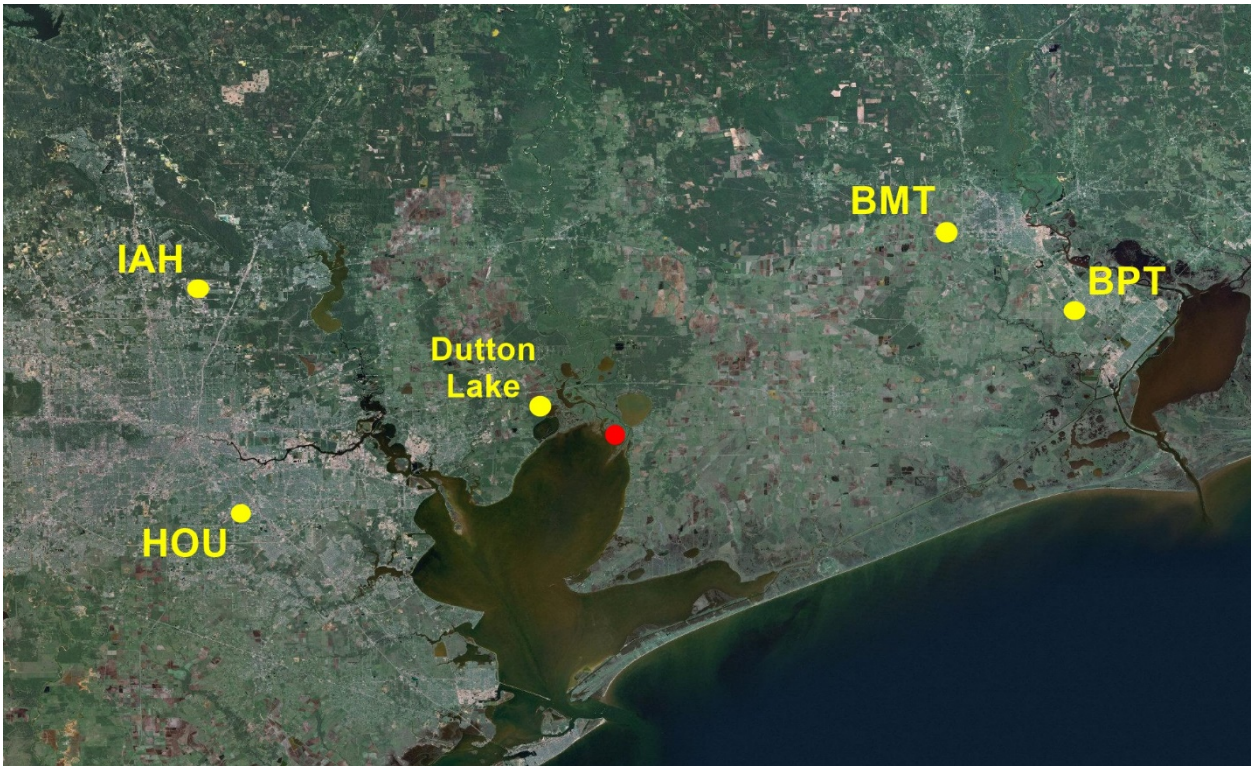

Figure 2 – Map of surface observation locations discussed in this section. Accident site is denoted by the red circle.

[5] Temp=temperature; RH=relative humidity; W_Mag=average wind magnitude; W_Dir=average wind direction; G_Mag=gust wind magnitude; Pres=barometric pressure

3.0 Weather Radar

WSR-88D Level-II and Level-III weather radar imagery from Houston, Texas (KHGX), is presented in figures 3-11. KHGX was located approximately 26 miles southwest of the accident site with an antenna elevation of about 115 feet. Assuming standard refraction and considering the 0.95° beam width for the WSR-88D radar beam, the KHGX ~0.48° tilt would have "seen" altitudes above the accident location of between about 600 and 3,200 feet msl. In addition, the ~1.8° and ~2.4° tilts would have seen between about 4,200 and 6,800 feet msl and between about 5,900 and 8,500 feet msl above the accident location, respectively.

Figures 3-5 present KGHX ~0.48° base reflectivity imagery at several times during the accident aircraft's descent toward the Houston area. In these images, features consistent with convection are noted to the west of the Houston metro area. Another feature, known as a fine line,[6] is found stretching across Trinity Bay to the west of the aforementioned convective region and between that convection and the accident airplane.

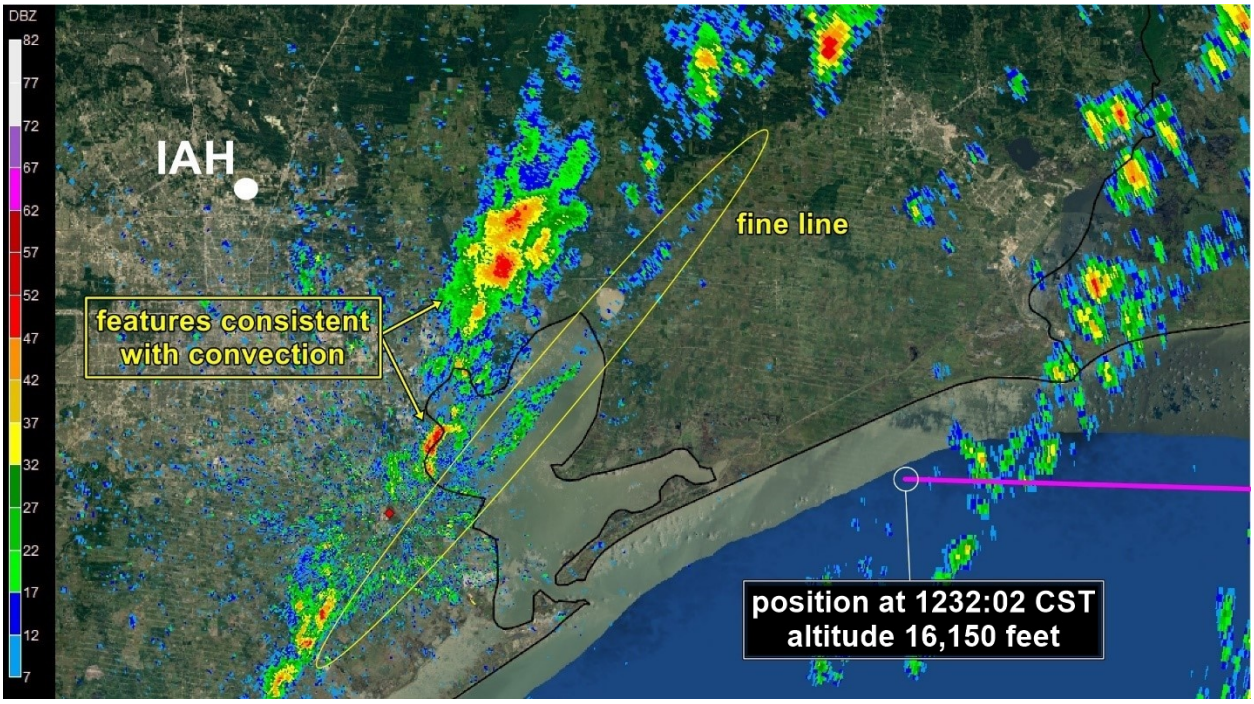

Figure 3 – KGHX WSR-88D Level-II ~0.48° base reflectivity imagery from a sweep that began at 1231:57 CST. Accident aircraft's flight track[7] denoted by purple line. dBZ values less than 7.5 have been masked out.

[6] Fine line - A narrow, elongated, non-precipitating echo. It is usually associated with thunderstorm outflows, fronts, or other density discontinuities.

[7] Flight track information for the accident aircraft is based on Automatic Dependent Surveillance-Broadcast (ADS-B) data found in the docket for this accident.

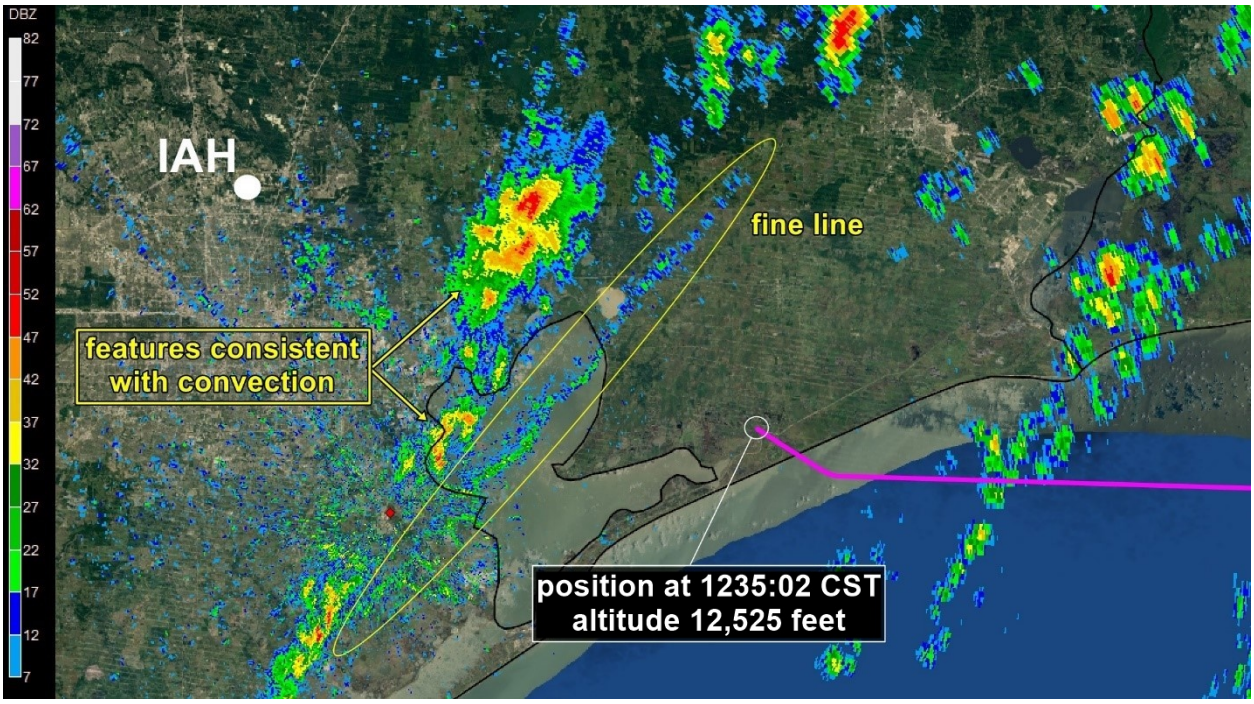

Figure 4 – KGHX WSR-88D Level-II ~0.48° base reflectivity imagery from a sweep that began at 1235:02 CST. Accident aircraft's flight track denoted by purple line. dBZ values less than 7.5 have been masked out.

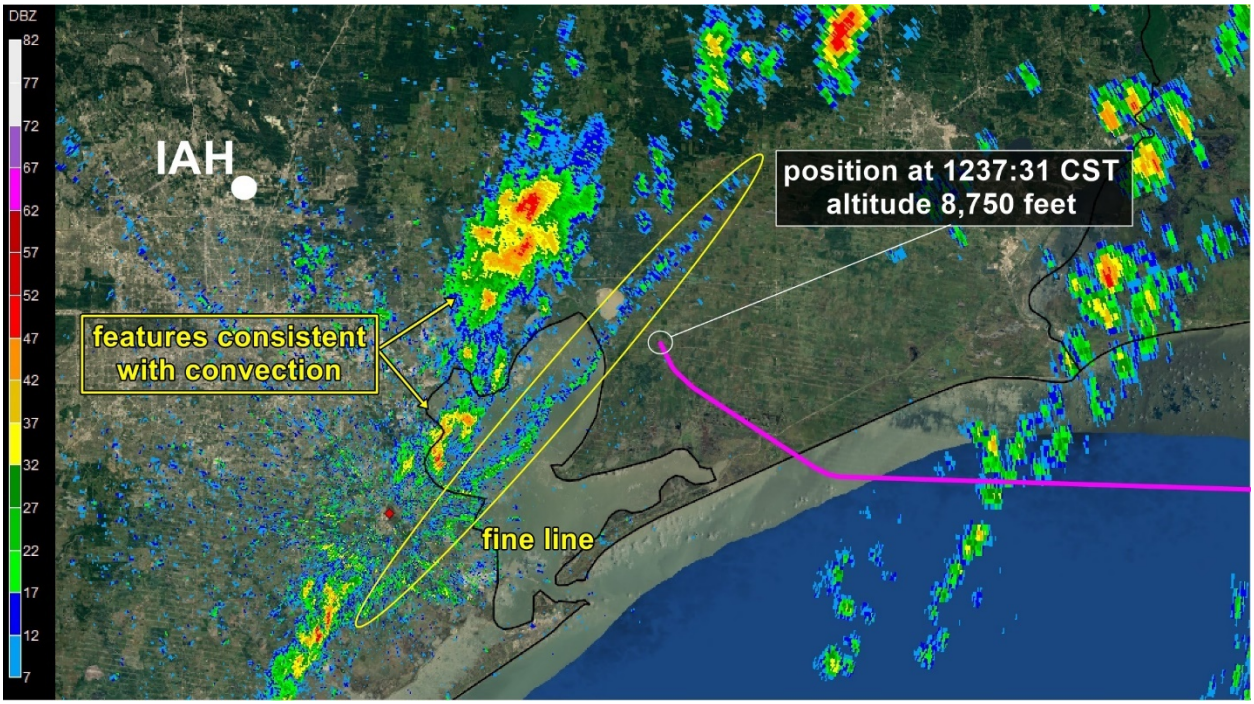

Figure 5 – KGHX WSR-88D Level-II ~0.48° base reflectivity imagery from a sweep that began at 1235:02 CST. Accident aircraft's flight track denoted by purple line. dBZ values less than 7.5 have been masked out.

Figures 6 and 7 present KGHX ~1.8° and ~2.4° base reflectivity imagery "zoomed in" on the accident aircraft's flight path as it nears the fine line. These images consider reflectivity values down to -10 dBZ. According to the NWS (see Attachment 1), the -10 dBZ isosurface should "correspond fairly well to cloud cover." Attachment 1 presents an analysis of the meteorology surrounding the event provided by the NWS Weather Forecast Office (WFO) in Houston/Galveston, Texas. According to the NWS (see Attachment 2), the time the KHFX WSR-88D radar sensed the 48.7° radial[8] in the ~1.8° sweep was 1238:05 CST and the time it sensed the 47.8° radial in the ~2.4° sweep was 1238:22 CST.

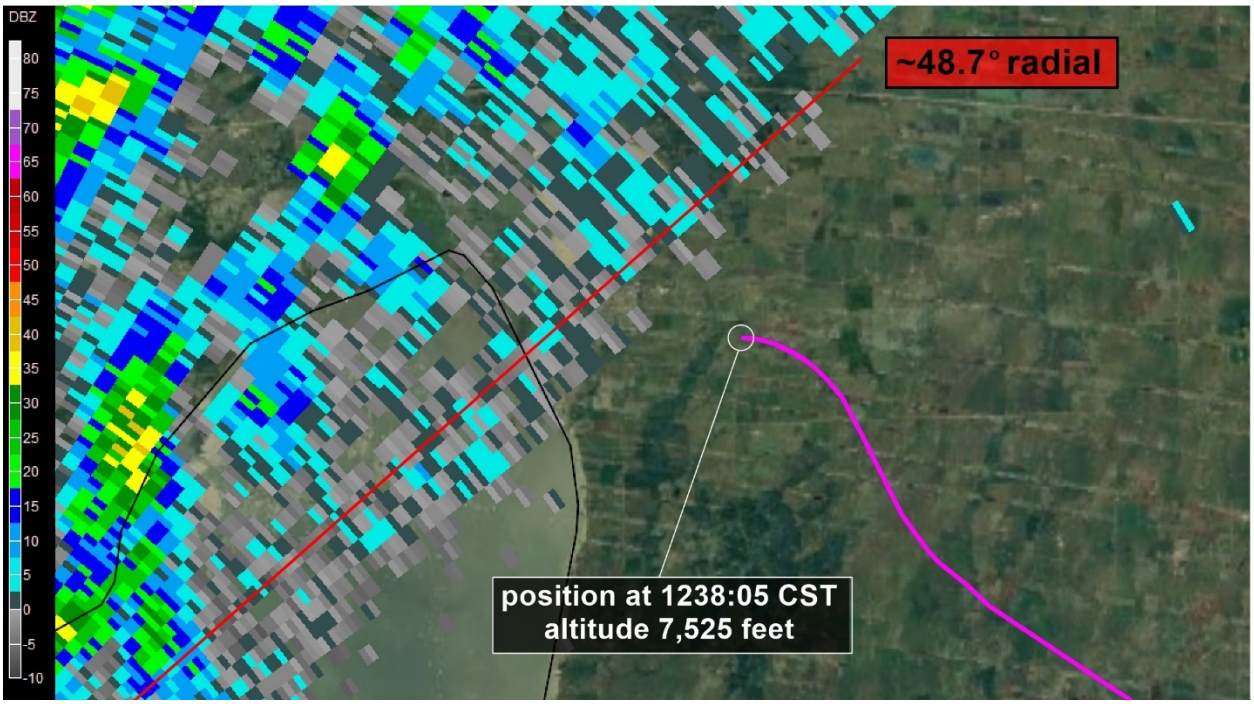

Figure 6 – KGHX WSR-88D Level-II ~1.8° base reflectivity imagery from a sweep that began at 1237:44 CST. Accident aircraft's flight track denoted by purple line. dBZ values greater than -10 dBZ are considered. The red line identifies the ~48.7° radial for this scan.

[8] radial – the path along the antenna's radar beam

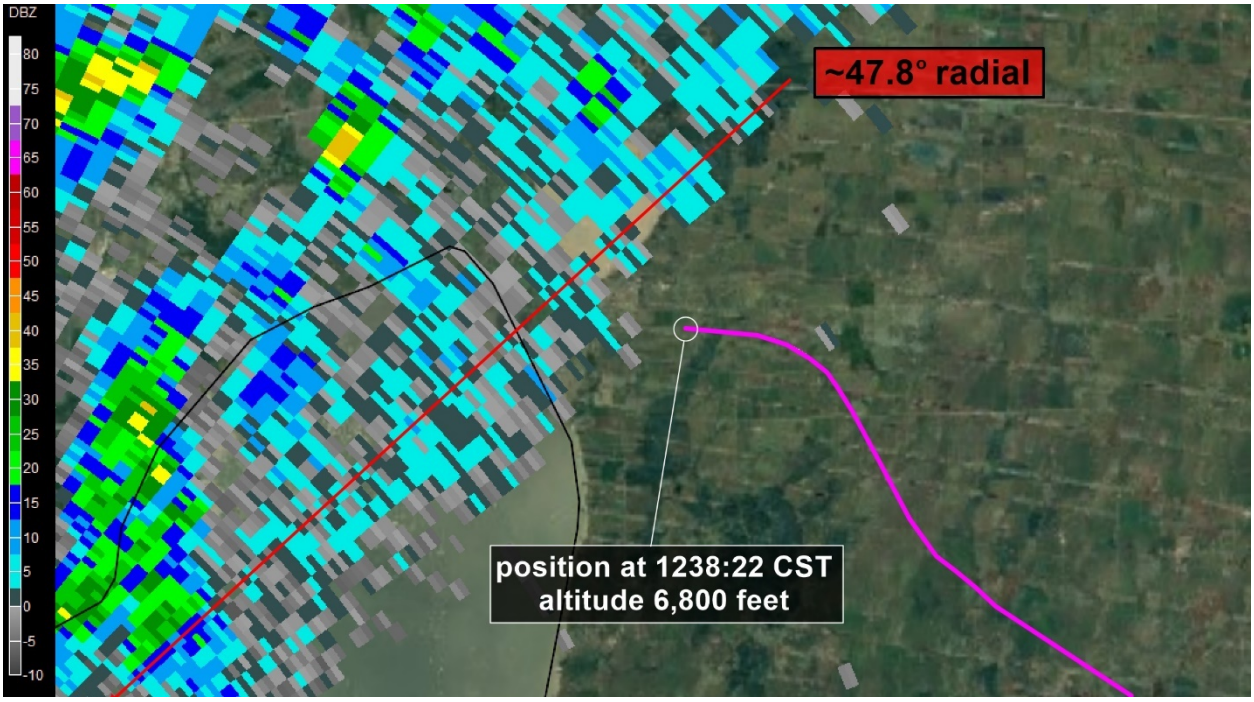

Figure 7 – KGHX WSR-88D Level-II ~2.4° base reflectivity imagery from a sweep that began at 1237:44 CST. Accident aircraft's flight track denoted by purple line. dBZ values greater than -10 dBZ are considered. The red line identifies the ~47.8° radial for this scan.

Figures 8-11 present KGHX ~0.9°, ~1.3°, ~1.8° and ~2.4° base velocity imagery "zoomed in" on the accident aircraft's flight path as it nears the fine line. Assuming standard refraction and considering the 0.95° beam width for the WSR-88D radar beam, the KHGX ~0.9° and ~1.3° tilts would have "seen" altitudes above the accident location of between about 1,700 and 4,400 feet msl and between about 2,800 and 5,500 feet msl above the accident location, respectively.

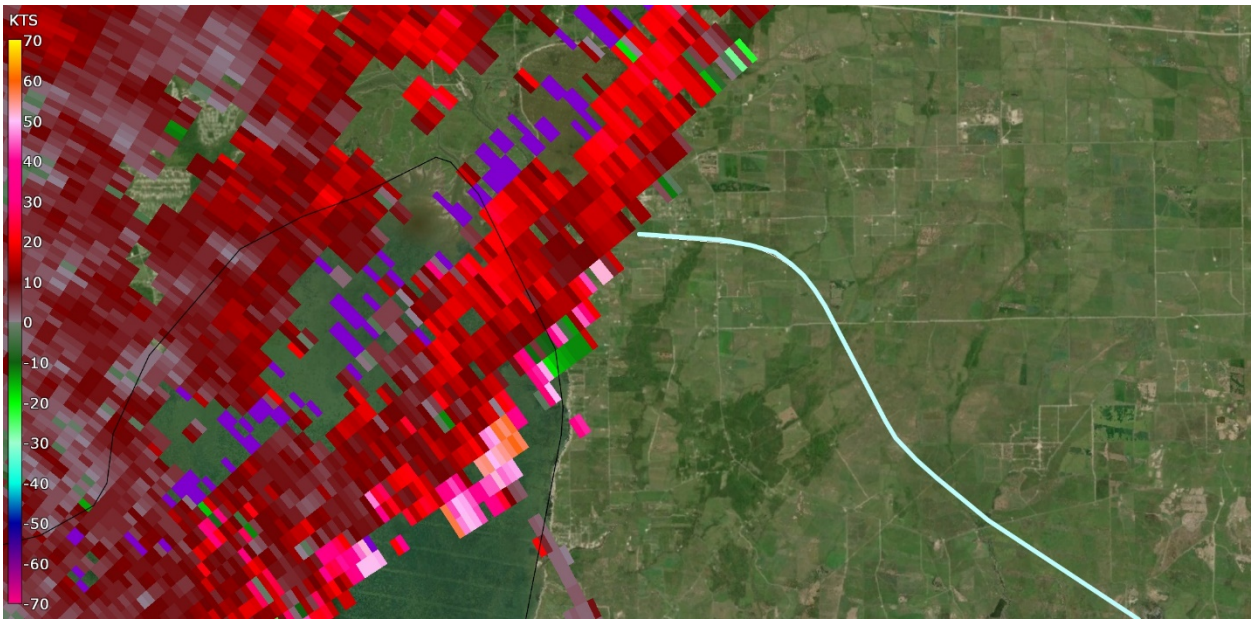

Figure 8 – KGHX WSR-88D Level-III ~0.9° base velocity imagery from a sweep that began at 1236:28 CST. Accident aircraft's flight track through 1238:31 CST denoted by light blue line.

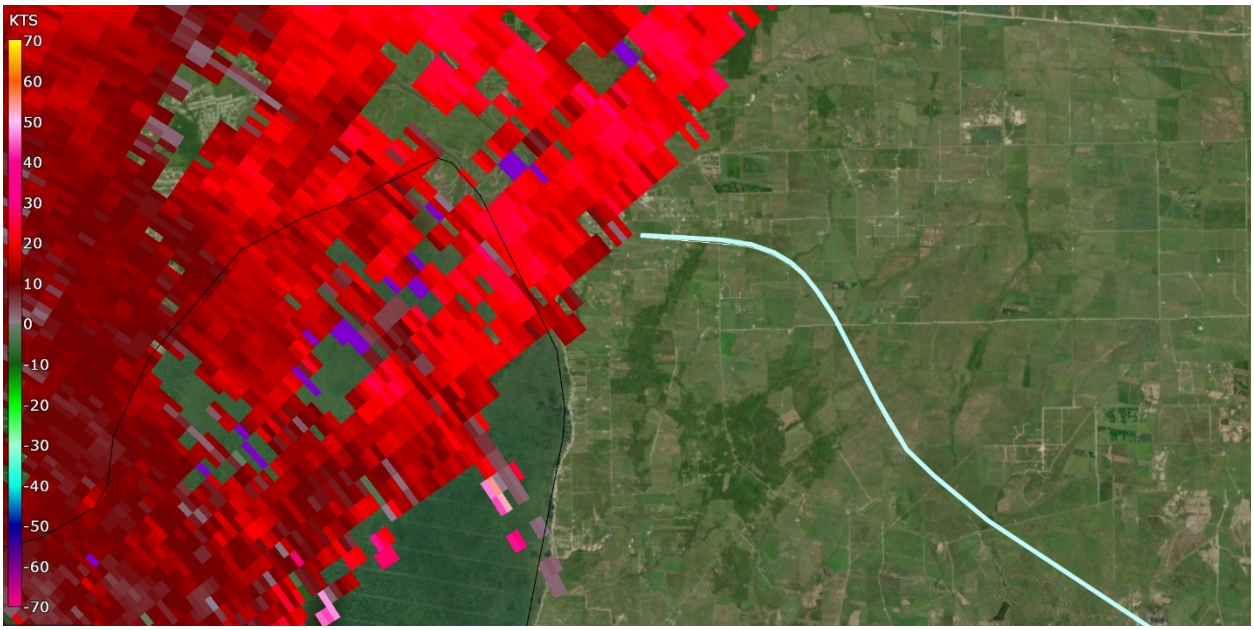

Figure 9 – KGHX WSR-88D Level-III ~1.3° base velocity imagery from a sweep that began at 1237:18 CST. Accident aircraft's flight track through 1238:31 CST denoted by light blue line.

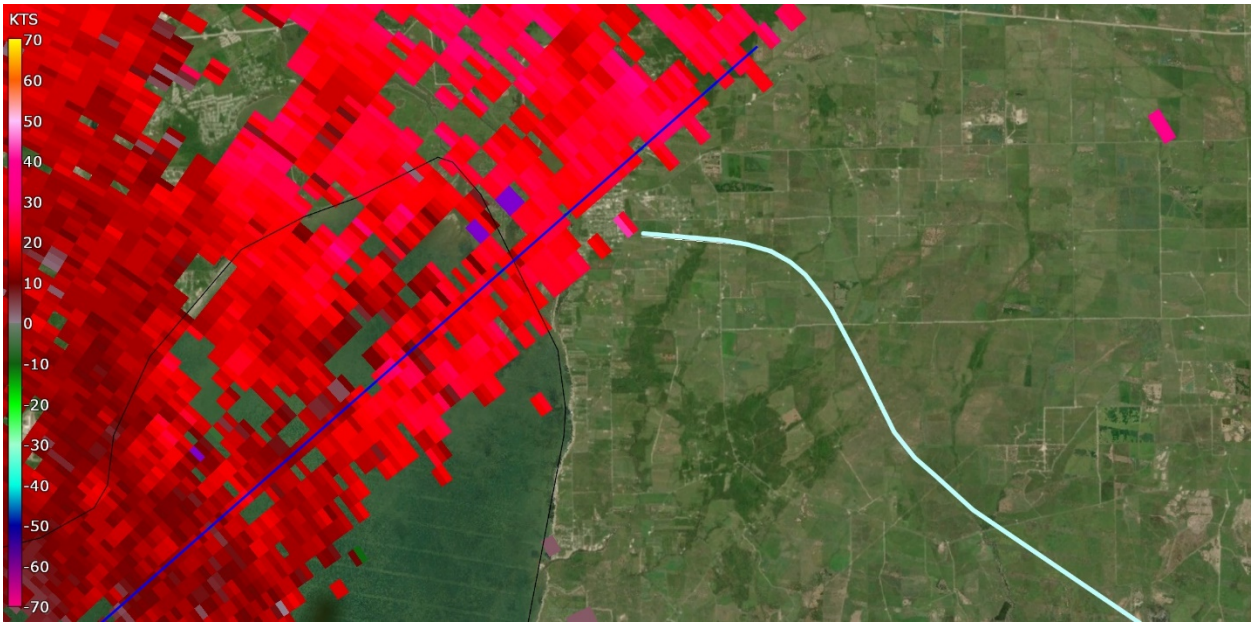

Figure 10 – KGHX WSR-88D Level-III ~1.8° base velocity imagery from a sweep that began at 1237:44 CST. Accident aircraft's flight track through 1238:31 CST denoted by light blue line. The dark blue line marks the radial depicted in Figure 6.

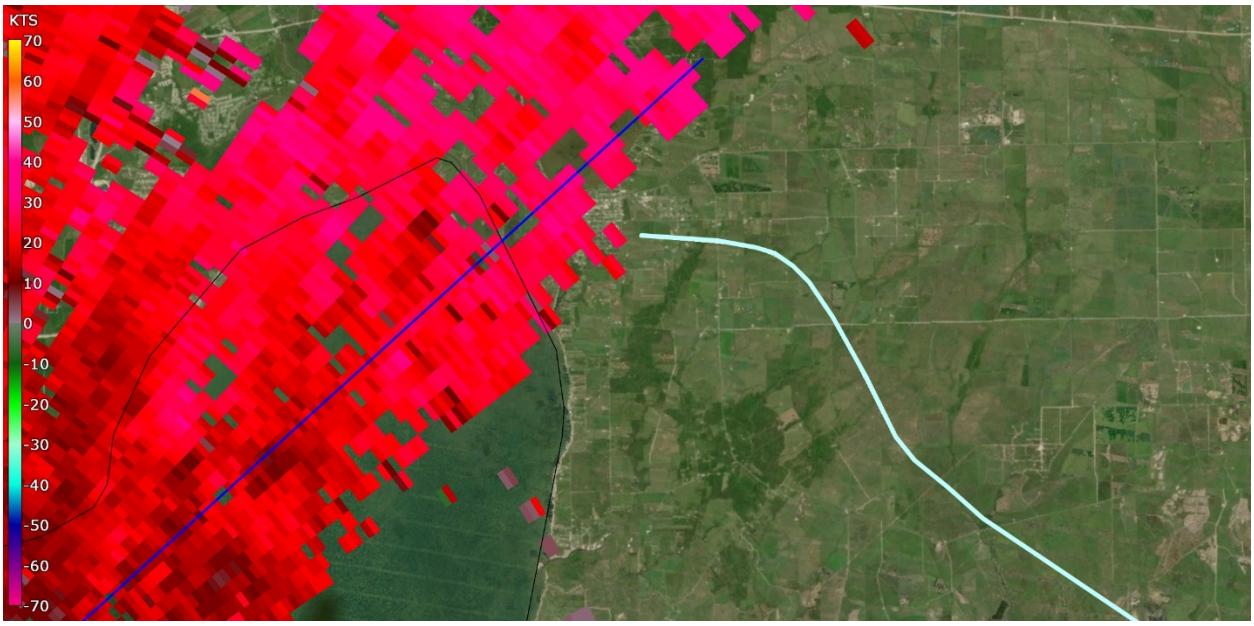

Figure 11 – KGHX WSR-88D Level-III ~2.4° base velocity imagery from a sweep that began at 1238:06 CST. Accident aircraft's flight track through 1238:31 CST denoted by light blue line. The dark blue line marks the radial depicted in Figure 7.

Figure 12 presents a Velocity-Azimuth Display (VAD) wind profile[9] for above KHGX for times surrounding the accident time. The KHGX VAD wind profile shows little variability in wind magnitude and direction above 4,000 feet and below 10,000 feet during the period.

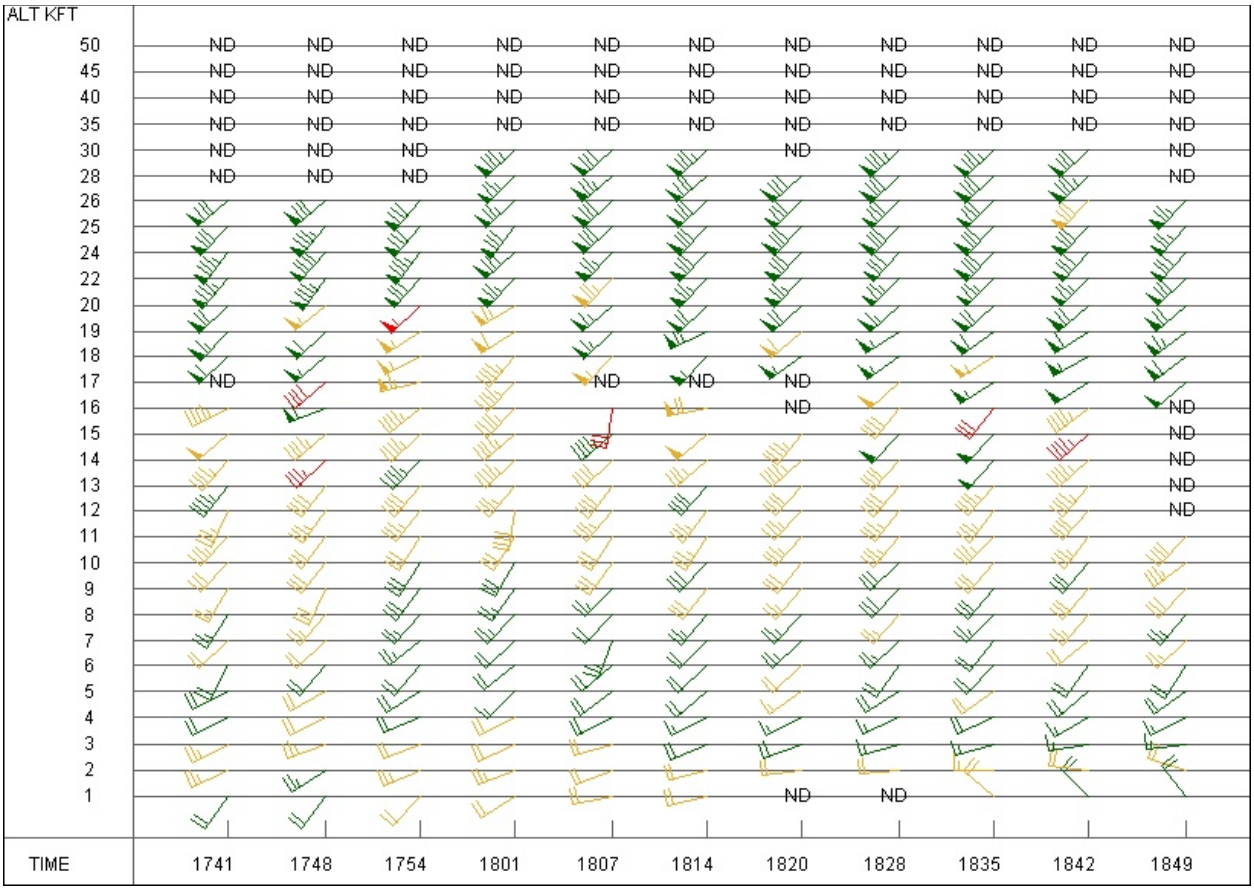

Figure 12 – KGHX VAD wind profile for times surrounding the accident time.

[9] VAD wind profile - A plot of horizontal winds as a function of height above a Doppler Radar. The display is plotted with height as the vertical axis and time as the horizontal axis which then depicts the change in wind with time at various heights.

4.0 Upper Air Data

High-Resolution Rapid Refresh (HRRR) model[10] soundings (figures 13 and 14) valid over the accident location at 1200 and 1300 CST were retrieved from the NOAA Air Resources Laboratory.

At 1200 CST, the wind near the surface was from the south-southwest at about 15 knots. Above this level the wind *veered*[11] slightly and increased in magnitude with height to a southwest wind of about 40 knots at about 2,800 feet. Between about 2,800 and 7,000 feet the wind was from the west-southwest at about 5 knots. Above this layer the wind *backed*[12] slightly and increased in magnitude with height to a southwest wind of about 45 knots at about 15,000 feet. Analysis by the RAwinsonde OBservation program (RAOB) identified cloudy conditions between near the ground and about 4,200 feet. RAOB also identified the potential for at least light clear air turbulence throughout much of the atmosphere below 15,000 feet and identified the potential for moderate clear air turbulence between about 2,800 and 4,500 feet. The most-unstable Convective Available Potential Energy (CAPE)[13] parameter was 1,728 Joules/kilogram (from 992 hPa), which would be considered a moderate value. The Lifting Condensation Level[14] (LCL) was calculated to be 126 feet and the Level of Free Convection[15] (LFC) was calculated to be 3,367 feet. Maximum vertical velocity (MVV) for this atmosphere was calculated as 42 meters/second (about 8,268 feet per minute).[16] Downdraft CAPE (DCAPE; 6 kilometers agl)[17] was measured at 1,083 Joules/kilogram which, according to RAOB, would be considered a strong value. The freezing level was at about 13,500 feet.

At 1300 CST, the wind near the surface was from the west at about 10 knots. Above this level the wind remained westerly and below 20 knots though about 3,600 feet. Above this level the wind backed to a southwest wind and increased in magnitude with height to a southwest wind of about 50 knots at about 15,300 feet. Analysis by RAOB identified cloudy conditions between about 600 and 8,300 feet. RAOB also identified the potential for at least light clear air turbulence above about 3,600 feet and identified the potential for moderate clear air turbulence between about 4,500 and 5,600 feet. The most-unstable CAPE parameter was 620 Joules/kilogram (from 862 hPa) which would be considered a weak value. The LCL and LFC were calculated to be 253 feet. MVV

[10] The HRRR is a National Oceanic and Atmospheric Administration (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.
[11] A veering wind's wind barbs turn clockwise with increasing height
[12] A backing wind's wind barbs turn counter-clockwise with increasing height
[13] Convective Available Potential Energy - A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.
[14] Lifting Condensation Level - The level at which a parcel of moist air lifted dry-adiabatically would become saturated.
[15] Level of Free Convection - The level at which a parcel of air lifted dry-adiabatically until saturated and saturation-adiabatically thereafter would first become warmer than its surroundings in a conditionally unstable atmosphere. On a thermodynamic diagram the level of free convection is given by the point of intersection of the process curve, representing the process followed by the ascending parcel, and the sounding curve, representing the lapse rate of temperature in the environment.
[16] 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.
[17] 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.

for this atmosphere was calculated as 35 meters/second (about 6,890 feet per minute). DCAPE (6 kilometers agl) was measured at 684 Joules/kilogram which, according to RAOB, would be considered a moderate value. The freezing level was at about 13,300 feet.

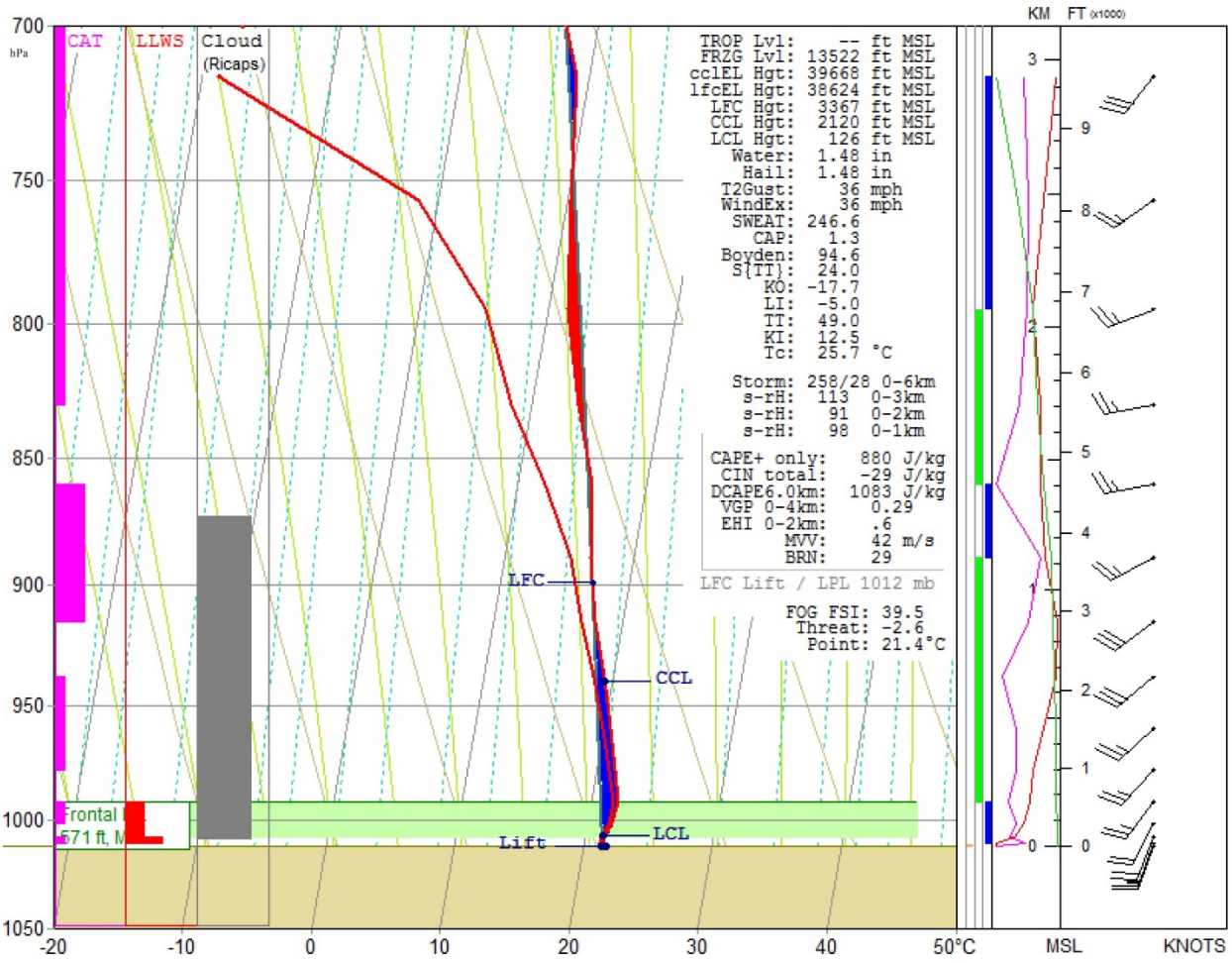

Figure 13 – HRRR model sounding data in SkewT/LogP format for 1200 CST at the accident site, surface to 700 hPa.

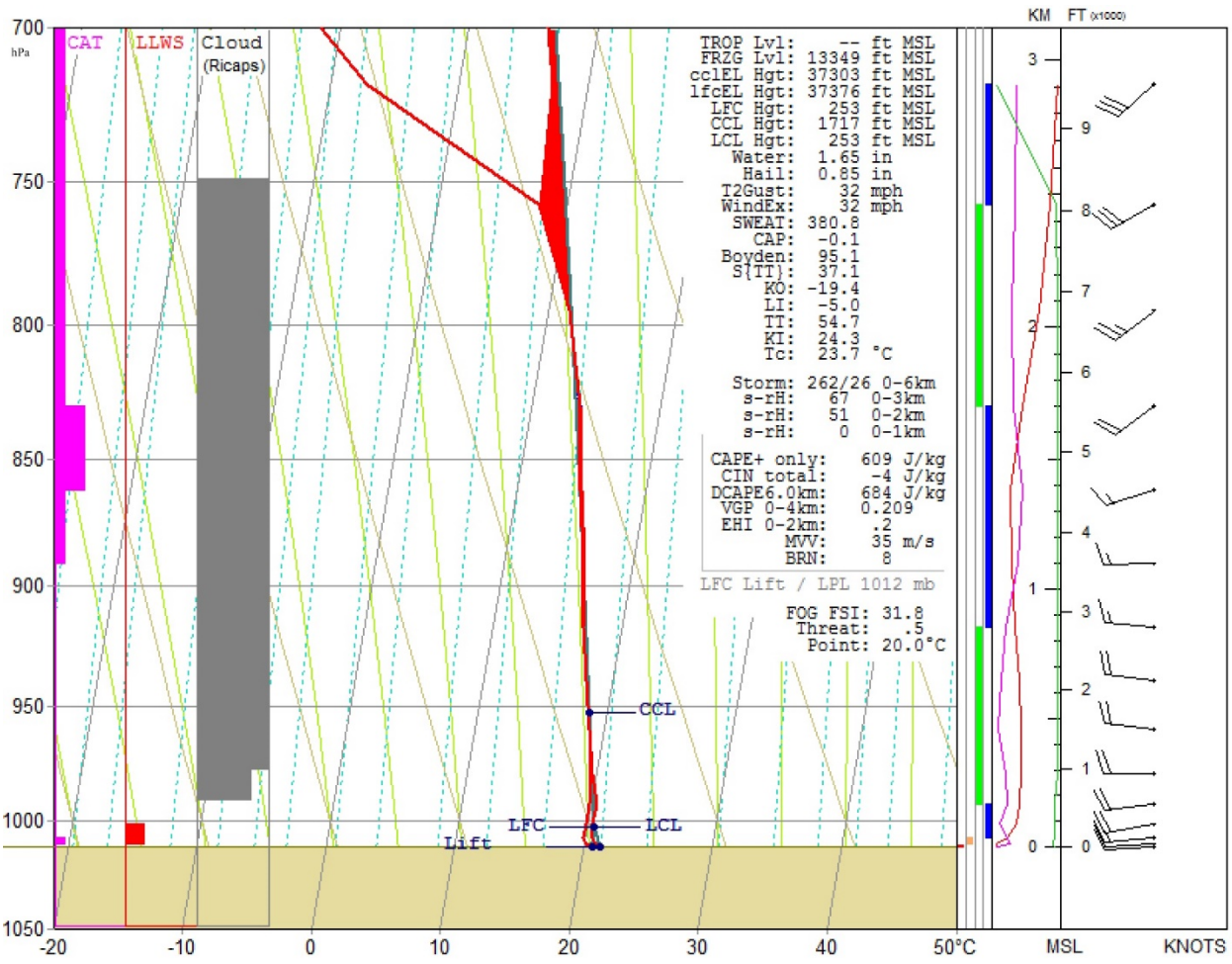

Figure 14 – HRRR model sounding data in SkewT/LogP format for 1300 CST at the accident site, surface to 700 hPa.

5.0 Satellite Imagery

Geostationary Operational Environmental Satellite (GOES)-16 visible (0.64µm) and infrared (10.3µm) data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison. Visible imagery between 1127 and 1237 CST is presented in Attachment 3. Visible and infrared imagery from 1237 CST is presented in figures 15 and 16. The visible imagery identified cloudy conditions across the region and over the accident location. Infrared cloud-top temperatures along the final portion of the accident aircraft's flight path (following the final turn presented in figures 15 and 16) varied between about -14°C and -27°C, which, when considering the 1300 CST HRRR sounding, corresponded to cloud top height of about 19,500 feet and about 27,300 feet, respectively.

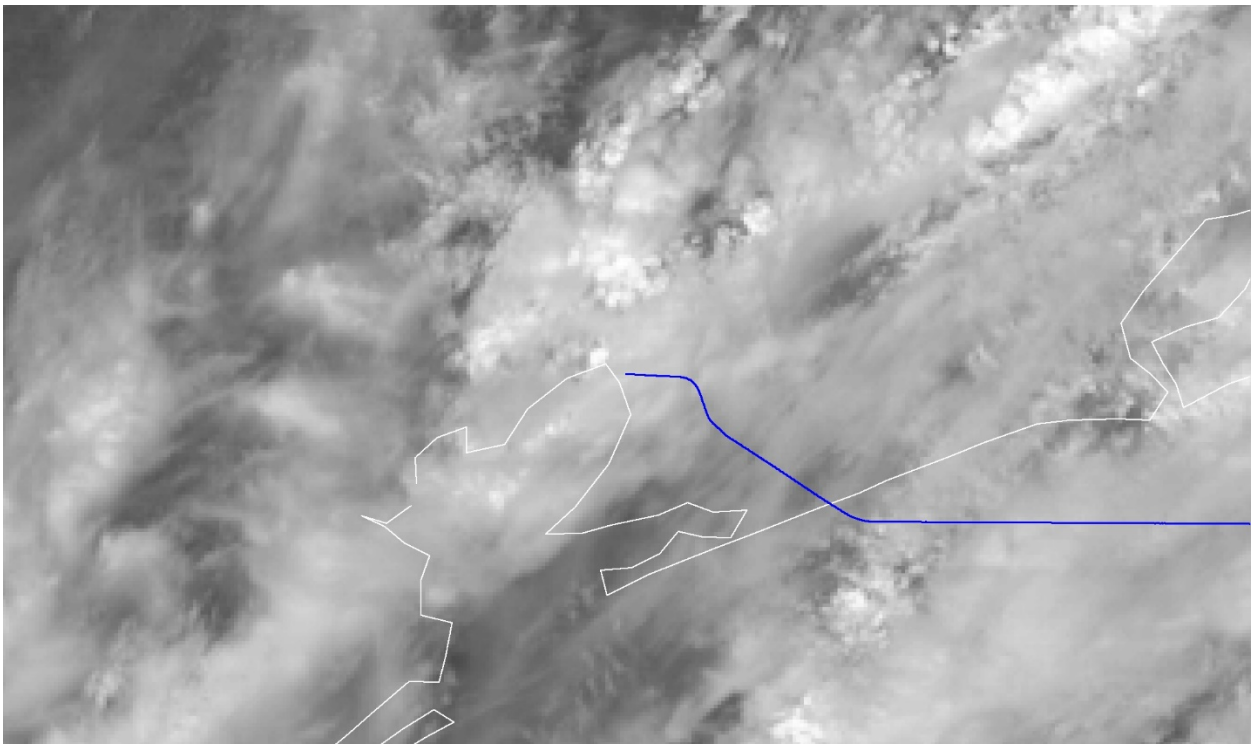

Figure 15 – GOES-16 visible imagery from 1237 CST. Final portion of the accident aircraft's flight path denoted by blue line. This image has not been corrected for any parallax error.

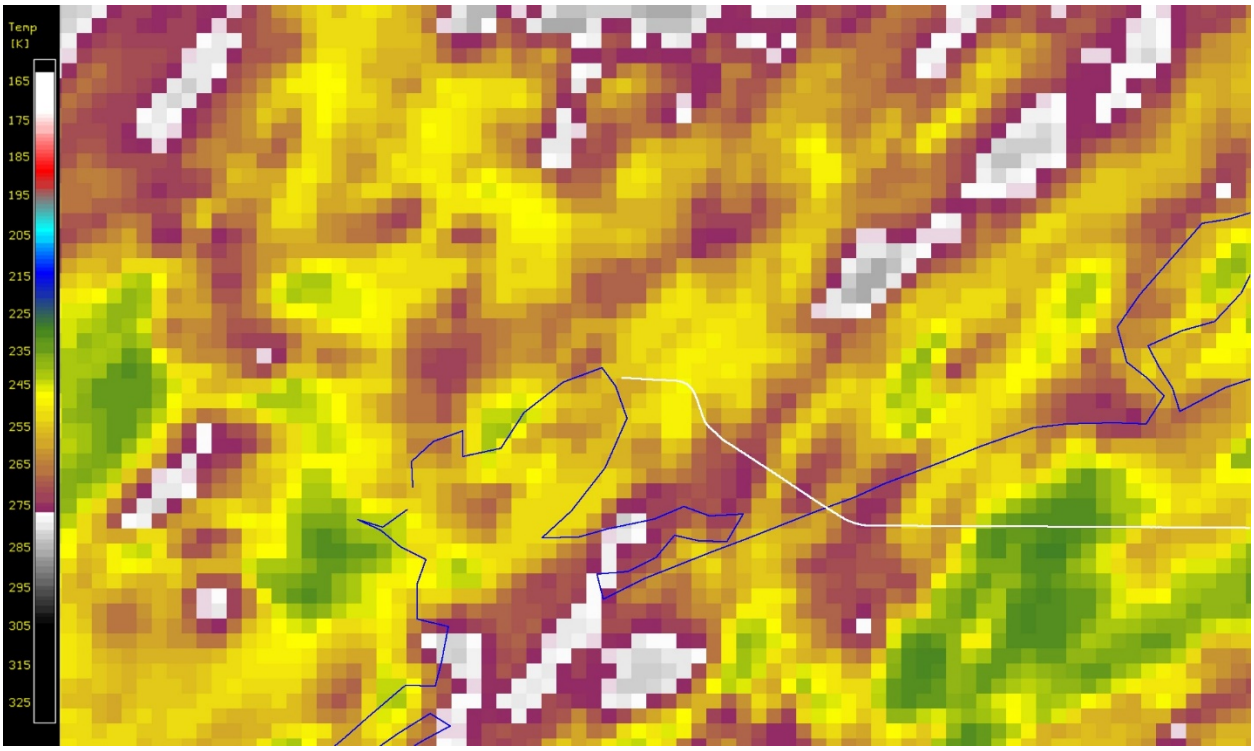

Figure 16 – GOES-16 infrared imagery (brightness temperature in Kelvin) from 1237 CST. Final portion of the accident aircraft's flight path denoted by white line. This image has not been corrected for any parallax error.

Figure 17 presents a "daytime microphysical RGB" GOES-16 band combination image for 1237 CST. According to the National Aeronautics and Space Administration, "[this imagery] combines information about the cloud brightness, cloud particle phase and size, and cloud top temperature in order to analyze convective clouds as well as other cloud and surface features. The cloud particle phase and size can be qualitatively determined to estimate if strong updrafts are associated with the convection or if warm rain processes are active. Other benefits are the identification of cloud types, including fog and low stratus as well as fires, snow, and contrails." [18] Figure 18 presents an interpretation of this image.

[18] https://weather.msfc.nasa.gov/sport/training/quickGuides/rgb/QuickGuide_DtMicroRGB_NASA_SPoRT.pdf

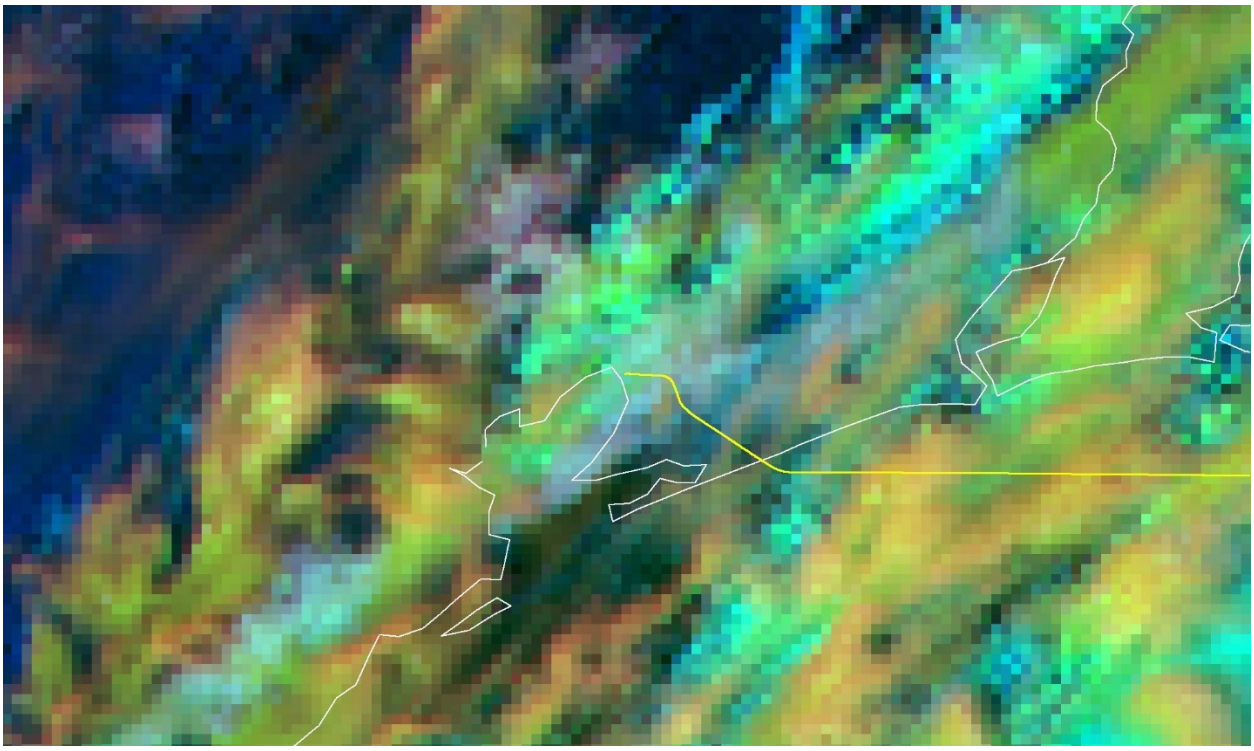

Figure 17 – GOES-16 daytime microphysical RGB image from 1237 CST. Final portion of the accident aircraft's flight path denoted by yellow line. This image has not been corrected for any parallax error.

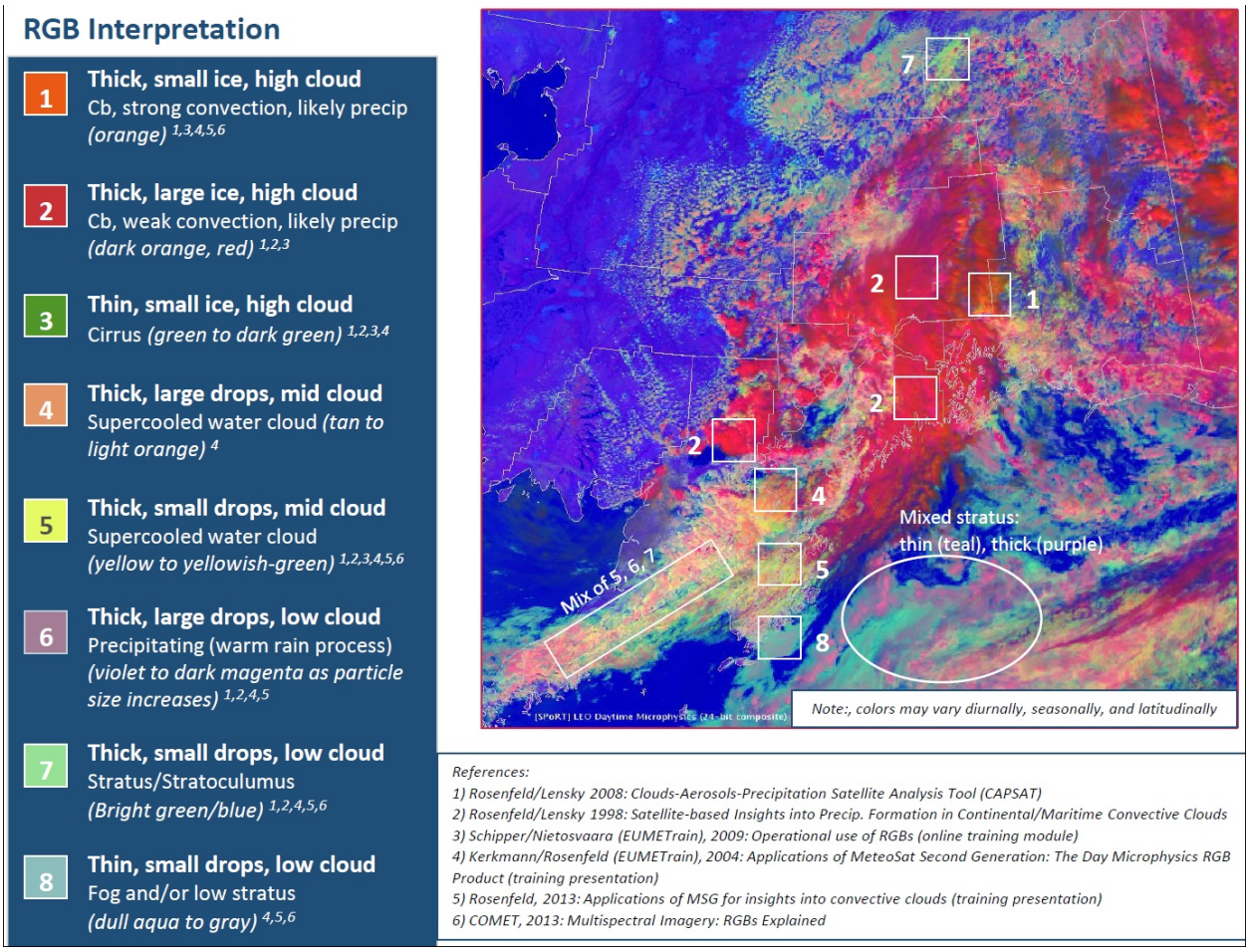

Figure 18 – Interpretation aid for the GOES-16 daytime microphysical RGB image found in Figure 17. Taken from *https://weather.msfc.nasa.gov/sport/training/quickGuides/rgb/QuickGuide _DtMicroRGB _NASA_SPoRT.pdf.*

6.0 Pilot Reports

The following pilot reports (PIREPs and AIREPs) were publicly disseminated longline[19] from aircraft within 100 miles of the accident location between 1100 and 1400 CST at altitudes below 15,000 feet. At 1238 CST, a Beech Bonanza located 25 miles north of BPT at 8,000 feet reported moderate turbulence.

IAH UUA /OV KIAH090003/TM 1700/FLUNK/TP E45X/RM LLWAS +10KTS
DURA LIGHT CHOP

[19] Only pilot reports with the World Meteorological Organization header UBSD** were considered. Pilot reports only publicly-disseminated via radio were also not considered.

IAH UA /OV IAH090010/TM 1720/FLDURGD/TP B737/TB MOD TURB AT 020 ON FINAL

IAH UA /OV KIAH090003/TM 1740/FLUNKN/TP MD80/SK OVC020/WX FV05SM

ARP UAL1920 2957N 09520W 1740 F070 TB MOD TURB RM A319 OV IAH DURC 030 THRU 120

LCH UA /OV 2 N/TM 1820/FLDURD/TP BE9L/SK OVC005

BPT UA /OV BPT360025/TM 1838/FL080/TP BE36/TB MOD

Additional information was solicited by the NTSB following the accident. At 1247 CST, United Airlines (UAL) flight #1788, who had flown over the accident area on approach to IAH about eight minutes after the accident aircraft, reported instrument meteorological conditions and "moderate chop" to air traffic control while at about 8,250 feet about one mile east of the accident location.[20] The flight crew of UAL flight #1788 provided further information to the NTSB, and those statements can be found in Attachment 4. Please see the Air Traffic Control Factual Report for this accident for further information on air traffic control communications.

7.0 Lightning

A review of the Earth Networks Total Lightning Network (ENTLN) lightning database indicated that there was no lightning activity between 1215 and 1300 CST around the accident location.[21]

8.0 CWSU Products

There were no Center Weather Advisories or Meteorological Impact Statements by the Center Weather Service Unit (CWSU) at the Houston Air Route Traffic Control Center (ZHU) that were valid for southeastern Texas at the accident time.

ZHU CWSU video weather briefings produced at about 0530 CST and about 1200 CST may be found in the docket for this accident.

The following Houston Terminal Radar Approach Control (TRACON) Gate Convective Forecasts were issued by the ZHU CWSU (figures 18 and 19).

[20] Approximate position is based on data found in the Flight Data Recorder - Ancillary Specialist's Factual Report regarding United Airlines flight #1788 (N47505) found in the docket for this accident investigation.
[21] The ENTLN was queried for a geographic area bounded by latitudes 30.03662°N and 29.40491°N, and longitudes 95.37781°W and 93.6145°W.

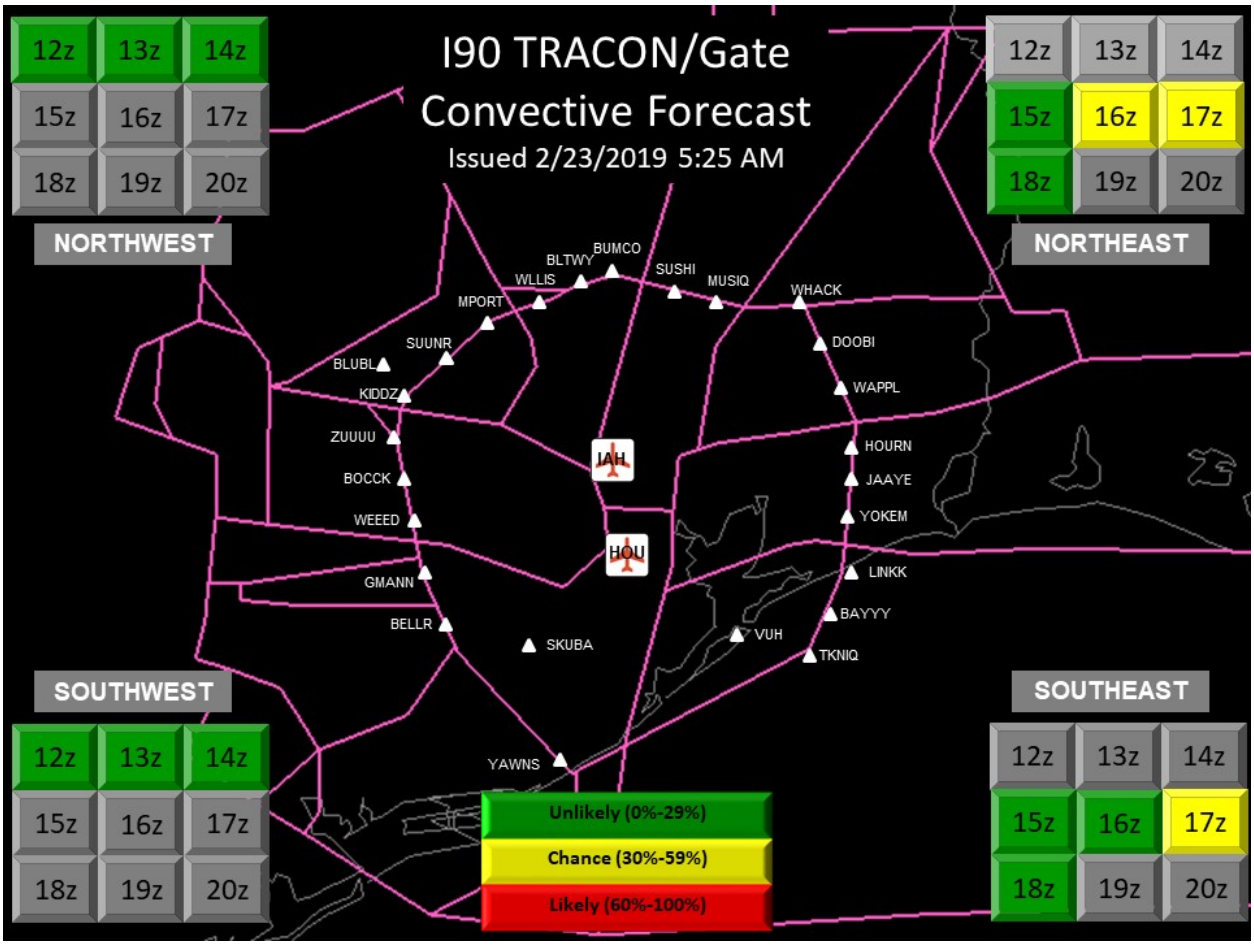

Figure 18 – Houston TRACON Gate Convective Forecast issued by the ZHU CWSU about 0530 CST.

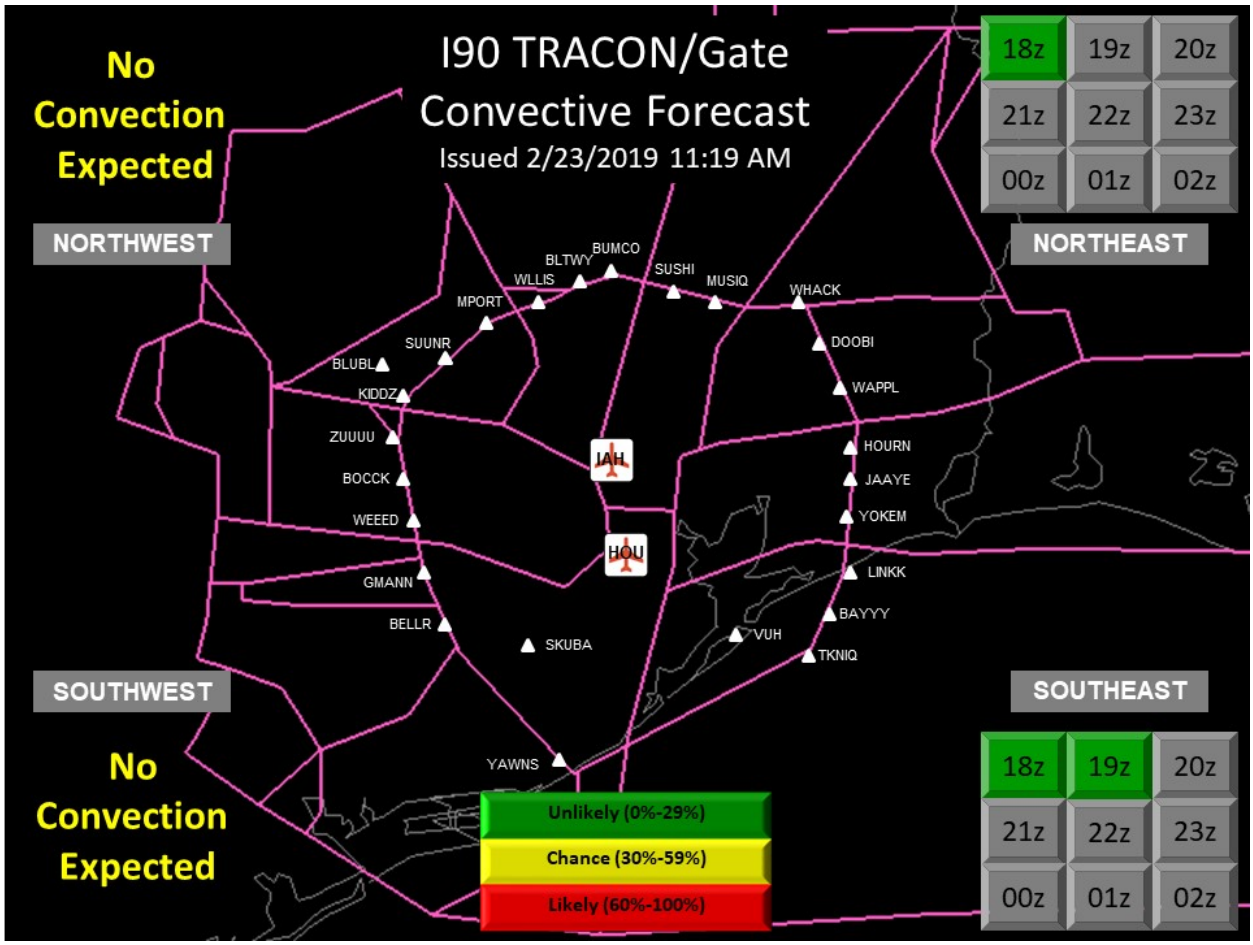

Figure 19 – Houston TRACON Gate Convective Forecast issued by the ZHU CWSU about 1130 CST.

9.0 SIGMETs

There were no Convective or non-Convective Significant Meteorological Information (SIGMET) advisories active for the accident location at the accident time.

10.0 Area Forecast Discussion

An Area Forecast Discussion (AFD) was issued at 1151 CST by the NWS Houston/Galveston WFO. The "Aviation" section of the AFD is presented here.

FXUS64 KHGX 231751
AFDHGX

Area Forecast Discussion
National Weather Service Houston/Galveston TX
1151 AM CST Sat Feb 23 2019

.AVIATION...
Prefrontal trough near a JAS-HOU-LBX line with the cold front quickly catching up to it. Scattered showers and a few thunderstorms still possible along and south of it as it overtakes the front. Winds turn to the NW and gusty for an hour or so then should start to back to the WNW-W this afternoon as the big wound up surface low over Oklahoma lifts ENE. MVFR-IFR ceilings along and south of the boundary with fog still along the immediate coast and out over the Gulf. Very abrupt improvement to VFR in the wake of the front with mainly cirrus this afternoon. Winds relaxing this evening and westerly then increase as second push of cold air comes through the area between 07-10z gradually swinging around to the NNE late Sunday morning.

11.0 Terminal Aerodrome Forecasts

Terminal Aerodrome Forecasts (TAF) were issued for IAH by the NWS Houston/Galveston WFO. Presented here is the most recently issued IAH TAF prior to the accident time.[22]

TAF KIAH 231721Z 2318/2424 ***33014G21KT 6SM BR VCSH SCT015 BKN019 OVC028***
FM231900 30010G16KT P6SM SCT050 BKN250
TEMPO 2319/2321 BKN050 OVC250
FM240300 26006KT P6SM SCT250
FM240800 34009KT P6SM FEW250
FM241600 01010G16KT P6SM FEW250=

At 1121 CST a TAF was issued for IAH that forecasted for the accident time: wind from 330° at 14 knots with gusts to 21 knots, visibility six statute miles, mist, moderate rain showers in the vicinity, scattered clouds at 1,500 feet agl, ceiling broken at 1,900 feet agl, overcast clouds at 2,800 feet agl.

Prior to this, the two previous IAH TAFs were issued at 0521and 0855 CST.

TAF KIAH 231121Z 2312/2418 16013KT 5SM -DZ BR OVC008
FM231400 22009G16KT 1SM -SHRA BR VCTS OVC007CB
TEMPO 2314/2316 TSRA
FM231700 29013G23KT P6SM SCT020 BKN050 BKN250
FM231900 30013G23KT P6SM SCT050 BKN250
FM240300 25005KT P6SM SCT250
FM240900 33009KT P6SM FEW250=

KIAH 231455Z 2315/2418 17009KT 5SM BR VCTS SCT010 BKN016CB BKN060
TEMPO 2315/2317 27010G23KT 3SM TSRA OVC015CB
FM231700 29013G23KT P6SM SCT020 BKN050 BKN250

[22] TAFs issued by the NWS for aerodromes in the United States are valid for an area within five statute miles of the center of an airport's runway complex.

FM231900 30013G23KT P6SM SCT050 BKN250
FM240300 25005KT P6SM SCT250
FM240900 33009KT P6SM FEW250=

12.0 Integrated Terminal Weather System

The Integrated Terminal Weather System (ITWS) is an air traffic management tool that provides terminal air traffic managers and controllers plus airline dispatchers with highly accurate, easily understood and immediately useable graphical weather information and hazard alerts on a single, integrated color display (the "Situation Display"). An ITWS Situation Display was present in the Houston TRACON facility on the day of the accident. Screenshots of the ITWS Situation Display TRACON windows applicable for IAH for the time period surrounding the accident time (at five-minute intervals) are present in Attachment 5. The screenshot for the ITWS Situation Display TRACON window applicable for IAH at 1235 CST is presented in figure 20, with the approximate location of the accident marked on the screenshot. The solid purple line represents a "gust front," the closest dotted purple line to the solid purple line represents the forecasted position of the gust front in 10 minutes, the other dotted purple line represents the forecasted position of the gust front in 20 minutes and the arrows and associated numbers represent the wind direction and magnitude, respectively, ten minutes behind the gust front.

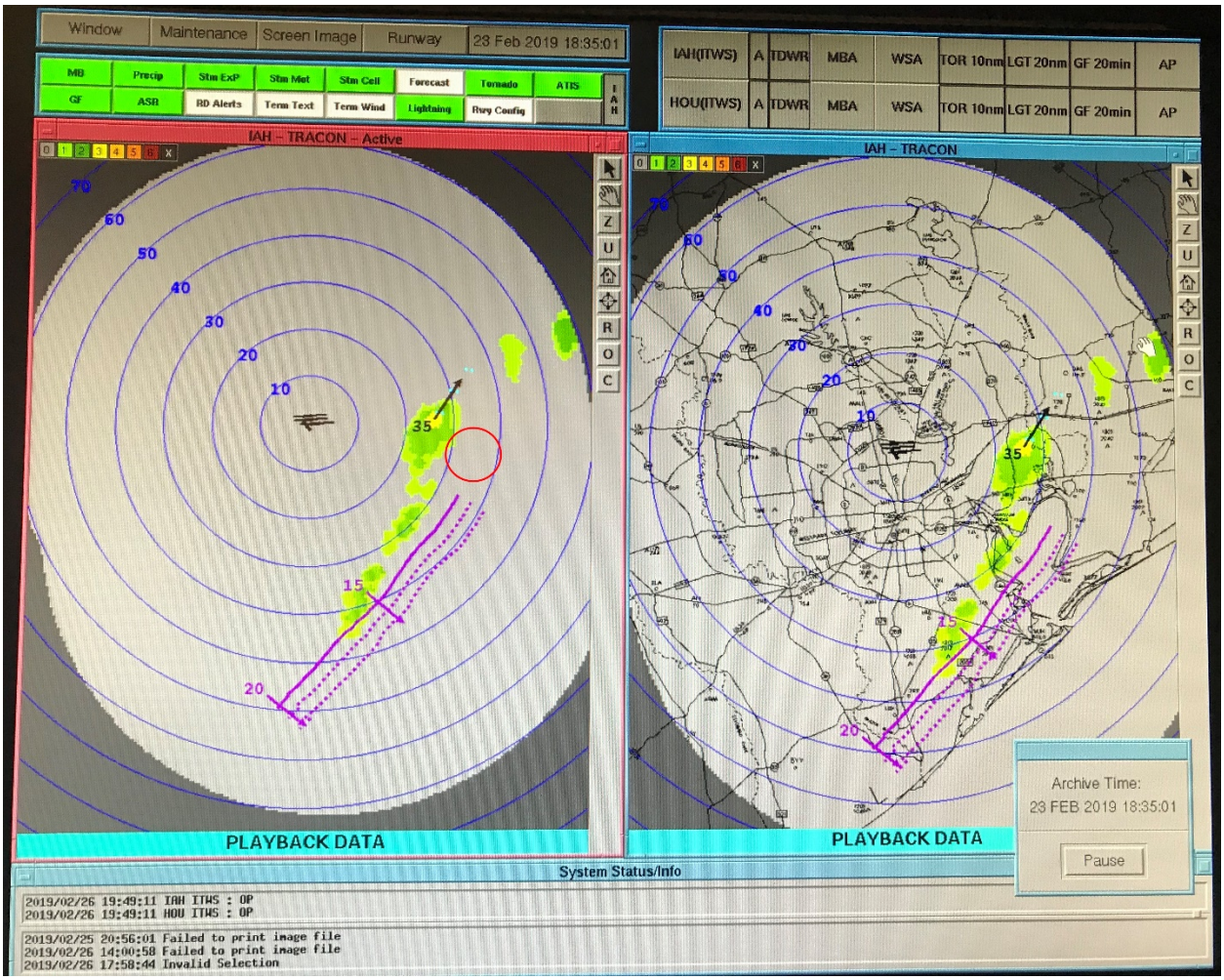

Figure 20 - Screenshot for the ITWS Situation Display TRACON windows (at two different zoom levels) applicable for IAH at 1235 CST. The red circle has been added to the screen shot and approximates the accident location.

13.0 STARS

A screenshot of the Standard Terminal Automation Replacement System (STARS) display from Houston TRACON at about the time of the accident is presented in Figure 21. No "precipitation" was depicted at the accident location. Figure 22 describes how different radar levels are presented in the STARS display. Figure 21 presents a slightly different color shading (a green shading rather than a blue shading), however the solid color/dots are consistent.

Figure 21 – Houston TRACON STARS weather depiction from about the time of the accident. The accident aircraft is circled in red.

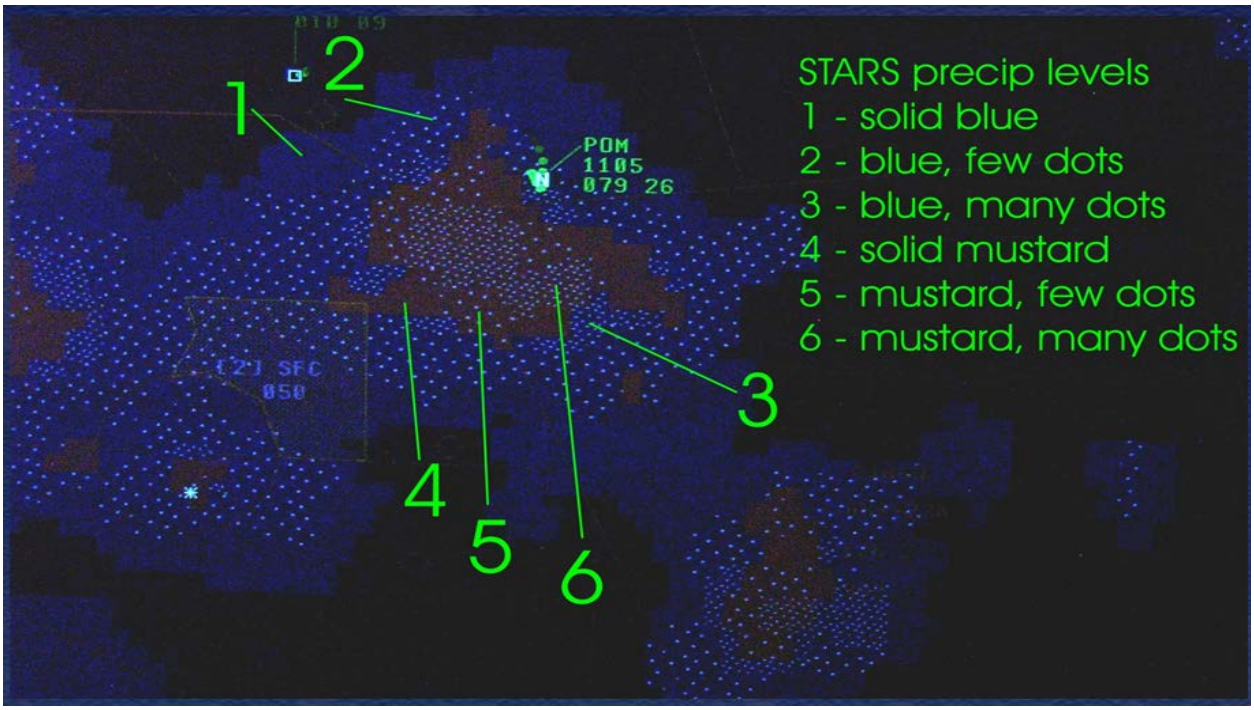

Figure 22 – Example of the weather radar presentation in STARS.

The dBZ thresholds for the color scale (levels) presented in the STARS display are as follows (approximately):

Level 1: 18 < 30 dBZ
Level 2: 30 < 41 dBZ
Level 3: 41 < 46 dBZ
Level 4: 46 < 50 dBZ
Level 5: 50 < 57 dBZ
Level 6: 57+ dBZ

14.0 CIWS

Archive data from the Federal Aviation Administration's Corridor Integrated Weather System (CIWS) for the accident region at 1240 CST is presented in figures 23-25. These images present the Precipitation product, the Winter Precipitation product and the Echo Tops product heights. The dBZ scale in the Precipitation product (Figure 23) is the same as, or very similar to, the levels 1-6 dBZ thresholds described for the STARS display. The Winter Precipitation's dBZ scale (figure 24) is the same as the Precipitation product's scale, except for Level 1, which is divided into three sub-scales with a larger dBZ range.[23] It should be noted that the Winter Precipitation product depicts a portion of the fine line around the accident location whereas the Precipitation product does not. This is likely due to the Winter Precipitation product presenting lower dBZ values. The Echo Tops product did not present echo tops for the fine line.

[23] In the Winter Precipitation product, Level 1a represents reflectivity values from 5 to about 23 dBZ, Level 1b represents reflectivity values from about 23 to about 27 dBZ and Level 1c represents reflectivity values from about 27 to 30 dBZ.

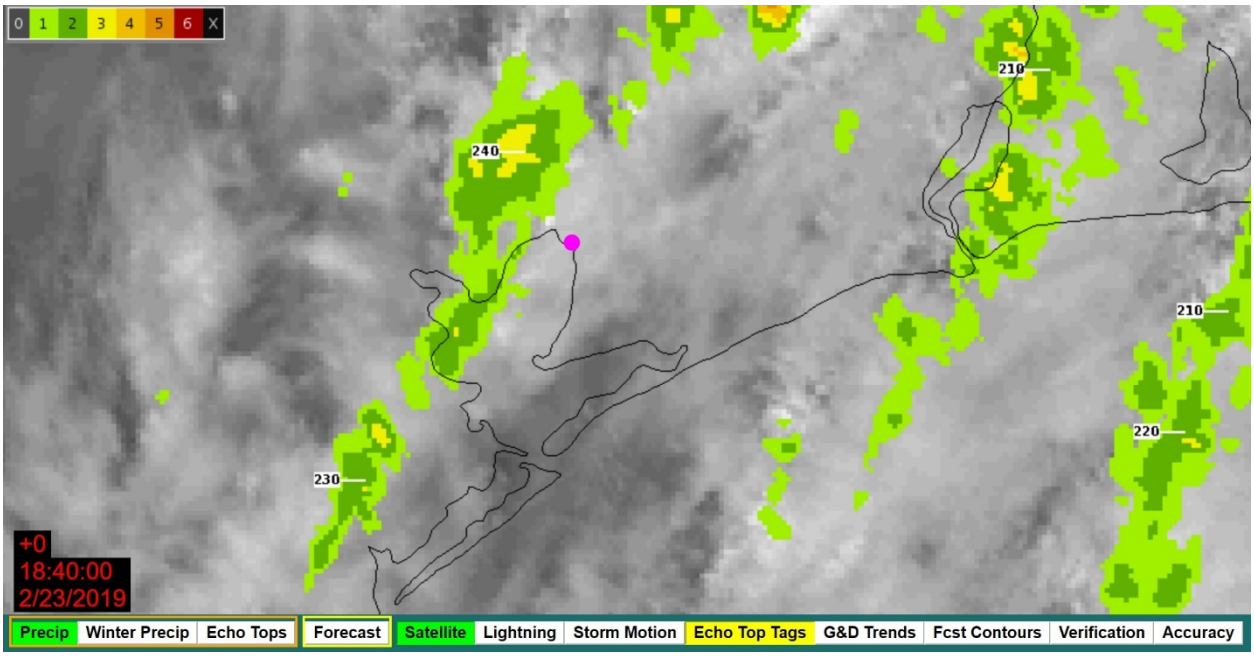

Figure 23 – Archive CIWS Precipitation product valid at 1240 CST. Accident location denoted by pink dot.

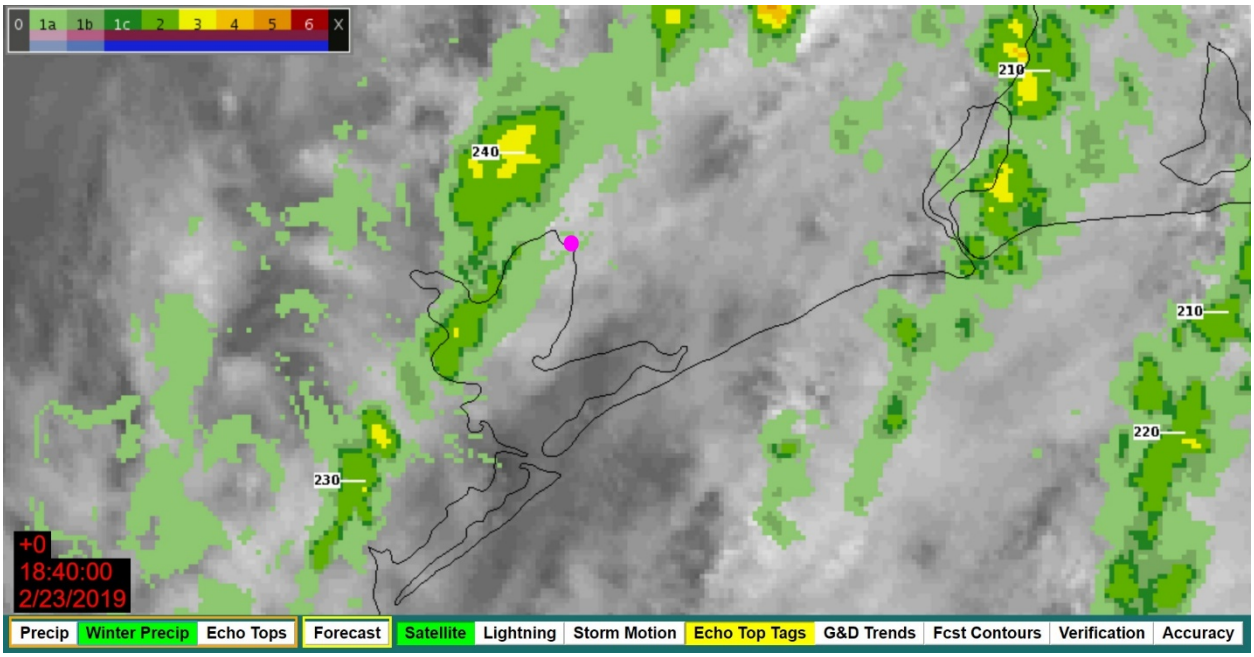

Figure 24 – Archive CIWS Winter Precipitation product valid at 1240 CST. Accident location denoted by pink dot.

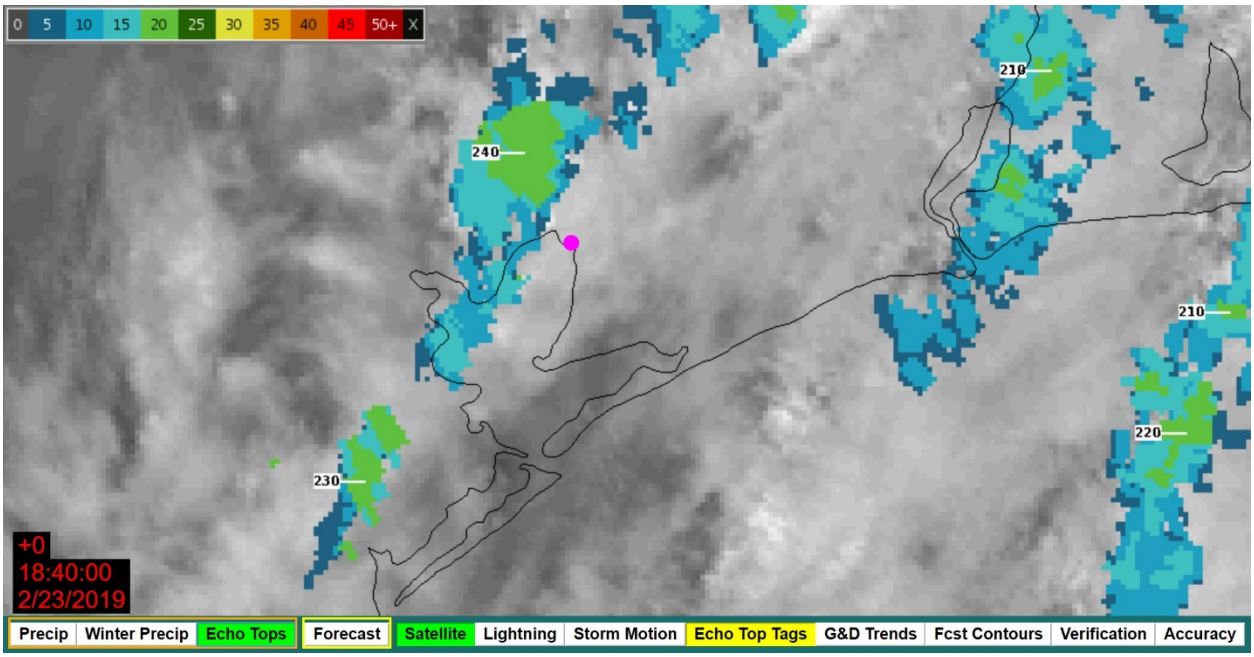

Figure 25 – Archive CIWS Echo Tops product valid at 1240 CST. Accident location denoted by pink dot. Numbers indicate echo top heights (hundreds of feet).

15.0 Local Video

A video was taken of the shelf cloud[24] associated with the fine line by a witness on the ground as it passed over Trinity Bay about 5 minutes after the accident time. According to the witness, the video was taken from Bob White Lane[25] facing generally west over the bay. The video in its entirety may be found in the public docket for this accident.

Figure 26 – A cropped screenshot of the local video.

[24] Shelf cloud - a low-level horizontal arcus-type accessory cloud that appears as wedge-shaped as it approaches. It is usually attached to the thunderstorm base and forms along the gust front or fine line. The leading edge of the shelf cloud is often smooth and at times layered

[25] The road is at coordinates: 29.631004°N, 94.702841°W.

F. LIST OF ATTACHMENTS

Attachment 1 - Meteorological analysis provided by the National Weather Service Weather Forecast Office in Houston/Galveston, Texas.

Attachment 2 - National Weather Service information on KHGX WSR-88D operations.

Attachment 3 - GOES-16 visible imagery between 1127 and 1237 CST.

Attachment 4 - Statements from the flight crew of United Airlines flight# 1788.

Attachment 5 - Screenshots of the Integrated Terminal Weather System Situation Display TRACON windows applicable for IAH for the time period surrounding the accident time (at five-minute intervals).

Attachment 6 - Analysis provided by United Airlines.

Attachment 7 - Communication with Dr. Robert Sharman of the National Center for Atmospheric Research/Research Applications Laboratory regarding turbulence severity classification based on aircraft vertical accelerations.

Attachment 8 - Engineering analysis by Collins Aerospace of the expected weather radar cockpit display on the accident aircraft immediately prior to the accident time.

Submitted by:

_____

Mike Richards
Senior Meteorologist

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