



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 6, 2019

Weather Study

METEOROLOGY

CEN19FA029

Table Of Contents

A. ACCIDENT	3
B. METEOROLOGIST	3
C. DETAILS OF THE INVESTIGATION	3
D. WEATHER INFORMATION	3
1.0 Synoptic Conditions.....	3
2.0 Surface Observations	5
3.0 Pilot Reports.....	10
4.0 Upper Air Data.....	11
5.0 Satellite Imagery	13
6.0 Graphical Forecasts for Aviation.....	14
7.0 Area Forecast Discussion.....	18
8.0 Terminal Aerodrome Forecasts.....	20
9.0 AIRMETs.....	20
10.0 SIGMETs	22
11.0 Current Icing Potential/Forecast Icing Potential.....	22
12.0 CWSU.....	23
13.0 Astronomical Data	24
14.0 Weather Briefing.....	24
E. Attachments	25

A. ACCIDENT

Location: Liberal, Kansas
Date: November 17, 2018
Time: about 1657 central standard time (2257 UTC)¹
Airplane: Beech 95-B-55; N4817M

B. METEOROLOGIST

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

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's meteorological specialist did not travel in support of this accident investigation and gathered all weather data remotely. Unless otherwise noted, all times are in central standard time (CST) for November 17, 2018 (based upon the 24-hour clock), directions are referenced to true north, distances are in nautical miles and heights are above mean sea level (msl).

Coordinates used for the accident location: 36.985000° north latitude, 100.955278° west longitude, at an elevation of about 2,860 feet.

D. WEATHER INFORMATION

1.0 Synoptic Conditions

The National Weather Service (NWS) Surface Analysis Chart for 1800 CST is presented in figure 1. The surface analysis chart showed a low-pressure system with a minimum pressure of 1017 hectopascals (hPa) over Oklahoma with a cold front extending southwestward into Texas and then back to the north as a stationary front through New Mexico and Colorado. The accident site was located on the cold air side north of the front and near the axis of a high pressure ridge. The isobars on the chart suggested, and the station models depicted, wind in the vicinity of the accident site from the north to northeast at magnitudes of 15-20 knots. Station models depicted overcast skies across the accident region, with temperatures below freezing and dew point depressions of 5 degrees Fahrenheit or less, with several stations reporting mist. A WSR-88D regional radar composite reflectivity mosaic obtained from the National Centers for Environmental Information (NCEI) for 1655 CST (figure 2) did not depict any pertinent reflectivity near the accident location.

¹ UTC – abbreviation for Coordinated Universal Time

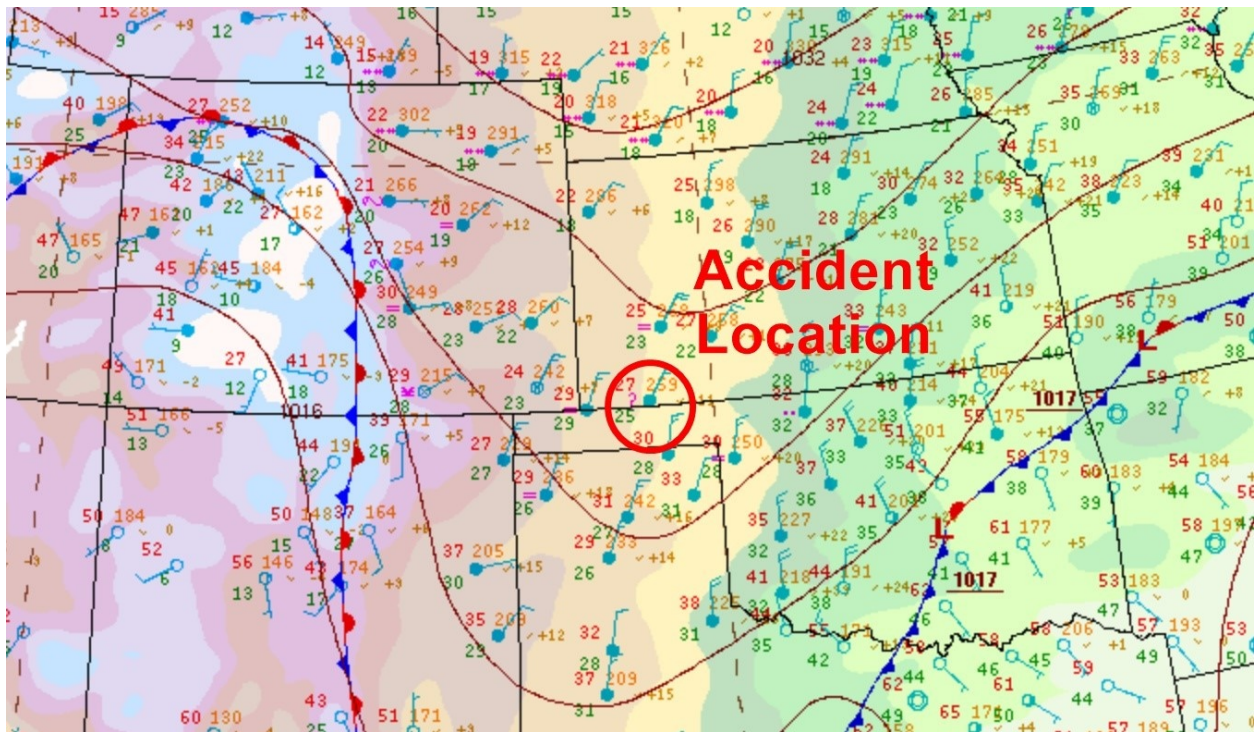


Figure 1 - NWS Surface Analysis Chart for 1800 CST.

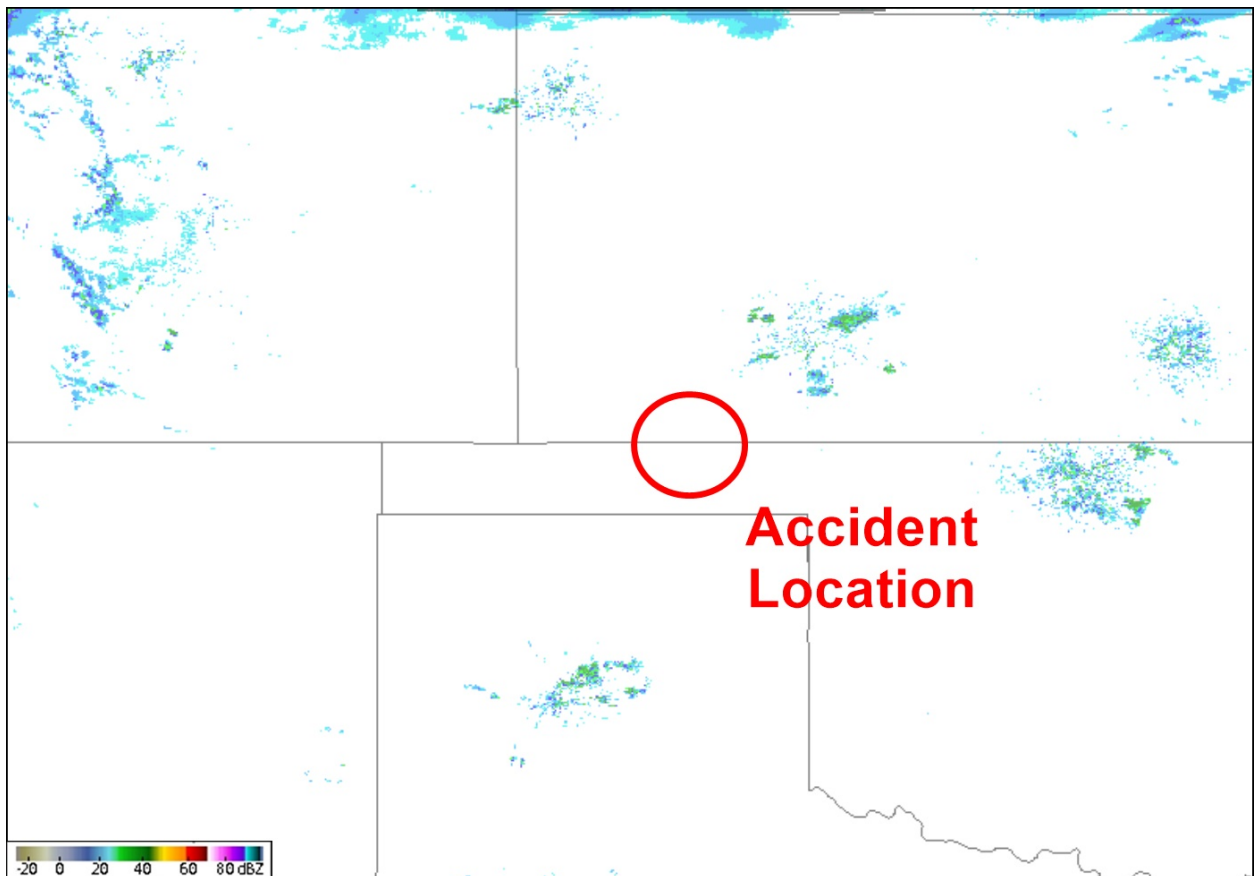


Figure 2 – NCEI WSR-88D mosaic from 1655 CST.

2.0 Surface Observations

An Automated Weather Observing System (AWOS) was located at Liberal Mid-America Regional Airport (LBL)² in Liberal, Kansas, and was located about 3 miles north of the accident location at an elevation of 2,885 feet. Automated reports from LBL during the times surrounding the accident time are presented here. LBL was the accident aircraft's final destination airport on the accident flight.

[1456 CST] METAR KLBL 172056Z AUTO 02015KT 10SM OVC010 M01/M03 A3020
RMK AO2 PK WND 02027/2023 SLP246 T10061028 55003 FZRANO=
[1556 CST] METAR KLBL 172156Z AUTO 02018G24KT 10SM OVC010 M02/M03
A3021 RMK AO2 SLP248 T10171033 FZRANO=
[1606 CST] SPECI KLBL 172206Z AUTO 02015KT 8SM OVC008 M02/M03 A3021
RMK AO2 FZRANO=
[1656 CST] METAR KLBL 172256Z AUTO 03015KT 7SM OVC006 M02/M04
A3023 RMK AO2 UPB44E50SNB12E44 SLP254 P0000 T10221039
FZRANO=
[1756 CST] METAR KLBL 172356Z AUTO 03017G22KT 7SM UP OVC006 M03/M04
A3024 RMK AO2 UPB11E19B40SNB01E11B31E40 SLP259 P0000 60000
T10281039 11006 21028 53011 FZRANO=

At 1606 CST, LBL reported a wind from 020° at 15 knots, visibility of 8 statute miles, ceiling overcast at 800 feet above ground level (agl), temperature of -2° Celsius (C) and a dew point temperature of -3°C, altimeter setting of 30.21 inches of mercury; remarks: automated station with a precipitation discriminator, freezing rain information not available.

At 1656 CST, LBL reported a wind from 030° at 15 knots, visibility of 7 statute miles, ceiling overcast at 600 feet agl, temperature of -2°C and a dew point temperature of -4°C, altimeter setting of 30.23 inches of mercury; remarks: automated station with a precipitation discriminator, unknown precipitation began at 1644 CST and ended at 1650 CST and snow began at 1612 CST and ended at 1644 CST, sea level pressure of 1025.4 hPa, trace amount of liquid equivalent precipitation since 1556 CST, temperature of -2.2°C and dew point temperature of -3.9°C, freezing rain information not available.

An Automated Surface Observing System (ASOS) was located at Dodge City Regional Airport (DDC) in Dodge City, Kansas, and was located about 67 miles northeast of the accident location at an elevation of 2,595 feet. Automated reports from DDC during the times surrounding the accident time are presented here. DDC was the accident aircraft's initial destination airport on the accident flight.

² The NWS uses the 4-digit International Civil Aviation Organization (ICAO) format for station identifiers (as seen in the body of some formatted weather observations). This report uses the 3-digit International Air Transport Association format for station identification, which does not use the geographic designating digit ("K" for stations in the continental U.S. and "P" for U.S. stations in Alaska and the Pacific region) as found in the ICAO format.

[1252 CST] METAR KDDC 171852Z AUTO 01018G29KT 9SM OVC006 M01/M04
A3020 RMK AO2 PK WND 02031/1834 SLP236 T10111039 \$=

[1352 CST] METAR KDDC 171952Z AUTO 01021G28KT 9SM OVC006 M02/M04
A3018 RMK AO2 PK WND 01032/1912 SLP235 T10171044 \$=

**[1452 CST] METAR KDDC 172052Z AUTO 01016G27KT 9SM OVC005 M02/M04
A3020 RMK AO2 PK WND 02032/2005 SLP241 T10221044 55004 \$=**

**[1513 CST] SPECI KDDC 172113Z AUTO 02014G26KT 7SM OVC004 M03/M04
A3020 RMK AO2 PK WND 36030/2102 T10281044 \$=**

[1552 CST] METAR KDDC 172152Z AUTO 02016G25KT 8SM OVC005 M03/M05
A3021 RMK AO2 PK WND 36030/2102 SLP247 T10281050 \$=

[1652 CST] METAR KDDC 172252Z AUTO 03017G28KT 9SM OVC007 M03/M06
A3022 RMK AO2 PK WND 02031/2236 SLP253 T10281056 \$=

[1752 CST] METAR KDDC 172352Z AUTO 04013G24KT 10SM OVC009 M03/M06
A3024 RMK AO2 PK WND 04028/2337 SLP258 T10281056 11006 21028
52014 \$=

At 1452 CST, DDC reported a wind at from 010° at 16 knots with gusts to 27 knots, visibility of 9 statute miles, ceiling overcast at 500 feet agl, temperature of -2°C and a dew point temperature of -4°C, altimeter setting of 30.20 inches of mercury; remarks included: automated station with a precipitation discriminator, peak wind of 32 knots from 020° observed at 1405 CST, sea level pressure of 1025.4 hPa, temperature of -2.2°C and dew point temperature of -4.4°C, 3-hour pressure change of 0.4 hPa, maintenance needed on the system.

At 1513 CST, DDC reported a wind at from 020° at 14 knots with gusts to 26 knots, visibility of 7 statute miles, ceiling overcast at 400 feet agl, temperature of -3°C and a dew point temperature of -4°C, altimeter setting of 30.20 inches of mercury; remarks included: automated station with a precipitation discriminator, peak wind of 30 knots from 360° observed at 1502 CST, temperature of -2.8°C and dew point temperature of -4.4°C, maintenance needed on the system.

An AWOS was located at Sublette Municipal Airport (19S) in Sublette, Kansas, and was located about 31 miles north of the accident location at an elevation of 2,910 feet. Automated reports from 19S during the times surrounding the accident time are presented here.

[1435 CST] METAR K19S 172035Z AUTO 01020KT 10SM OVC009 M01/M03 A3021
RMK AO2 T10141032=

[1455 CST] METAR K19S 172055Z AUTO 01019G24KT 10SM OVC009 M02/M03
A3022 RMK AO2 T10161034=

[1515 CST] METAR K19S 172115Z AUTO 01021KT 10SM OVC009 M02/M03 A3022
RMK AO2 T10171032=

[1535 CST] METAR K19S 172135Z AUTO 02019G26KT 7SM OVC007 M02/M03
A3023 RMK AO2 T10201031=

[1555 CST] METAR K19S 172155Z AUTO 03017KT 4SM BR OVC007 M02/M03
A3023 RMK AO2 T10231031=

[1615 CST] METAR K19S 172215Z AUTO 03017KT 5SM BR OVC007 M02/M03
A3023 RMK AO2 T10221031=

[1635 CST] METAR K19S 172235Z AUTO 02019G25KT 7SM BR OVC007 M02/M03
A3024 RMK AO2 T10241035=

[1655 CST] METAR K19S 172255Z AUTO 03018KT 5SM BR OVC007 M02/M03
A3024 RMK AO2 T10241034=

[1715 CST] METAR K19S 172315Z AUTO 03017KT 5SM BR OVC007 M02/M03
A3024 RMK AO2 T10241034=

An ASOS was located at Guymon Municipal Airport (GUY) in Guymon, Oklahoma, and was located about 32 miles southwest of the accident location at an elevation of 3,125 feet. Automated reports from GUY during the times surrounding the accident time are presented here:

[1413 CST] SPECI KGUY 172013Z AUTO 01019G24KT 10SM OVC010 M01/M04
A3018 RMK AO2 T10061039=

[1453 CST] METAR KGUY 172053Z AUTO 02018G23KT 9SM OVC009 M01/M04
A3019 RMK AO2 SLP229 T10061039 55001=

[1513 CST] SPECI KGUY 172113Z AUTO 01015G23KT 10SM OVC010 M01/M04
A3019 RMK AO2 T10061039=

[1553 CST] METAR KGUY 172153Z AUTO 01017KT 10SM OVC011 M01/M04
A3019 RMK AO2 SLP231 T10111039=

[1645 CST] SPECI KGUY 172245Z AUTO 01014G22KT 5SM BR BKN009 OVC013
M02/M03 A3020 RMK AO2 CIG 006V011 T10171033=

[1653 CST] METAR KGUY 172253Z AUTO 02014G23KT 6SM BR OVC011
M02/M04 A3020 RMK AO2 SLP236 T10171039=

[1702 CST] SPECI KGUY 172302Z AUTO 02014G20KT 6SM BR OVC009 M02/M03
A3021 RMK AO2 CIG 006V013 T10171033=

An AWOS was located at Perryton Ochiltree County Airport (PYX) in Perryton, Texas, and was located about 36 miles south of the accident location at an elevation of 2,918 feet. Automated reports from PYX during the times surrounding the accident time are presented here:

[1435 CST] METAR KPYX 172035Z AUTO 36015G22KT 7SM OVC007 00/M01
A3016 RMK AO2 T00001012=

[1455 CST] METAR KPYX 172055Z AUTO 01019G23KT 7SM OVC007 00/M01
A3016 RMK AO2 T00001013=

[1515 CST] METAR KPYX 172115Z AUTO 01016G22KT 5SM OVC007 00/M01 A3016 RMK AO2 T00001014=

[1535 CST] METAR KPYX 172135Z AUTO 01017KT 4SM OVC007 00/M01 A3016 RMK AO2 T00001013=

[1555 CST] METAR KPYX 172155Z AUTO 02015G21KT 2SM OVC007 00/M01 A3016 RMK AO2 T00001012=

[1615 CST] METAR KPYX 172215Z AUTO 01017G22KT 2 1/2SM BKN007 OVC011 00/M01 A3017 RMK AO2 VIS 1 1/2V4 T00001012=

[1635 CST] METAR KPYX 172235Z AUTO 03012G19KT 2SM OVC009 00/M01 A3018 RMK AO2 T10021013=

[1655 CST] METAR KPYX 172255Z AUTO 02013G20KT 3SM OVC008 00/M01 A3018 RMK AO2 T10011012=

[1715 CST] METAR KPYX 172315Z AUTO 02015KT 3SM BKN006 OVC010 M01/M02 A3019 RMK AO2 T10061016=

An AWOS was located at Ulysses Airport (ULS) in Ulysses, Kansas, and was located about 42 miles north-northwest of the accident location at an elevation of 3,071 feet. Automated reports from ULS during the times surrounding the accident time are presented here:

[1435 CST] METAR KULS 172035Z AUTO 01017G25KT 10SM OVC012 M01/M03 A3020 RMK AO2=

[1455 CST] METAR KULS 172055Z AUTO 02019G25KT 10SM OVC012 M01/M03 A3020 RMK AO2=

[1515 CST] METAR KULS 172115Z AUTO 01018G22KT 10SM OVC012 M01/M03 A3021 RMK AO2=

[1535 CST] METAR KULS 172135Z AUTO 01018G22KT 10SM OVC010 M01/M03 A3021 RMK AO2=

[1555 CST] METAR KULS 172155Z AUTO 01015G21KT 10SM OVC010 M02/M03 A3022 RMK AO2=

[1615 CST] METAR KULS 172215Z AUTO 02014KT 10SM OVC008 M02/M03 A3022 RMK AO2=

[1635 CST] METAR KULS 172235Z AUTO 02017G21KT 10SM OVC008 M02/M03 A3022 RMK AO2=

[1655 CST] METAR KULS 172255Z AUTO 03013KT 10SM OVC008 M02/M03 A3023 RMK AO2=

[1715 CST] METAR KULS 172315Z AUTO 03012KT 10SM OVC008 M02/M03 A3023 RMK AO2=

An AWOS was located at Elkhart-Morton County Airport (EHA) in Elkhart, Kansas, and was located about 44 miles west of the accident location at an elevation of 3,621 feet. Automated reports from EHA during the times surrounding the accident time are presented here:

[1435 CST] METAR KEHA 172035Z AUTO 01017G20KT 4SM BR OVC007 00/M01 A3018 RMK AO2 T10031010=
[1444 CST] METAR KEHA 172055Z AUTO 01015KT 7SM OVC007 00/M01 A3018 RMK AO2 T10051011=
[1515 CST] METAR KEHA 172115Z AUTO 01016G23KT 7SM OVC009 00/M01 A3019 RMK AO2 T10041012=
[1535 CST] METAR KEHA 172135Z AUTO 02016KT 10SM OVC009 00/M02 A3020 RMK AO2 T10051016=
[1555 CST] METAR KEHA 172155Z AUTO 01016G21KT 10SM OVC009 M01/M02 A3019 RMK AO2 T10071018=
[1615 CST] METAR KEHA 172215Z AUTO 01015G19KT 10SM OVC009 M01/M02 A3019 RMK AO2 T10071018=
[1635 CST] METAR KEHA 172235Z AUTO 03014KT 7SM OVC007 M01/M01 A3019 RMK AO2 T10101015=
[1655 CST] METAR KEHA 172255Z AUTO 02016G21KT 7SM OVC007 M01/M02 A3020 RMK AO2 T10111017=
[1715 CST] METAR KEHA 172315Z AUTO 02016KT 7SM OVC005 M01/M02 A3020 RMK AO2 T10141016=

An AWOS was located at Stanton County Municipal Airport (JHN) in Johnson, Kansas, and was located about 52 miles northwest of the accident location at an elevation of 3,325 feet. Automated reports from JHN during the times surrounding the accident time are presented here:

[1435 CST] METAR KJHN 172035Z AUTO 36014KT 10SM OVC011 00/M04 A3021 RMK AO2 T10021045=
[1455 CST] METAR KJHN 172055Z AUTO 36017G21KT 10SM OVC011 00/M04 A3021 RMK AO2 T00001042=
[1515 CST] METAR KJHN 172115Z AUTO 36015G19KT 10SM OVC011 00/M04 A3022 RMK AO2 T10051042=
[1535 CST] METAR KJHN 172135Z AUTO 01015KT 10SM OVC011 00/M04 A3022 RMK AO2 T10051041=
[1555 CST] METAR KJHN 172155Z AUTO 36015G22KT 10SM OVC009 M01/M04 A3022 RMK AO2 T10081040=
[1615 CST] METAR KJHN 172215Z AUTO 01010KT 5SM HZ OVC009 M01/M04 A3023 RMK AO2 T10111037=

[1635 CST] METAR KJHN 172235Z AUTO 01011KT 4SM HZ OVC009 M01/M04 A3023 RMK AO2 T10121036=
 [1655 CST] METAR KJHN 172255Z AUTO 02014KT 7SM OVC009 M01/M04 A3023 RMK AO2 T10141037=
 [1715 CST] METAR KJHN 172315Z AUTO 02010KT 5SM BR OVC009 M01/M04 A3023 RMK AO2 T10151036=

A weather reporting station (KSPD) of unknown type was located at the Comanche National Grassland near Springfield, Colorado, and was located about 82 miles west-northwest of the accident location at an elevation of 4,380 feet. Automated reports from KSPD during the times surrounding the accident time are presented here:

[1456 CST] METAR KSPD 172056Z AUTO 01014KT M03/M04 A3017 RMK AO1 SLP229 T10281039 55006=
 [1556 CST] METAR KSPD 172156Z AUTO 02013KT M04/M04 A3017 RMK AO1 SLP231 T10391044=
 [1656 CST] METAR KSPD 172256Z AUTO 02014KT M04/M04 A3018 RMK AO1 SLP237 T10391044=
 [1756 CST] METAR KSPD 172356Z AUTO 03014KT M04/M05 A3020 RMK AO1 SLP242 T10441050 11011 21044 53007=

3.0 Pilot Reports

Some publicly disseminated pilot reports³ (PIREPs) made between about 1300 CST and the accident time within 150 statute miles of the accident location below 15,000 feet are presented here. There were numerous pilot reports of trace to moderate/severe icing between 3,000 and 7,300 feet, including several urgent reports. The final two pilot reports (aircraft type: BE58) are believed to have originated from the accident aircraft.

LBL UA /OV JHN/TM 1919/FL073/TP BE9L/SK 042 OVC 075/TA 0/IC LGT RIME /RM CONT LGT IC IN CLOUDS BASE 900AGL / ZKC FDC/AF

DDC UA /OV DDC17020/TM 1939/FL050/TP BE9L/TA M03/IC LGT RIME /RM / ZKC FDC/AF

GCK UA /OV KGCK/TM 1948/FL037/TP E135/SK OVC037/TA M03/TB NEG/IC LGT RIME 054-037/RM DURD RY35

DDC UUA /OV DDC/TM 1954/FL031/TP BE9L/TA 00/IC MOD-SEV RIME 040-031/RM ZKCFD

³ These do not include pilot reports only broadcast via radio.

DDC UA /OV DDC/TM 2020/FL060/TP BE9L/SK TOP060/IC MOD MXD 040-060/RM ZKCFD

LBL UA /OV LBL090030/TM 2100/FL060/TP SF50/TA M06/IC LGT RIME/RM ZKCFDC/OH

DHT UA /OV DHT310058/TM 2110/FL115/TP AEST/SK SKC/IC NEG/RM SOLID LAYER ABOUT 2-3 THOUSAND BELOW ZAB/FDCS

GCK UA /OV GCK240020/TM 2125/FL050/TP B350/SK OVC060/TA M06/IC TRACE RIME/RM ZKCFDC/OH

AMA UA /OV AMA2450140/TM 2152/FLDURD/TP CRJ7/TA M05/IC MOD RIME 070-045/RM ZAB/FDCS

LBL UA /OV LBL250025/TM 2241/FL060/TP BE58/TA M12/IC MOD RIME/RM ZKCFD

LBL UUA /OV LBL200010/TM 2242/FL051/TP BE58/TA M12/IC MOD-SEV RIME/RM ZKCFD

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR) model⁴ sounding (figure 3) for the accident site at 1700 CST was retrieved from the National Oceanic and Atmospheric Administration's Air Resources Laboratory. Near the surface, the wind was from the north-northeast at 15 knots and increased in magnitude to a north-northeast wind of 25 knots at about 4,100 feet. Above this level the wind decreased in magnitude to a northeast wind of 12 knots at about 6,900 feet. Above 6,900 feet the wind backed significantly to a west wind of 15 knots at about 10,000 feet.

Temperature inversions were noted between about 7,700 feet and 10,000 feet and between about 5,300 feet and 6,900 feet. The entire atmosphere below 500 hPa was below freezing except for a layer between about 8,400 feet and 11,000 feet. The relative humidity was greater than 95 percent between about 3,500 feet and 7,00 feet.

Calculations made by the Rawinsonde Observation Program (RAOB) indicated the potential for light clear icing between about 3,100 feet and 3,500 feet and the potential for moderate clear icing between about 3,500 feet and 4,400 feet. Between about 4,400 feet and 6,900 feet RAOB indicated the potential for light rime icing. RAOB identified a shallow layer of potential moderate low level wind shear near the surface. RAOB also identified the potential for severe clear air turbulence between about 6,000 and 6,800 feet.

⁴ 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.

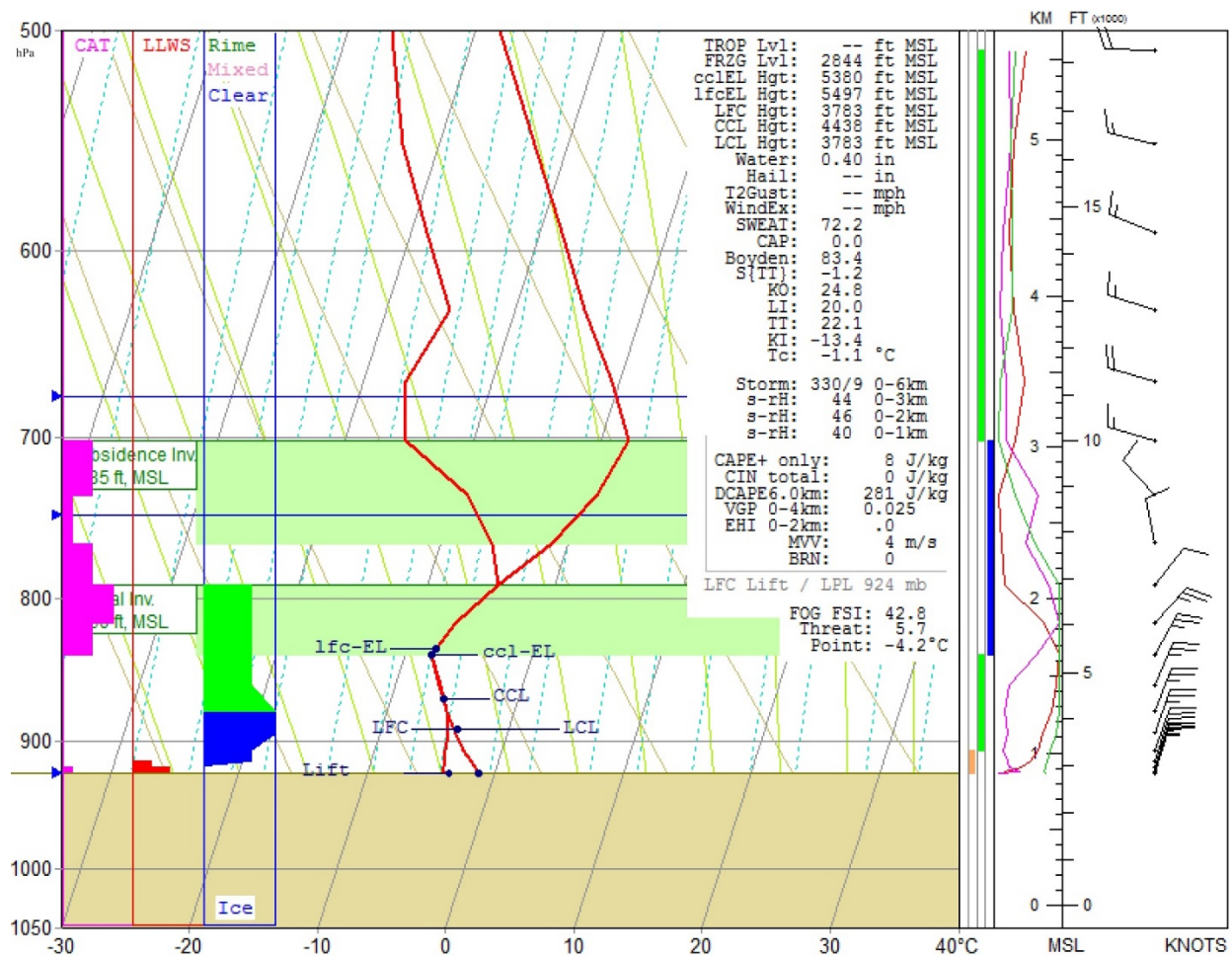


Figure 3 – HRRR model sounding data in SkewT/LogP format for 1700 CST at the accident site, surface to 500 hPa.

5.0 Satellite Imagery

Geostationary Operational Environmental Satellite (GOES)-16 visible ($0.64\mu\text{m}$) and infrared ($10.3\mu\text{m}$) data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison. Imagery from 1655 CST are presented in figures 4 and 5. The GOES-16 visible imagery depicted cloudy conditions across the region. Infrared cloud-top temperatures were about -5°C over the accident location at the accident time. Considering the HRRR sounding temperature and moisture profiles, this cloud top temperature likely corresponded to cloud top heights of about 6,600 feet.

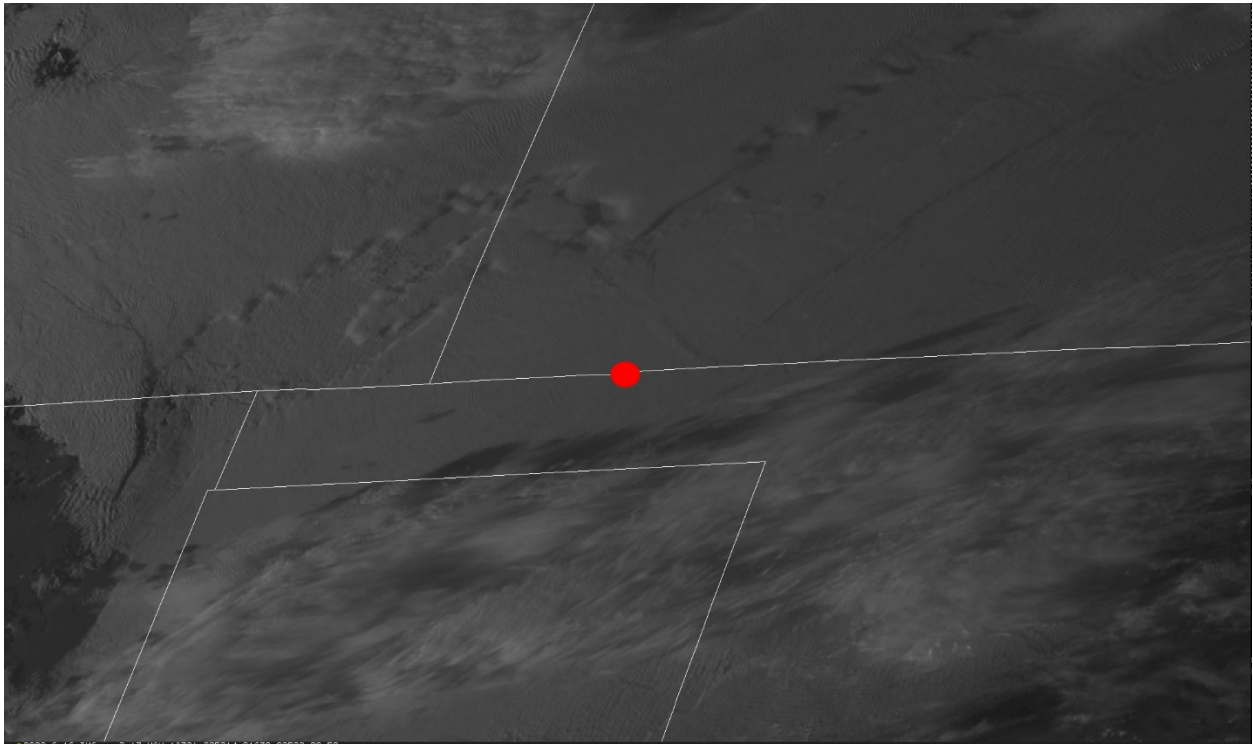


Figure 4 – GOES-16 visible imagery from 1655 CST. Accident location denoted by red dot. This image has not been corrected for any parallax error.

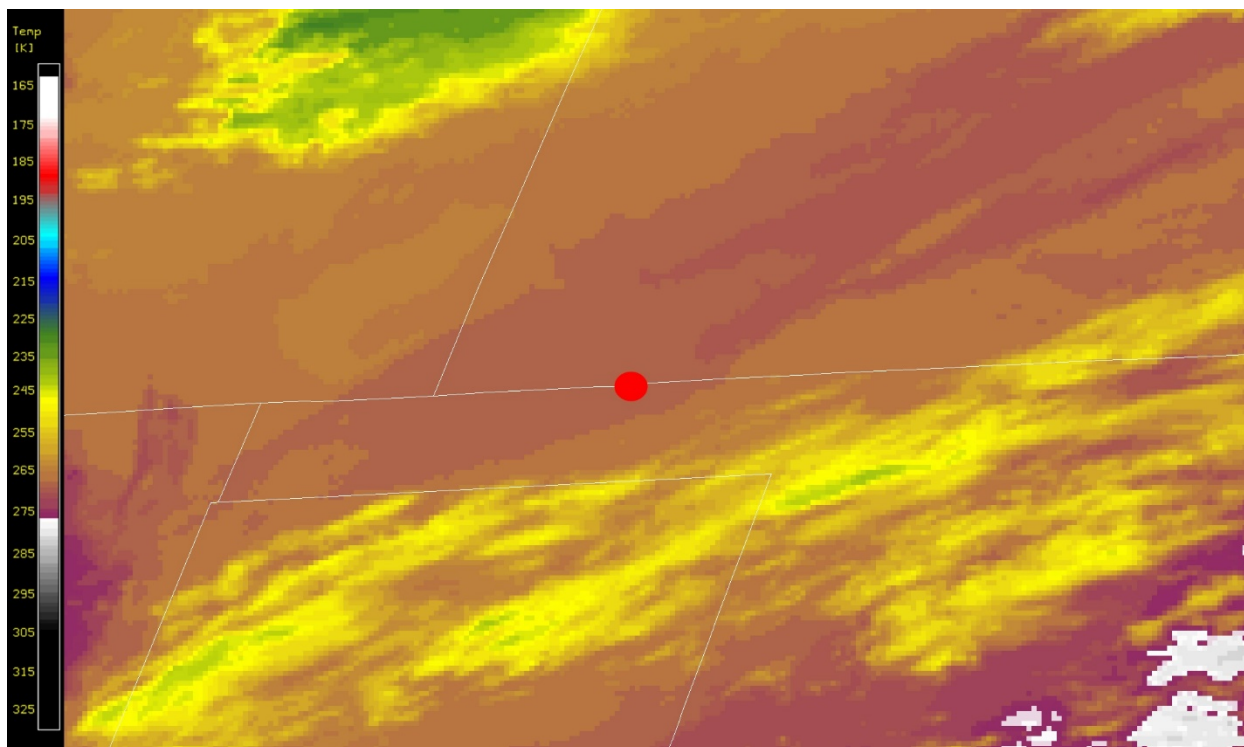


Figure 5 – GOES-16 infrared imagery (brightness temperature in degrees Kelvin) from 1655 CST. Accident location denoted by red dot. This image has not been corrected for any parallax error.

Attachment 1 presents satellite cloud retrievals and icing analysis performed by the National Aeronautics and Space Administration’s (NASA) Langley Research Center (LaRC)⁵ using GOES satellite data for 1245 and 1445 CST. Because the retrievals are complicated by low-light (e.g., sunset) conditions, and because the low-level cloud field and properties appeared fairly static during the period, the analysis was focused on a timeframe prior to the accident time when the retrievals were more reliable. Phase and droplet size are both most representative of cloud top, while optical depth and liquid water path represent the vertical column.

6.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) are intended to provide the necessary aviation weather information to give users a complete picture of the weather that might impact flight in the continental United States. Hourly model data and forecasts, including information on clouds, flight category, precipitation, icing, turbulence, wind, and other output from the NWS are available, however only certain imagery are archived by the NWS.

⁵ Courtesy of Dr. William Smith Jr.

The following images (figures 6-9) depict GFA forecast information on sky condition, icing, mountain obscuration, instrument flight rule (IFR)⁶ condition and surface wind Airmen's Meteorological Information (AIRMET) advisories, surface visibility, surface wind, precipitation, and other obscurations and hazards, valid for the times surrounding the accident.

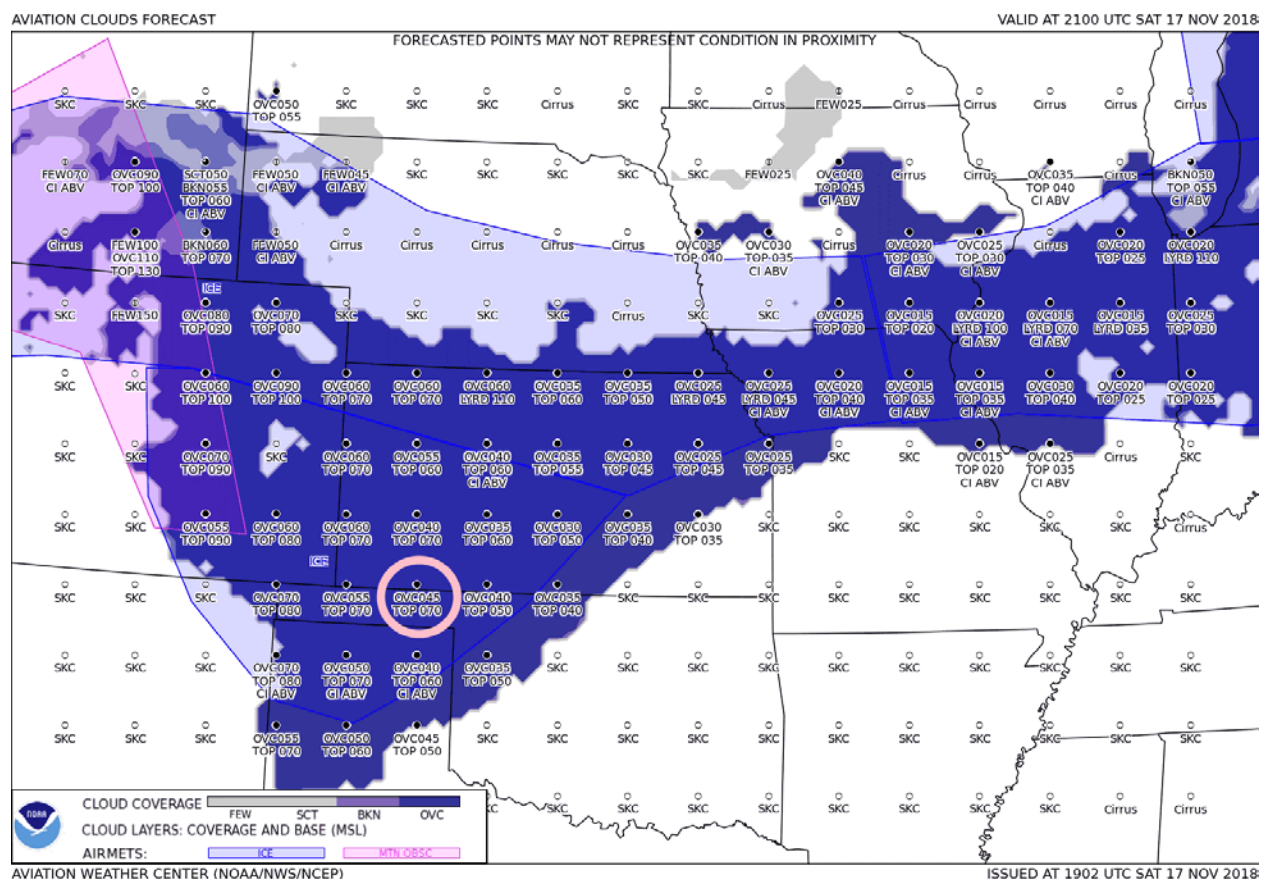


Figure 6 – GFA forecast imagery depicting sky condition and icing and mountain obscuration AIRMETs. Issued about 1300 CST and valid for 1500 CST. This GFA forecast imagery depicted overcast sky conditions over the accident region with cloud tops at 7,000 feet and cloud bases at 4,500 feet noted near the accident site. An AIRMET for icing was active over the accident site. The accident location is within the pink circle.

⁶ IFR conditions - Ceilings less than 1,000 feet agl and/or visibility less than three statute miles.

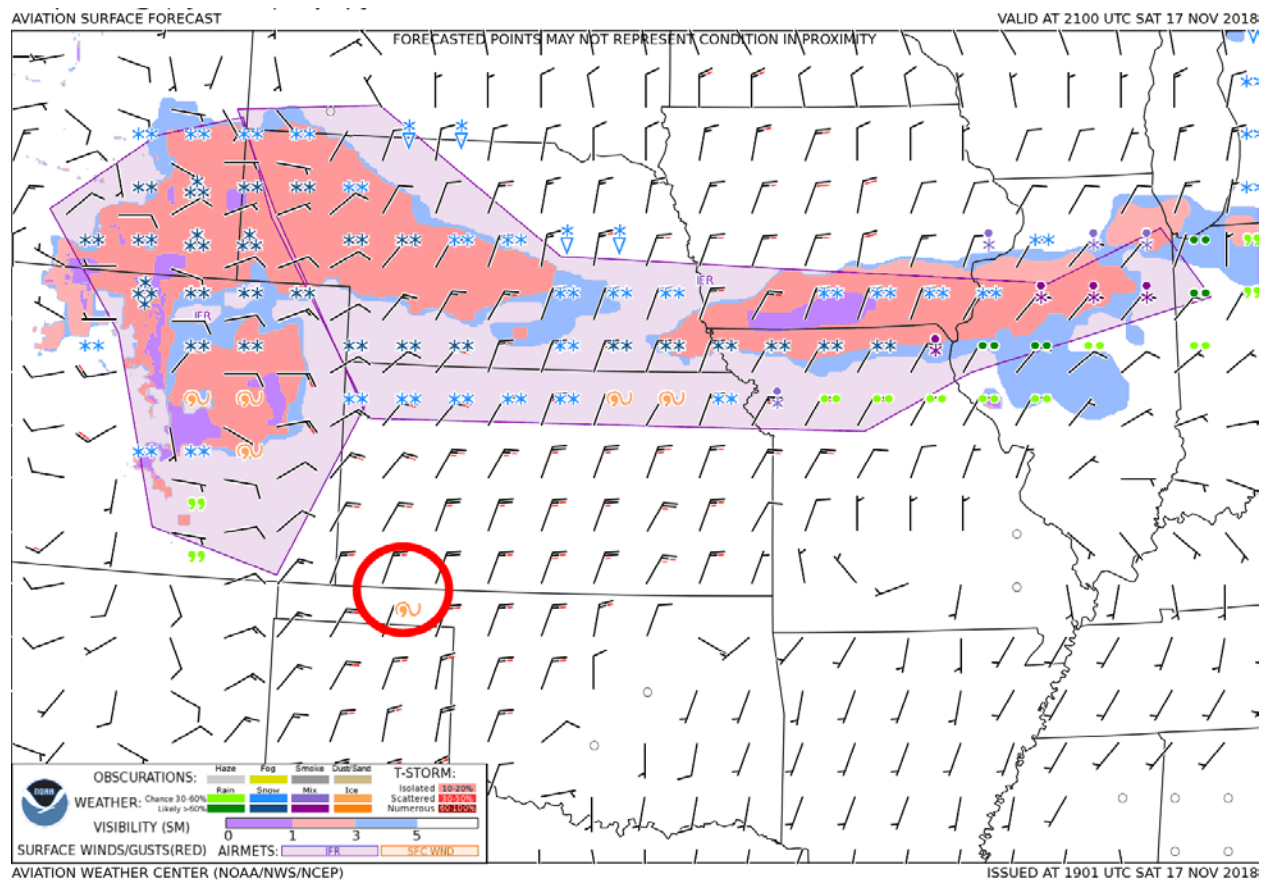


Figure 7 – GFA forecast imagery depicting IFR conditions and surface wind AIRMETs, surface visibility, surface wind, precipitation, and other obscurations and hazards. Issued about 1300 CST and valid for 1500 CST. This GFA forecast imagery depicted a surface visibility of greater than 5 statute miles, a northerly surface wind of 20 knots and light freezing drizzle near the accident location. The accident location is within the red circle.

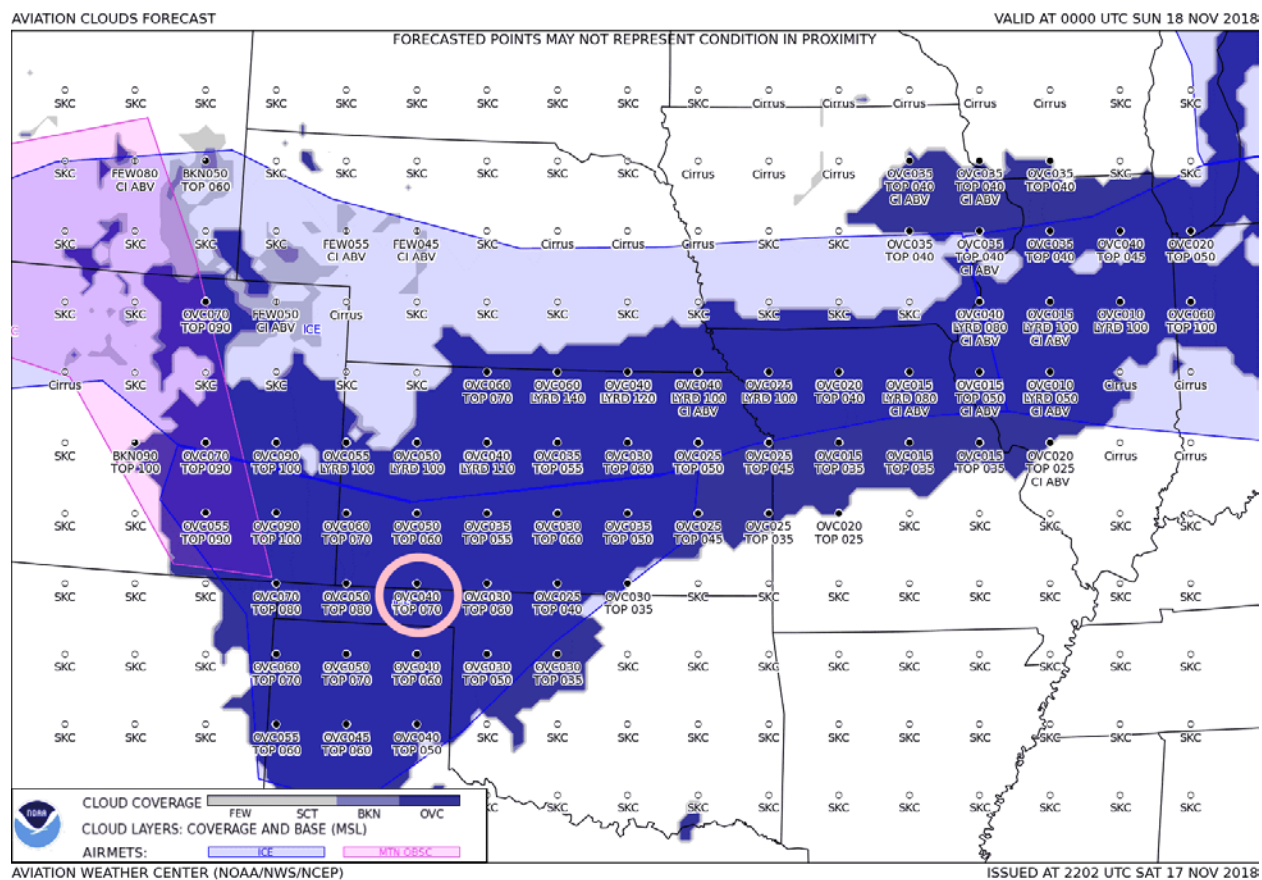


Figure 8 – GFA forecast imagery depicting sky condition and icing and mountain obscuration AIRMETS. Issued about 1600 CST and valid for 1800 CST. This GFA forecast imagery depicted overcast sky conditions over the accident region with cloud tops at 7,000 feet and cloud bases at 4,000 feet noted near the accident site. An AIRMET for icing was active over the accident site. The accident location is within the pink circle.

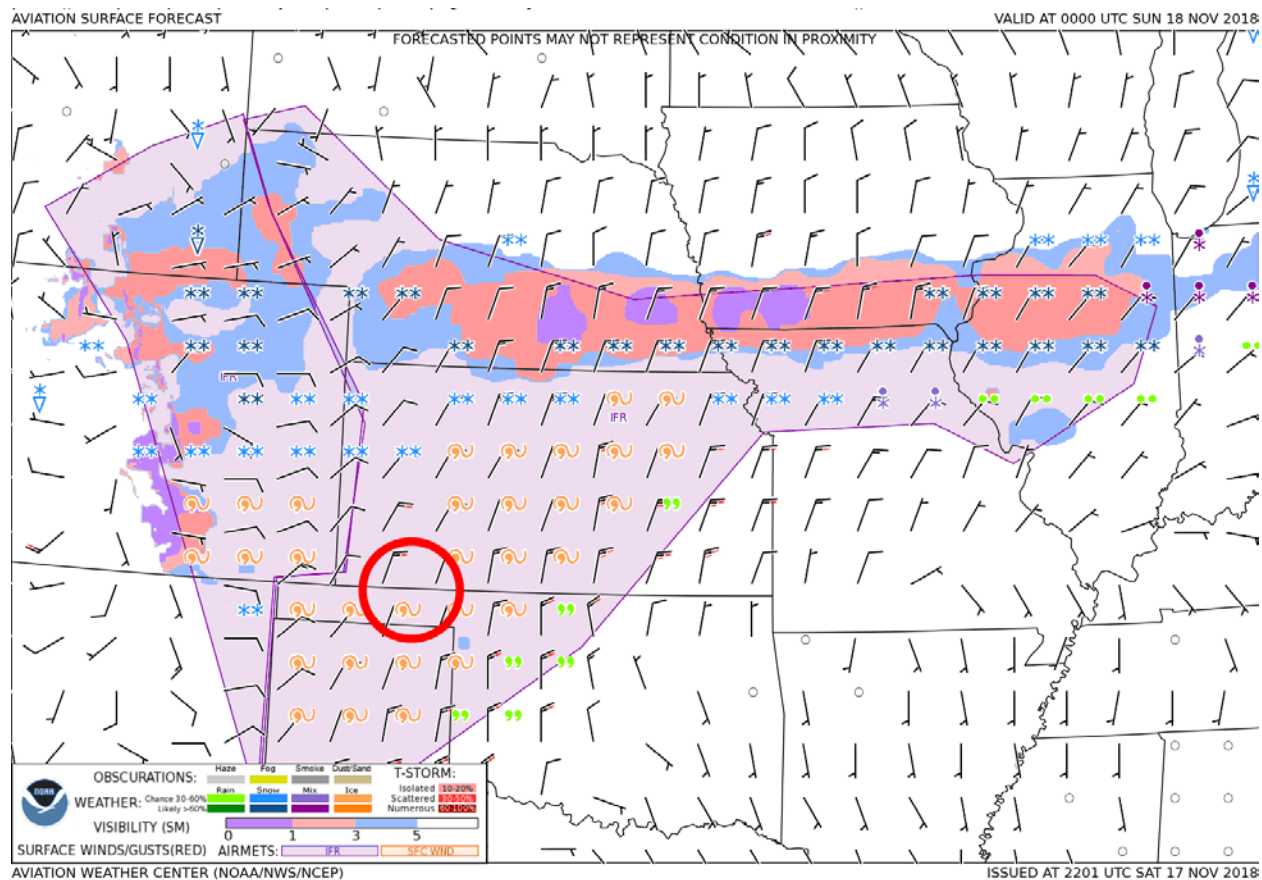


Figure 9 – GFA forecast imagery depicting IFR conditions and surface wind AIRMETs, surface visibility, surface wind, precipitation, and other obscurations and hazards. Issued about 1600 CST and valid for 1800 CST. This GFA forecast imagery depicted a surface visibility of greater than 5 statute miles, nearby northerly surface wind gusts of 20 knots and light freezing drizzle near the accident location. An AIRMET for IFR conditions was active over the accident region. The accident location is within the red circle.

7.0 Area Forecast Discussion

The accident site was located within one mile of the border of the County Warning Areas for the NWS Weather Forecast Office (WFO) in Amarillo, Texas, and the NWS WFO in Dodge City, Kansas.

An Area Forecast Discussion (AFD) was issued at 1529 CST by the NWS WFO in Amarillo, Texas. This AFD did not contain an “Aviation” section. Presented here is the “Short Term” section of that AFD. The Short Term section conveyed an expectation for patchy freezing drizzle across the Oklahoma and Texas panhandles.

FXUS64 KAMA 172129
AFDAMA

Area Forecast Discussion
National Weather Service Amarillo TX
329 PM CST Sat Nov 17 2018

.SHORT TERM...Tonight through Sunday...

Breezy north winds from this mornings cold front will continue through the evening across the Panhandles, but will diminish by later tonight. Winds will still remain out of the north thereafter, they will just be lighter. Saturated layer near the surface about 3000-5000ft thick will result in patchy freezing drizzle across the Panhandles. Right now it looks too sparse to pinpoint any specific area that might be more favored than others, and therefore no winter weather highlights will be issued. It looks like mainly elevated surfaces and bridges will be the most prone areas to get a thin ice coating, if at all. Later tonight the temperatures should be cold enough aloft to get some dendrite growth and thus have shifted to a patchy freezing drizzle with isolated flurries.

With the shallow cold layer in place tonight the conditions are favorable for industrial enhanced snowfall from power plants. If the power plants are running we might see some light accumulations in the Pampa, Borger, Eastern Amarillo areas.

Clouds will begin to break up Sunday morning and sunny skies will take over by afternoon. Cold airmass will still be in place, but winds will be light, so may not feel too cold, at least compared to todays mid 20s wind chills, if in direct sunlight. Highs are expected to be in the lower 40s on Sunday.

An AFD was issued at 1109 CST by the NWS WFO in Dodge City, Kansas. This was the latest AFD issued by this WFO to contain an updated "Aviation" section at the accident time. Presented here is the Aviation section of that AFD, which conveyed the potential for patchy and very light freezing drizzle around the accident time east of Dodge City, Kansas.

Area Forecast Discussion
National Weather Service Dodge City KS
147 PM CST Sat Nov 17 2018

.AVIATION...(For the 18Z TAFS through 18Z Sunday afternoon)
Issued at 1109 AM CST Sat Nov 17 2018

Gusty northeast winds at around 20 knots at 18z will gradually subside late today and early this evening as an area of high pressure at the surface builds into western Kansas. Wind speeds are expected to fall back to less than 10 knots between 06z and 09z Sunday. BUFR Model soundings indicating the IFR ceilings at 18z will improve into the MVFR category at all four TAF sites between 21z Saturday and 00z Sunday. There is a chance for some patchy very light freezing drizzle or snow between 21z Saturday to 03z Sunday along and east of a Hays to Dodge City line. At this time give the low probability that any of this very light precip will occur at any TAF site will not include mention of this very light precipitation in the 18z TAFS. If however some of this very light freezing drizzle does develop at either HAYS or Dodge City late today and/or early this evening then little if any accumulation is expected.

8.0 Terminal Aerodrome Forecasts

The Terminal Aerodrome Forecast (TAF) issued at 1123 CST for DDC, which was the accident aircraft's initial destination airport, forecasted from 1200 CST until 1700 CST: a wind from 020° at 21 knots with gusts to 29 knots, visibility greater than 6 statute miles, ceiling overcast at 600 feet agl. The TAF forecasted from 1700 CST to 0300 CST on the following day: a wind from 020° at 15 knots, visibility greater than 6 statute miles, ceiling overcast at 1,200 feet agl.

TAF KDDC 171723Z 1718/1818 02021G29KT P6SM OVC006
FM172300 02015KT P6SM OVC012
FM180900 01009KT P6SM BKN020
FM181600 35007KT P6SM BKN050=

The TAF issued at 1509 CST for DDC forecasted from 1500 CDT until 1700 CST: a wind from 010° at 16 knots with gusts to 27 knots, visibility greater than 6 statute miles, ceiling overcast at 500 feet agl. The TAF forecasted from 1700 CST to 0300 CST on the following day: a wind from 020° at 15 knots, visibility greater than 6 statute miles, ceiling overcast at 900 feet agl.

KDDC 172109Z 1721/1818 01016G27KT P6SM OVC005
FM172300 02015KT P6SM OVC009
FM180900 01009KT P6SM BKN020
FM181600 35007KT P6SM BKN050=

The TAF issued at 1123 CST for LBL, which was the accident aircraft's final destination airport on its accident flight, forecasted from the time of issuance until 1700 CST: a wind from 360° at 18 knots with gusts to 24 knots, visibility greater than 6 statute miles, ceiling overcast at 1,200 feet agl. The TAF forecasted from 1700 CST to 1900 CST: a wind from 020° at 15 knots, visibility greater than 6 statute miles, ceiling overcast at 800 feet agl.

TAF KLBL 171723Z 1718/1818 36018G24KT P6SM OVC012
FM172300 02015KT P6SM OVC008
FM180100 03012KT P6SM OVC020
FM181300 35008KT P6SM BKN030=

9.0 AIRMETs

AIRMET ZULU advisories for moderate ice below 10,000 feet were issued by the NWS' Aviation Weather Center (AWC) at 1445 CST and applicable for the accident aircraft's route of flight and airspace over DDC, LBL and the accident location (see figure 10).

WAUS45 KPCI 172045
WA5Z
-SLCZ WA 172045

AIRMET ZULU UPDT 4 FOR ICE AND FRZLVL VALID UNTIL 180300

.
AIRMET ICE...CO NM
FROM 50SE DBL TO 40E LAA TO 50W LBL TO 30ESE TBE TO 70SSW TXO TO
40NE CME TO 50SE DBL
MOD ICE BLW 100. CONDS CONTG BYD 03Z THRU 09Z.

WAUS44 KPCI 172045

WA4Z

-DFWZ WA 172045

AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 180300

.
AIRMET ICE...OK TX NE KS
FROM GLD TO 30SSW SLN TO 40WNW BUM TO 30NW OSW TO 20ENE END TO
30ESE CDS TO 20SW LBB TO 70SSW TXO TO 30ESE TBE TO 50W LBL TO GLD
MOD ICE BLW 100. CONDS CONTG BYD 03Z THRU 09Z.

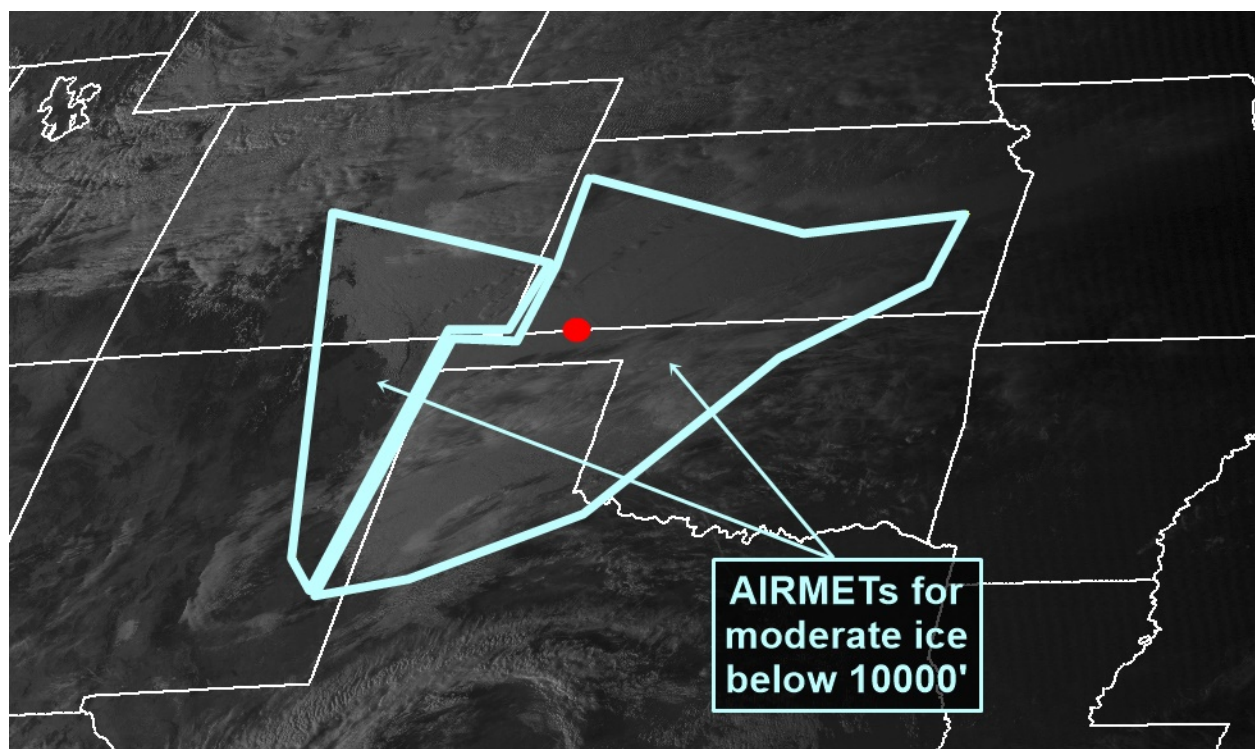


Figure 10 – AIRMETs for moderate ice below 10,000 feet issued by the AWC, overlaid on a GOES-16 visible image. The accident location is denoted by the red circle.

At 1445 CST, the AWC issued an AIRMET SIERRA for IFR conditions that was active for the accident location at the accident time.

WAUS43 KPCI 172045

WA3S

-CHIS WA 172045

AIRMET SIERRA UPDT 6 FOR IFR VALID UNTIL 180300

.

AIRMET IFR...SD NE KS IA MO LM MI IL IN OK TX

FROM 50WNW RAP TO OBH TO DXO TO FWA TO 40WSW ROD TO 60S AXC
TO 20NNW FAM TO 40ESE OSW TO 70WSW LBB TO 30ESE TBE TO 50W LBL
TO GLD TO BFF TO 70SW RAP TO 50WNW RAP

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

At 1445 CST, the AWC also issued an AIRMET SIERRA for IFR conditions and mountain obscuration active for the aircrafts rout of flight over Colorado.

WAUS45 KPCI 172045

WA5S

-SLCS WA 172045

AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 180300

.

AIRMET IFR...WY CO NM

FROM 60WNW RAP TO 70SW RAP TO BFF TO GLD TO 50W LBL TO 30ESE TBE
TO 70WSW LBB TO 20S FTI TO 20SE DBL TO 30NW CHE TO 50WSW BOY TO
CZI TO 60WNW RAP

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

.

AIRMET MTN OBSCN...ID WY NV UT CO AZ NM

FROM CZI TO 20E DDY TO CYS TO TBE TO 60NW CME TO 20W CIM TO 60E
HBU TO 50N JNC TO DTA TO 70ESE BAM TO 70ENE BAM TO 30NNW BVL TO
60SW BPI TO BPI TO CZI

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

10.0 SIGMETs

There were no convective or non-convective Significant Meteorological Information (SIGMET) advisories active for the accident aircraft's route of flight and the accident location.

11.0 Current Icing Potential/Forecast Icing Potential

Images presenting output from the Current Icing Potential (CIP) and Forecast Icing Potential (FIP) products valid for 1600 and 1700 CST for between 3,000 and 7,000 feet for the accident region were provided by the National Center for Atmospheric Research (NCAR).⁷ These images are presented in Attachment 2.

⁷ Courtesy of Mr. Daniel Adriaansen and Ms. Allyson Rugg, NCAR.

The CIP and FIP imagery provide information on expected icing severity as five categories: none, trace, light, moderate, and heavy. The severity estimations are roughly based on the accretion rate of ice on an airplane, and the levels are determined by the time it would take for an airfoil to accrete 1/4 of an inch of ice: trace = 1 hour; light = 15 minutes to 1 hour; moderate = 5 to 15 minutes; severe = less than 5 minutes. The rates are estimated from the amount of supercooled liquid water expected with a nominal drop diameter of 15 microns, and are further tuned by nearby pilot reports of encountered severity. These are relative values and the use of which should take into account the airframe and the level of icing protection provided by the aircraft. Different aircraft and different flight configurations (airspeed, angle of attack, etc.) will experience variations in accretion rate, and these rates have been simulated for a range of aircraft and are a "broad brush" approach to severity prediction.

The images presented in this report were generated using NCAR's graphics software and were not the publicly available images of the same fields accessible through the AWC on the accident day. For the FIP imagery, the NCAR graphics should present the same data as the FIP graphics that were publicly available via the AWC. For the CIP imagery, according to NCAR, "...there are small differences that can exist between observational data sources, and dataset availability. What's run at AWC is realtime- when CIP runs it uses the data available at that instant. If some data come in late, or a satellite image is slightly behind then CIP won't use it. When we run it [at NCAR] by hand after the fact, it's in 'research mode' so there's no possibility of late data. The datastreams also differ slightly at the AWC vs. what we use here but it's by and large the same data...[we are] more confident our [CIP and FIP] answers would be indistinguishable when plotted using the same software, with perhaps minor differences on occasion with CIP due to the dataset issue."

12.0 CWSU

There were no Center Weather Advisories or Meteorological Impact Statements issued by the Center Weather Service Units (CWSU) at the Denver, Kansas City or Albuquerque Air Route Traffic Control Centers that were active for the accident aircraft's route of flight and the accident location.

An interview was conducted with the Kansas City CWSU meteorologist on duty at the time of the accident. The record of that conversation is presented in Attachment 3. According to the meteorologist, the ZKC CWSU creates "red/green graphics" that indicate whether PIREP solicitation is required for certain airports under ZKC airspace according to the "five-and-five rule" (visibility at or below five statute miles and/or ceilings at or below 5,000 feet agl), moderate or greater turbulence and light or greater icing.⁸ There are six individual graphics made every 20 minutes, one for each ZKC controller area and displayed via the web on monitors within each area. For further information see Attachment 3. Figure 11 presents an exemplar image of this graphic for the ZKC "Prairie" controller area for a time unrelated to the accident, which indicates PIREPs are not required to be solicited for the 7 airports listed or for icing ("green" colors), however PIREPs are required to be solicited for both "high" and "low" turbulence ("red" colors).

⁸ See Federal Aviation Administration Order JO 7110.65X (with Change 1 and Change 2), section 2-6-2: https://www.faa.gov/documentLibrary/media/Order/7110.65X_ATC_w_chg_1_and_chg_2.pdf

PIREP FORM-PRAIRIE					NO	YES	PIREPs Required?	
SLN	MHK	GBD	GUY	DDC	ICG	TURB HI	TURB LO	
GCK	HYS	LBL	WWR		FRZG LVL 070-090			

19/2240z

Figure 11 – Exemplar image of the ZKC PIREP solicitation graphic for the Prairie controller area.

The ZKC CWSU provided the following logs which indicated that between 1500:03 and 1700:02 CST, the PIREP solicitation graphic for the ZKC Prairie controller area indicated that PIREP solicitation was required for icing and for all airports listed in Figure 11.

11-17-2018 20:04:15 / Trails(IRK TOP EMP ICG) Rivers(UIN SPI ICG)
 Prairie(SLN MHK GBD GUY DDC GCK HYS LBL WWR ICG) Ozark(ICG) Gateway(1H2 ICG) Flint Hills(WDG ICG)

11-17-2018 21:00:03 / Trails(IRK SZL TOP EMP ICG) Rivers(UIN SPI ICG)
 Prairie(SLN MHK GBD GUY DDC GCK HYS LBL WWR ICG) Ozark(ICG) Gateway(1H2 ICG) Flint Hills(WDG ICG)

11-17-2018 23:00:03 / Trails(IRK SZL TOP EMP ICG) Rivers(UIN SPI ICG)
 Prairie(SLN MHK GBD GUY DDC GCK HYS LBL WWR ICG) Ozark(ICG) Gateway(1H2 ICG) Flint Hills(PNC WDG ICG)

13.0 Astronomical Data

Astronomical data obtained from the United States Naval Observatory for 36° 59' north latitude and 100° 57' west longitude indicated that moonrise occurred at 1450 CST, sunset occurred at 1733 CST and end of civil twilight occurred at 1801 CST.

14.0 Weather Briefing

According to Leidos, “Leidos flight Services and any third party vendor that utilizes the LFS system had no contact with N4817M on 11/17/2018.”

See the NTSB’s accident docket for emails from ForeFlight that speak to communication with ForeFlight services from the accident pilot.

E. Attachments

- Attachment 1. Satellite cloud retrievals and icing analysis performed by the NASA's LaRC using GOES satellite data for 1245 and 1445 CST.
- Attachment 2. Images presenting output from the Current Icing Potential and Forecast Icing Potential products valid for 1600 and 1700 CST for between 3,000 and 7,000 feet for the accident region.
- Attachment 3. Record of Conversation with the Kansas City CWSU meteorologist on duty at the time of the accident.

Submitted by:

Mike Richards
Senior Meteorologist

THIS PAGE INTENTIONALLY BLANK