



NATIONAL TRANSPORTATION SAFETY BOARD

**Office of Aviation Safety
Washington, D.C. 20594**

October 26, 2020

WEATHER FACTUAL

METEOROLOGY

ERA20LA305

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A. ACCIDENT

Location: Luray, Virginia
Date: August 31, 2020
Time: 1900 eastern daylight time (2300 UTC¹)
Airplane: Piper PA-20-135; Registration: N7323K

B. METEOROLOGIST

Donald Eick
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Operational Factors Division (AS-30)
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Washington, D.C. 20594-2000

C. SUMMARY

On August 31, 2020, about 1900 eastern daylight time, a Piper PA-20-135 airplane, N7323K, was destroyed when it impacted trees and terrain near Luray, Virginia. The private pilot was fatally injured. The airplane was operated by the pilot as a personal flight conducted under the provisions of Title 14 *Code of Federal Regulations* Part 91.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are eastern daylight time (EDT) based upon the 24 hour clock, local time is +4 hours to UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are feet (ft) 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 38.640450° N and longitude 78.307167° W, at an elevation of approximately 2,340 ft.

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)

¹ UTC – is an abbreviation for Coordinated Universal Time.

located in Camp Springs, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular “Aviation Weather Services”, AC 00-45H change 2.

1.1 Surface Analysis Chart

The east-central section of the NWS Surface Analysis Chart for 2000 EDT (0000Z September 1, 2020) with a high resolution topography is included as figure 1 with the approximate accident site marked by a red star. The chart depicted a low-pressure system at 1011-hectopascals (hPa)² near the Kentucky and West Virginia border with a warm front extending east-southeast across southwest Virginia into North Carolina and into the Atlantic Ocean. The accident site was located north of the warm front in the cool air side of the front.

Another feature on the chart was newly developed Tropical Depression #15 with a central pressure of 1008-hPa off the coast of North Carolina which was forecast to move to the northeast at 15 knots and would later be upgraded to Tropical Storm Omar on September 1, 2020 at approximately 1700 EDT. This tropical system was threatening the mid-Atlantic region with potential weather concerns.

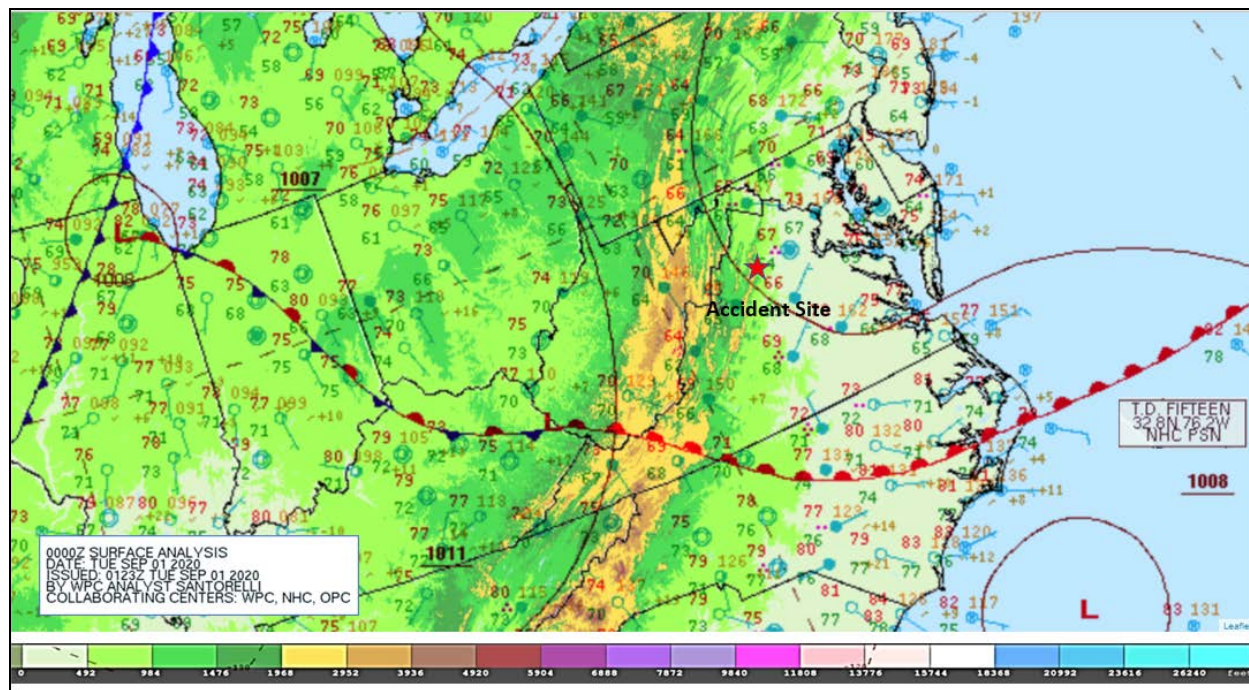


Figure 1 - NWS Surface Analysis Chart for 2000 EDT with the accident noted by red star

The station models in the vicinity of the accident site on the surface analysis chart depicted light northeasterly winds of 5 knots or less, with overcast sky cover, with temperatures near 67° F, and dew points near 64° F, with several stations reported light, moderate, and heavy rain.

² Hectopascals is the new NWS reference for reporting sea level pressure and is interchangeable with the former term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa at 59° Fahrenheit (F) or 15° Celsius (C).

1.2 National Composite Reflectivity Mosaic

The National Composite Radar Mosaic for 1900 EDT is included as figure 2 and depicted an area of echoes near 30 dBZ located west, north, and south of the accident site over Virginia. No well-defined echoes were identified over the accident site; however, some echoes were identified within 5 miles. Due to the potential of echoes along the flight path and in the area of the accident site, the closest NWS weather surveillance radar will be further documented in section 5.0 of this report.

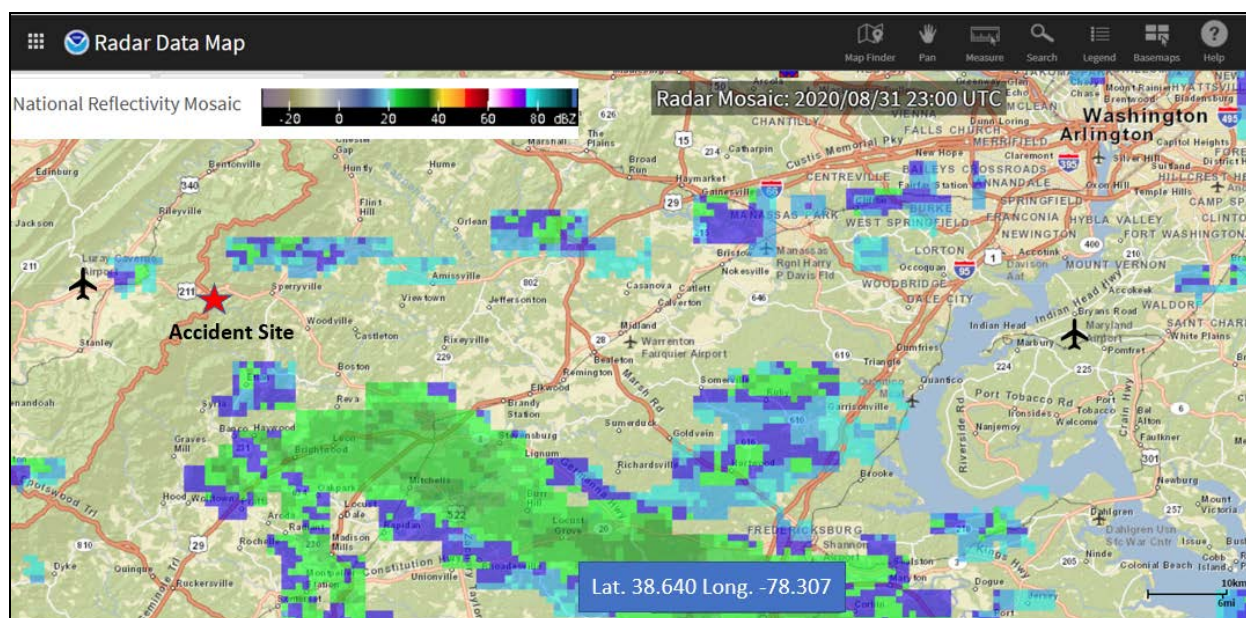


Figure 2 - NWS National Composite Radar Mosaic for 1900 EDT with accident site

1.3 Short-Range Surface Prognostic Chart

The NWS's WPC 12-hour Surface Prognostic Chart valid for 0200 EDT on September 1, 2020 is included as figure 3. The chart combined the WPC forecast of fronts, isobars, and pressure systems with the National Digital Forecast Database (NDFD) digital forecast for precipitation. The chart continued to depict the low pressure system (section 1.1) moving southeast into South Carolina along the stationary front. A large band of rain was expected from along and north of the front over the east coast with rain likely³ (depicted in dark green) over most of Virginia, with a chance⁴ of rain (light green) over much of the mid-Atlantic coastal states and the northeast.

³ Rain Likely – indicated a greater than or equal to 55% probability for measurable rain ($\geq 0.01''$) at the valid time.

⁴ Chance – indicated a 25% to 54% probability of measurable rain ($\geq 0.01''$) at the valid time.

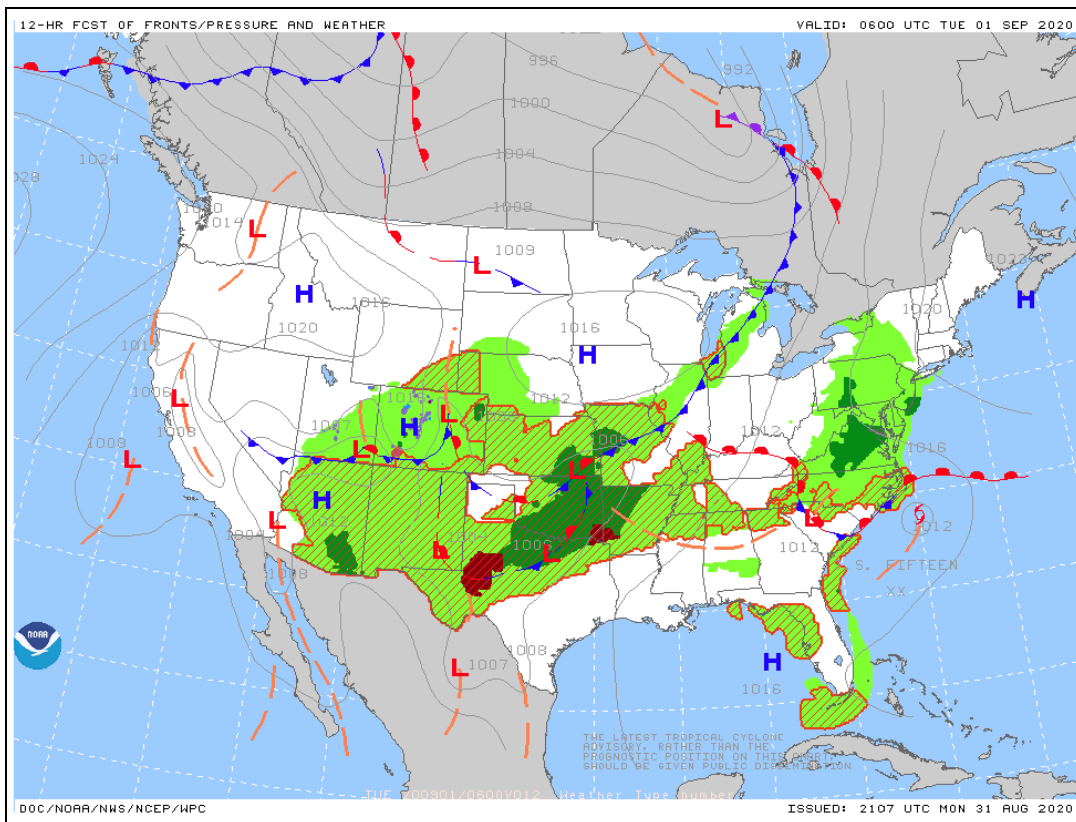


Figure 3 - 12-hour Surface Prognostic Chart valid for 0200 EDT

1.4 Low-Level Significant Weather Prognostic Chart

The NWS Low-Level Significant Weather Prognostic chart valid at the time of the accident is included as figure 4 and provided a forecast of aviation weather hazards with the general flight categories⁵, the freezing level, and areas of organized turbulence below 24,000 ft. The 12-hour forecast (left panel) was valid for 2000 EDT and the 24-hour forecast (right panel) valid for 0800 EDT on September 1, 2020. The 12-hour forecast expected an area of IFR conditions over Pennsylvania, eastern West Virginia, western Maryland, and Virginia, with MVFR conditions surrounding the IFR area covering the rest of Maryland, Virginia, West Virginia, and Kentucky. The freezing level was identified above 12,000 ft, and no areas of turbulence outside of

⁵ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories based on weather conditions reported:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

convection turbulence was expected. The 24-hour forecast valid for 0800 EDT depicted the IFR conditions expanding over most of the central and eastern half of the country by morning due to low ceilings and/or visibilities in precipitation or fog.

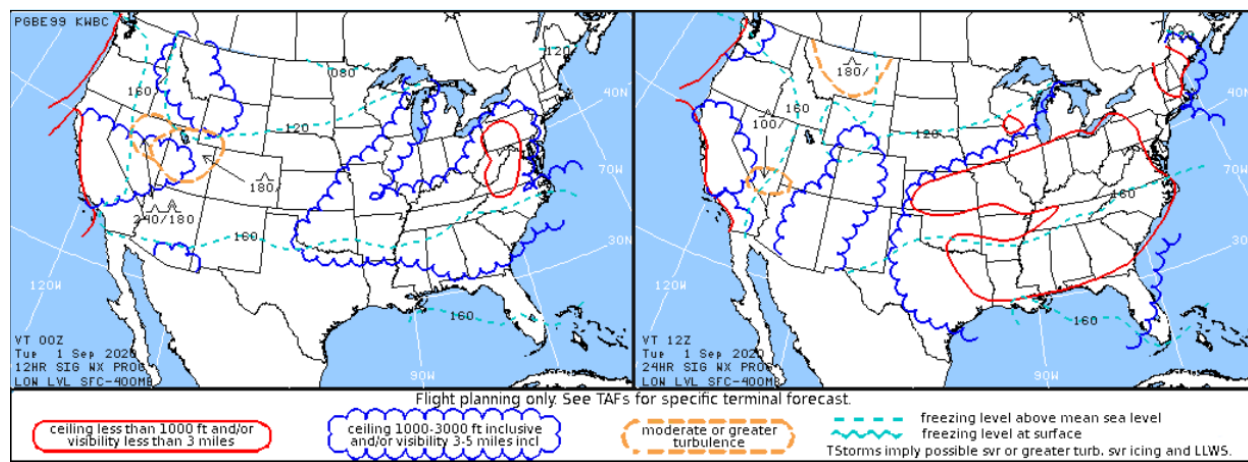


Figure 4 - 12-hour (left) & 24-hour (right) Low-Level Significant Weather Prognostic Chart valid at the time of the accident depicting the expected general flight categories

2.0 Surface Observations

The official NWS Meteorological Aerodrome Reports (METARs) and special reports (SPECIs) surrounding the period were documented for the area within 30 miles of the accident site. The cloud heights are reported above ground level (agl). Figure 5 is a portion of the sectional chart for the area with the approximate accident site marked by a red star with a 30 mile radius circle marked and the closest airports with weather reporting capability labelled. The accident site was located 0.8 mile east and below a ridge with a height of 3,300 ft with Pinnacle Peak at 3,730 ft the highest peak in the Shenandoah National Park about 1.5 miles to the southwest and Mary's Rock at 3,514 ft less than a mile to the northwest. The magnetic variation was noted as 10° W over the area.

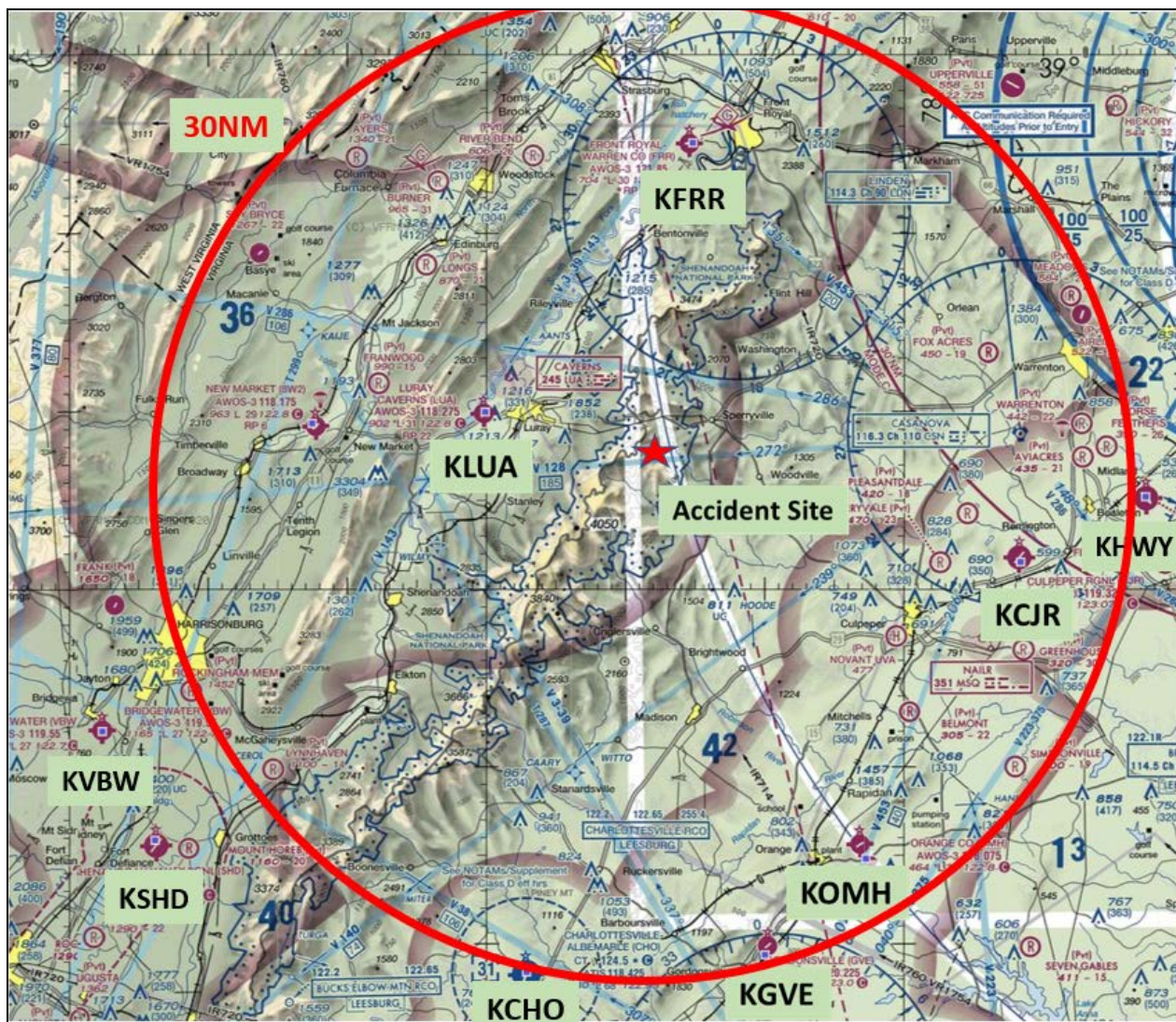


Figure 5 - Sectional map over the region with 30NM radius of accident site

2.1 Luray, Virginia

The closest weather reporting station to the accident site was Luray Caverns Airport (KLUA), Luray, Virginia, located approximately 9 miles west of the accident site at an elevation of 902 feet. The airport had an Automated Weather Observation System (AWOS), which was not augmented by any observers and issued observations every 20-minutes. The following conditions were reported at the approximate time of the accident.

Weather observation for KLUA at 1855 EDT, automated, wind from 360° at 4 knots, visibility 7 miles in moderate rain, ceiling overcast at 2,300 ft agl, temperature 19° C, dew point 19° C, altimeter setting 30.01 inches of mercury (Hg). Remarks: automated station with a precipitation discriminator, hourly precipitation 0.07 of an inch.

The general flight categories and raw observations surrounding the period from 1455 through 1955 EDT were as follows.

MVFR METAR KLUA 311855Z AUTO 22004KT 3SM +RA SCT017 BKN024 OVC046 18/18 A3002 RMK AO2 P0022
MVFR METAR KLUA 311915Z AUTO 00000KT 4SM RA SCT017 BKN035 OVC044 18/18 A3001 RMK AO2 P0005=
MVFR METAR KLUA 311935Z AUTO 00000KT 5SM RA SCT004 BKN040 OVC046 18/18 A3001 RMK AO2 P0009=
LIFR METAR KLUA 311955Z AUTO 00000KT 4SM -RA BKN004 BKN015 OVC036 18/18 A3000 RMK AO2 P0011
LIFR METAR KLUA 312015Z AUTO 00000KT 10SM DZ BKN004 BKN015 OVC031 19/19 A3000 RMK AO2 P0001
VFR METAR KLUA 312035Z AUTO 00000KT 10SM -DZ SCT004 BKN031 OVC060 19/18 A3000 RMK AO2 P0001
VFR METAR KLUA 312055Z AUTO 00000KT 10SM DZ SCT004 BKN034 OVC060 19/19 A3000 RMK AO2 P0001
MVFR METAR KLUA 312115Z AUTO 35003KT 10SM DZ SCT022 BKN029 OVC037 19/19 A3000 RMK AO2=
MVFR METAR KLUA 312135Z AUTO 35003KT 7SM DZ SCT020 OVC027 19/19 A3000 RMK AO2 P0001=
MVFR METAR KLUA 312155Z AUTO 36003KT 10SM DZ SCT014 BKN022 OVC027 19/19 A3000 RMK AO2 P0001
MVFR METAR KLUA 312215Z AUTO 34003KT 10SM DZ BKN025 OVC029 19/19 A3001 RMK AO2=
MVFR METAR KLUA 312235Z AUTO 35004KT 5SM -RA OVC025 19/19 A3001 RMK AO2 P0006=
MVFR **METAR KLUA 312255Z AUTO 36004KT 7SM RA OVC023 19/19 A3001 RMK AO2 P0007=**
Accident 2300Z
MVFR METAR KLUA 312315Z AUTO 00000KT 10SM -RA OVC021 19/19 A3001 RMK AO2=
MVFR METAR KLUA 312335Z AUTO 00000KT 10SM RA SCT019 OVC028 19/19 A3001 RMK AO2=
MVFR METAR KLUA 312355Z AUTO 00000KT 10SM -RA SCT012 BKN026 OVC032 18/18 A3003 RMK AO2=

2.2 Front Royal, Virginia

Front Royal-Warren County Airport (KFRR), Frontal Royal, Virginia, was located approximately 17 miles north of the accident site at an elevation of 704 ft. The airport had an AWOS, was not augmented, and issued observations every 20-minutes. The AWOS also did not have a precipitation discriminator and did not report any precipitation type when measurable rain was occurring. The following conditions were reported at the time of the accident.

Weather observation for KFRR at 1855 EDT, automated, wind calm, visibility greater than 10 miles, ceiling broken 2,000 ft agl, overcast 2,500 ft, temperature 18° C, dew point 18° C, altimeter 30.01 inches of Hg. Remarks: automated station without a precipitation discriminator, hourly precipitation 0.03 of an inch⁶.

The general flight categories and raw observations surrounding the period from 1455 through 1955 EDT were as follows.

VFR METAR KFRR 311855Z AUTO 00000KT 7SM SCT027 SCT032 OVC045 18/18 A3001 RMK AO1 P0005=
MVFR METAR KFRR 311915Z AUTO 00000KT 4SM SCT043 BKN048 OVC055 18/18 A3001 RMK AO1 P0003=
MVFR METAR KFRR 311935Z AUTO 00000KT 4SM SCT027 BKN036 OVC060 18/18 A3001 RMK AO1 P0006=
VFR METAR KFRR 311955Z AUTO 00000KT 7SM SCT029 BKN044 OVC060 18/18 A3000 RMK AO1 P0007=
VFR METAR KFRR 312015Z AUTO 00000KT 10SM SCT040 BKN050 OVC070 19/19 A3000 RMK AO1 P0001
MVFR METAR KFRR 312035Z AUTO 00000KT 10SM SCT006 BKN023 OVC050 19/19 A3000 RMK AO1 P0001

⁶ Light rain – up to 0.10 inch per hour, or maximum 0.01 inch in 6-minutes.

MVFR METAR KFRR 312055Z AUTO 00000KT 10SM SCT003 SCT007 OVC021 19/19 A3000 RMK AO1 P0001
MVFR METAR KFRR 312115Z AUTO 00000KT 10SM BKN013 OVC021 19/19 A3000 RMK AO1=
MVFR METAR KFRR 312135Z AUTO 11004KT 10SM BKN015 OVC022 19/19 A3000 RMK AO1=
MVFR METAR KFRR 312155Z AUTO 12003KT 10SM BKN015 OVC022 18/18 A3000 RMK AO1=
MVFR METAR KFRR 312215Z AUTO 00000KT 10SM BKN015 OVC022 18/18 A3001 RMK AO1=
MVFR METAR KFRR 312235Z AUTO 12003KT 4SM BKN020 OVC031 19/18 A3001 RMK AO1 P0002=
MVFR METAR KFRR 312255Z AUTO 00000KT 10SM BKN020 OVC025 18/18 A3001 RMK AO1 P0003=
Accident 2300Z
MVFR METAR KFRR 312315Z AUTO 00000KT 10SM OVC022 18/18 A3001 RMK AO1=
MVFR METAR KFRR 312335Z AUTO 00000KT 10SM OVC022 18/18 A3002 RMK AO1=
MVFR METAR KFRR 312355Z AUTO 00000KT 10SM BKN022 OVC029 18/18 A3002 RMK AO1=

2.3 Culpeper, Virginia

Culpeper Regional Airport (KCJR), Culpeper, Virginia, was located approximately 22 miles east of the accident site, at an elevation of 316 ft. The airport also had an AWOS, which was not augmented by any observers and issued observations every 20-minutes. The following conditions were reported at the approximate time of the accident.

Weather observation for KCJR at 1855 EDT, automated, wind from 090° at 3 knots, visibility 10 miles or more, ceiling overcast at 4,800 ft agl, temperature 20° C, dew point 19° C, altimeter 30.03 inches of Hg. Remarks; automated station with a precipitation discriminator, hourly precipitation 0.01 of an inch. Temperature 19.9° C, dew point 19.1° C.

The general flight categories and observations reported between 1455 through 1955 EDT surrounding the period of the accident were as follows.

MVFR METAR KCJR 311855Z AUTO 00000KT 5SM RA SCT006 BKN013 OVC045 21/20 A3001 RMK AO2
 P0016 T02060197=
IFR METAR KCJR 311915Z AUTO 00000KT 10SM RA BKN007 BKN010 OVC014 21/20 A3001 RMK AO2
 P0002 T02080200=
IFR METAR KCJR 311935Z AUTO 36005KT 4SM RA BKN009 OVC014 21/20 A3001 RMK AO2 P0008
 T02050197
IFR METAR KCJR 311955Z AUTO 00000KT 1 1/2SM +RA BKN009 OVC014 21/20 A3002 RMK AO2 P0022
 T02050195=
IFR METAR KCJR 312015Z AUTO 33003KT 1SM +RA OVC012 21/20 A3004 RMK AO2 P0016 T02050196
IFR METAR KCJR 312035Z AUTO 11004KT 1 1/2SM +RA BKN008 OVC012 21/20 A3002 RMK AO2 P0032
 T02050195
MVFR METAR KCJR 312055Z AUTO 00000KT 5SM -RA SCT008 BKN080 OVC085 21/20 A3003 RMK AO2
 P0036 60075 T02060197
VFR METAR KCJR 312115Z AUTO 18003KT 10SM RA OVC075 20/19 A3003 RMK AO2 P0001 T02020194
VFR METAR KCJR 312135Z AUTO 11003KT 7SM RA OVC065 20/19 A3003 RMK AO2 P0002 T02010192
VFR METAR KCJR 312155Z AUTO 07003KT 10SM DZ BKN050 OVC065 20/19 A3003 RMK AO2 P0002
 T02010193
MVFR METAR KCJR 312215Z AUTO 07004KT 5SM +DZ OVC050 20/19 A3002 RMK AO2 P0001 T02000192
VFR METAR KCJR 312235Z AUTO 08003KT 10SM -DZ OVC050 20/19 A3003 RMK AO2 P0001 T02000191
VFR METAR KCJR 312255Z AUTO 09003KT 10SM OVC048 20/19 A3003 RMK AO2 P0001 T01990191=
Accident 2300Z
VFR METAR KCJR 312315Z AUTO 00000KT 10SM RA OVC044 20/19 A3004 RMK AO2 P0001 T02000190=
MVFR METAR KCJR 312335Z AUTO 01003KT 4SM +RA SCT032 OVC040 20/19 A3004 RMK AO2 P0006
 T01960187=

MVFR METAR KCJR 312355Z AUTO 04003KT 5SM RA SCT021 BKN034 OVC045 19/19 A3005 RMK AO2
P0010 60088 T01930185 10211 20193=

2.4 Orange, Virginia

Orange County Airport (KOMH), Orange, Virginia, was located approximately 26 miles south-southeast of the accident site at an elevation of 464 ft. The airport also had an AWOS and issued observations every 20-minutes. The following conditions were reported at the time of the accident.

Weather observation for KOMH at 1855 EDT, automated, wind from 030° at 4 knots, visibility 7 miles in heavy rain, ceiling broken at 700 ft, broken at 1,000 ft, and overcast at 3,700 ft, temperature and dew point missing, altimeter 30.01 inches of Hg. Remarks; automated station with a precipitation discriminator, hourly precipitation 0.16 of an inch.

The general flight categories and observations reported between 1455 through 1955 EDT surrounding the period of the accident were as follows.

MVFR METAR KOMH 311855Z AUTO 11007KT 4SM +RA SCT014 BKN023 OVC090 A2999 RMK AO2
P0022
MVFR METAR KOMH 311915Z AUTO 07003KT 5SM +RA SCT016 BKN033 OVC065 A2999 RMK AO2 P0006
MVFR METAR KOMH 311935Z AUTO 00000KT 5SM RA SCT009 BKN033 OVC065 A2999 RMK AO2 P0011=
IFR METAR KOMH 311955Z AUTO 34003KT 4SM +RA BKN007 BKN014 OVC022 A3001 RMK AO2 P0018
IFR METAR KOMH 312015Z AUTO 35003KT 2 1/2SM +RA BKN007 BKN016 OVC022 A3002 RMK AO2
P0013
IFR METAR KOMH 312035Z AUTO 05004KT 1 3/4SM +RA SCT014 OVC020 A3002 RMK AO2 P0029
MVFR METAR KOMH 312055Z AUTO 06006KT 3SM +RA SCT021 SCT036 OVC065 A3000 RMK AO2 P0042
VFR METAR KOMH 312115Z AUTO 07009KT 7SM RA BKN040 BKN049 OVC055 A3000 RMK AO2 P0002
MVFR METAR KOMH 312135Z AUTO 06006KT 5SM RA SCT036 OVC046 A3000 RMK AO2 P0006
VFR METAR KOMH 312155Z AUTO 05005KT 10SM RA SCT027 SCT034 OVC044 A3000 RMK AO2 P0007
VFR METAR KOMH 312215Z AUTO 06006KT 10SM RA SCT021 SCT028 OVC038 A3000 RMK AO2
IFR METAR KOMH 312235Z AUTO 05005KT 2 1/2SM +RA SCT010 BKN026 OVC036 A3000 RMK AO2
P0012
IFR METAR KOMH 312255Z AUTO 03004KT 7SM +RA BKN007 BKN010 OVC037 A3001 RMK AO2
P0016
Accident 2300Z
IFR METAR KOMH 312315Z AUTO 01003KT 7SM +RA OVC007 A3003 RMK AO2 P0001
IFR METAR KOMH 312335Z AUTO 02004KT 7SM RA BKN009 BKN013 OVC032 A3003 RMK AO2 P0003
MVFR METAR KOMH 312355Z AUTO 05004KT 7SM +RA SCT009 BKN019 OVC027 A3003 RMK AO2 P0005

2.5 Gordonsville, Virginia

Gordonsville Municipal Airport (KGVE), Gordonsville, was located about 29 miles south of the accident site at an elevation of 454 feet. The airport also had an AWOS and issued observations every 20-minutes and reported the following conditions.

Weather observation for KGVE at 1855 EDT, automated, wind from 040° at 4 knots, visibility 4 miles in mist, ceiling overcast at 700 ft agl, temperature 19° C, dew point 19° C, altimeter 30.01 inches of Hg. Remarks: automated station without a precipitation

discriminator, hourly precipitation 0.14 of an inch, temperature 18.9° C, dew point 18.9° C.

The general flight categories and observations reported between 1455 through 1955 EDT surrounding the period of the accident were as follows.

IFR METAR KGVE 311855Z AUTO 02003KT 2 1/2SM BR OVC005 19/19 A2998 RMK AO1 P0029
T01910191=
LIFR METAR KGVE 311915Z AUTO 01003KT 2 1/2SM BR OVC003 19/19 A2999 RMK AO1 P0008
T01920192=
LIFR METAR KGVE 311935Z AUTO 00000KT 3SM BR BKN003 OVC008 20/20 A2999 RMK AO1 P0020
T01960196=
IFR METAR KGVE 311955Z AUTO 33005KT 2 1/2SM BR BKN010 OVC016 19/19 A3001 RMK AO1
VIS 1 1/4V5 P0035 T01920192=
IFR METAR KGVE 312015Z AUTO 03005KT 2 1/2SM BR SCT012 BKN018 OVC028 19/19 A3001 RMK AO1
P0021 T01900190
IFR METAR KGVE 312035Z AUTO 03007KT 2SM BR SCT018 BKN025 OVC030 19/19 A3000 RMK AO1
P0046 T01900190
MVFR METAR KGVE 312055Z AUTO 03004KT 3SM BR SCT003 BKN028 OVC042 19/19 A2999 RMK AO1
P0056 60129 T01910191
IFR METAR KGVE 312115Z AUTO 07003KT 2SM BR BKN005 OVC020 19/19 A3000 RMK AO1 P0010
T01910191
IFR METAR KGVE 312135Z AUTO 05005KT 4SM BR BKN005 BKN015 OVC023 19/19 A2999 RMK AO1
P0021 T01910191
IFR METAR KGVE 312155Z AUTO 04006KT 2 1/2SM BR BKN005 BKN015 OVC023 19/19 A2999 RMK
AO1 P0030 T01910191
IFR METAR KGVE 312215Z AUTO 05004KT 3SM BR BKN005 BKN015 OVC021 19/19 A3000 RMK AO1
P0009 T01900190
IFR METAR KGVE 312235Z AUTO 03003KT 5SM BR BKN007 OVC016 19/19 A3000 RMK AO1 P0012
T01900190
IFR **METAR KGVE 312255Z AUTO 04004KT 4SM BR OVC007 19/19 A3001 RMK AO1 P0014**
T01890189
Accident 2300Z
IFR METAR KGVE 312315Z AUTO 03004KT 5SM BR BKN007 OVC012 19/19 A3002 RMK AO1 P0002
T01880188
MVFR METAR KGVE 312335Z AUTO 03005KT 7SM SCT007 BKN012 OVC019 19/19 A3002 RMK AO1 P0004
T01880188
IFR METAR KGVE 312355Z AUTO 05005KT 7SM BKN008 OVC013 19/19 A3002 RMK AO1 P0005 60182
T01870187 10196 20187=

2.6 Martinsburg, West Virginia

The expected planned destination was Eastern WV Regional Airport/Shepherd Field (KMVB), Martinsburg, West Virginia, located approximately 60 miles north-northeast of the accident site (just north of KFRR in figure 5) at an elevation of 565 ft. The airport had Automated Weather Observation System (ASOS) and was augmented by air traffic control personnel during the hours of operation. The following conditions were reported surrounding the period.

Weather observation for KMVB at 1853 EDT, wind from 090° at 4 knots, visibility 4 miles in light rain and mist, a few clouds at 1,900 ft agl, ceiling broken at 2,700 ft, overcast at 5,000 ft agl, temperature 18° C, dew point 18° C, altimeter 30.03 inches of Hg.

Remarks: automated station without a precipitation discriminator, sea level pressure 1016.5-hPa, hourly precipitation 0.11 of an inch, temperature 18.3° C, dew point 17.8° C.

The general flight categories and raw observations issued surrounding the period were as follows.

IFR SPECI KMRB 311843Z 19006KT 2SM RA BR FEW007 BKN029 OVC040 19/18 A3001 RMK AO2 P0012 T01940183=
IFR METAR KMRB 311853Z 18003KT 2SM RA BR FEW009 BKN028 OVC039 19/18 A3001 RMK AO2 SLP159 P0014 T01940183=
MVFR SPECI KMRB 311900Z 00000KT 3SM RA BR FEW010 BKN028 OVC039 19/19 A3001 RMK AO2 P0002 T01940189=
IFR SPECI KMRB 311943Z 21003KT 2SM RA BR FEW012 SCT018 OVC025 19/18 A3000 RMK AO2 P0010 T01940183=
IFR METAR KMRB 311953Z 21003KT 2 1/2SM RA BR SCT010 BKN016 OVC025 19/18 A3001 RMK AO2 SLP158 P0012 T01890183=
MVFR SPECI KMRB 312025Z 00000KT 3SM RA BR SCT018 BKN028 OVC041 19/18 A3000 RMK AO2 P0007 T01940183=
IFR SPECI KMRB 312038Z 00000KT 2 1/2SM -RA BR SCT015 BKN019 OVC041 19/18 A3001 RMK AO2 P0009 T01890183=
IFR SPECI KMRB 312047Z 00000KT 1 3/4SM RA BR BKN013 BKN019 OVC025 19/18 A3000 RMK AO2 P0011=
IFR SPECI KMRB 312048Z 00000KT 2SM RA BR BKN013 BKN019 OVC028 19/18 A3000 RMK AO2 P0011=
IFR METAR KMRB 312053Z 10003KT 2SM RA BR SCT007 BKN013 OVC019 19/18 A3001 RMK AO2 SLP158 P0012 60038 T01890183 55001=
IFR SPECI KMRB 312103Z 14003KT 1 3/4SM -RA BR BKN009 OVC014 19/18 A3001 RMK AO2 P0002 T01890183=
IFR SPECI KMRB 312142Z 12006G15KT 2SM RA BR SCT007 BKN013 OVC018 18/18 A3002 RMK AO2 P0022 T01830178=
IFR SPECI KMRB 312145Z 13007KT 1 3/4SM RA BR SCT007 OVC016 18/18 A3002 RMK AO2 P0023 T01830178=
IFR METAR KMRB 312153Z 14006KT 1 1/2SM RA BR SCT007 BKN016 OVC028 18/18 A3002 RMK AO2 SLP163 P0026 T01830178=
IFR SPECI KMRB 312206Z 14004KT 2SM RA BR FEW014 BKN033 OVC044 18/18 A3002 RMK AO2 P0005 T01830178=
MVFR SPECI KMRB 312222Z 14003KT 4SM -RA BR BKN036 BKN045 OVC055 18/18 A3003 RMK AO2 P0009 T01830178=
MVFR METAR KMRB 312253Z 09004KT 4SM -RA BR FEW019 BKN027 OVC050 18/18 A3003 RMK AO2 SLP165 P0011 T01830178=
Accident 2300Z
MVFR SPECI KMRB 312321Z 12004KT 4SM -RA BR SCT023 BKN040 OVC050 18/17 A3002 RMK AO2 P0002 T01830172=
VFR METAR KMRB 312353Z 12003KT 10SM -RA FEW044 OVC050 18/17 A3003 RMK AO2 SLP167 P0002 60077 T01830172 10194 20183 51009=

2.7 METAR Display

The NWS Aviation Weather Center's (AWC) graphic depiction of the METARs for 1900 EDT is included as figure 6, with the radar mosaic overlaid and with ceiling heights depicted in ft agl. The image depicts light to moderate precipitation surrounding the accident site with KCRJ and Warrenton-Fauquier Airport (KHWY), Warrenton, Virginia, east reporting VFR conditions and stations KLUA and KFRR reporting MVFR conditions due to ceiling overcast between 2,000 to

2,300 ft agl (2,700 to 3,200 ft msl) below the height of the high terrain in the vicinity of the accident site with KLUA reporting moderate rain at the time. Multiple stations south of the accident site, such as KOMH, KGVE, and KCHO reporting IFR conditions at the time with visibility between 3 and 7 miles in mist, light to heavy rain, with ceilings between 500 at 700 ft agl (950 to 1,150 ft msl).

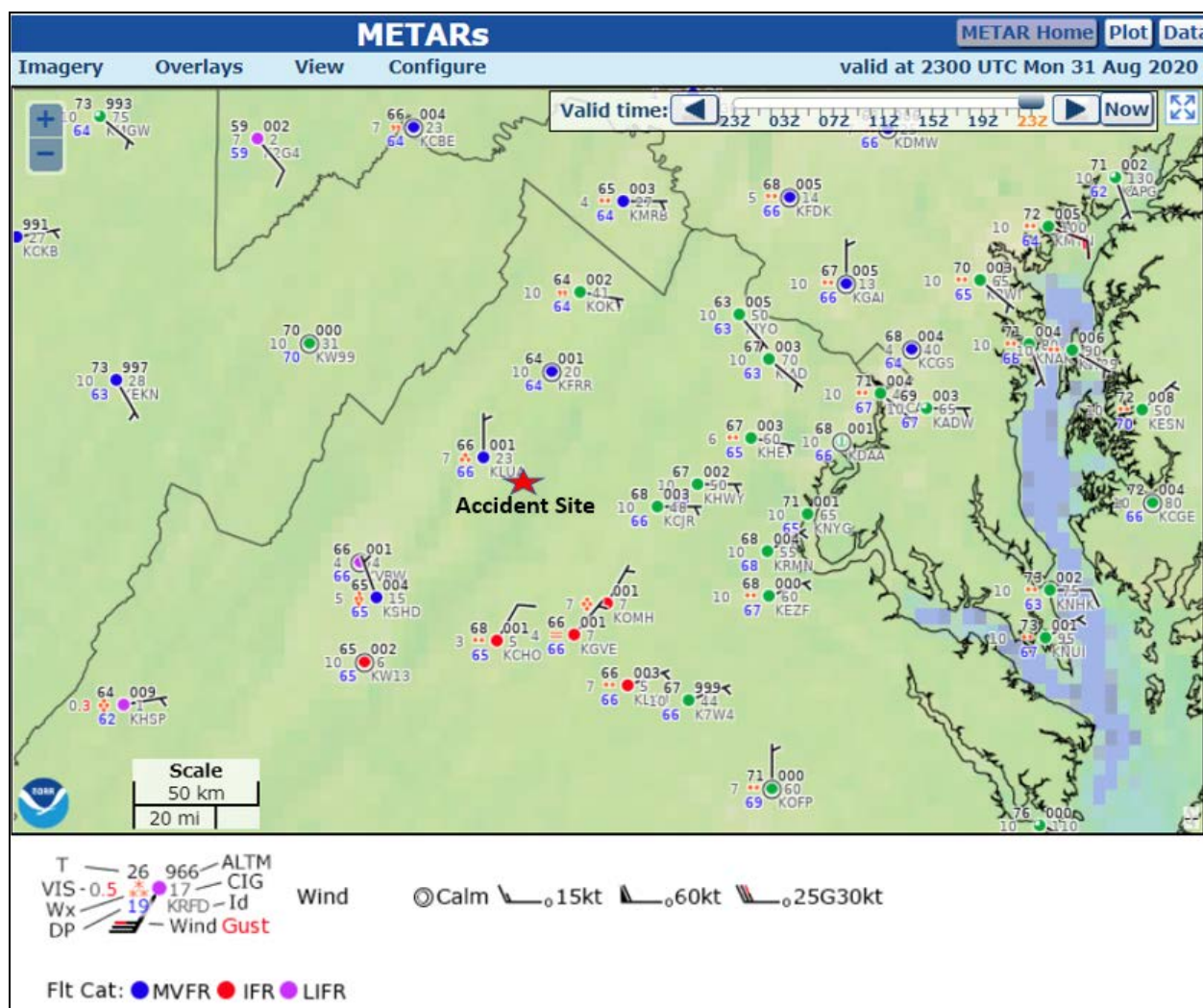


Figure 6 - METAR display for 1900 EDT with accident site marked

3.0 Numerical Model Sounding

A High Resolution Rapid Refresh (HRRR) numerical model was obtained from the NOAA Air Resource Laboratory archive for 1900 EDT over the accident site coordinates. The HRRR model sounding was then plotted on a standard Skew T log P diagram⁷ from the surface to 400-hPa or

⁷ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram 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.

24,000 ft using RAOB software⁸ and is included as figure 7. The HRRR model sounding estimated the elevation at 2,188 ft, with a near surface temperature and dew point of 15° C. The lifted condensation Level (LCL)⁹ and the level of free convection (LFC)¹⁰ were identified at the surface, with the convective condensation level (CCL)¹¹ was at 1,236 ft agl. The sounding had a relative humidity greater than 90% from the surface through 18,500 ft with the RAOB program supported nimbostratus type clouds and rain. The precipitable water content was 1.54 inches, with the Lifted Index of +5.7 which supported a stable atmosphere. The freezing level was identified at 14,760 ft well above the accident airplanes cruising level.

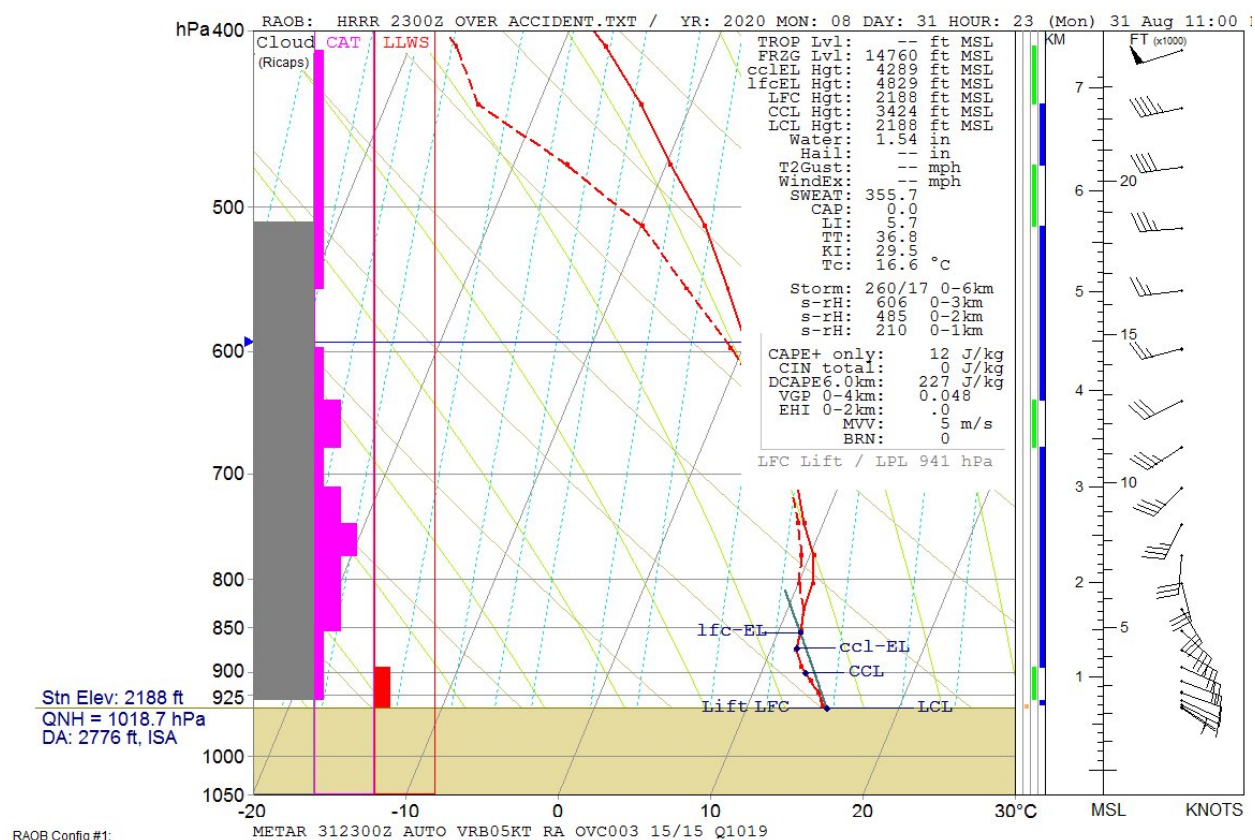


Figure 7 - HRRR numerical model over the accident site for 1900 EDT

⁸ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

⁹ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁰ 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.

¹¹ Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

The HRRR wind profile indicated light east-southeasterly winds at 5 knots at the surface which increased rapidly above the surface to 25 knots about 1,000 ft above the surface and began to veer or turn clockwise to the southwest with height and increase in speed. The RAOB program supported light low-level wind shear threat due to the rapid increase in winds above the surface, and the potential for light turbulence between 5,000 and 10,000 ft.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison (UW) in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible band imagery were obtained surrounding the time of the accident. The infrared long wave imagery (band 16) at a wavelength of 13.3 microns (μm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km. The visible imagery (band 2) at a wavelength of 0.64 μm provided a resolution of 1 km.

The GOES-16 infrared and visible images for 1856 EDT are included as figures 8 and 9. The GOES-16 infrared image at 3X magnification with a standard MB temperature enhancement curve applied depicted an extensive area of low and mid-level clouds over Virginia, which obscured the accident site consistent with nimbostratus type clouds. The radiative cloud top temperature over the accident site was 260 K or -13°C over the accident site, which corresponded to cloud tops near 20,000 ft based on the HRRR sounding. The GOES-16 visible image at 2X magnification depicted the overcast layer of nimbostratus clouds over the region and the accident site, which obscured the higher terrain.

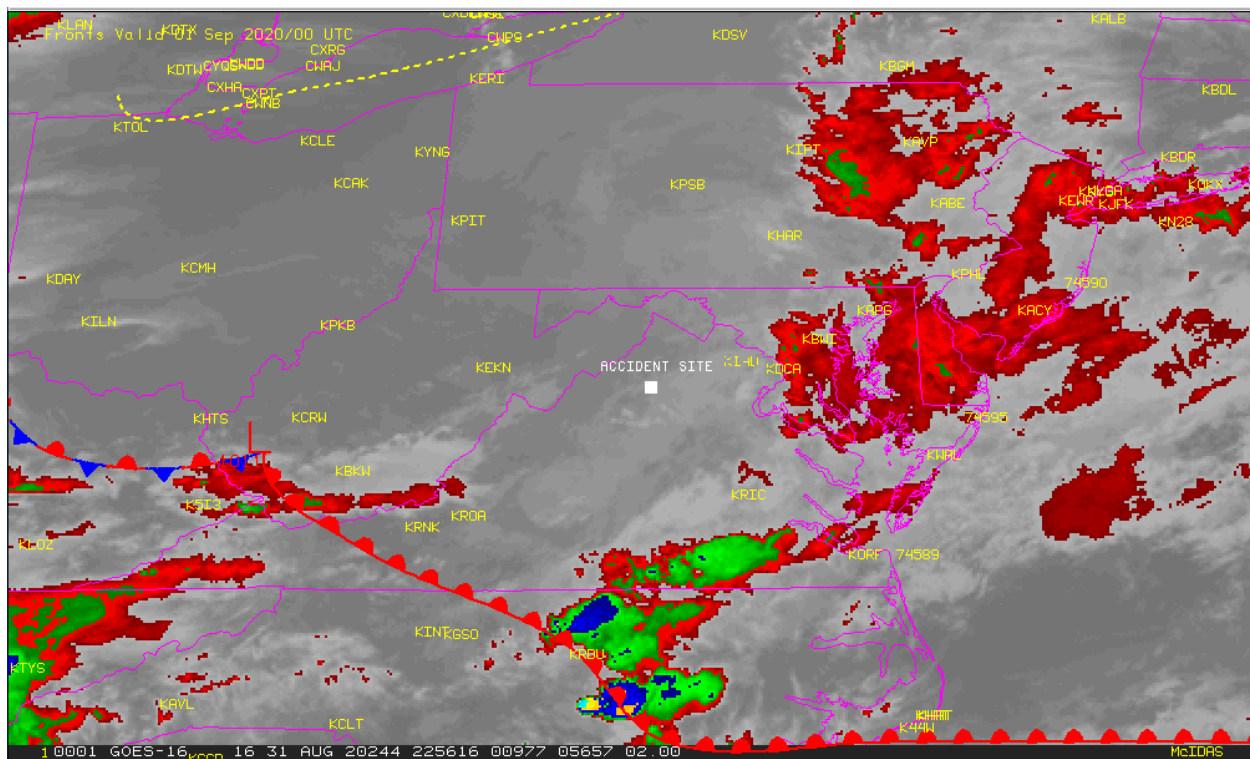


Figure 8 - GOES-16 infrared image for 1856 EDT at 3X magnification with the fronts overlaid

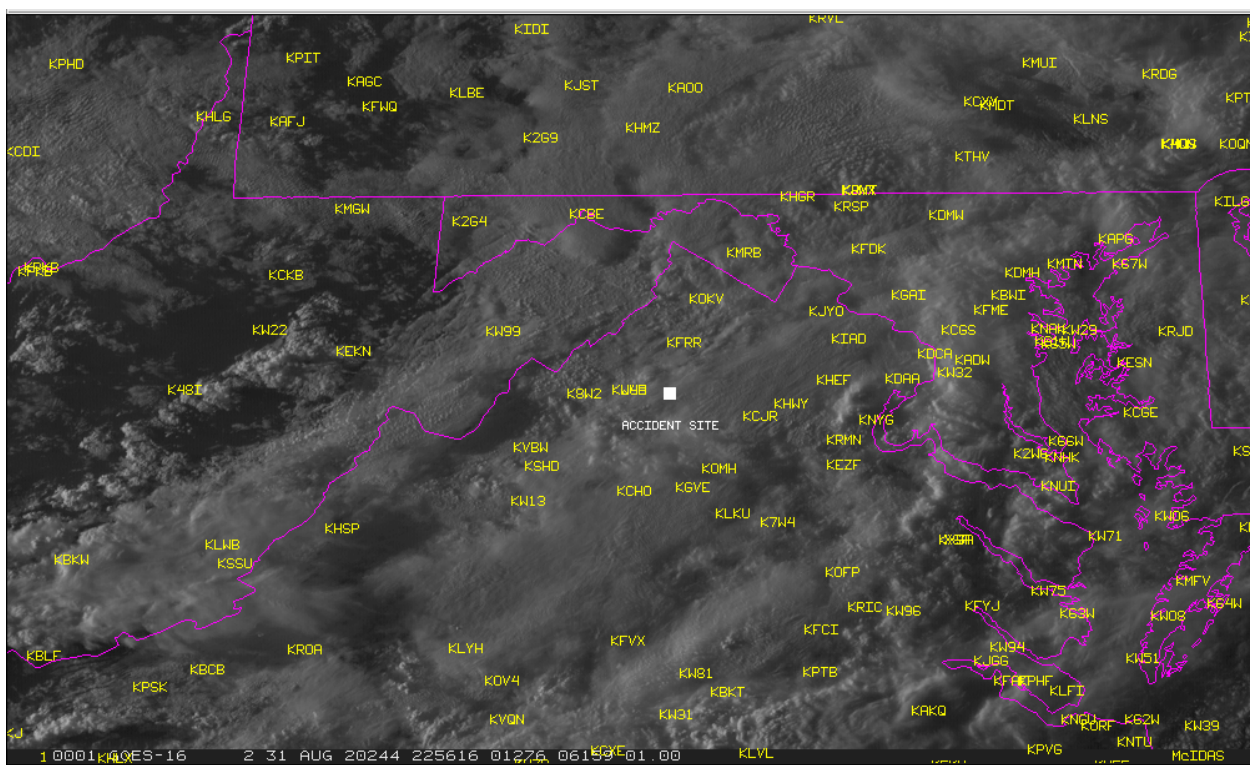


Figure 9 - GOES-16 visible image at 1856 EDT at 2X magnification

5.0 Weather Radar Information

The closest Weather Surveillance Radar-1988, Doppler (WSR-88D) to the accident site was from the NWS Sterling, Virginia (KLWX), located approximately 43 miles north-northeast of the accident site. The level II and III archive data were obtained from the National Climatic Data Center (NCDC) using the Hierarchical Data Storage System and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The WSR-88D is a S-band 10-centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

5.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the volume scan, which can range from 4 to 10-minutes depending on the scan being utilized. During the period of the accident, the NWS KLWX WSR-88D was operating in the precipitation mode, volume coverage pattern (VCP) 212, where the radar makes where the radar makes 14 different elevation scans in 4 ½ minutes. This mode is typically used by the NWS during periods when rapidly evolving widespread severe convection is expected and allows for improved low-level vertical resolution of the storms.

5.2 Beam Height Calculation

Assuming standard refraction¹² of the 0.95° radar beam of the KLWX WSR-88D with an antenna height of 404 feet and a distance of 43 miles from the radar, the following table shows the approximate beam height and width information of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.45°	3,730 feet	1,540 feet	5,930 feet	4,380 feet

Based on the air traffic control provided track data at 1855 EDT the accident airplane was at 3,625 ft and within the KLWX WSR-88D's 0.45° elevation scan. At the time of the accident the airplane's last recorded altitude was 2,950 ft was also within this scan.

¹² Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹³, 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 (dBZ¹⁴) and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

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

Advisory Circular AC 00-24C - "Thunderstorm" further defines the base reflectivity from the NWS and ATC weather radar systems to simplify the reflectivity products to the following intensity levels. Air Traffic Control (ATC) also uses these reflectivity levels to communicate the radar intensity precipitation levels to pilots.

¹³ 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 glaze ice.

¹⁴ dBZ - $10 \log Z_e$

Reflectivity (dBZ) Ranges	Weather Radar Echo Intensity Terminology
< 30 dBZ	Light
30 – 40 dBZ	Moderate
>40 – 50 dBZ	Heavy
>50 dBZ	Extreme

5.4 Composite Reflectivity Image

Composite reflectivity images utilize all elevation scans during each volume scan to create the image with a 1 km X 1 km resolution. It is composed of the greatest echo intensity (reflectivity) from any elevation angle seen from the radar. It is used to reveal the highest reflectivity in that area. Figure 10 is the KLWX WSR-88D composite radar image at 1855 EDT with the flight track overlaid in purple, with echoes less than 5 dBZ not displayed. The image depicts the flight track basically operating between two bands of echoes of 20-30 dBZ, with the final minutes of the flight entering into very light intensity echoes. An area of 30 dBZ echoes was located immediately east of KLUA, which had reported moderate rain at the time.

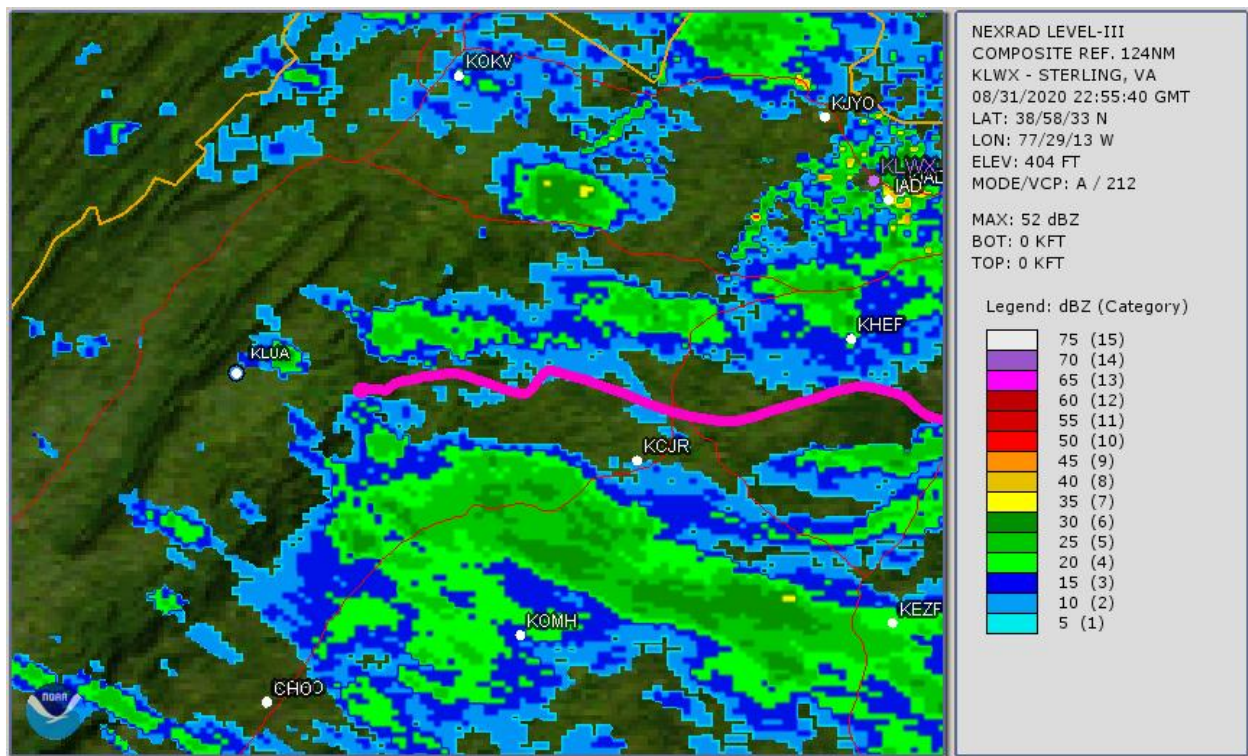


Figure 10 - KLWX WSR-88D Composite Reflectivity image at 1855 EDT with flight track overlaid

5.5 Base Reflectivity Image

The WSR-88D base reflectivity images are the individual elevation scan images for the VCP being operated. The NWS KLWX WSR-88D 0.45° base reflectivity images with the flight track overlaid for 1855 and 1900 EDT are included as figure 11 and 12 respectively. The images depict very light intensity echoes on the range of -5 to 15 dBZ extending over most of the route of flight

and over the accident site. The presence of the very light intensity echoes identified an extensive area of cloud with significant droplets present in the beam, and potential drizzle activity, with light rain typically associated with echoes of 15 dBZ and higher.

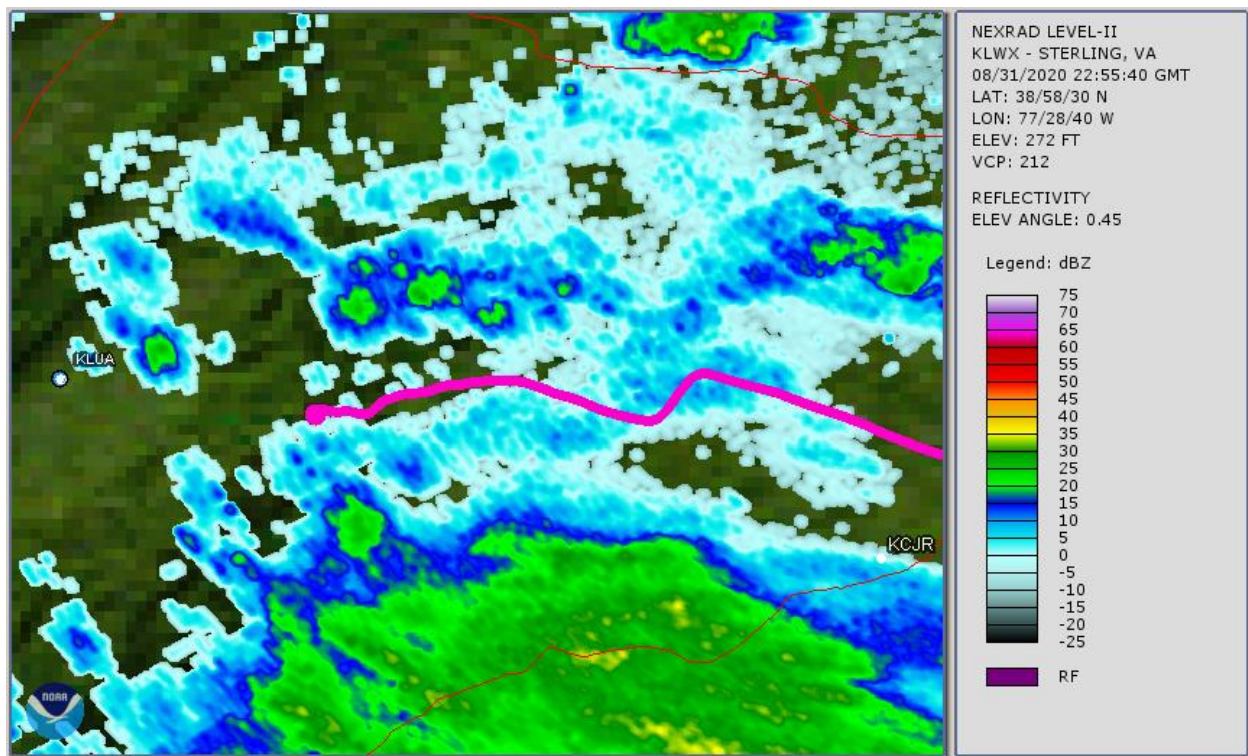


Figure 11 - KLWX WSR-88D 0.45° base reflectivity image for 1855 EDT with the flight track

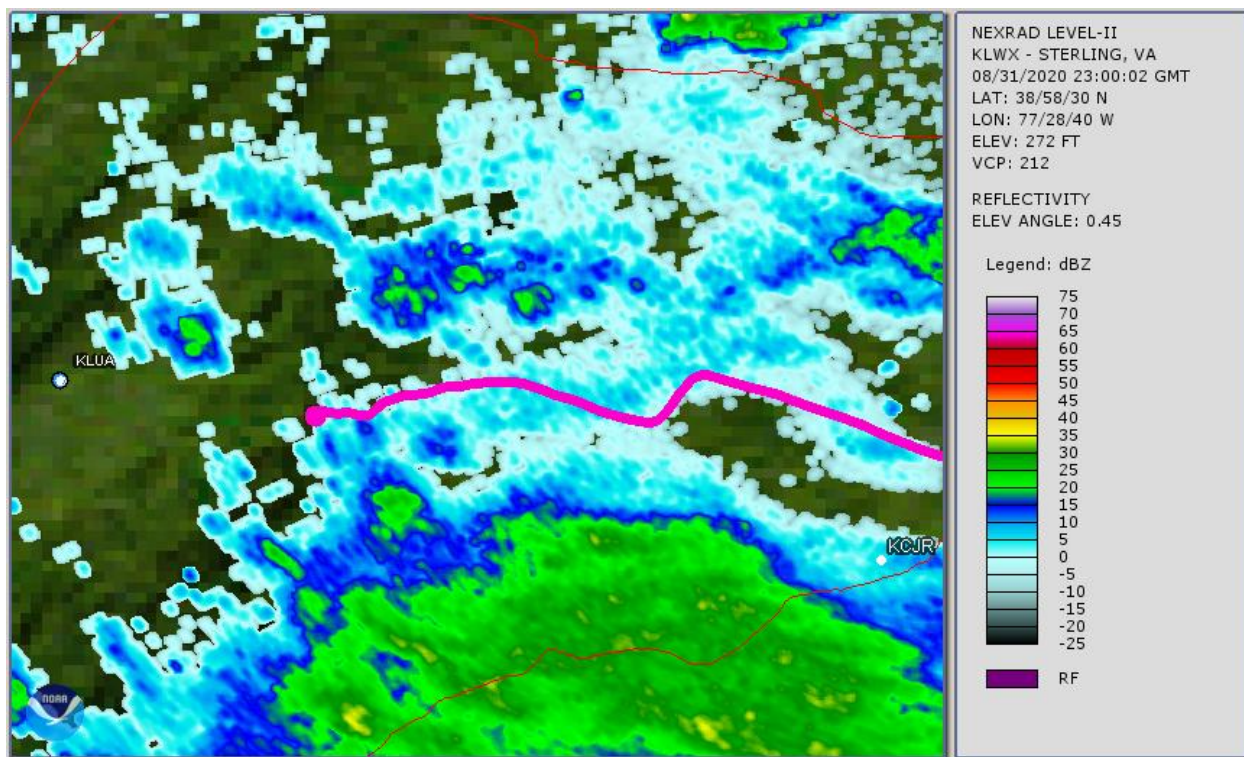


Figure 12 - KLWX WSR-88D 0.45° base reflectivity image for 1900 EDT with the flight track

6.0 Pilot Reports

The following pilot reports or PIREPs were noted over the region below 18,000 ft surrounding the period from 1400 through 1900 EDT. The reports are provided in raw code and abbreviations, with time in UTC, followed by a decoded report in plain language with the approximate distance from the accident site included and local time.

BWI UA /OV BAL180005/TM 1813/FL090/TP B737/TB NEG

Baltimore/Washington International Thurgood Marshall Airport (BWI), Baltimore, MD, routine pilot report (UA); Over – Baltimore VORTAC¹⁵ (BAL) 180° azimuth at distance of 5 miles (approximately 90 miles northeast); Time – 1813Z (1413 EDT); Altitude – 9,000 ft; Type aircraft – Boeing 737; Turbulence – negative.

DCA UA /OV AML300020/TM 1818/FL160/TP B737/TB LIGHT – MOD CHOP/RM 160-100 LIGHT BELOW 100

Ronald Reagan Washington National Airport (DCA), Washington, DC, routine pilot report; Over – Herndon VORTAC (ALM) 300° azimuth at a distance of 20 miles (approximately 70 miles northeast); Time – 1818Z (1418 EDT); Altitude – 16,000 ft; Type aircraft – Boeing 737; Turbulence – light to moderate chop; Remarks – turbulence from 16,000 to 10,000 ft and light below 10,000 ft.

¹⁵ VORTAC – is a radio-based navigational aid for aircraft pilots consisting of a co-located VHF omnidirectional range (VOR) beacon for azimuth and a tactical air navigation system (TACAN) beacon for distance information. Unless otherwise noted, the station name is often co-located with the airport city.

ROA UA /OV ROA/TM 1820/FL004/TP PA27/SK BASES 004 AGL

Roanoke-Blacksburg Regional Airport/Woodrum Field (ROA), Roanoke, VA, routine pilot report; Over – Roanoke VORTAC (106 miles southwest); Time – 1825Z (1425 EDT); Altitude – 400 ft; Type aircraft – Piper Aztec PA-27; Sky cover – bases at 400 ft agl.

LYH UA /OV LYH/TM 1825/FL040/TP C560/SK BASES 009 AGL TOPS 040 MSL

Lynchburg Regional Airport/Preston Glenn Field (LYH), Lynchburg, VA, routine pilot report; Over – Lynchburg VORTAC (87 miles south-southwest); Time – 1825Z (1425 EDT); Altitude – 4,000 ft; Type aircraft – Cessna Citation V (C650); Sky cover – bases at 900 ft agl tops at 4,000 ft msl.

BWI UA /OV 30 SE BAL/TM 1842/FL110/TP E75S/TB CONT MOD CHOP

BWI routine pilot report; Over – 30 miles southeast of Baltimore VORTAC (BAL) (approximately 110 miles northeast); Time – 1842Z (1442 EDT); Altitude – 11,000 ft; Type aircraft – Embraer ERJ 175; Turbulence – continuous moderate chop.

HEF UA /OV FINAL 16L/TM 1847/FL012/TP M20P/SK OVC012/RM DURD

Manassas Regional Airport/Harry P. Davis Field (HEF), Manassas, VA, routine pilot report; Over – on final for runway 16L (approximately 55 miles east); Time – 1847Z (1447 EDT); Altitude – 1,200 ft; Type aircraft – Mooney M20P; Sky cover – overcast at 1,200 ft; Remarks – during descent.

IAD UA /OV FINAL RWY 19L/TM 1950/FL014 /TP E145/SK BKN014

Washington Dulles International Airport (IAD), Sterling, VA, routine pilot report; Over – on final for runway 19L (approximately 50 miles north); Time – 1950Z (1550 EDT); Altitude – 1,400 ft; Type aircraft – Embraer ERJ 145; Sky cover – broken at 1,400 ft.

IAD UA /OV FINAL RWY 19L/TM 2055/FL014/TP C750/SK BKN014

IAD routine pilot report; Over – on final for runway 19L (approximately 50 miles north); Time – 2055Z (1655 EDT); Altitude – 1,400 ft; Type aircraft – Cessna Citation X (C750); Sky cover – broken at 1,400 ft.

CHO UA /OV CHO315010/TM 2100/FL100/TP B350/SK BASES 004 OVC

Charlottesville-Albemarle Airport (CHO), Charlottesville, VA, routine pilot report; Over – CHO 315° and 10 miles from airport (approximately 30 miles); Time – 2100Z (1700 EDT); Altitude 10,000 ft; Type aircraft – Beechcraft Super King air (B350); Sky cover – overcast bases at 400 ft.

IAD UA /OV RWY 19L FINAL /TM 2138/FL020/TP CL35/SK BKN020

IAD routine pilot report; Over – on final for runway 19L (approximately 50 miles north); Time – 2138Z (1738 EDT); Altitude – 2,000 ft; Type aircraft – Bombardier Challenger 300 jet (CL35); Sky cover – broken at 2,000 ft.

BWI UA /OV 3 SW BAL/TM 2215/FL040/TP B737/SK BASES 038

BWI routine pilot report; Over – 3 miles southwest of Baltimore VORTAC (approximately 90 miles northeast); Time – 2215Z (1815 EDT); Altitude – 4,000 ft; Type aircraft – Boeing 737; Sky cover – bases at 3,800 ft.

LYH UA /OV LYH/ TM 2258/FL180/TP COL4/TA 18/IC LGT RIME

LYH routine pilot report; over – LYH (approximately 90 miles south-southwest); Time – 2258Z (1858 EDT), Altitude 18,000 ft; Type aircraft – Cessna 400 Corvalis; Temperature – 18° F (-7 °C); Icing – light rime type ice.

7.0 NWS Forecast and Advisories

7.1 Terminal Aerodrome Forecast

The NWS Baltimore/Washington (KLWX), Weather Forecast Office (WFO) was responsible for the Luray, Virginia, area. The closest NWS Terminal Aerodrome Forecast (TAF) to the accident site was for Charlotte-Albemarle Airport (KCHO), Charlottesville, Virginia, approximately 30 miles south of the accident site at an elevation of 640 ft. While a TAF is only valid for a 5-mile radius of the airport center point, pilots and other weather software will often display the closest TAF along the proposed route of flight for a more time specific breakdown of wind, visibility, and cloud layers over the area. The forecast issued at 1340 EDT is included below and expected LIFR to IFR conditions during the period. Cloud heights in TAFs are provided in agl heights.

***TAF KCHO 311740Z 3118/0118 08005KT 1SM +SHRA BR BKN004 OVC015
FM312300 06005KT 3SM SHRA BR BKN008 OVC020
FM010600 07004KT 5SM -RADZ BR OVC008
FM010900 05003KT 2SM -RADZ BR BKN003 OVC008
FM011400 06003KT 5SM -DZ BR OVC008***

The forecast for KCHO expected from 1400 through 1900 EDT, winds from 080° at 5 knots, visibility 1 mile in heavy rain showers and mist, ceiling broken at 400 ft agl, and overcast at 1,500 ft. From 1900 through 0200 EDT on September 1, 2020, wind from 060° at 5 knots, visibility 3 miles in moderate rain showers and mist, ceiling broken at 800 ft, overcast at 2,000 ft. IFR conditions continued to be forecast through the end of the valid period of 1400 EDT on September 1, 2020.

The TAF for KMRB current at the time was issued by KLWX WFO at the same time of 1340 EDT and was as follows.

***TAF KMRB 311740Z 3118/0118 13007KT 6SM -SHRA BKN014 OVC050
FM312100 12007KT 2SM SHRA BR OVC008
FM010000 11006KT 4SM -SHRA BR OVC010
FM010900 10004KT 5SM -DZ BR BKN008 OVC015=***

The forecast for KMRB from 1700 through 2000 EDT expected wind from 120° at 7 knots, visibility 2 miles in moderate rain showers and mist, ceiling overcast at 800 ft agl.

7.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short term weather conditions within their region with an aviation section that includes the general conditions as they relate to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF. The discussion also gives some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The AFD issued at 1516 EDT is included below, with the long term and marine sections excluded.

FXUS61 KLWX 311916

AFDLWX

Area Forecast Discussion
National Weather Service Baltimore MD/Washington DC
316 PM EDT Mon Aug 31 2020

.SYNOPSIS...

A wave of low pressure will track across the Appalachians, reaching the Mid-Atlantic coast on Tuesday. High pressure will briefly build in on Wednesday before a cold front drops southeastward out of Canada toward the end of the week.

.NEAR TERM /UNTIL 6 AM TUESDAY MORNING/...

Radar indicates light to moderate rain across the area this afternoon, with heavier elements toward central Virginia, as a jet streak, mid level shortwave trough, low level jet, and onshore surface flow combine to bring moisture into the region. Automated gauges are already indicating several inches of rain across our southwestern zones, but the rain is losing intensity with northern extent, being farther removed from any instability and closer to surface high pressure over New England. A Flood Watch remains in effect through 2 AM, where the greatest potential exists for multiple inches of rain to overlap more saturated soil conditions.

As the shortwave moves east through this evening, the I-95 corridor will have better opportunities for steadier rain, although rates/amounts and duration should preclude any flooding issues. Precipitation intensity should decrease late tonight as the shortwave departs and drier air moves in aloft. However, the surface system will be moving toward the Carolina coast, allowing moist onshore flow to continue. Thus expect a combination of light rain showers and drizzle...and potentially some fog as ceilings lower in the mountains. Lows will be in the 60s to around 70.

.SHORT TERM /6 AM TUESDAY MORNING THROUGH WEDNESDAY NIGHT/...

The surface low will continue eastward Tuesday while high pressure remains anchored to the north. Thus onshore flow will continue while warm advection continues aloft. Low clouds will likely persist most of the day, though a few breaks could exist across southern areas. Some weak instability may form in these areas and allow for a thunderstorm or two, but otherwise only light showers or drizzle are possible with the weak ascent. Clouds will likely hold high temperatures in the 70s.

Weak warm front will lift north slowly Tuesday night into Wednesday, while a weak cold front approaches from the northwest. This should allow clouds to break for some sun later Wednesday, but with the added instability in the warmer and more moist air mass, spotty showers and thunderstorms will remain possible. Temps will rise into the 80s. Computer guidance isn't in strong agreement as to whether the front works back south through Wednesday night. If so, some showers may continue, but otherwise conditions should dry out.

.AVIATION /19Z MONDAY THROUGH SATURDAY/...

Light to moderate rain continues to overspread the area, with heavier rains near CHO. IFR is most likely at CHO, followed by MRB. There is some uncertainty as to how quickly IAD/DCA will become predominantly MVFR, and how persistent it will be. However, intermittent MVFR conditions are certainly possible (and occurring) this afternoon and evening. Cigs may have trouble dropping at BWI/MTN as the significant rain struggles to reach that area. Low cigs/vsby (low MVFR to IFR) likely persist in areas where they develop through tonight. However, it's possible sub-VFR ceilings don't fully envelop the metro until Tuesday morning. The rain should taper to lighter showers and drizzle tonight into Tuesday. Low clouds likely persist through Tuesday with continued onshore flow (MVFR most likely), before potentially decreasing again Tuesday night.

VFR conditions likely return Wednesday, although a stray afternoon thunderstorm will be possible.

Mostly VFR conditions are expected Thursday and Friday aside from any afternoon showers /thunderstorms that may result in brief sub-VFR conditions.

.HYDROLOGY...

August has been fairly wet across the region and approaching low pressure will have plenty going for it - high PW's moving in from the south on a strong low level jet coupled with a decent mid-level vort max and upper level jet streak. Thus, flooding seems quite possible across our southwestern zones. Further north and east, limited instability and waning forcing likely keeps the flood risk at bay. Flood watch remains in effect for these favored areas. Best guess QPF is greater than 1.5-3 inches in the watch area (with locally higher amounts), but more manageable amounts further north and east, mostly near or less than 1 inch. At this time, larger river forecast points are not forecast to reach flood stage.

7.3 Graphic Forecast for Aviation

The NWS Graphic Forecast for Aviation (GFA) product provides a graphical depiction of surface wind, weather, with color coded general flight categories, and cloud cover, with the graphic AIRMET Sierra for IFR conditions, mountain obscuration, and icing conditions overlaid. The GFA is available at the NWS AWC website and through other weather briefing services.

Figure 13 is the GFA Surface Forecast issued at 1501 EDT and valid for the period between 1700 through 2000 EDT. The charts depicted the expected surface wind, visibility, flight category, precipitation and weather from data output from the NWS Localized Aviation Model Output Statistics Product (LAMP), with any G-AIRMETs for IFR conditions expected for the period. The GFA Surface Forecast depicted wind from the east to southeast at 5 knots, visibility less than 3 miles, and an areas less than 1 mile near the higher terrain with thunderstorms and rain showers likely. A Graphic or G-AIRMET for IFR conditions was depicted over the area.

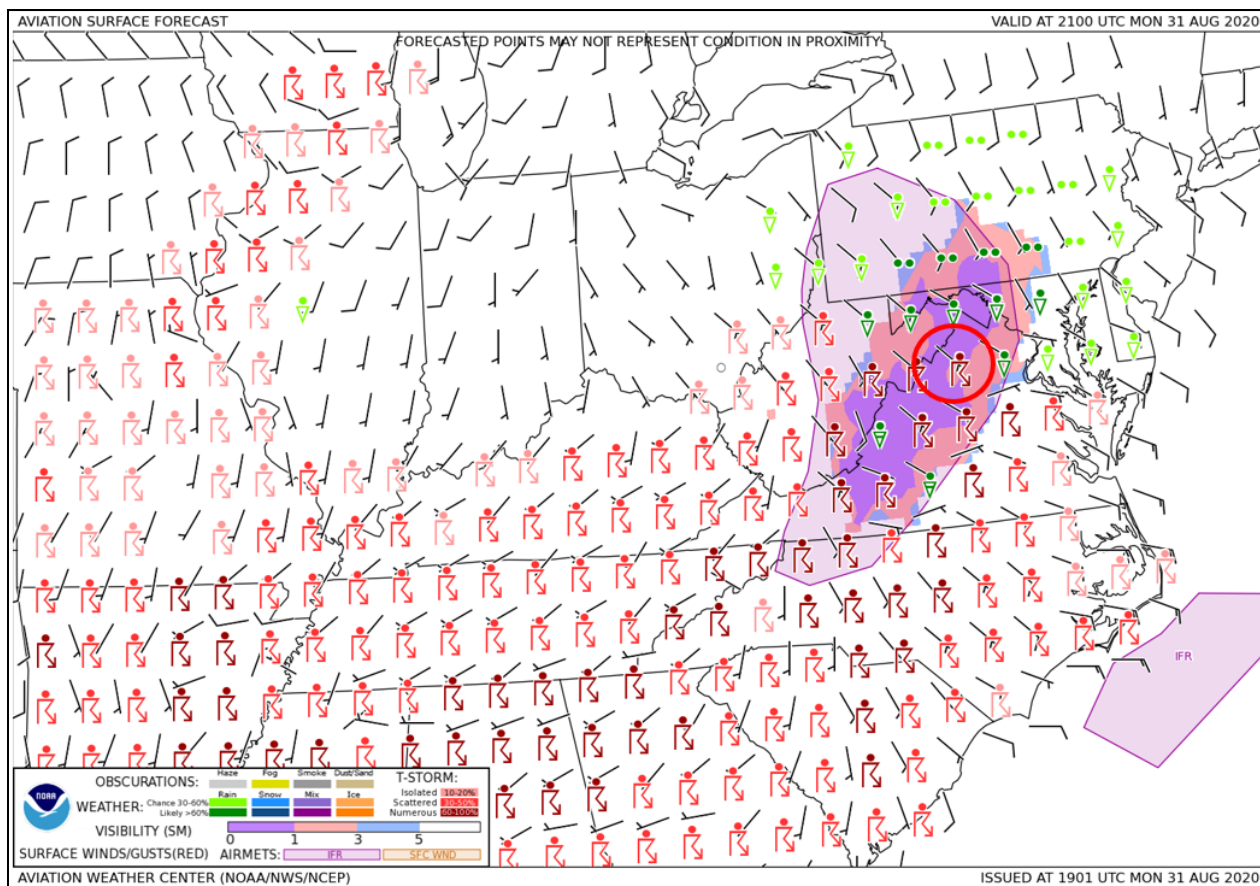


Figure 13 - Graphic Forecast for Aviation Surface Forecast valid for 1700 to 2000 EDT

Figure 14 is the GFA Cloud Forecast issued at about 1502 EDT and was also valid from 1700 through 2000 EDT. The GFA Cloud forecast is obtained from primary data are derived from the NWS Rapid Refresh (RAP) continental-scale NOAA hourly-updated assimilation modeling system run operational at NCEP to produce cloud layers, bases and tops. Cloud heights from the model are in ft msl. The GFA Cloud Forecasts valid during the period depicted overcast clouds at 4,000 ft decreasing to 2,000 ft msl near the accident site with tops to 16,000 ft over western Virginia. A G-AIRMET for mountain obscuration and icing conditions was depicted over the route of flight and the accident site.

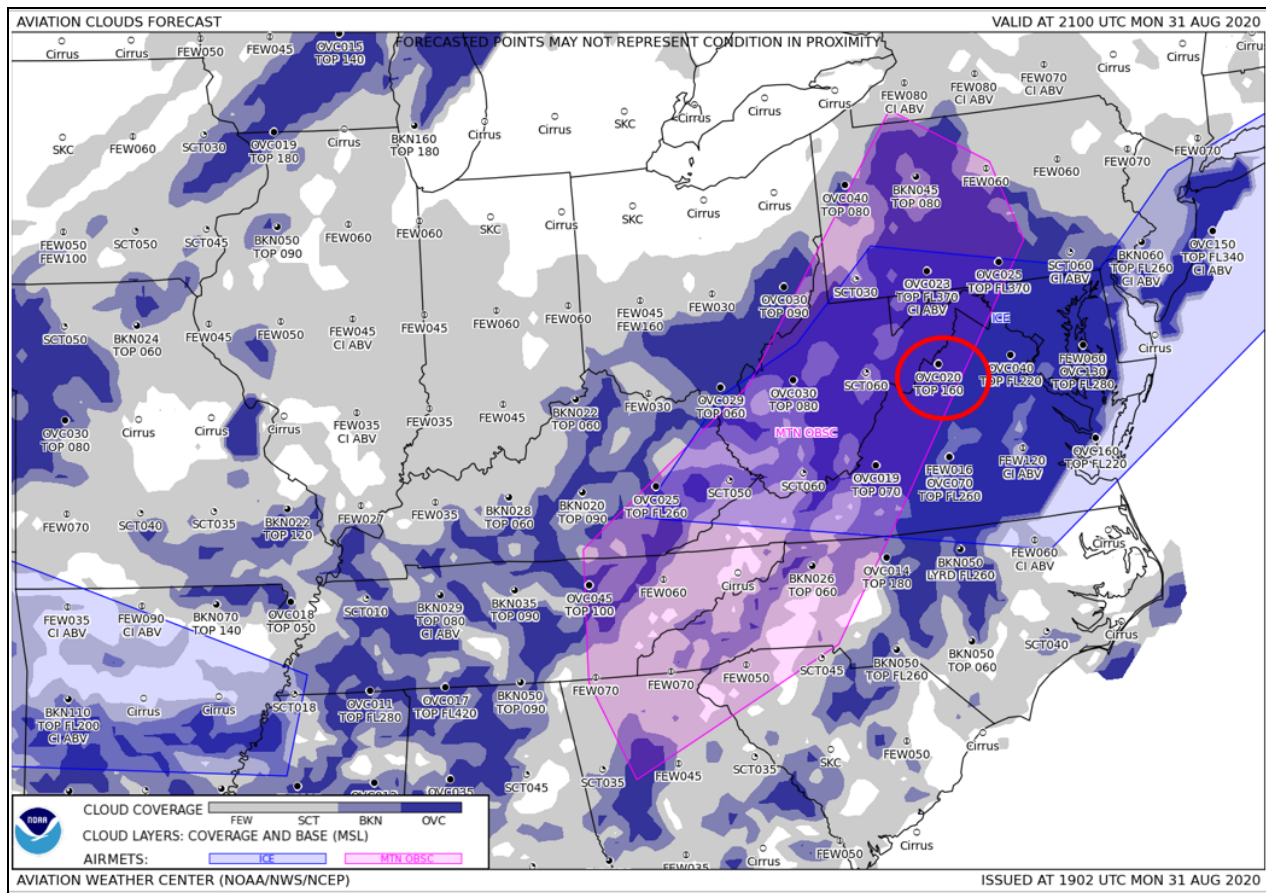


Figure 14 - Graphic Forecast for Aviation Cloud Forecast valid for 1700 to 2000 EDT

7.4 Winds Aloft Forecast

The Winds and Temperature Aloft Forecast taken from the FBUS bulletin for the area was as follows, with the forecasts for 45,000 and 53,000 ft excluded.

WINDS ALOFT FORECASTS

DATA BASED ON 311800Z

VALID 010000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
RIC	1524	2022+15	2328+10	2423+05	2629-06	2542-17	274632	275241	266750
EKN	2413+15	2516+10	2618+05	2928-07	2642-18	264232	284440	275951	
ROA	1714	2108+16	2613+11	2724+06	2831-07	2542-17	275231	286340	276650

The forecast for Elkins (EKN), West Virginia, approximately 80 miles west-northwest of the accident site forecast for 6,000 ft expected winds from 240° at 13 knots with a temperature of 15° C. The forecast for Roanoke (ROA), Virginia, approximately 100 miles southwest of the accident site forecasted for 3,000 ft a wind from 170° at 14 knots, and at 6,000 ft a wind from 210° at 8 knots with a temperature of 16° C.

7.5 In-Flight Weather Advisories

The NWS AWC had no Significant Meteorological Information (SIGMET) current during the period for any organized turbulence or icing. Several Convective SIGMETs were issued over the region earlier in the day and continued over southern Virginia and North Carolina at the time of the accident. The NWS also had a full series of Airmen Meteorological Advisories (AIRMETs) current over the region. The advisories are documented below.

7.5.1 Convective SIGMETs

At 1655 EDT the NWS AWC had Convective SIGMET 90E current for most of Virginia which impacted the route of flight for an area of severe thunderstorms moving eastward at 20 knots, with cumulonimbus cloud tops to 45,000 ft. The advisory was current until 1855 EDT. Figure 15 is a depiction of the Convective SIGMETs issued at 1655 EDT with the accident site located within advisories 90E, with the advisories text following.

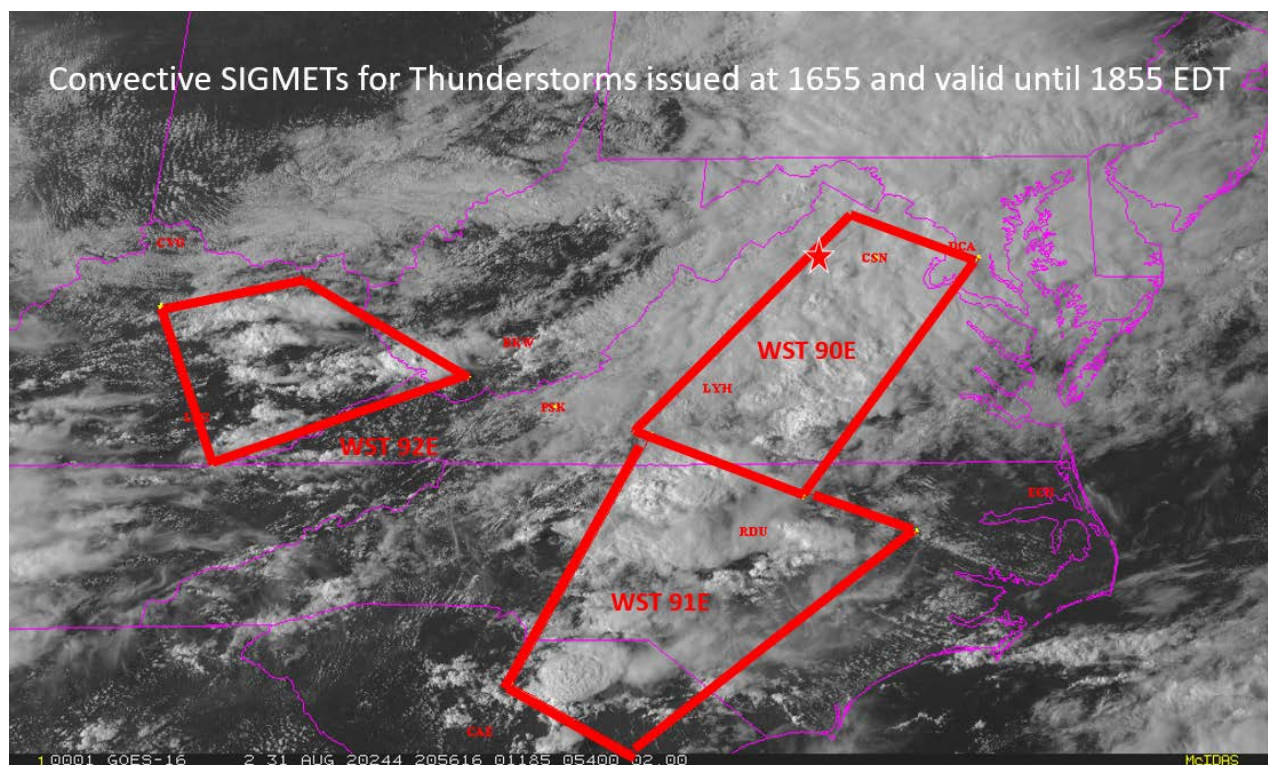


Figure 15 - Convective SIGMET 90E for thunderstorms valid from 1655 through 1855 EDT

WSUS31 KNCI 312055
SIGE
-MKCE WST 312055
CONVECTIVE SIGMET 90E
VALID UNTIL 2255Z
MD VA NC DC
FROM 30NNW CSN-10SE DCA-30NE RDU-40ESE PSK-30NNW CSN
AREA SEV TS MOV FROM 25020KT. TOPS TO FL450.
TORNADOES POSS.

CONVECTIVE SIGMET 91E
VALID UNTIL 2255Z
VA NC SC
FROM 40SW LYH-60WSW ECG-20WSW CHS-30NNE CAE-40SW LYH
AREA TS MOV FROM 24010KT. TOPS TO FL450.

CONVECTIVE SIGMET 92E
VALID UNTIL 2255Z
VA WV KY
FROM 70ESE CVG-30SW BKW-30SSE LOZ-40S CVG-70ESE CVG
AREA TS MOV FROM 24015KT. TOPS TO FL420.

At 1755 EDT the NWS AWC updated the advisories and forecast the main area of thunderstorms over southern Virginia and North Carolina, which is depicted in figure 16.

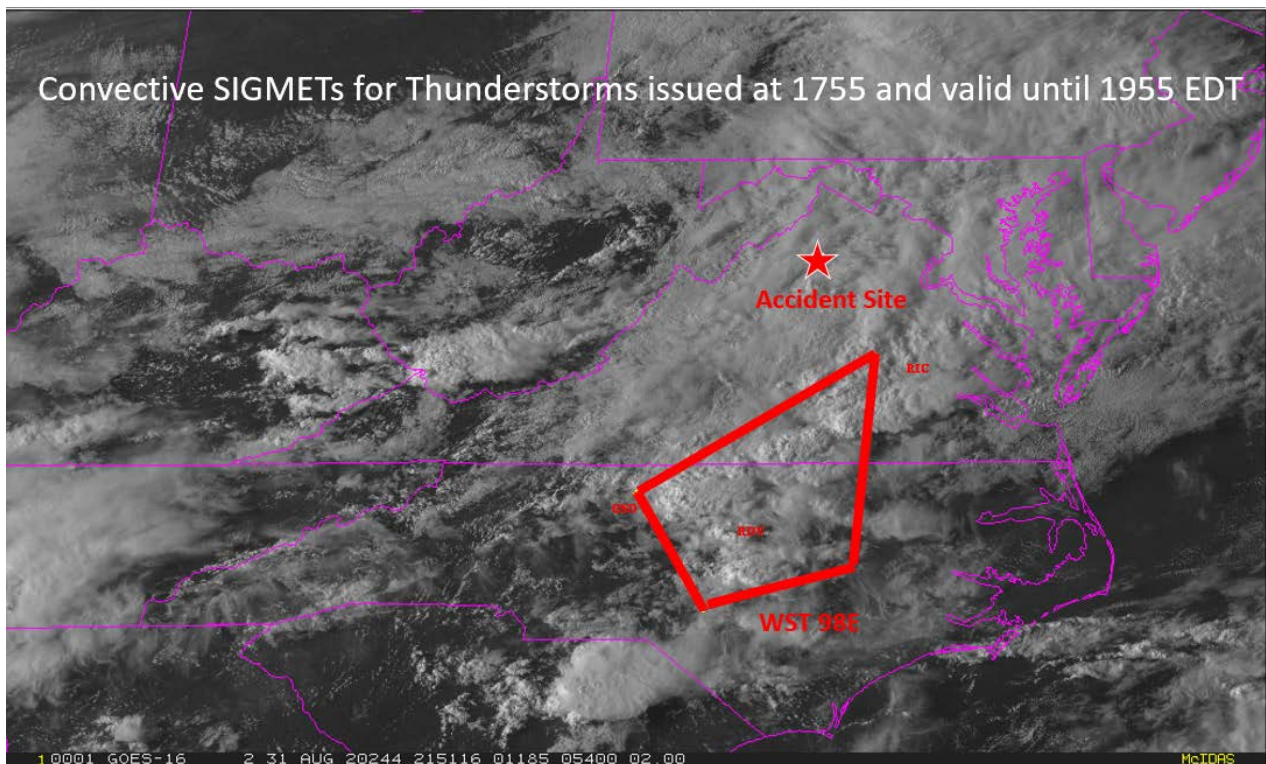


Figure 16 - Convective SIGMETs issued at 1755 EDT

WSUS31 KNCI 312155
SIGE
-MKCE WST 312155
CONVECTIVE SIGMET 98E
VALID UNTIL 2355Z
VA NC
FROM 20WNW RIC-50ESE RDU-50SSW RDU-10NNE GSO-20WNW RIC
AREA SEV TS MOV FROM 25020KT. TOPS TO FL450.
TORNADOES...HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

At 1855 EDT the NWS AWC updated the Convective SIGMET over southern Virginia and North Carolina as shown in figure 17, with the advisory text following.

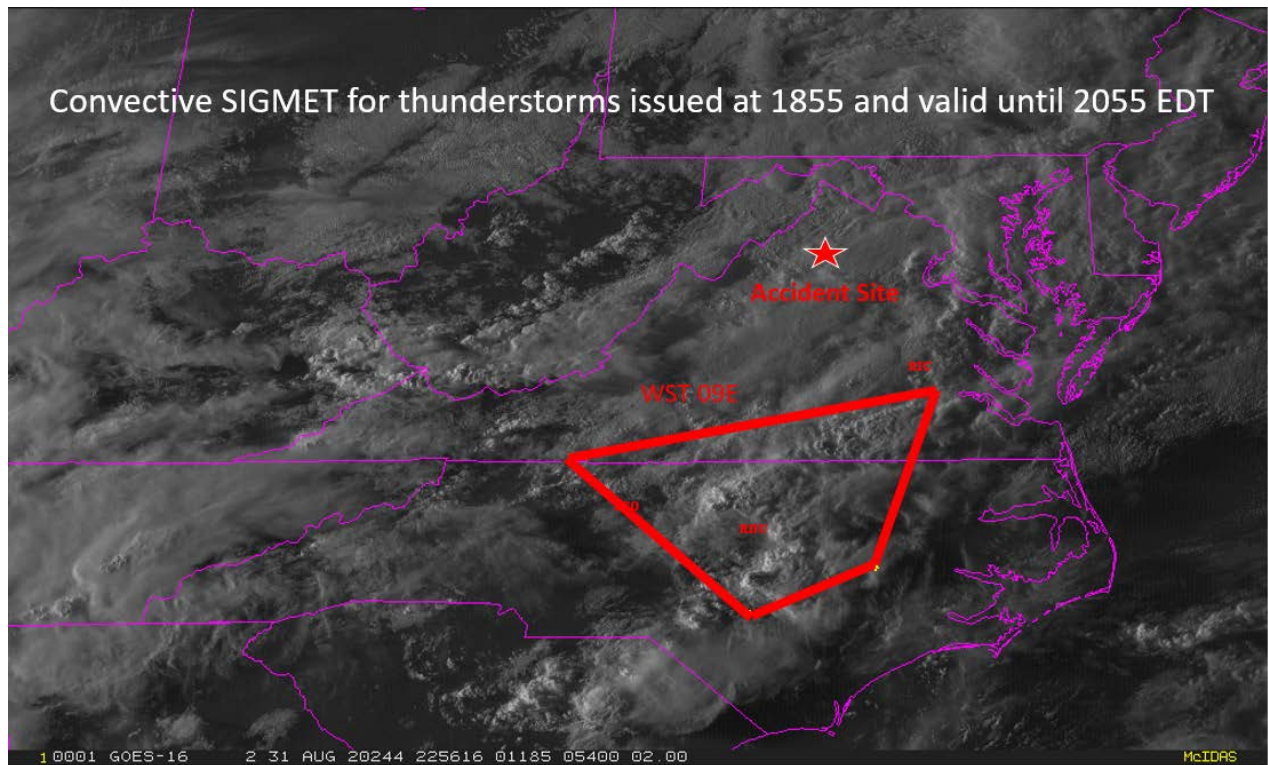
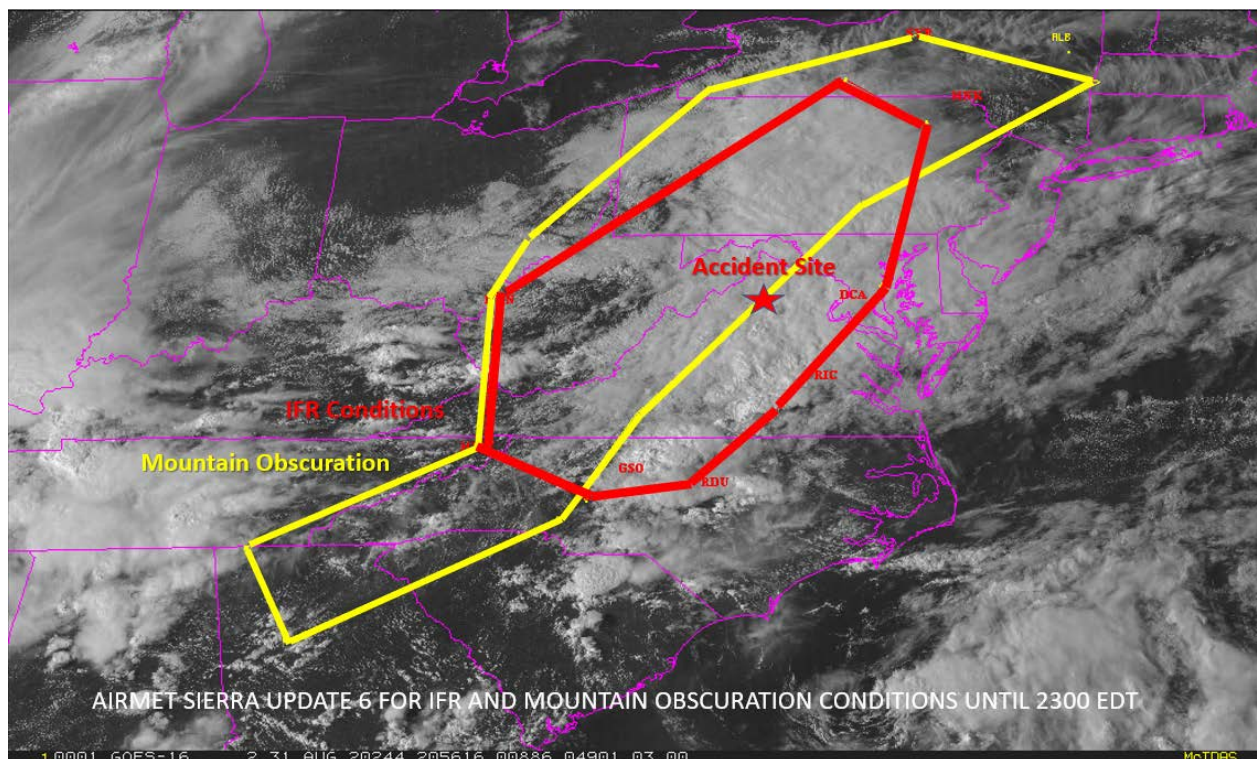


Figure 17 - Convective SIGMET issued at 1855 EDT

WSUS31 KNCI 312255
SIGE
-MKCE WST 312255
CONVECTIVE SIGMET 09E
VALID UNTIL 0055Z
VA NC
FROM 20SSE RIC-60ESE RDU-50S RDU-40NW GSO-20SSE RIC
AREA SEV TS MOV FROM 25020KT. TOPS TO FL450.
TORNADOES...HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

7.5.2 AIRMETs

The NWS AWC had a full set of AIRMETs current over the area for IFR, mountain obscuration, icing, and turbulence conditions. The AIRMET Zulu for icing conditions extended above 14,000 ft above the accident airplanes cruising altitude, and AIRMET Tango was for occasional moderate turbulence above 24,000 ft and were not applicable to the accident flight. A graphic depiction of AIRMET Sierra for IFR and mountain obscuration conditions is included as figure 18 with the advisories text following. The accident site was in both advisories for IFR and mountain obscuration conditions.



WAUS41 KNCI 312045

WA1S

BOSS WA 312045

AIRMET SIERRA UPDT 6 FOR IFR AND MTN OBSCN VALID UNTIL 010300

AIRMET IFR...NY PA WV MD DC VA NC

FROM 70SW SYR TO 40SW HNK TO 20ENE DCA TO 40SW RIC TO 20W RDU TO

40SW GSO TO HNV TO HNN TO 40S AIR TO 20SSE JHW TO 70SW SYR

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET MTN OBSCN...MA NY PA WV MD VA NC SC GA

FROM SYR TO 40SE ALB TO HAR TO 30N GSO TO CLT TO ATL TO GQO TO HNV TO

HNN TO 40NNE HNN TO JHW TO SYR

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

OTLK VALID 0300-0900Z

AREA 1...IFR NY PA OH LE WV MD DC VA NC SC GA AND CSTL WTRS

BOUNDED BY 40WSW BUF-60SW SYR-50SSW HNK-ETX-20N RIC-40WSW ORF-40NNE ILM-

20NNE CHS-40SSE IRQ-40W ATL-GQO-HMV-HNN-CVG-FWA-40WSW BUF

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

AREA 2...IFR ME NH VT MA CT NY PA AND CSTL WTRS

BOUNDED BY 40NNE PQI-50ESE BGR-20ENE BDL-40NE SAX-30SSW HNK-60WSW YSC-

30ESE YSC-40NNE PQI

CIG BLW 010/VIS BLW 3SM BR/FG. CONDS DVLPG 03-06Z. CONDS CONTG THRU 09Z.

AREA 3...MTN OBSCN VT MA NY PA WV MD VA NC SC GA

BOUNDED BY MSS-50SW CON-HAR-30N GSO-CLT-ATL-GQO-HMV-HNN-JHW-SYR-MSS

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG THRU 09Z.

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8.0 Preflight Weather Briefing

A search of the Federal Aviation Administration (FAA) contract Automated Flight Service Station (AFSS) provider Leidos for any filed flight plans or weather briefings indicated that they had no contact with the accident pilot on that day, and there was no record of any third party vendors who utilize their system having any record of any contact. Witnesses indicated that the accident pilot was utilizing his iPad to monitor the weather or “storms” prior to departing and was concerned about the weather along the route and was waiting for the weather to improve. It is unknown what the pilot specifically reviewed prior to departure on the day of the accident, and if it included the inflight weather advisories for IFR and mountain obscuration conditions over the region.

9.0 Astronomical Data

The astronomical conditions for Luray, Virginia on August 31, 2020 were as follows, with the time of the accident added in bold italic type.

SUN

Beginning of civil twilight	0615 EDT
Sunrise	0642 EDT
Sun transit	1314 EDT
<i>Accident</i>	<i>1900 EDT</i>
Sunset	1945 EDT
End of civil twilight	2012 EDT

At the time of the accident the Sun was at an elevation of 8° above the horizon at an azimuth of 274°.

Submitted by:

Donald Eick
NTSB Senior Meteorologist