NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 12, 2018

Weather Study

METEOROLOGY

CEN17FA064

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A. ACCIDENT

Location: Near Vienna, Illinois
Date: December 31, 2016
Time: 1745 central standard time
2345 Coordinated Universal Time (UTC)
Airplane: Piper PA 28R-200, Registration: N2806R

B. METEOROLOGIST

Paul Suffern
Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are central standard time (CST) on December 31, 2016, and are based upon the 24-hour clock, where local time is -6 hours from UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 37.3542° N, longitude 88.8114° W, at an approximate elevation of 415 feet (ft).

D. WEATHER INFORMATION

1.0 Synoptic Situation

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

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1800 CST is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart depicted a cold frontal boundary just north of the accident site from southwestern Illinois northeastward into northern Ohio. A stationary front stretched southwest from southwestern Illinois into northeastern Texas. There was a surface high pressure center located in northeastern Kansas with a pressure of 1015-hectopascals (hPa). Further to the south, a 1007-hPa low pressure center was located in northeastern Texas associated with another developing stationary front. The accident site was located immediately south of the frontal system in the warm air sector of the front.

The station models around the accident site depicted air temperatures in the mid 30's to mid 40's degrees Fahrenheit (°F), dew point temperatures in the mid 30's to mid 40's °F with temperature-dew point spreads of 3° F or less, a south wind of 5 knots or less, and mostly clear skies north of the accident site and cloudy skies at the accident site and points southward.

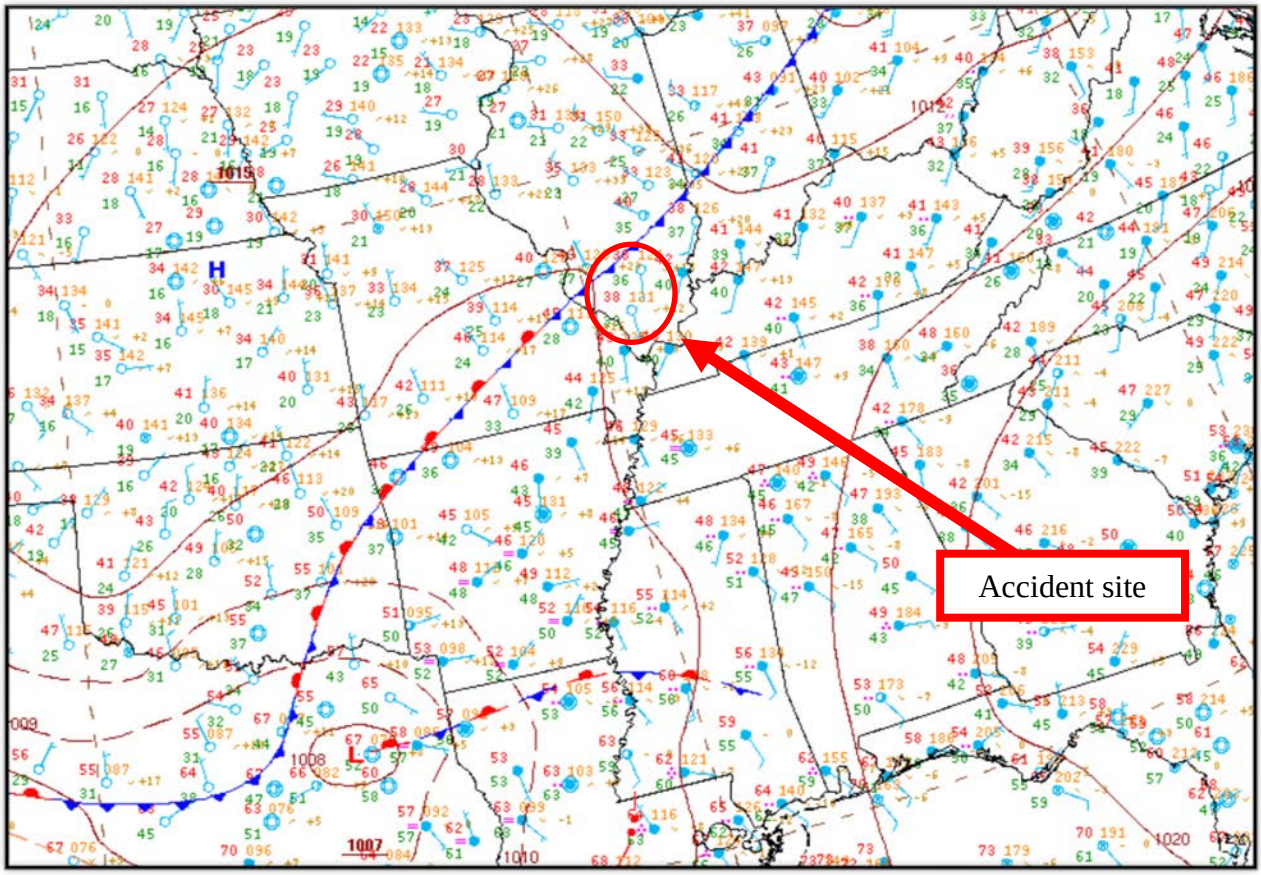

Figure 1 – NWS Surface Analysis Chart for 1800 CST

1.2 Upper Air Charts

The NWS Storm Prediction Center Constant Pressure Charts for 1800 CST (0000Z on January 1, 2017) at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There was a low-level trough[1] located directly west and above the accident site at 1800 CST and this low-level trough was associated with the frontal boundaries described in section 1.1 (figure 1). Troughs and frontal boundaries can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. In addition, there was upper-level divergence[2] (yellow lines, figure 6) located above the accident site and this would have aided in any cloud formation. There was a southwest wind ahead of the low-level trough near the accident site of 30 to 35 knots at 925-hPa, and 40 to 50 knots at 850-hPa. The wind became westerly by 700-hPa above the accident site with a wind speed near 50 knots. The westerly wind increased in speed to 110 knots by 300-hPa (figure 6).

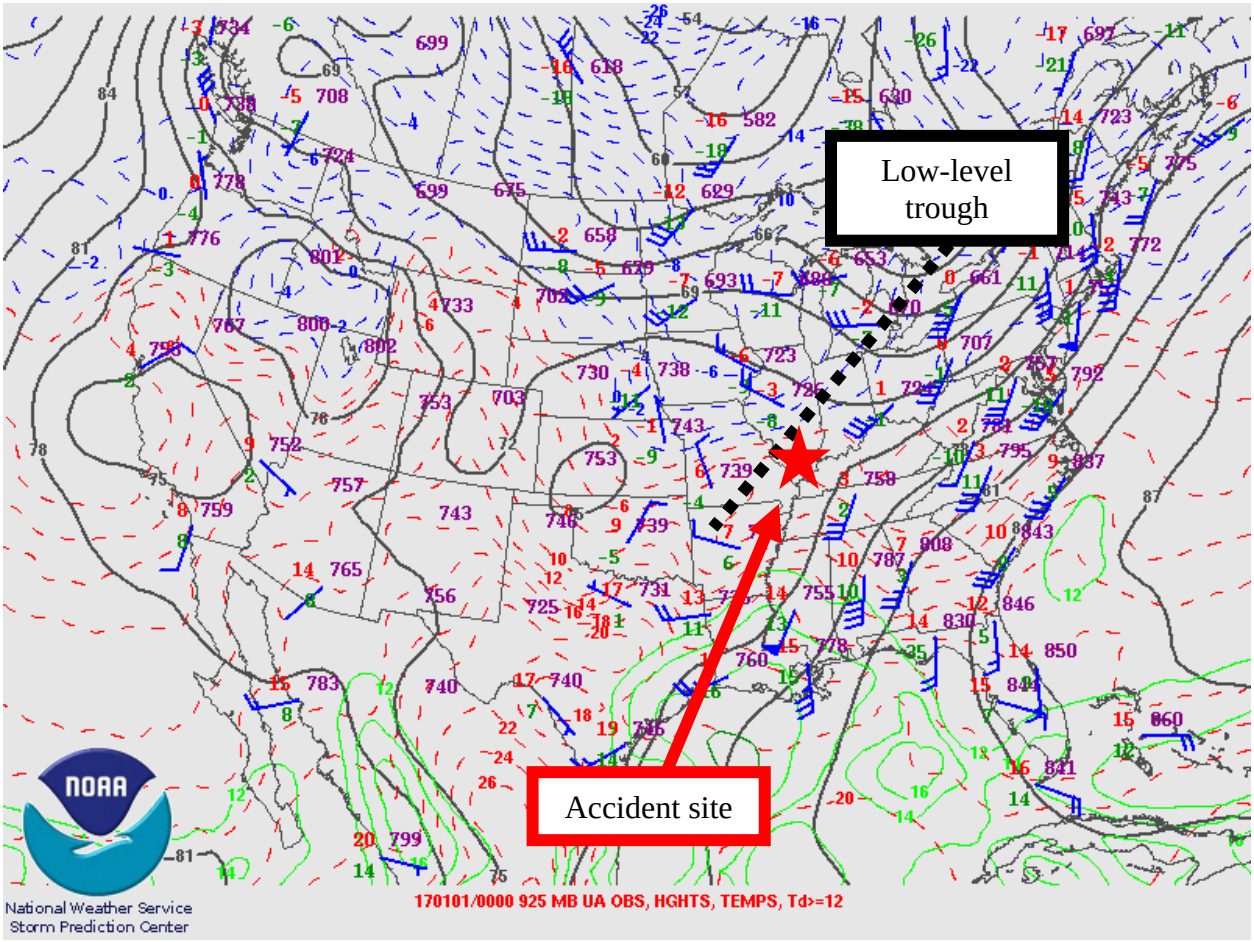

Figure 2 – 925-hPa Constant Pressure Chart for 1800 CST

[1] Trough – An elongated area of relatively low atmospheric pressure or heights.
[2] Upper-level divergence - Diverging winds aloft allow for lower pressure and convergence at the Earth's surface, which leads to upward motion.

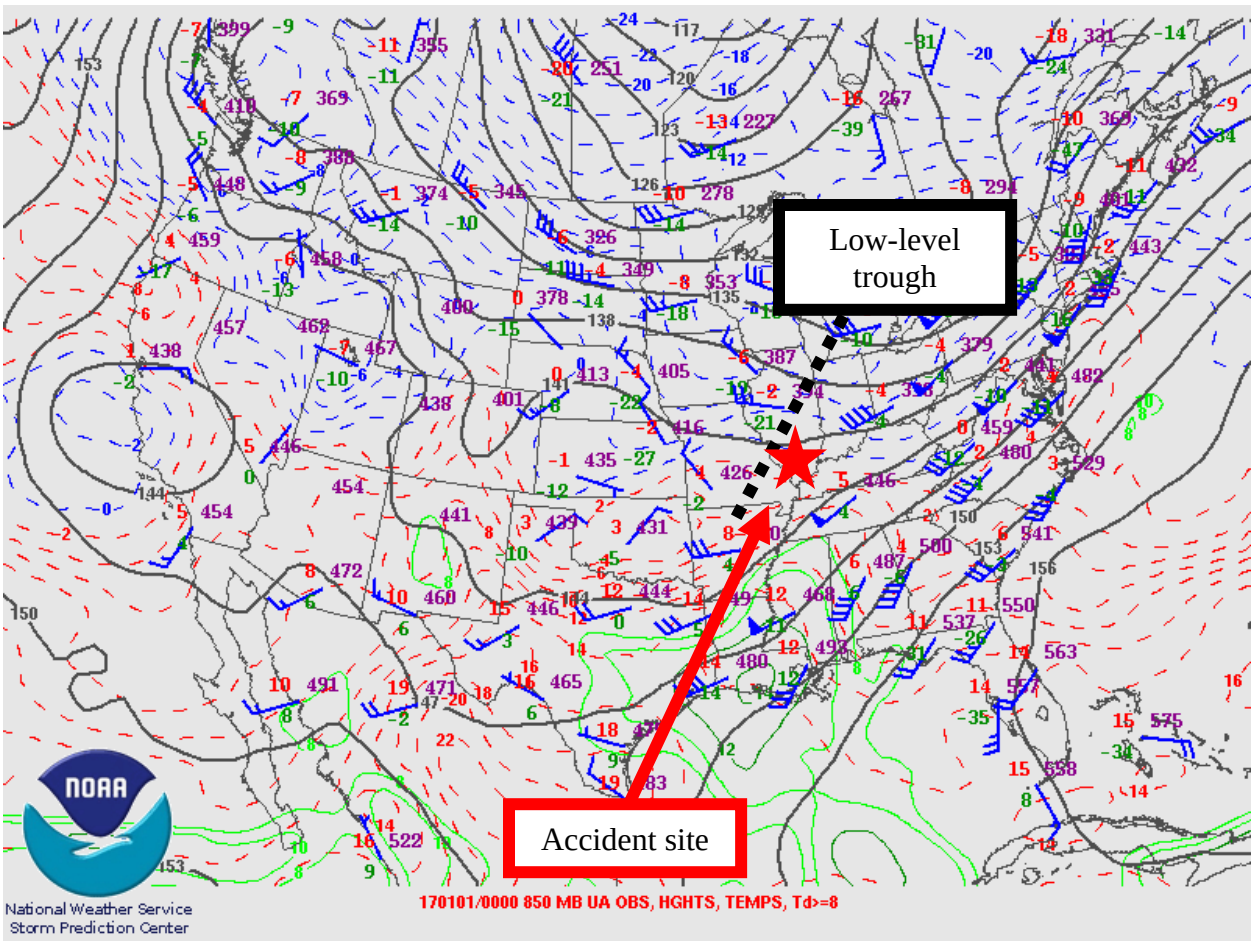

Figure 3 – 850-hPa Constant Pressure Chart for 1800 CST

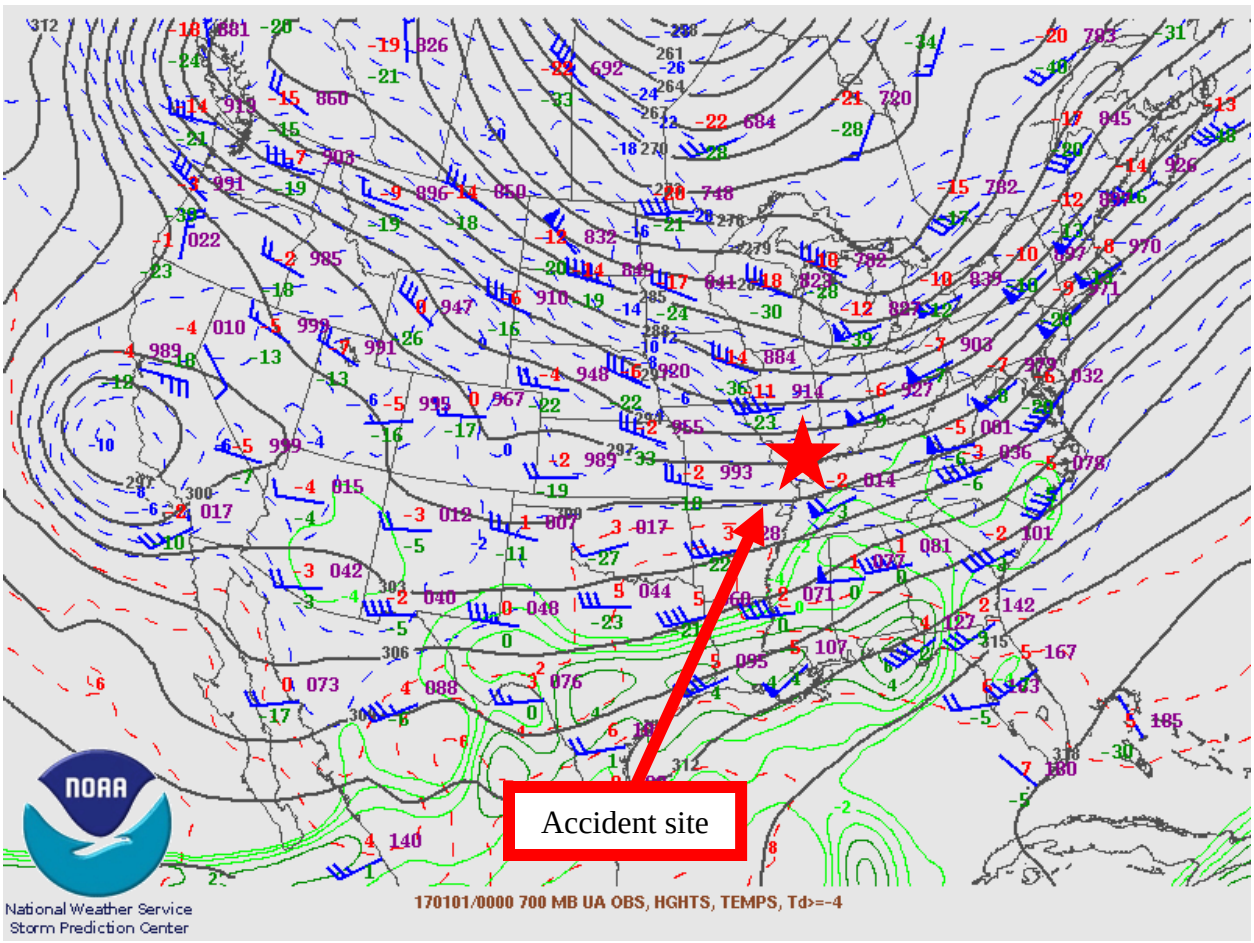

Figure 4 – 700-hPa Constant Pressure Chart for 1800 CST

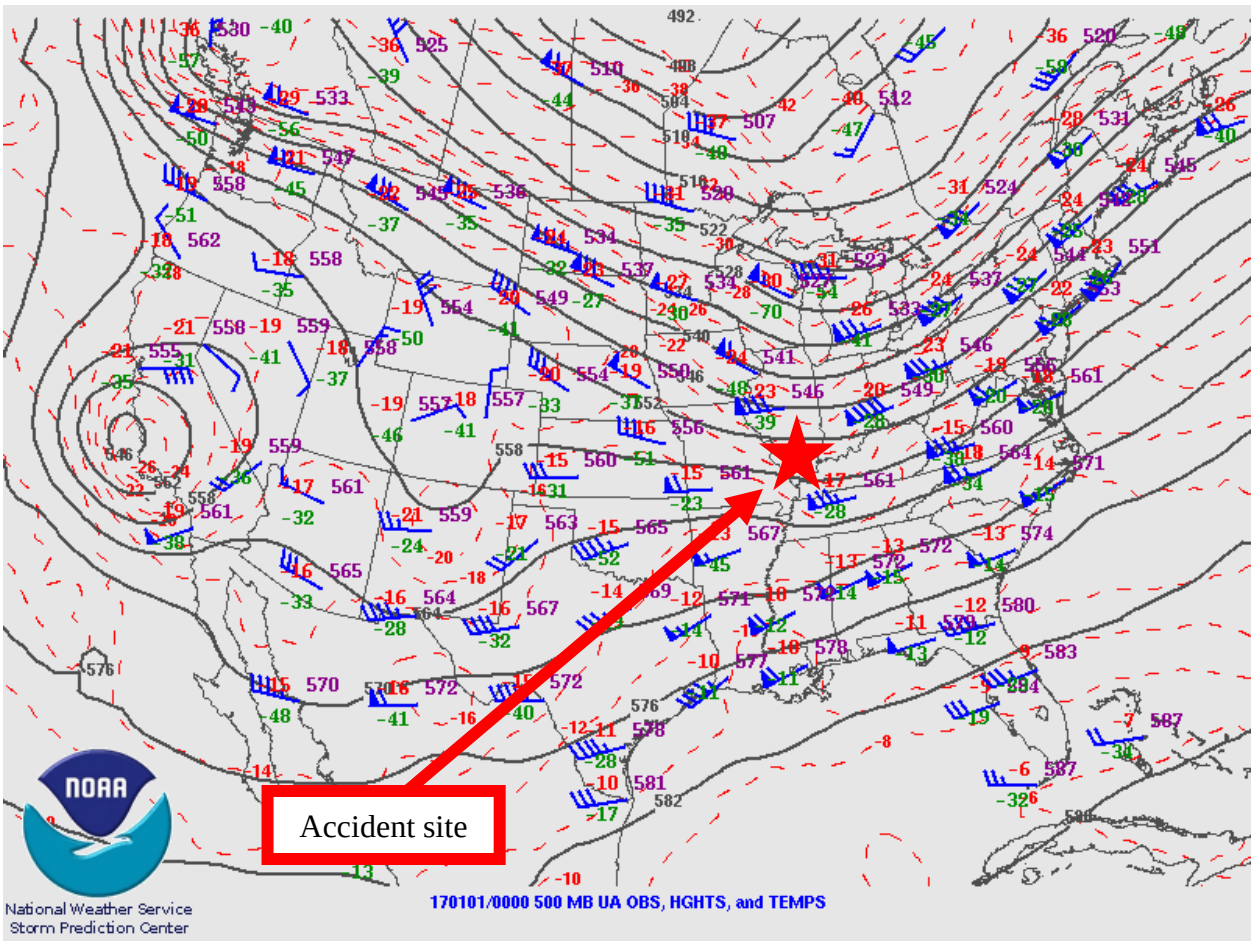

Figure 5 – 500-hPa Constant Pressure Chart for 1800 CST

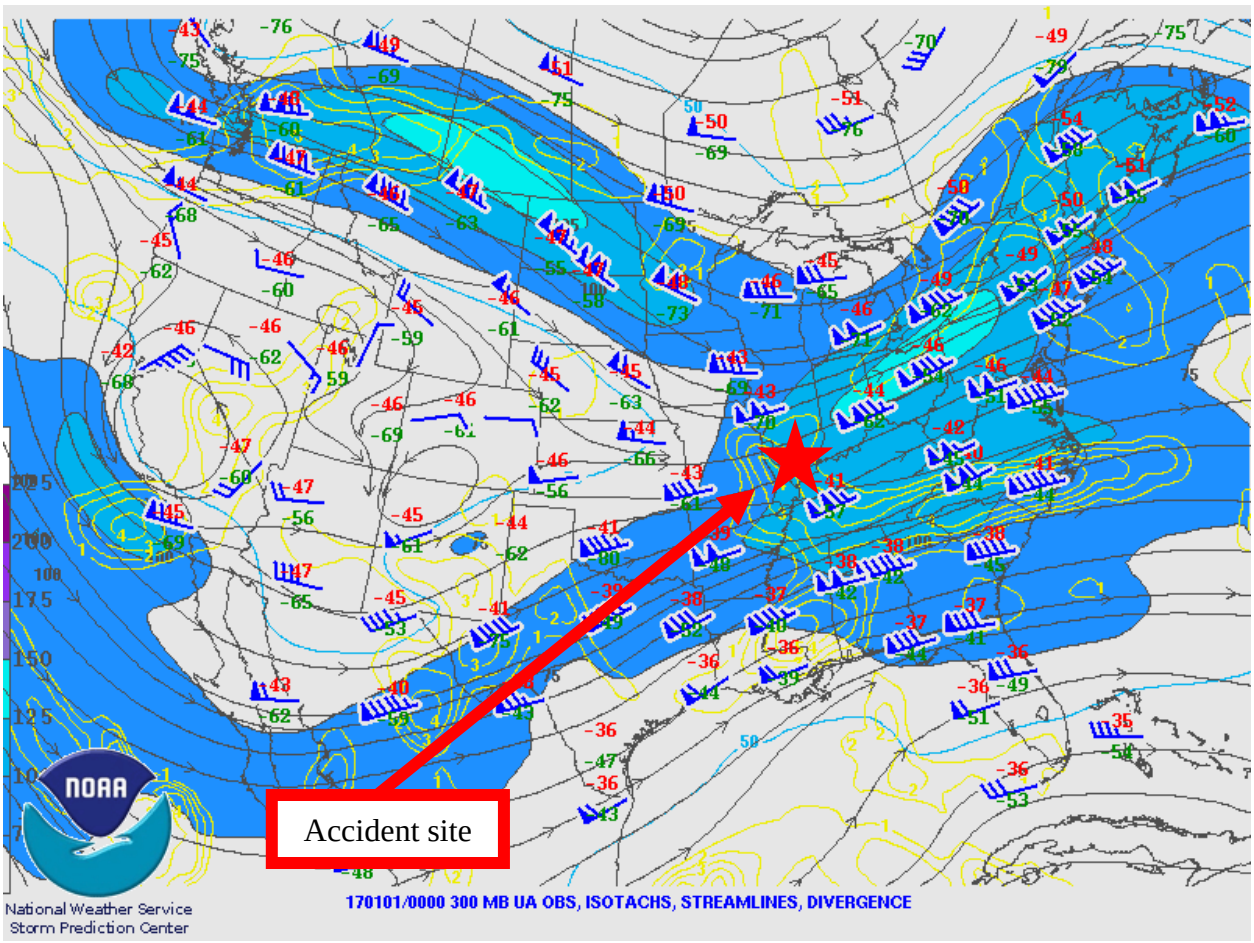

Figure 6 – 300-hPa Constant Pressure Chart for 1800 CST

2.0 Storm Prediction Center Products

There were no thunderstorms forecast for the accident site at the accident time.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language with visibility in statute miles for this section. Figure 7 is a sectional chart with the accident site and the closest weather reporting locations marked.

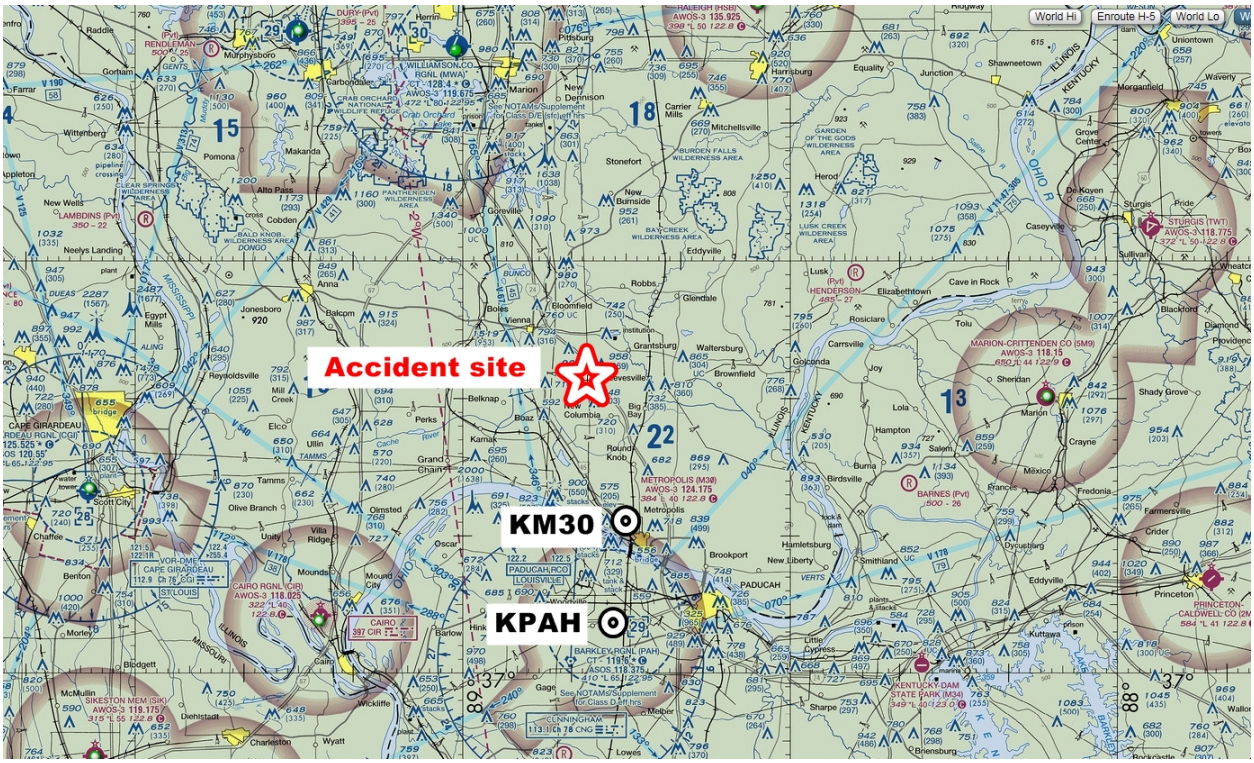

Figure 7 – Sectional chart of accident area with the location of the accident site and surface observation sites

Metropolis Municipal Airport (KM30) was the closest airport to the accident site located 2 miles northwest of Metropolis, Illinois. KM30 had an Automated Weather Observing System (AWOS[3]) whose reports were not supplemented. KM30 was located 11 miles south-southeast of the accident site, at an elevation of 384 ft, and had a 1° easterly magnetic variation[4] (figure 7). The following observations were taken and disseminated during the times surrounding the accident:[5]

[1535 CST] METAR KM30 312135Z AUTO 00000KT 10SM OVC007 06/05 A2989 RMK AO2 T00600051=

[1555 CST] METAR KM30 312155Z AUTO 00000KT 10SM OVC007 06/05 A2990 RMK AO2 T00610052=

[1615 CST] METAR KM30 312215Z AUTO 00000KT 10SM OVC007 06/05 A2991 RMK AO2 T00600052=

[3] 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 ft, and altimeter setting.

[4] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from http://www.airnav.com/airport/M30

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

[1635 CST] METAR KM30 312235Z AUTO 00000KT 5SM BR OVC005 06/05 A2991 RMK AO2 T00600053=

[1655 CST] METAR KM30 312255Z AUTO 00000KT 7SM OVC005 06/05 A2991 RMK AO2 T00600054=

[1715 CST] METAR KM30 312315Z AUTO 00000KT 10SM OVC005 06/06 A2991 RMK AO2 T00600055=

[1735 CST] METAR KM30 312335Z AUTO 00000KT 10SM OVC005 06/06 A2991 RMK AO2 T00600055=

ACCIDENT TIME 1745 CST

[1755 CST] METAR KM30 312355Z AUTO 00000KT 10SM OVC005 06/06 A2992 RMK AO2 60001 T00600055 10061 20045=

[2055 CST] METAR KM30 010255Z AUTO 00000KT 10SM OVC008 06/05 A2996 RMK AO2 T00600052=

[2115 CST] METAR KM30 010315Z AUTO 00000KT 10SM OVC008 06/05 A2996 RMK AO2 T00600051=

[2135 CST] METAR KM30 010335Z AUTO 00000KT 10SM OVC008 06/05 A2997 RMK AO2 T00600052=

KM30 weather at 1715 CST, wind calm, 10 miles visibility or greater, overcast ceiling at 500 ft above ground level (agl), temperature of 6° Celsius (C), dew point temperature of 6° C, and an altimeter setting of 29.91 inches of mercury. Remarks, station with a precipitation discriminator, temperature 6.0° C, dew point temperature 5.5° C.

KM30 weather at 1735 CST, wind calm, 10 miles visibility or greater, overcast ceiling at 500 ft agl, temperature of 6° C, dew point temperature of 6° C, and an altimeter setting of 29.91 inches of mercury. Remarks, station with a precipitation discriminator, temperature 6.0° C, dew point temperature 5.5° C.

KM30 weather at 1755 CST, wind calm, 10 miles visibility or greater, overcast ceiling at 500 ft agl, temperature of 6° C, dew point temperature of 6° C, and an altimeter setting of 29.92 inches of mercury. Remarks, station with a precipitation discriminator, 6-hourly precipitation of 0.01 inches, temperature 6.0° C, dew point temperature 5.5° C, 6-hourly maximum temperature 6.1° C, 6-hourly minimum temperature 4.5° C.

KM30 weather at 2055 CST, wind calm, 10 miles visibility or greater, overcast ceiling at 800 ft agl, temperature of 6° C, dew point temperature of 5° C, and an altimeter setting of 29.96 inches of mercury. Remarks, station with a precipitation discriminator, temperature 6.0° C, dew point temperature 5.2° C.

Barkely Regional Airport (KPAH) was the next closest official weather station to the accident site, located 12 miles west of Paducah, Kentucky. KPAH had Automated Surface Observing System (ASOS[6]) whose reports were supplemented by air traffic control. KPAH was located 18 miles south of the accident site, at an elevation of 410 ft, and had a 1° westerly magnetic variation[7] (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[1053 CST] METAR KPAH 311653Z 21006KT 3SM -RA BR BKN009 BKN012 OVC021 04/03 A2995 RMK AO2 SLP141 P0007 T00440028=

[1153 CST] METAR KPAH 311753Z 22010KT 3SM -RA BR OVC009 05/03 A2993 RMK AO2 CIG 006V013 SLP136 P0003 60017 T00500028 10078 20044 58009=

[1253 CST] METAR KPAH 311853Z 22007KT 10SM OVC007 05/03 A2990 RMK AO2 RAE05 SLP127 P0000 T00500033=

[1353 CST] METAR KPAH 311953Z 22007KT 10SM OVC007 06/03 A2988 RMK AO2 SLP120 T00560033=

[1453 CST] METAR KPAH 312053Z 18006KT 10SM OVC007 06/04 A2988 RMK AO2 SLP117 60000 T00610039 56018=

[1553 CST] METAR KPAH 312153Z 21005KT 10SM OVC006 06/04 A2988 RMK AO2 SLP120 T00610044=

[1653 CST] METAR KPAH 312253Z 21004KT 10SM OVC007 06/04 A2990 RMK AO2 SLP124 T00610044=

ACCIDENT TIME 1745 CST

[1753 CST] METAR KPAH 312353Z 22004KT 10SM OVC007 06/04 A2991 RMK AO2 SLP130 60000 T00610044 10061 20050 53013=

[1853 CST] METAR KPAH 010053Z 16003KT 10SM OVC007 06/04 A2993 RMK AO2 CIG 006V011 SLP135 T00610044=

[1953 CST] METAR KPAH 010153Z 14003KT 10SM BKN008 OVC012 06/04 A2993 RMK AO2 CIG 006V011 SLP138 T00610044=

[2000 CST] SPECI KPAH 010200Z 15004KT 10SM OVC010 06/04 A2994 RMK AO2 CIG 006V013 T00610044=

[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] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2005, latest measurement taken from http://www.airnav.com/airport/kpah

KPAH weather at 1553 CST, wind from 210° at 5 knots, 10 miles visibility or greater, overcast ceiling at 600 ft agl, temperature of 6° C, dew point temperature of 4° C, and an altimeter setting of 29.88 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1012.0 hPa, temperature 6.1° C, dew point temperature 4.4° C.

KPAH weather at 1653 CST, wind from 210° at 4 knots, 10 miles visibility or greater, overcast ceiling at 700 ft agl, temperature of 6° C, dew point temperature of 4° C, and an altimeter setting of 29.90 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1012.4 hPa, temperature 6.1° C, dew point temperature 4.4° C.

KPAH weather at 1753 CST, wind from 220° at 4 knots, 10 miles visibility or greater, overcast ceiling at 700 ft agl, temperature of 6° C, dew point temperature of 4° C, and an altimeter setting of 29.91 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1013.0 hPa, 6-hourly precipitation of a trace, temperature 6.1° C, dew point temperature 4.4° C, 6-hourly maximum temperature of 6.1° C, 6-hourly minimum temperature of 5.0° C, 3-hourly pressure increase of 1.3 hPa.

KPAH weather at 1853 CST, wind from 160° at 3 knots, 10 miles visibility or greater, overcast ceiling at 700 ft agl, temperature of 6° C, dew point temperature of 4° C, and an altimeter setting of 29.93 inches of mercury. Remarks, station with a precipitation discriminator, ceiling varying between 600 to 1,100 ft agl, sea level pressure 1013.5 hPa, temperature 6.1° C, dew point temperature 4.4° C.

The observations from KM30 and KPAH surrounding the accident time indicated IFR[8] ceiling conditions around the accident site at the accident time with surface winds under 10 knots. The IFR ceiling conditions were present before the accident flight departed through the accident time.

[8] Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 ft agl and/or less than 3 miles visibility.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)[9] model sounding was created for the accident site for 1800 CST. The 1800 CST sounding was plotted on a standard Skew-T log P diagram[10] with the derived stability parameters included in figure 8 (with data from the surface to 700-hPa, or about 10,000 ft. This data was analyzed using the RAOB[11] software package. The sounding depicted the lifted condensation level (LCL)[12] at 686 ft msl and a convective condensation level (CCL)[13] of 1,393 ft. The freezing level was 8,837 ft. The precipitable water value was 0.54 inches.

[9] The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three kilometer grids with three kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one hour period.

[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, Matamoras, 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.

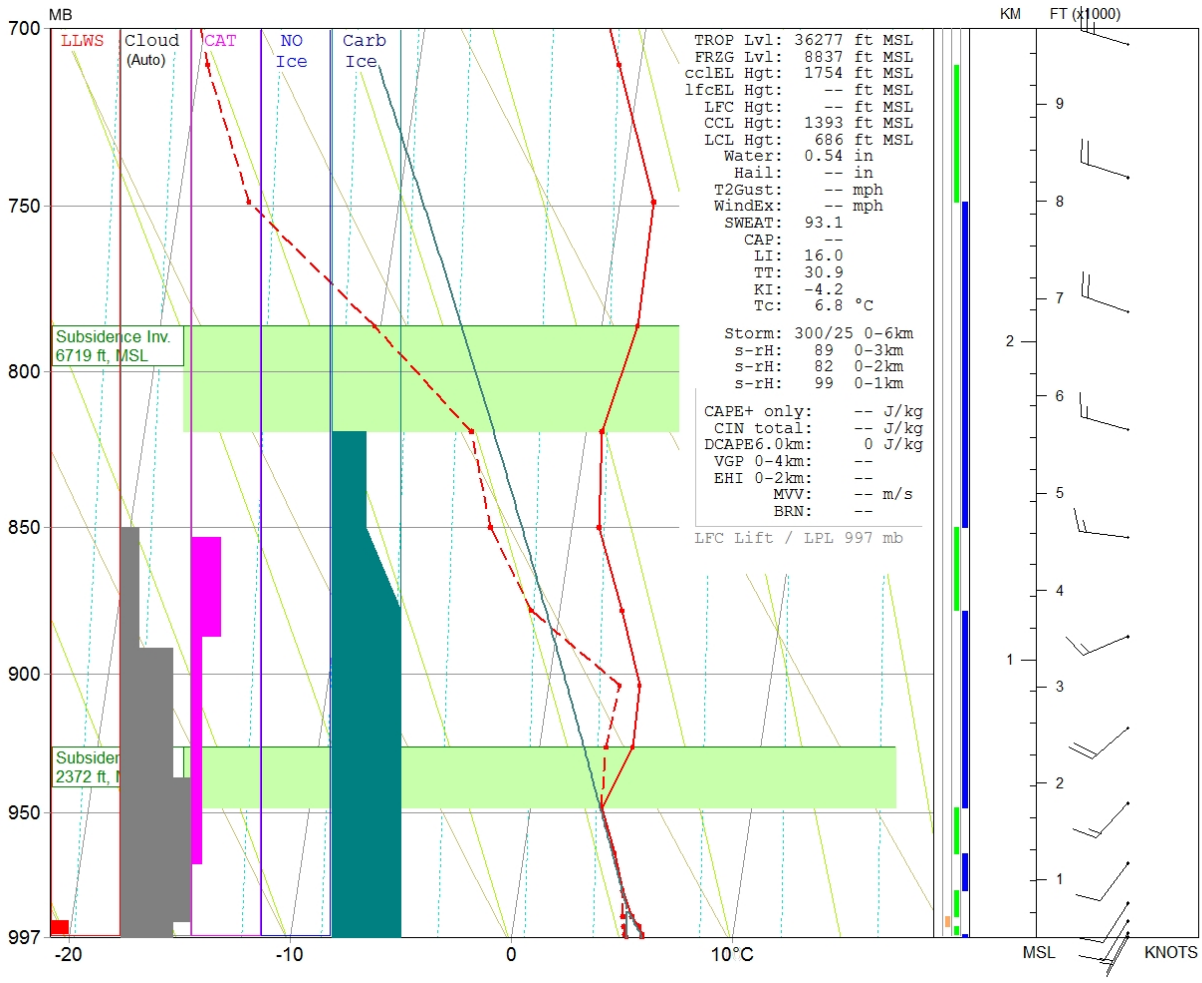

Figure 8 – 1800 CST HRRR sounding for the accident site

The 1800 CST HRRR sounding indicated a mix of stable and conditionally unstable layers between the surface and 4,000 ft. An inversion (increase in temperature with height) was in place between 1,800 and 2,372 ft. With the relatively moist atmosphere between the surface and 5,000 ft which the RAOB program indicated that clouds were likely. No icing was indicated by RAOB below 10,000 ft. Given the relatively light wind field, moist environment from the surface through 5,000 ft, an inversion around 2,000 ft, and lifting mechanisms near the accident site at the accident time (sections 1.1 and 1.2), the formation of clouds was likely.

The 1800 CST HRRR sounding wind profile indicated a surface wind from 207° at 6 knots with the wind remaining southwesterly through 3,500 ft. The wind speed increased to 20 knots by 2,500 ft with the wind speed remaining between 15 and 25 knots from 2,500 ft through 10,000 ft. The southwesterly wind at 3,500 became westerly by 4,500 ft and remained westerly through 10,000 ft. RAOB indicated the possibility of minimal low-level wind shear (LLWS) between the surface and 500 ft. RAOB did indicate the possibility of light clear-air turbulence between 1,500 ft and 5,000 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-13 bands 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm, respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1500 CST through 2100 CST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 9 and 10 present the GOES-13 infrared imagery at 1745 and 1815 CST at 7X magnification with the accident site highlighted with a red square, and the other two closest reporting sites KPAH and KM30 in blue. Inspection of the infrared imagery indicated cloud cover to the south and east of the accident site. The difference in brightness temperatures of the cloud tops above the accident site and the surface temperatures (with clear skies) to the north and west of the frontal boundary (section 1.1) was very small, therefore using infrared imagery, it is difficult to determine where the cloud edges were near the accident site. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1800 CST HRRR sounding, the approximate cloud-top heights over the accident site were 5,000 ft. It should be noted these figures have not been corrected for any parallax error.

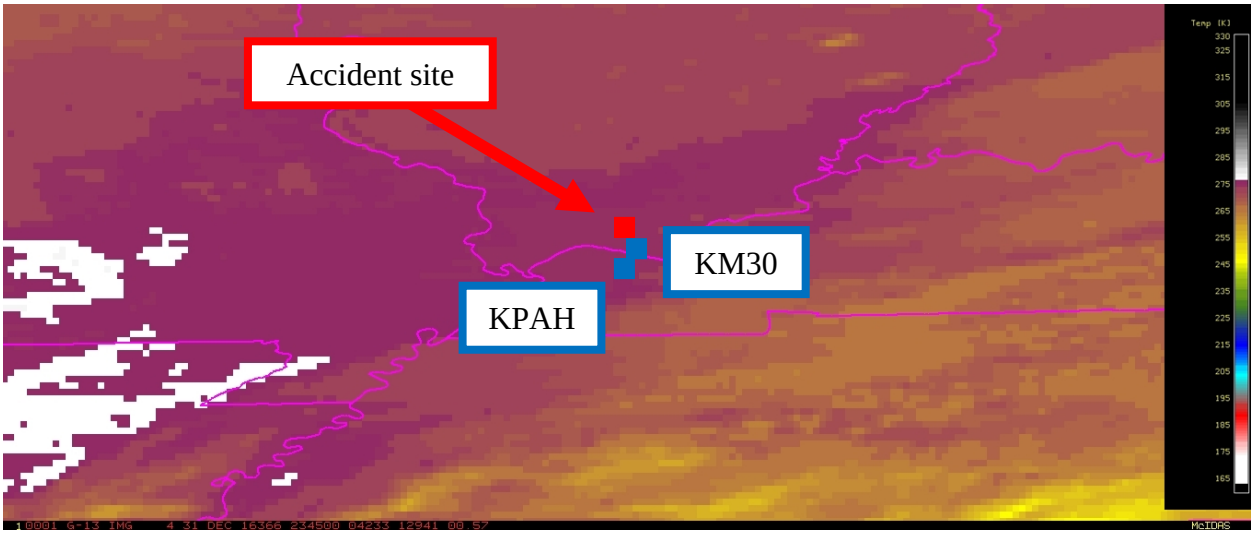

Figure 9 – GOES-13 infrared image at 1745 CST

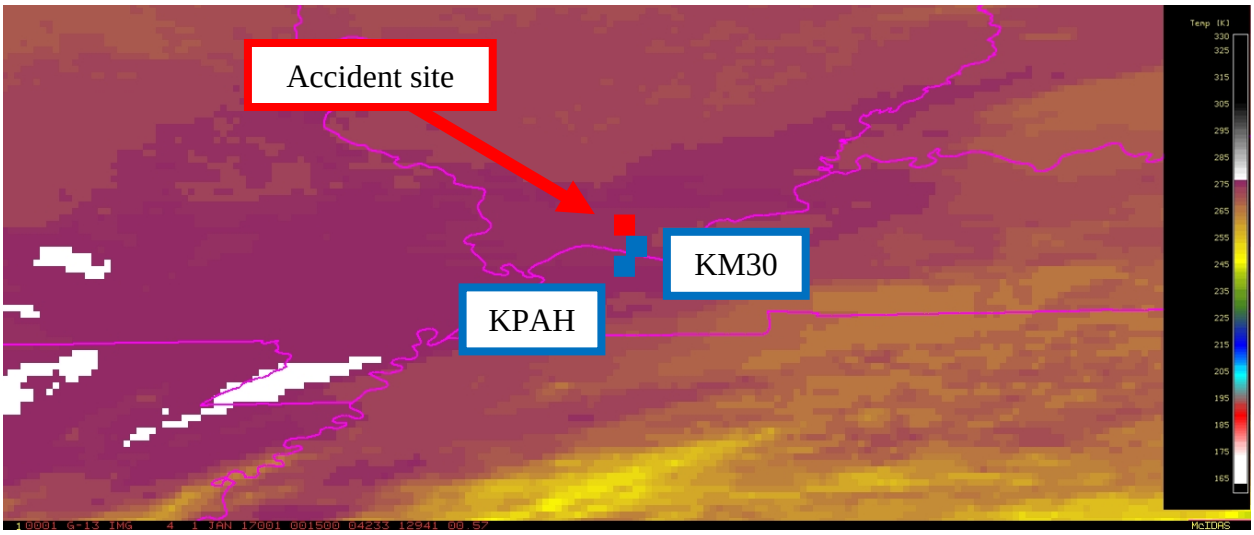

Figure 10 – GOES-13 infrared image at 1815 CST

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[14] to the accident site was KPAH. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. No reflectivity targets were above the accident site around the accident time.

A review of the Earth Networks total lightning archive data base, indicated that there were no lightning strikes over the area at the time of the accident.

7.0 Pilot Reports[15]

All pilot reports (PIREPs) close to the accident site from about three hours prior to the accident time to about two hours after the accident time were reviewed. Only PIREPs for below FL180[16] are provided below:

OWB UA /OV OWB/TM 2117/FLDURD/TP MD83/SK 013 OVC=

MEM UA /OV NQA030015/TM 2127/FL025/TP BE55/TA 7/TB LGT 030-050/RM IMC=

KMEM UA /OV KMEM/TM 2212/FLDURC/TP B763/SK OVC005 =

KMEM UA /OV KMEM/TM 2216/FLDURC/TP A306/SK TOP075 =

[14] The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

[15] Only pilot reports with the WMO header UBIL**, UBIN**, UBKY**, UBTN**, and UBMO** identifier were considered.

[16] Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

OWB UA /OV OWB/TM 2224/FLDURC/TP C402/SK 012 OVC 026 =

MEM UA /OV MEM270020/TM 2244/FLDURC/TP DC10/SK TOP100 =

KMEM UA /OV KMEM/TM 2251/FLDURD/TP MD88/SK SCT004 BKN008=

MEM UA /OV MEM020015/TM 2330/FL030/TP CL30/TB LGT/RM IMC=

KMEM UA /OV KMEM/TM 2338/FLDURD/TP CL30/SK OVC003=

MEM UA /OV 8 SE MEM/TM 0017/FL083/TP B737/SK TOPS 083 BASES 002 =

KMEM UA /OV KMEM/TM 0105/FLDURD/TP B737/SK OVC002=

The decoded PIREPs in plain language were as follows:

Routine pilot report (UA); Over Owensboro, Kentucky; Time – 1517 CST (2117Z); Altitude – During descent; Type aircraft – McDonnell Douglas MD83; Sky – Overcast clouds with bases at 1,300 ft.

Routine pilot report (UA); 15 miles from Millington, Tennessee, on the 030° radial; Time – 1527 CST (2127Z); Altitude – 2,500 ft; Type aircraft – Beechcraft Baron; Temperature – 7° C; Turbulence – Light turbulence between 3,000 to 5,000 ft; Remarks – In instrument meteorological conditions (IMC).

Routine pilot report (UA); Over Memphis, Tennessee; Time – 1612 CST (2212Z); Altitude – During climb; Type aircraft – Boeing 767-300; Sky – Overcast cloud layer with bases at 500 ft.

Routine pilot report (UA); Over Memphis, Tennessee; Time – 1616 CST (2216Z); Altitude – During climb; Type aircraft – Airbus A300-600; Sky – Tops at 7,500 ft.

Routine pilot report (UA); Over Owensboro, Kentucky; Time – 1624 CST (2224Z); Altitude – During climb; Type aircraft – Cessna 402; Sky – Overcast skies with bases at 1,200 ft and tops at 2,600 ft.

Routine pilot report (UA); 20 miles from Memphis, Tennessee, on the 270° radial; Time – 1644 CST (2244Z); Altitude – During climb; Type aircraft – McDonnell Douglas DC-10; Sky – Tops at 10,000 ft.

Routine pilot report (UA); Over Memphis, Tennessee; Time – 1651 CST (2251Z); Altitude – During descent; Type aircraft – McDonnell Douglas MD-88; Sky – Scattered clouds with bases at 400 ft with a broken ceiling with bases at 800 ft.

Routine pilot report (UA); 15 miles from Memphis, Tennessee, on the 020° radial; Time – 1730 CST (2330Z); Altitude – 3,000 ft; Type aircraft – Bombardier Challenger 300; Turbulence – Light; Remarks – Instrument meteorological conditions.

Routine pilot report (UA); Over Memphis, Tennessee; Time – 1738 CST (2338Z); Altitude – During descent; Type aircraft – Bombardier Challenger 300; Sky – Overcast ceiling with bases at 300 ft.

Routine pilot report (UA); 8 miles southeast of Memphis, Tennessee; Time – 1817 CST (0017Z); Altitude – 8,300 ft; Type aircraft – Boeing 737; Sky – Tops at 8,300 ft with bases at 200 ft.

Routine pilot report (UA); Over Memphis, Tennessee; Time – 1905 CST (0105Z); Altitude – During descent; Type aircraft – Boeing 737; Sky – Overcast ceiling with bases at 200 ft.

8.0 SIGMET and CWSU Advisory

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

No Center Weather Service Unit (CWSU) Center Weather Advisories (CWA) issued surrounding the period, and no Meteorological Impact Statements (MIS) issued during the period.

9.0 AIRMETs

AIRMETs Tango and Sierra were valid for the accident site at the accident time (figure 11). The AIRMETs were issued at 1445 CST and warned of LLWS and IFR conditions due to low ceilings and visibility in precipitation and mist. The conditions were expected to continue past the 2100 CST forecast period:

WAUS43 KKCI 312045
WA3T
_CHIT WA 312045
AIRMET TANGO UPDT 3 FOR TURB AND LLWS VALID UNTIL 010300
.
AIRMET TURB...KS IA MO IL
FROM 40NNW UIN TO 50E UIN TO STL TO 20NW SGF TO 70SE ICT TO 40NW
ICT TO 20NW MCI TO 40NNW UIN
MOD TURB BLW FL180. CONDS ENDG 21-00Z.
.
AIRMET TURB...NE KS IA MO IL IN KY OK TX TN
FROM DBQ TO CVG TO HNN TO HMV TO GQO TO 20S SGF TO 20NW TXO TO
30ESE TBE TO 50W LBL TO GLD TO 40E LBF TO 50W OVR TO DBQ
MOD TURB BTN FL180 AND FL450. CONDS CONTG BYD 03Z ENDG 03-06Z.
.
LLWS POTENTIAL...MO IL IN KY AR TN LA MS AL AND CSTL WTRS
BOUNDED BY 40NW CVG-CVG-HNN-HMV-GQO-50SW PZD-40W CEW-40SE SJI-
40W SJI-30SSW MHZ-30S EIC-20NE FSM-20ESE FAM-40NW CVG
LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.
....
WAUS43 KKCI 312045
WA3S
_CHIS WA 312045
AIRMET SIERRA UPDT 5 FOR IFR AND MTN OBSCN VALID UNTIL 010300
.
AIRMET IFR...ND MN

FROM 70SW YWG TO 30N INL TO 80E INL TO 50NE DLH TO 40WSW DLH TO
20S FAR TO 70SW YWG
CIG BLW 010/VIS BLW 3SM PCPN. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET IFR...MO IL IN KY OK TX AR TN LA MS AL AND CSTL WTRS
FROM 40NW CVG TO 40ENE BWG TO 50NW CEW TO 20SSE HRV TO 120SSW
LCH TO 50NE BRO TO 20ESE LRD TO 20SW CWK TO 30NW GGG TO 60SSE
MLC TO 70ESE SGF TO 20SW TTH TO 40NW CVG
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET MTN OBSCN...KY TN
FROM 50WSW BKW TO HMV TO GQO TO 50WSW LOZ TO 20NNE LOZ TO 50WSW
BKW
MTNS OBSC BY CLDS/PCPN. CONDS DVLPG 00-03Z. CONDS CONTG BYD 03Z
THRU 09Z.
.
OTLK VALID 0300-0900Z
AREA 1...IFR MN WI LS MI
BOUNDED BY 30NNW INL-YQT-70NE SAW-50E SAW-70S DLH-20NE FAR-70WNW
INL-30NNW INL
CIG BLW 010/VIS BLW 3SM PCPN. CONDS CONTG THRU 09Z.
.
AREA 2...IFR MO IL IN KY OK TX AR TN LA MS AL AND CSTL WTRS
BOUNDED BY 40NW CVG-CVG-60E CVG-50WSW BKW-HMV-GQO-50SW PZD-40W
CEW-20SSE HRV-120SSW LCH-50ESE CRP-20E BRO-40W BRO-30WNW LRD-DLF-
30ESE ACT-40SSE ADM-20NNE MLC-50NE FAM-40NW CVG
CIG BLW 010/VIS BLW 3SM PCPN/BR/FG. CONDS CONTG THRU 09Z.
....

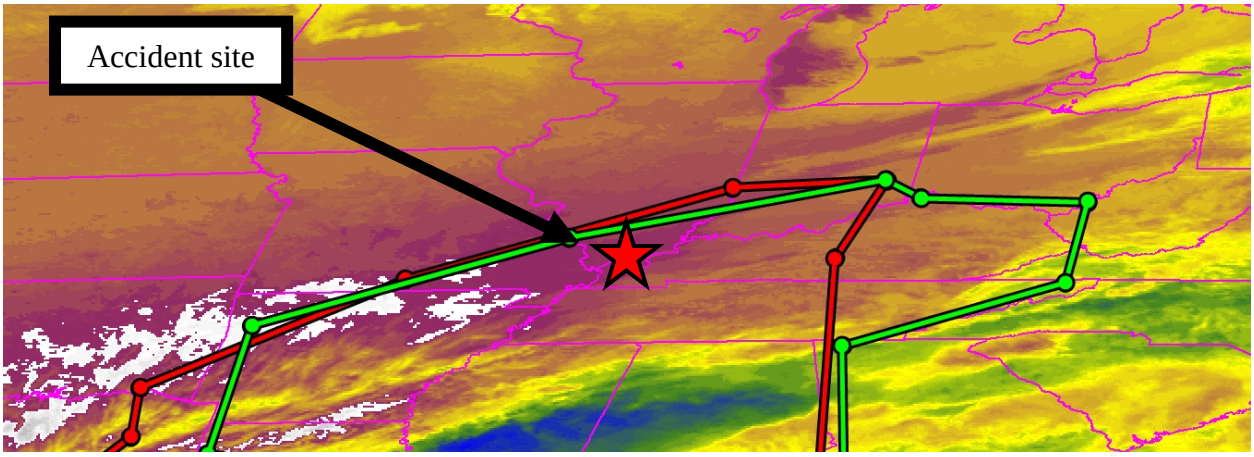

Figure 11 – AIRMETs valid at and before the accident time (green line AIRMET for LLWS potential, red line AIRMET for IFR conditions)

10.0 Area Forecast

The Area Forecast issued at 1414 CST, valid at the accident time, forecasted scattered to broken clouds at 7,000 ft with tops at 13,000 ft for southern Illinois. For western Kentucky the Area Forecast indicated overcast clouds at 2,000 ft with tops to FL220 with widely scattered light rain showers, the forecast was amended by AIRMET Sierra for IFR conditions across the region:

FAUS43 KKCI 312014 AAA
FA3W
_CHIC FA 312014 AMD
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 011400
CLDS/WX VALID UNTIL 010800...OTLK VALID 010800-011400
ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY
.
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...CDFNT CNTRL LH-E CNTRL IL-SERN MO. SFC TROF NERN
ND-SWRN ND. SFC HIGH NERN KS/SERN NEB BRDR. 14Z SFC RDG NERN
IN-MO/IA BRDR. CDFNT CNTRL LS-SRN MN-NWRN SD.
.
ND
WRN...BKN120 TOPS FL210. 03Z OVC040. OTLK...IFR CIG.
CNTRL...BKN060 TOPS FL220. 05Z OVC050. OTLK...MVFR CIG.
ERN...BKN060 TOPS FL220. 06Z SCT050. OTLK...VFR.
.
SD
NERN...BKN030 TOPS 060. 06Z SCT CI. OTLK...VFR.
RMNDR...SCT120 SCT CI. OTLK...VFR.
.
NE
SKC. OTLK...VFR.
.
KS
WRN...SCT-BKN CI. 00Z OVC130 TOPS FL250. OTLK...VFR.
CNTRL-ERN...SKC-SCT CI. OTLK...VFR.
.
MN
NWRN...OVC030 TOPS 170. ISOL -SHSN. 00Z OVC040. -SN. 05Z OVC025.
OTLK...IFR CIG.
NERN...SCT025. 03Z OVC025 TOPS 170. VIS 4SM -SN. OTLK...MVFR CIG
BR.
SWRN...SKC. 03Z SCT120. OTLK...VFR.
SERN...SCT030. 01Z BKN120 TOPS 170. OTLK...VFR.
.
IA
NWRN...BKN035 TOPS 060. 22Z SCT040. 01Z SKC. OTLK...VFR.
SERN...OVC035 TOPS 060. 23Z SCT040. 02Z SCT030. OTLK...VFR.
.
MO...UPDT
XTRM NRN...SCT035. 23Z SKC. OTLK...VFR.
RMNDR NRN...SKC. OTLK...VFR.
SWRN...SKC-SCT CI. OTLK...VFR.
SERN...OVC070 TOPS 130. 03Z SKC. VIS 4SM BR. OTLK...VFR.
.
WI
NWRN...BKN025 TOPS 070. 23Z SCT025 BKN040. OTLK...MVFR CIG.
NERN...SCT025 OVC050 TOPS 070. 23Z SCT050. OTLK...VFR.
SWRN...BKN060 TOPS 100. 00Z SCT100. 02Z SCT CI. OTLK...VFR.
SERN...BKN045 TOPS 110. 01Z SCT050. OTLK...VFR.
.

LS UPR MI
WRN LS...SCT040. 04Z OVC030 TOPS 100. ISOL -SHSN. OTLK...MVFR CIG SHSN.
CNTRL LS/WRN UPR MI...BKN035 TOPS 080. ISOL -SHSN. 01Z BKN050. ISOL -SHSN. OTLK...VFR SHSN 09Z MVFR CIG SHSN.
ERN LS/ERN UPR MI...OVC025 TOPS 130. SCT -SHSN. 00Z BKN030. SCT -SHSN. OTLK...MVFR CIG SHSN.
.
LM LWR MI LH
NWRN...OVC025 TOPS 110. WDLY SCT -SHSN. 03Z OVC040. OTLK...VFR.
NERN...OVC020 LYRD FL250. ISOL -SHSN. 05Z BKN CI. OTLK...VFR.
SWRN...OVC030 LYRD FL230. 01Z BKN050. OTLK...VFR.
SERN...BKN050 OVC090 LYRD FL250. WND SW 20G30KT. 23Z OVC030. 03Z SCT030. OTLK...VFR.
.
IL
NRN...SCT030 OVC040 TOPS 100. 23Z SCT035. 02Z SKC. OTLK...VFR.
CNTRL...SCT040 SCT-BKN120 TOPS FL220. 00Z SCT CI. OTLK...VFR.
SRN...SCT-BKN070 TOPS 130. 01Z SCT CI. OTLK...VFR.
.
IN
NRN...SCT070 BKN130 TOPS FL220. 03Z SCT060. OTLK...VFR.
CNTRL...OVC035 TOPS FL190. 22Z OVC030. 01Z BKN045. OTLK...MVFR BR.
SRN...OVC035 TOPS FL190. WDLY SCT -SHRA. 00Z SCT020 BKN040. OTLK...MVFR CIG.
.
KY
WRN...OVC020 TOPS FL220. WDLY SCT -SHRA. 01Z TOPS 140. VIS 4SM BR. OTLK...MVFR CIG BR.
CNTRL..OVC030 TOPS FL220. -RA. 23Z OVC020. 04Z TOPS 140. VIS 4SM BR. OTLK...MVFR CIG BR.
ERN...OVC050 TOPS FL250. -RA. 00Z OVC045. -RA. 07Z OVC030. VIS 3SM -RA BR. OTLK...IFR CIG RA BR.
....

11.0 Terminal Aerodrome Forecast

KPAH was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 1737 CST, but was valid for a 24-hour period beginning at 1800 CST (after the accident time). The TAF for KPAH was as follows:

TAF KPAH 312337Z 0100/0124 **VRB05KT P6SM OVC007**
FM010600 03005KT 3SM BR OVC004
FM011300 05007KT 4SM BR OVC012
FM011900 06006KT P6SM OVC015=

The forecast expected a variable wind at 5 knots, greater than 6 miles visibility, and an overcast ceiling at 700 ft agl.

The KPAH TAF valid before the 1737 CST was issued at 1337 CST and was valid for a 22-hour period beginning at 1400 CST. The 1337 CST TAF for KPAH was as follows:

TAF KPAH 311937Z 3120/0118 **21010KT P6SM OVC007**
TEMPO 3120/3124 21012G20KT SCT007 BKN025
FM010000 VRB04KT 5SM BR OVC010
FM010600 VRB03KT 3SM BR SCT010 BKN040
TEMPO 0109/0113 1SM BR BKN010
FM011500 06007KT P6SM BKN012=

The 1337 CST KPAH TAF expected a wind from 210° at 10 knots, greater than 6 miles visibility, and an overcast ceiling at 700 ft agl. Temporary conditions between 1400 and 1800 CST were forecast and those conditions expected a wind from 210° at 12 knots with gusts to 20 knots, scattered clouds at 700 ft agl, and a broken ceiling at 2,500 ft agl.

12.0 NWS Area Forecast Discussion

The NWS Office in Paducah, Kentucky, issued the following Area Forecast Discussions (AFD)s at 1402 and 1744 CST (closest AFDs to the accident time with an aviation section). The aviation sections of both of the AFDs discussed that MVFR[17] to temporary IFR conditions were expected to continue into the overnight hours with the abundant low-level moisture and inversion in place. The wind was expected to remain at or below 10 knots:

196
FXUS63 KPAH 312002
AFDPAH

Area Forecast Discussion
National Weather Service Paducah KY
202 PM CST Sat Dec 31 2016

.SHORT TERM...(Tonight through Monday night)
Issued at 152 PM CST Sat Dec 31 2016

A cold front, currently stretched from about STL-SGF, will continue its dive southeastward into the PAH FA tonight. Behind it, is some drier air, which will effectively end the near term chance of pcpn. We'll continue to carry high pops south and east tonight, and taper them off to the north and west, as the front moves in and makes passage.

By tmrw morning, the boundary could hang along our southern/southeastern border. This could focus some continued/lingering light pcpn or foggy/drizzly conditions. Will include that possibility late tonight-early tmrw morning as well.

Heights rise as vort energy drives height falls over the desert SW. The resultant teleconnected shift to a deeper swly flow aloft will result in a moisture return as the Gulf opens up, and isentropic lift develops later Sunday. This will return the chance of raini in more earnest Sunday night into Monday, which will include a chance of Thunder, esp across our south. That'll last on into Monday-Monday night, or until that short wave of energy

[17] Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 ft agl and/or 3 to 5 miles visibility.

ejects out and across the lower Mississippi and Tennessee Valleys by Tuesday morning.

Seasonal near term temps will begin their warming trend tmrw night with 60s returning for Highs by Monday.

.LONG TERM...(Tuesday through Saturday)
Issued at 152 PM CST Sat Dec 31 2016

The overwhelming consensus for the long term period is much colder weather will arrive Wednesday and persist through Saturday. There remains an unusually large spread in the models concerning the potential for wintry precip later in the week.

The models indicate the polar branch of the jetstream will dominate much of the nation later next week, guaranteeing a period of very cold weather. The models have not been consistent regarding the influence of the moist Pacific branch of the jet. The Friday 12z suite of models was in strong agreement on a moist southwest flow aloft Thursday into Friday, with plenty of cold air for wintry precip in our area. However, the 00z model suite suppressed the Pacific sub-tropical jet down to the Gulf coast, resulting in much drier and even colder weather late in the week for our area.

Given all the model fluctuations lately, the forecast will not contain any high chances of wintry precip in the latter part of the week. This mornings 12z guidance indicates a 500 mb arctic shortwave will dig southeast across the Great Lakes region and possibly into the upper Ohio Valley Thursday and Thursday night. This system will be starved for moisture, so only a slight chance of snow showers will be forecast for Thursday night.

The models diverge Friday into Saturday concerning the placement of the moist southern branch of the jet. The 12z gfs and most of its ensemble members suggest a moist 500 mb shortwave will move east from the Rockies along our latitude Friday night. The precip type would be snow for our area. The 12z ecmwf keeps the sub-tropical jet suppressed well to our south, keeping our area dry. Pops will be kept at or below 30 percent for Friday night and Saturday, with the highest chances in se Missouri and sw Kentucky.

As far as temps, there is currently pretty good model agreement between the ecmwf and gfs mos. Highs will fall from the upper 50s on Tuesday to the 30s Wednesday. The coldest air is likely Thursday and Friday, when highs will struggle to reach 30. Overnight lows will be mainly in the teens, barring the presence of any snow cover.

&&

.AVIATION...
Issued at 152 PM CST Sat Dec 31 2016

MVFR cigs with temporary restrictions to IFR will remain a possibility into the evening hours. A cold front moves in/makes passage tonight and should temporarily scatter the lowest clouds, although lingering sub boundary layer moisture remains high. Thus

fog/low clouds/drizzle may develop overnight. Rain chances end west to east with the front. Conditions should improve tmrw, before the front returns warm and clouds increase again/with more rain chances, but that will hold off til the planning period and mainly beyond.

&&

.PAH WATCHES/WARNINGS/ADVISORIES...
IL...None.
MO...None.
IN...None.
KY...None.

&&

$$

405
FXUS63 KPAH 312344 AAA
AFDPAH

Area Forecast Discussion...UPDATED
National Weather Service Paducah KY
544 PM CST Sat Dec 31 2016

.UPDATE...
Issued at 544 PM CST Sat Dec 31 2016

Updated the AVIATION discussion for the 00Z TAF issuance.

&&

.SHORT TERM...(Tonight through Monday night)
Issued at 152 PM CST Sat Dec 31 2016

A cold front, currently stretched from about STL-SGF, will continue its dive southeastward into the PAH FA tonight. Behind it, is some drier air, which will effectively end the near term chance of pcpn. We'll continue to carry high pops south and east tonight, and taper them off to the north and west, as the front moves in and makes passage.

By tmrw morning, the boundary could hang along our southern/southeastern border. This could focus some continued/lingering light pcpn or foggy/drizzly conditions. Will include that possibility late tonight-early tmrw morning as well.

Heights rise as vort energy drives height falls over the desert SW. The resultant teleconnected shift to a deeper swly flow aloft will result in a moisture return as the Gulf opens up, and isentropic lift develops later Sunday. This will return the chance of raini in more earnest Sunday night into Monday, which will include a chance of Thunder, esp across our south. That'll last on into Monday-Monday night, or until that short wave of energy ejects out and across the lower Mississippi and Tennessee Valleys

by Tuesday morning.

Seasonal near term temps will begin their warming trend tmrw night with 60s returning for Highs by Monday.

.LONG TERM...(Tuesday through Saturday)
Issued at 152 PM CST Sat Dec 31 2016

The overwhelming consensus for the long term period is much colder weather will arrive Wednesday and persist through Saturday. There remains an unusually large spread in the models concerning the potential for wintry precip later in the week.

The models indicate the polar branch of the jetstream will dominate much of the nation later next week, guaranteeing a period of very cold weather. The models have not been consistent regarding the influence of the moist Pacific branch of the jet. The Friday 12z suite of models was in strong agreement on a moist southwest flow aloft Thursday into Friday, with plenty of cold air for wintry precip in our area. However, the 00z model suite suppressed the Pacific sub-tropical jet down to the Gulf coast, resulting in much drier and even colder weather late in the week for our area.

Given all the model fluctuations lately, the forecast will not contain any high chances of wintry precip in the latter part of the week. This mornings 12z guidance indicates a 500 mb arctic shortwave will dig southeast across the Great Lakes region and possibly into the upper Ohio Valley Thursday and Thursday night. This system will be starved for moisture, so only a slight chance of snow showers will be forecast for Thursday night.

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As far as temps, there is currently pretty good model agreement between the ecmwf and gfs mos. Highs will fall from the upper 50s on Tuesday to the 30s Wednesday. The coldest air is likely Thursday and Friday, when highs will struggle to reach 30. Overnight lows will be mainly in the teens, barring the presence of any snow cover.

&&

.AVIATION...
Issued at 544 PM CST Sat Dec 31 2016

Even with a weak frontal passage during the period, copious amounts of low level moisture trapped under a strong inversion should produce MVFR/IFR conditions at all sites through the period. South southwest winds AOB 10 knots will slowly veer around to the northeast through the period.

&&

.PAH WATCHES/WARNINGS/ADVISORIES...
IL...None.
MO...None.
IN...None.
KY...None.
&&

$$

13.0 Winds and Temperature Aloft Forecast

The NWS 1356 CST Winds and Temperature Aloft forecast valid for the accident flight is included below:

```
078
FBUS31 KWNO 311956
FD1US1
-DATA BASED ON 311800Z
VALID 010000Z   FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT  3000    6000    9000   12000   18000   24000  30000  34000  39000
-
CGI 2913 2721+02 2828+00 2644-05 2768-16 2679-28 269943 762451 761953
```

The accident site was closest to the CGI (Cape Girardeau, Missouri) forecast point. The 1356 CST CGI forecast indicated a wind at 3,000 ft from 290° at 13 knots, a wind at 6,000 ft from 270° at 21 knots with a temperature of 2° C, and a wind at 9,000 ft from 280° at 28 knots with a temperature of 0° C.

14.0 Pilot Weather Briefing

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS) and Direct User Access Terminal Service (DUATS) was done and the accident pilot did not receive a weather briefing from LMFS or DUATS.

A search of ForeFlight weather information revealed that the accident pilot did not request a weather briefing using his ForeFlight account prior to his flight. However, the accident pilot did enter several routes during the accident flight using his ForeFlight account (attachment 1). Those routes include (all times in UTC, accident time 2345 UTC):

12/31/2016 22:52:01: KHSB CKV
12/31/2016 23:11:56: KHSB KJWN
12/31/2016 23:19:49: KHSB KPAH

The accident pilot did not check any weather imagery using the ForeFlight account, because that information would have been archived, however, the accident pilot could have reviewed text products on his ForeFlight account as ForeFlight did not log those text information requests. It is unknown if the accident pilot checked or received anymore weather information before or during the accident flight.

15.0 Witness Information

The passengers on the accident flight took pictures during the accident flight and information gleaned from those images is described below (figures 12 through 16). The image from near Hannibal, Missouri, indicated mostly clear skies near the accident aircraft with cirrus clouds along the horizon (figure 12), while the accident flight was at 1,774.76 ft (direction unknown). Figure 13 indicated a scattered to broken deck of stratocumulus type clouds below the accident aircraft's altitude in the easterly direction with the accident aircraft at 9,000 ft as the sun was beginning to set. Figure 14 indicated a broken deck of stratocumulus clouds below the accident aircraft's altitude with additional altostratus clouds above the stratocumulus deck of clouds, but still below the accident aircraft's altitude. Figure 14 image was taken in the westerly direction as the sun was continuing to set. Figure 15 indicated an overcast layer of stratocumulus clouds below the accident aircraft's altitude with scattered altostratus clouds above the accident aircraft's altitude while the sun was continuing to set with the image in the westerly direction. Figure 16 was taken after the previous 4 images, however, it is unknown at what time the image was taken. Figure 16 indicated night time conditions, but no other weather information can be gleaned from the image.

Figure 12 – Image from the accident flight

Figure 13 – Image from the accident flight

Figure 14 – Image from the accident flight

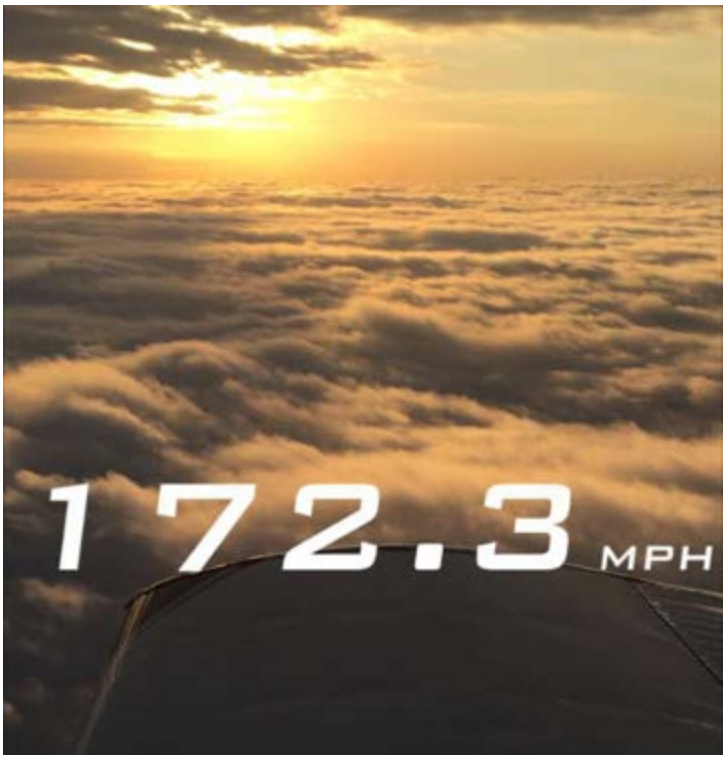

Figure 15 – Image from the accident flight

Figure 16 – Image from the accident flight

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on December 31, 2016, indicated the following:

SUN	
Begin civil twilight	0640 CST
Sunrise	0709 CST
Sun transit	1159 CST
Sunset	1648 CST
End civil twilight	1717 CST
Accident	1745 CST

MOON	
Moonrise	0840 CST
Moon transit	1359 CST
Moonset	1921 CST

The phase of the Moon was Waxing Crescent with 6% of the Moon's visible disk illuminated. Given that the accident flight at the accident time was likely in clouds, no Moon would have been visible.

E. LIST OF ATTACHMENTS

Attachment 1 – ForeFlight Information for the accident flight

Submitted by:

_____

Paul Suffern
Senior Meteorologist

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