



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

March 11, 2019

Weather Study

METEOROLOGY

CEN19LA049

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A. ACCIDENT

Location: Sioux Falls, South Dakota
Date: December 25, 2018
Time: 1703 central standard time (CST)
2303 Universal Coordinated Time (UTC)
Airplane: Beech BE58; Registration: N6745V

B. METEOROLOGIST

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C. SUMMARY

On December 25, 2018, about 1703 central standard time, a Beech BE58, N6745V, owned by a private individual impacted terrain in a residential area 3 miles south of the Sioux Falls Regional Airport (FSD), Sioux Falls, South Dakota. A post impact fire ensued. The pilot and passenger on board were fatally injured and the airplane was destroyed. The airplane was operated by the pilot as a 14 *Code of Federal Regulations* Part 91 personal flight. Instrument meteorological conditions prevailed and an instrument flight rules flight plan was filed for the cross-country flight that originated at Grand Rapids, Michigan, and was destined for Tea, South Dakota.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's 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 central standard time (CST) based upon the 24-hour clock, local time is -6 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was estimated at latitude 43.501944° N and longitude -96.700833° W.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

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) located in College Park, 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.

1.1 Surface Analysis Chart

The northcentral section of the NWS Surface Analysis Chart for 1800 CST is included in figure 1 with the approximate accident site marked by a red star and the departure airport by a yellow star. The chart depicted a low-pressure system at 1025-hectopascal (hPa) over Lake Superior with a cold front extending southwestward across Wisconsin, southern Minnesota. An east-to-west oriented stationary front was located extending from extreme southern Michigan, Wisconsin, into Iowa where another low-pressure system was located at 1024-hPa, with the stationary front continuing into northern Nebraska into Wyoming. The accident site was located on the cold air side of the fronts and was north of the stationary front and west of the cold front. A high-pressure system at 1035-hPa was located to the north over southern Manitoba, Canada with a ridge of high pressure extending southward into the eastern Dakota's.

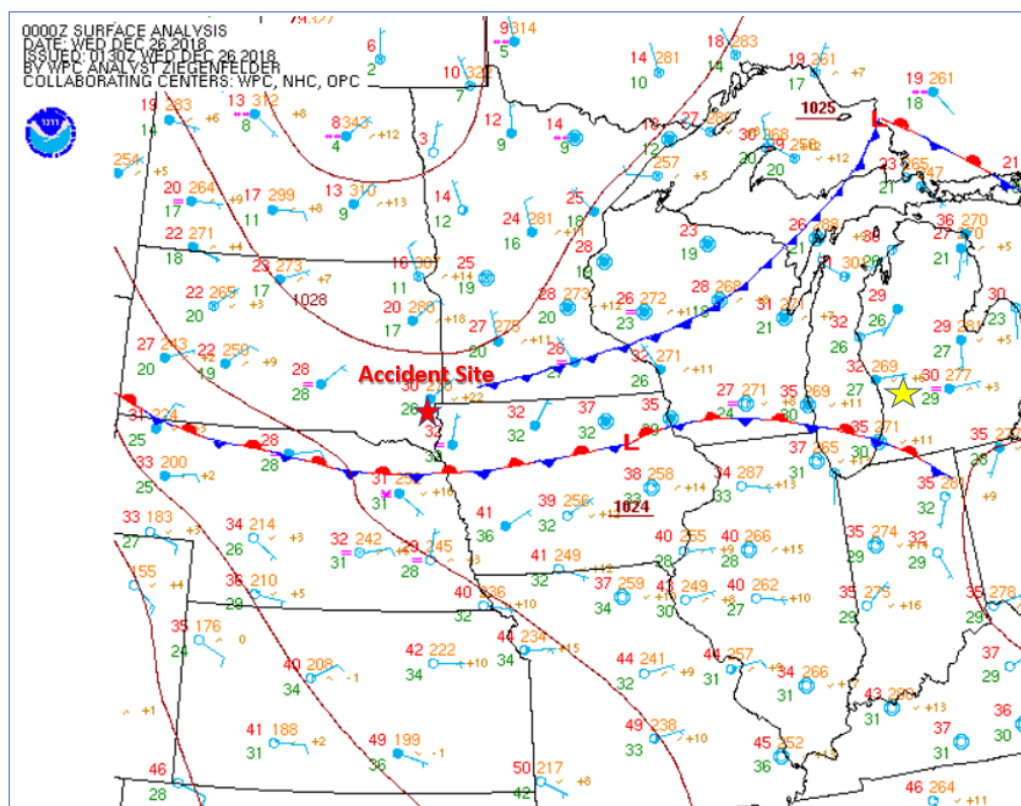


Figure 1 - Northcentral section of the Surface Analysis Chart for 1800 CST

The station models in the immediate vicinity of the accident site indicated winds from the northeast at 10 knots or less, overcast clouds, a temperature of 30° Fahrenheit (F), with a dew point of 26° F. Multiple stations surrounding the area reported visibility restricted in mist.

1.2 National Composite Radar Mosaic

A review of the NWS archive National Composite Radar Mosaic for 1700 CST depicted no meteorological echoes associated with precipitation in the vicinity of the flight track and accident site over South Dakota.

1.3 12-hour Surface Prognostic Chart

Figure 2 is the NWS 12-hour Surface Prognostic Chart depicting the primary pressure systems, fronts, and precipitation expected for the 12-hour period ending at midnight local (2400 CST). The chart depicted the low-pressure system over Lake Superior as having moved southeastward over Lake Huron with the cold front extending southwestward into Iowa. Lake effect snow showers were depicted over Michigan along and ahead of the cold front. The Manitoba high-pressure system was depicted near the North Dakota and Minnesota borders at 1037-hPa. A large area of precipitation in the form of snow was depicted over Montana, Idaho, Wyoming, Colorado, into western South Dakota, and western Nebraska, and New Mexico associated with a developing low pressure system and associated frontal system. No precipitation was depicted in the Sioux Falls area for the period.

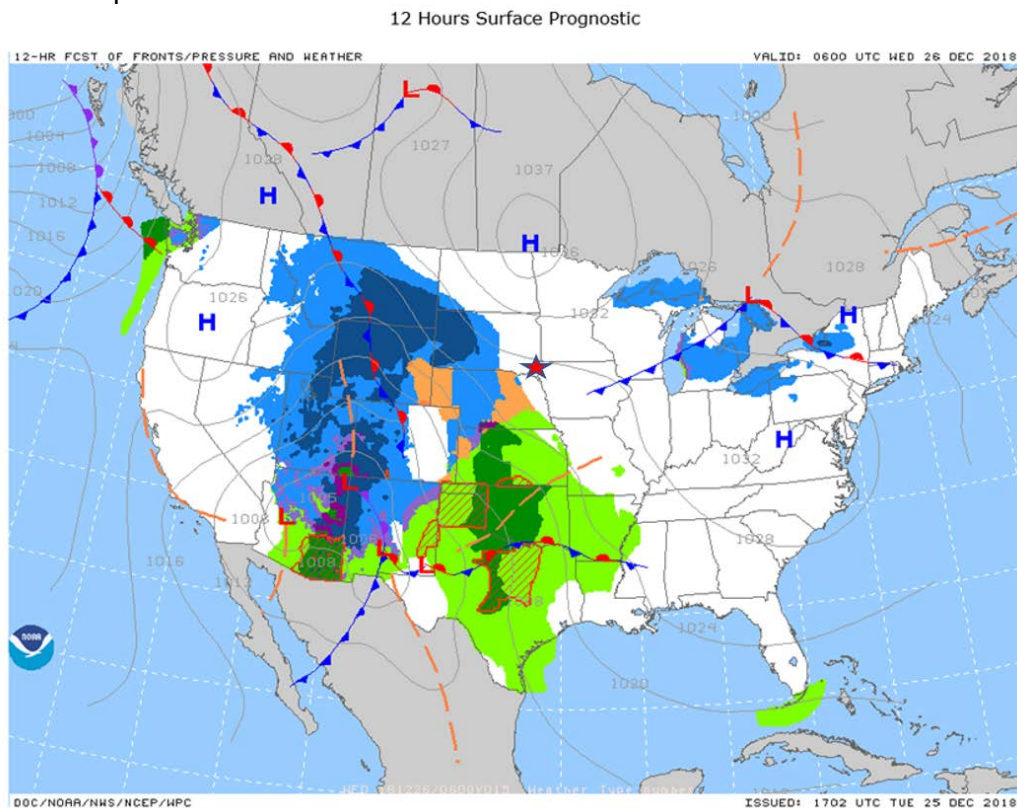


Figure 2 - NWS 12-hour Surface Prognostic Chart valid for Midnight

1.4 12-hour and 24-hour Low-Level Significant Weather Prognostic Chart

The NWS 12- and 24-hour Low-Level Significant Weather Prognostic Chart valid at the time of departure is included as figure 3, with the 12-hour section of the chart valid for 1800 CST on the left and the 24-hour forecast valid for 0600 CST on December 26, 2018 on the right. The chart provided a depiction of the general flight categories¹ of IFR, MVFR, and VFR conditions, low-level turbulence below 24,000 ft, and the expected freezing level.

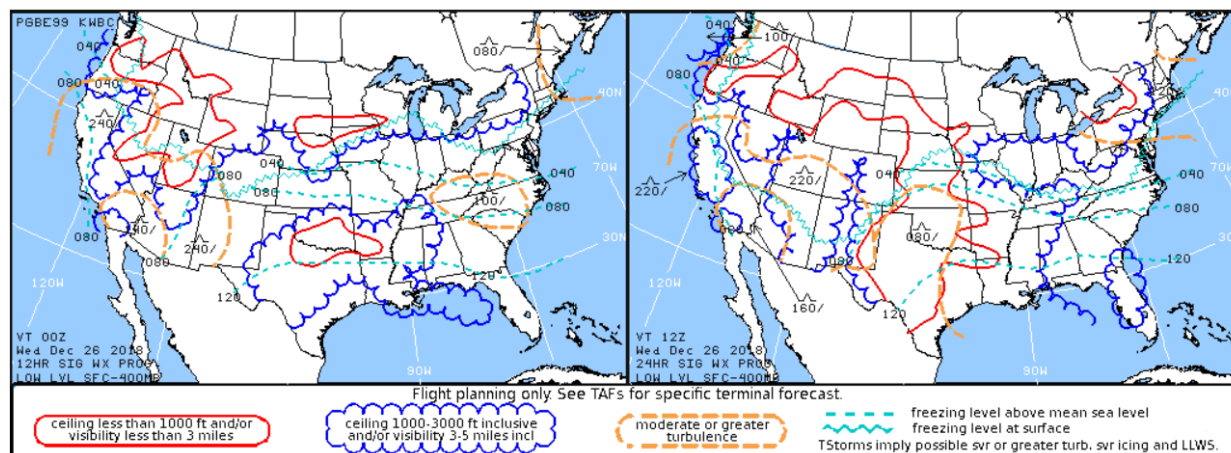


Figure 3 - NWS 12- and 24-hour Low-Level Significant Weather Prognostic Chart

The 12-hour chart expected an area of IFR conditions extending over southern Minnesota, northern Iowa, and southeastern South Dakota, and northeast Nebraska by the red contour line. MVFR conditions were depicted by a blue scalloped line and extending over the route from Michigan, Wisconsin, Iowa, into Nebraska. No significant turbulence was expected along the route of flight, and the freezing level was depicted on the surface south of the accident site.

2.0 Observations

The surrounding area was documented using Meteorological Aerodrome Reports (METAR) and Specials observations (SPECI). The area had a magnetic variation of 3° East based on the sectional chart for the area. Cloud heights are reported in height above ground level (agl) in the following section.

¹ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- 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.

2.1 Marv Skie-Lincoln County Airport, Tea, South Dakota

The accident flight intended destination was Marv Skie-Lincoln County Airport (Y14), Tea, South Dakota located approximately 5 miles southwest from the accident site at an elevation of 1,515 ft. The airport does not have any weather reporting capability. The airport had a single runway 16/34 and no published instrument approach procedures.

2.2 Joe Foss Field Airport, Sioux Falls, South Dakota

The closest weather reporting location to the planned destination and the accident site was Joe Foss Field Airport (KFSD), Sioux Falls, South Dakota, located 8 miles north of Y14 and 5 miles north (340°) of the accident site. The airport listed an elevation of 1,430 ft and had an Automated Surface Observation System (ASOS) and was augmented by Air Traffic Control Tower personnel. The following conditions were reported at the time of the accident:

KFSD weather observation at 1656 CST, wind from 040° at 8 knots, visibility 10 miles or more, ceiling² overcast at 800 ft agl, temperature -1° Celsius (C), dew point temperature -3° C, altimeter 30.24 inches of mercury (Hg). Remarks: automated observation system with a precipitation discriminator, sea-level pressure 1026.0-hPa, temperature -1.1° C, dew point -3.3° C.

The general flight categories and raw observations surrounding the period from approximately 1000 through 2100 CST on December 25, 2018 were as follows:

LIFR METAR KFSD 251556Z 06007KT 1 1/2SM BR OVC003 M02/M03 A3018 RMK AO2 SFC VIS 2 1/2 SLP240 T10171028

LIFR SPECI KFSD 251602Z 06005KT 2 1/2SM BR OVC003 M02/M02 A3019 RMK AO2 T10171022

LIFR SPECI KFSD 251646Z 06004KT 3SM BR OVC004 M02/M03 A3021 RMK AO2 T10171028

IFR METAR KFSD 251656Z 05004KT 3SM BR OVC005 M02/M03 A3022 RMK AO2 SLP252 T10171028 11011 21017 50012

IFR METAR KFSD 251756Z 04004KT 5SM BR OVC006 M01/M03 A3020 RMK AO2 SLP247 60000 I6000 T10111028 11011 21017 50012

IFR METAR KFSD 251856Z 04007KT 7SM OVC007 M01/M03 A3019 RMK AO2 SLP243 T10061033

IFR METAR KFSD 251956Z 03006KT 8SM OVC009 00/M03 A3020 RMK AO2 SLP245 T00001028

MVFR SPECI KFSD 252046Z 07008KT 10SM OVC010 00/M03 A3020 RMK AO2 T00001028

MVFR METAR KFSD 252056Z 04009KT 10SM OVC010 01/M03 A3020 RMK AO2 SLP246 T00061028 55000

MVFR METAR KFSD 252156Z 03008KT 10SM OVC010 00/M03 A3022 RMK AO2 SLP253 T00001028

IFR SPECI KFSD 252251Z 04010KT 10SM OVC008 M01/M03 A3024 RMK AO2

IFR METAR KFSD 252256Z 04008KT 10SM OVC008 M01/M03 A3024 RMK AO2 SLP260 T10111033

² A ceiling is defined as the lowest layer of clouds reported as broken or overcast, or the vertical visibility into a surface base obscuration.

Accident 2303Z

IFR SPECI KFSD 252344Z 06008KT 10SM OVC007 M01/M03 A3026 RMK AO2 T10111033

IFR METAR KFSD 252356Z 05009KT 9SM OVC007 M01/M03 A3027 RMK AO2 SLP270 T10111033 10006
21011 53022

IFR METAR KFSD 260056Z 06008KT 7SM OVC007 M02/M03 A3029 RMK AO2 SLP276 T10171033

IFR METAR KFSD 260156Z 06011KT 3SM BR OVC005 M02/M03 A3028 RMK AO2 SFC VIS 5 SLP274
I1000 T10221033

LIFR SPECI KFSD 260201Z 06012KT 3SM BR OVC004 M02/M04 A3028 RMK AO2 SFC VIS 4 T10221039

IFR METAR KFSD 260256Z 07009KT 8SM OVC005 M03/M04 A3029 RMK AO2 SLP276 I3000 T10281039
51005

The observations indicated that LIFR to IFR conditions prevailed during the period with a short period of time approximately an hour prior to the accident of MVFR conditions, with IFR conditions being reported at the time of the accident.

3.0 Sounding

To determine the vertical structure and state of the atmosphere over the accident site a High-Resolution Rapid Refresh (HRRR)³ numerical model data was retrieved from the NOAA Air Resources Laboratory and plotted on a standard Skew T log P diagram⁴ using the complete Rawinsonde Observation RAOB program software⁵. Figure 4 is the HRRR plot from the surface through 600-hPa (or approximately 14,000 ft) from the initial 1200 CST model run valid at 1700 CST.

³ The HRRR is a National Oceanic and Atmospheric Administration (NOAA) real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

⁴ 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.

⁵ RAOB software – The complete RAwinsonde OBservation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data.

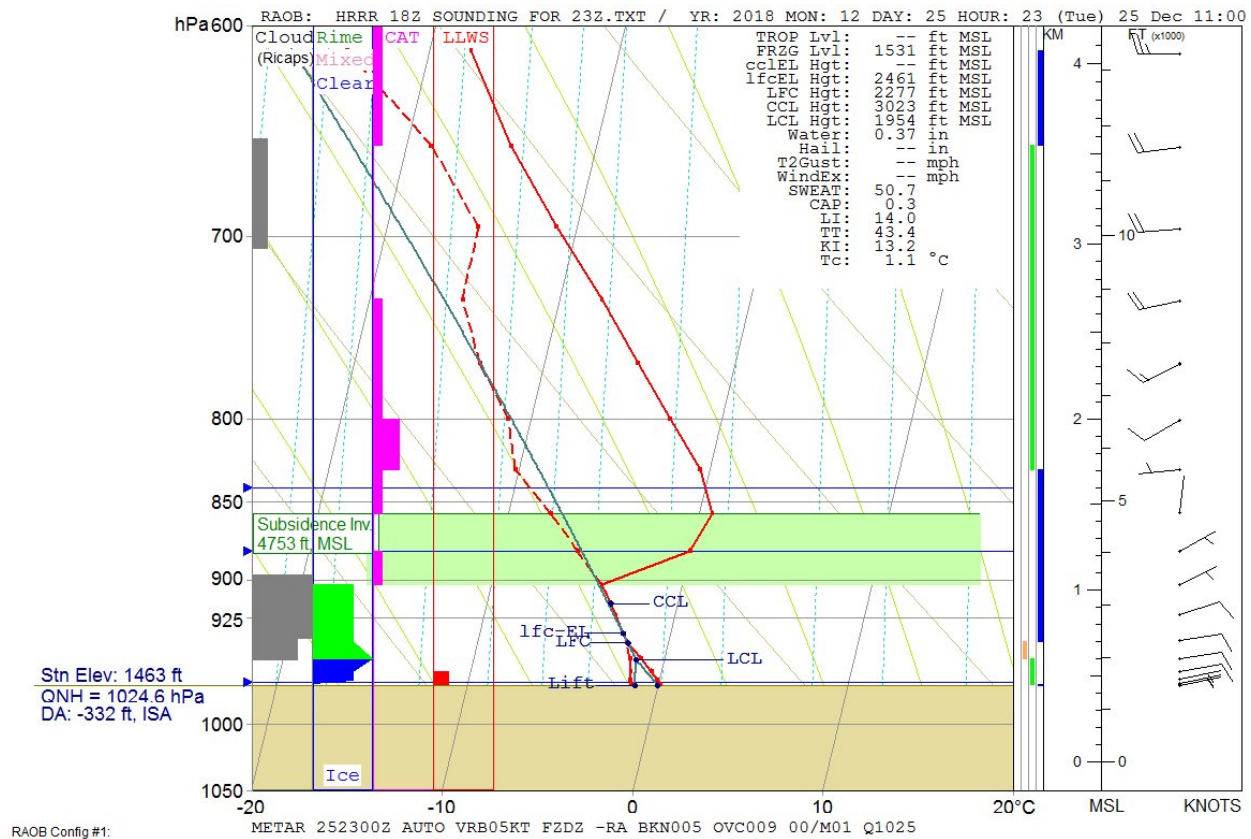


Figure 4 - HRRR numerical model sounding for 1700 CST

The HRRR model sounding depicted an elevation of 1,463 ft, with a surface wind from approximately 080° at 5 knots, a surface temperature of 0° C, a dew point of -1.2° C, with a 92% relative humidity. The lifted condensation level (LCL)⁶ was 490 ft agl (1,954 ft msl), a level of free convection (LFC)⁷ at 814 ft agl (2,277 ft msl), and a convective condensation level (CCL)⁸ at 1,560 ft agl (3,024 ft msl). The sounding was saturated from the LCL or about 500 ft agl through 3,400 ft, which supported a layer of stratiform clouds based on the lapse rate, which is indicated on the left side of the chart. The RAOB algorithm supported a greater than 90% probability of light icing conditions in the cloud layer to 3,290 ft (also shown on left side bars). A defined temperature inversion was noted immediately above the cloud layer between 3,290 through 4,753 ft msl with temperatures warming to +0.7° C. Another scattered layer of clouds was also suggested between 10,000 and 12,000 ft based on the sounding. The precipitable water content was 0.37 inches.

⁶ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

⁷ 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.

⁸ Convective Condensation Level (CCL) – The height where an air parcel becomes saturated when heated from below and lifted adiabatically due to buoyancy. It marks where the cloud base begins when air is heated from below to the convective temperature, without mechanical lift.

The HRRR wind profile indicated an easterly low-level flow from the surface through 5,000 ft with wind backing counterclockwise to the west immediately above the inversion and gradually increased in speed with height. The mean 0 to 6 kilometer or 18,000 ft wind was from 270° at 24 knots. A shallow layer of potential turbulence existed immediately above the temperature inversion where the winds abruptly shifted to the west and indicated a potential for moderate turbulence at approximately 5,600 ft.

A table of the HRRR model heights, pressure, temperature (T), dew point (Td), relative humidity (RH%), and wind direction and speed, clear air turbulence (CAT), low-level wind shear (LLWS), and icing potential from the surface to 21,000 ft is included below in figure 5.

Level	Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)
1	1463	972	0.0	-1.2	92	77 / 5			LGT Clear
2	1490	971	0.1	-1.4	90	77 / 5		LIGHT	
3	1571	968	-0.1	-1.5	90	77 / 7		LIGHT	LGT Clear
4	1734	962	-0.5	-1.6	92	78 / 9			LGT Clear
5	1980	953	-1.2	-1.8	96	79 / 10			MDT Clear
6	2311	941	-2.2	-2.2	100	80 / 10			LGT Rime
7	2814	923	-3.1	-3.1	100	70 / 8			LGT Rime
8	3382	903	-4.2	-4.2	100	62 / 7	LGT		LGT Rime
9	4026	881	0.0	-5.9	64	58 / 3			
10	4753	857	0.7	-7.8	53	5 / 2	LGT		
11	5595	830	-0.5	-10.2	48	264 / 3	MDT		
12	6557	800	-2.7	-11.2	52	237 / 9	LGT		
13	7614	768	-5.1	-13.4	52	240 / 15	LGT		
14	8811	733	-7.8	-15.1	56	256 / 19			
15	10161	695	-11.1	-15.2	72	264 / 20			
16	11645	655	-14.5	-18.7	70	262 / 21	LGT		
17	13363	611	-17.8	-24.3	57	271 / 27	LGT		
18	15230	566	-20.8	-27.8	53	275 / 36	LGT		
19	17227	521	-24.0	-28.3	68	274 / 43	LGT		
20	19128	481	-27.3	-30.2	76	271 / 49			
21	20850	447				269 / 53			

Figure 5 - HRRR 1700 CST sounding parameters

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 at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared long wave and water vapor imagery were obtained surrounding the time of the accident. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The visible (band 2) at a wavelength of 0.64 μm images at a resolution of 1 km were also reviewed; however, at the time of the accident the low Sun angle prevented a clear image at the time of the accident.

The GOES-16 infrared long wave image (band 13) at 1700 CST at 2X magnification is included as figure 6. The image depicted an extensive band of low stratiform type clouds with a band of higher clouds immediately south of KFSD. The image depicted a radiative cloud top temperature

Figure 7 is the GOES-16 visible image at 1632 CST or approximately 30 minutes prior to the accident at normal magnification depicting an extensive area of low stratiform type clouds that extended over the area, with a stream of altostratus clouds immediately south of the KFSD area. Due to the low Sun angle the visible image at the time of the accident was not useable.

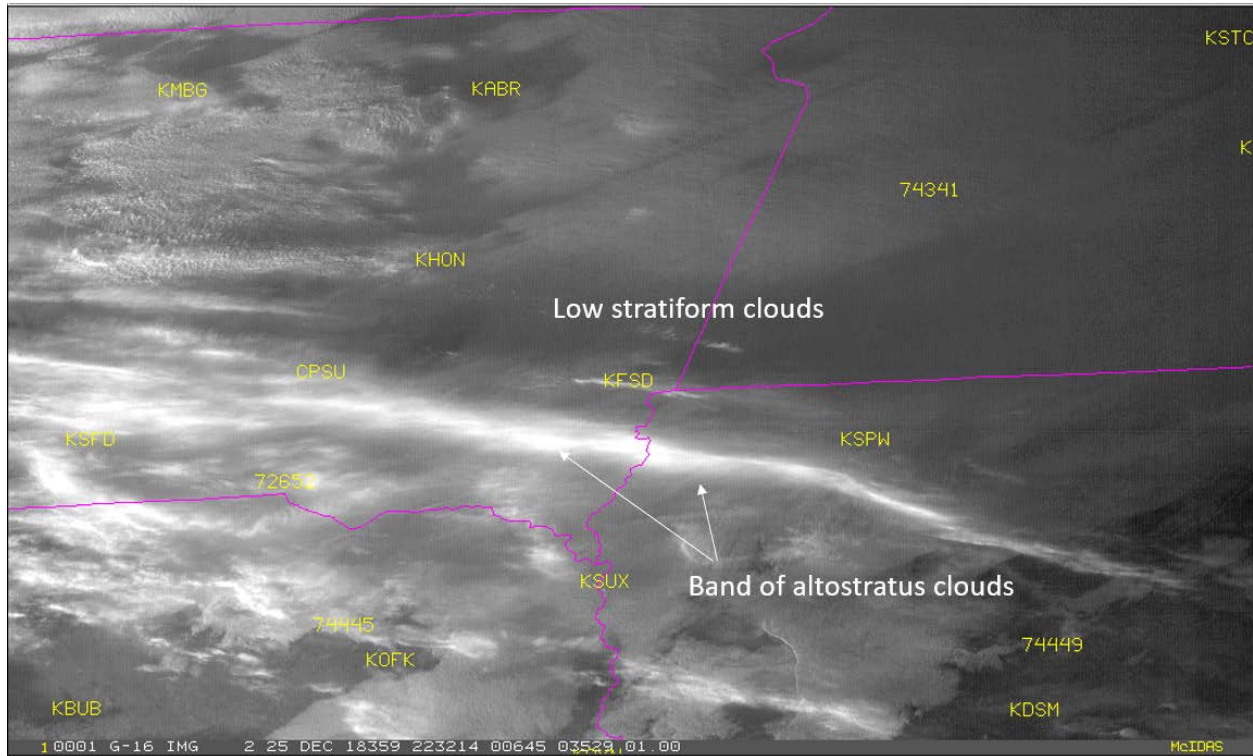


Figure 7 - GOES-16 visible image at 1632 CST

5.0 Weather Surveillance Radar Imagery

The closest Weather Surveillance Radar 1988 Doppler (WSR-88D) was located at the NWS FSD Weather Forecast Office (WFO). During the period the radar was operating in the clear air mode with an update rate approximately every 10-minutes. Figure 8 is the KFSD WSR-88D 0.5° base reflectivity image at 1709 CST with the flight track of N6745V overlaid (purple track). No significant meteorological echoes were detected over the flight path or the accident site, only false echoes associated with ground clutter were depicted.



Figure 8 - KFSD WSR-88D base reflectivity image at 1709 CST with flight track

6.0 Pilot Reports

The following pilot reports or PIREPs below 18,000 ft and within 100 miles of the accident site were in the NWS database for the period from 1200 to 2350 CST. Cloud bases and tops are reported in msl heights. The reports in raw format were as follows:

FSD UA /OV FSD180010/TM 1535/FL028/TP PC12/SK OVC017-TOP028/TA M01/IC TRACE RIME

FSD UA /OV FSD180010/TM 1637/FL018/TP CRJ2/SK OVC018-TOP029/TA M02/IC TRACE RIME

FSD UA /OV FSD180010/TM 1823/FL018/TP CRJ2/SK OVC019 TOP028/TA 00/IC TRACE RIME

*SUX UA /OV KSUX360001/TM 2015/FL020/TP C182/SK OVC-TOP020/TA 00/IC NEG/RM DURD RY31 SUX
VISIBLE MOISTURE ON CLIMBOUT*

FSD UA /OV FSD/TM 2024/FL023/TP CRJ2/SK T-030 OVC B-023/RM CLR ABV

SUX UA /OV SUX/TM2133/FL022/TP C68A/SK OVC011-TOP022/RM SFC OBSCURATION PRESENT

SUX UA /OV SUX/TM 2230/FL022/TP B35/SK OVC011-022/RM DURD SFC OBSCURATION

Accident 2303Z

*FSD UA /OV FSD180010/TM 2340/FL020/TP PA46/SK TOPS 034 BASE 020/IC LGT-MOD/RM DURD FINAL
RWY 03*

SUX UA /OV KSUX310001/TM 2348/FL023/TP E145/SK OVC-TOP023/RM DURC RY31 SUX

Several pilot reports over the KFSD area and available at the time of the pilot's preflight briefing indicated light rime icing was encountered with cloud tops at 2,300 ft. Several other reports of light rime icing continued to be reported while the flight was en route.

Immediately after the accident at 1740 CST a pilot operating a Piper Malibu (PA46) landed at KFSD and reported cloud bases at 2,000 ft (~600 ft agl) with tops at 3,400 ft, with light to moderate intensity icing conditions on final approach to runway 3.

7.0 NWS Forecast Products

7.1 Terminal Aerodrome Forecast

The NWS Sioux Falls (KFSD) Weather Forecast Office (WFO) was located at Joe Foss Field and was responsible for the Terminal Aerodrome Forecast (TAF) and local weather warnings for South Dakota. TAFs are valid for a 5 mile radius around an airport's center. When planning a flight to an airport that does not have a TAF, pilots typically refer to the closest available TAFs to supplement the information in weather forecast products that cover large areas, such as the Graphic Aviation Forecast (GFA), Airmen's Meteorological Information (AIRMET) bulletins, and other graphical products. The forecast available for preflight planning prior to the accident airplanes departure was an amended TAF issued at 0755 CST, the next schedule forecast was updated at 1127 CST. The forecasts were as follows with the forecast valid at the time of the accident in bold italic print:

*AMD TAF KFSD 251355Z 2514/2612 VRB03KT 3SM BR OVC005
TEMPO 2514/2515 1 1/2SM -FZDZSN BKN004
FM251700 VRB03KT P6SM BKN006
FM252000 06005KT P6SM BKN010
FM252200 07005KT P6SM BKN060
FM260700 09006KT P6SM OVC025=*

*TAF KFSD 251727Z 2518/2618 VRB03KT 3SM BR BKN005
FM252000 06005KT P6SM SCT006 BKN010
FM260300 09006KT P6SM OVC008
FM261600 10010G16KT 2SM -SN OVC008=*

The initial 0755 CST forecast expected the IFR conditions to improve to VFR conditions at the time of the accident, with wind from 070° at 5 knots, visibility better than 6 miles, with ceiling broken at 6,000 ft agl. The updated forecast at 1127 CST continued to expect improving conditions with MVFR conditions with wind from 060° at 5 knots, visibility better than 6 miles, with a ceiling broken at 1,000 ft agl. The forecasts did not verify with reported weather conditions at the time of the accident, where IFR conditions prevailed versus the forecast MVFR conditions.

7.2 Area Forecast Discussion

Although not a routine aviation flight planning product, the Area Forecast Discussion (AFD) is a plain language description of the weather conditions impacting a region and includes an aviation discussion by the NWS forecaster on his reasoning behind the issued TAF forecasts. The NWS KFSD WFO issued AFD at 1132 CST was as follows:

*FXUS63 KFSD 251732
AFDFSD*

*Area Forecast Discussion
National Weather Service Sioux Falls SD*

1132 AM CST Tue Dec 25 2018

.SHORT TERM...(Today and Tonight)
Issued at 424 AM CST Tue Dec 25 2018

Merry Christmas! This Christmas Day will be the proverbial calm before the storm, with our main concerns being patchy fog and scattered flurries. Mid to high clouds associated with subtle wave have overspread much of the forecast area, which has largely kept fog in check. Seeing patchy visibility below a mile, but expect most areas to remain higher with stratus more predominant than fog. Spotty radar echoes beneath the thicker mid clouds to our west, and anticipate these will move across the forecast area as the wave slides east today. With moisture limited between the mid clouds and stratus layer, think measurable precip will be difficult to achieve, so will spread a chance of flurries across northern parts of the CWA today. Highs today will again be mainly in the 30s, though lingering stratus and cooler easterly flow may hold readings in the upper 20s for parts of southwest Minnesota.

Boundary layer winds remain easterly tonight, while flow above the surface swings around to the south with elevated warm front lifting across the area. This will hold any stratus in place, and could again see some patchy fog develop as the stratus is compressed toward the surface beneath a strengthening inversion. This more probable in southern parts of the CWA where should also see some low level moisture increase late tonight. Meanwhile, northeast portions of the forecast area should see a somewhat drier east-northeast flow much of the night, which should hold fog potential at bay. Stratus and increasing higher clouds in advance of main storm system should hold temperatures up in the 20s overnight.

.AVIATION...(For the 18Z TAFS through 18Z Wednesday afternoon)
Issued at 1128 AM CST Tue Dec 25 2018

IFR to LIFR conditions continue at the 3 terminals as of midday. Still expect some improvement into the MVFR category this afternoon although this may be fairly short lived. IFR or lower ceilings/visibilities may return by as early as this evening ahead of an incoming winter storm. Snow is expected to spread from west to east thru the mid to late morning hours, before mixing with or changing to rain at KFSD and KSUX.

The aviation discussion indicated that IFR to LIFR conditions were expected to prevail, with some potential improvement to MVFR conditions during the afternoon, although it was expected to be short lived with IFR to LIFR conditions returning by early evening.

7.3 Graphic Aviation Forecast

The NWS Graphic Aviation Forecast (GFA) of cloud cover and surface wind, visibility, and precipitation issued at 1300 CST depicting the forecast enroute conditions are included as figures 9 through 12, with the accident site located within the red circle. The images depicted east-northeast winds at 5 knots, with snow showers and mist over the destination, with an extensive layer of low overcast clouds with tops near 5,000 ft.

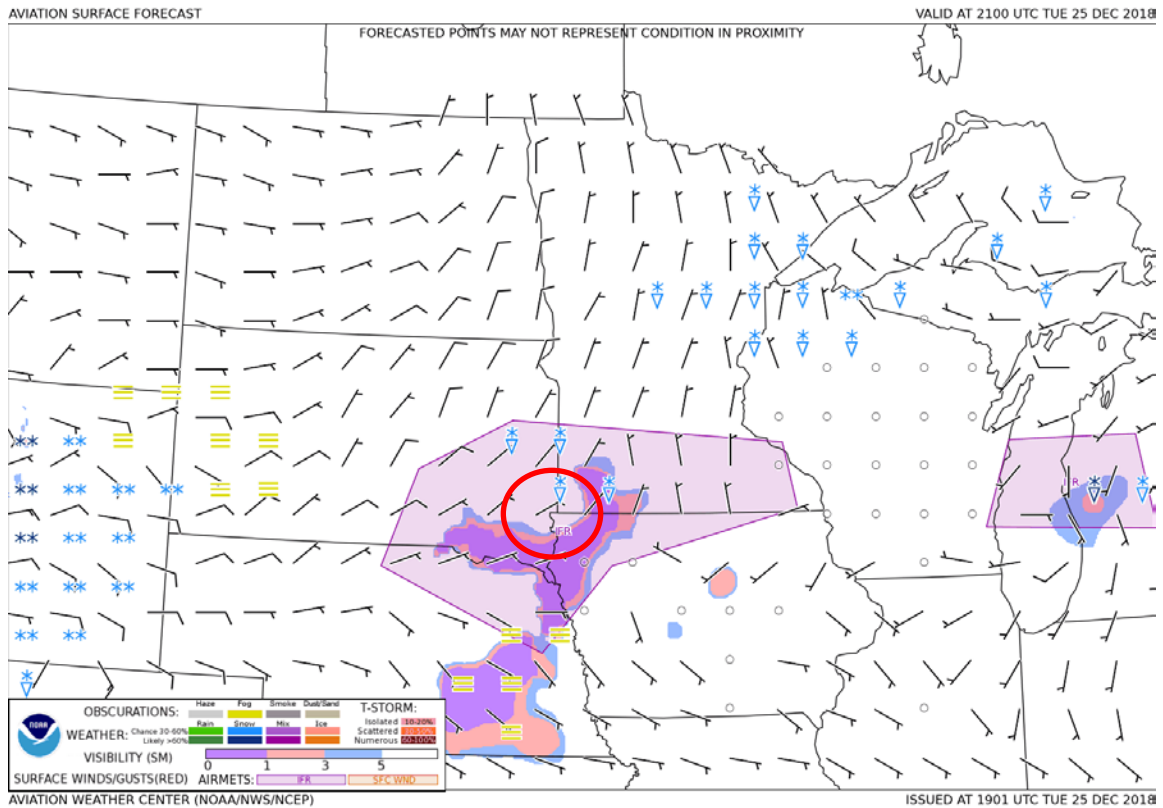


Figure 9 - GFA surface wind, visibility, weather valid for 1500 CST with AIRMET Sierra IFR conditions

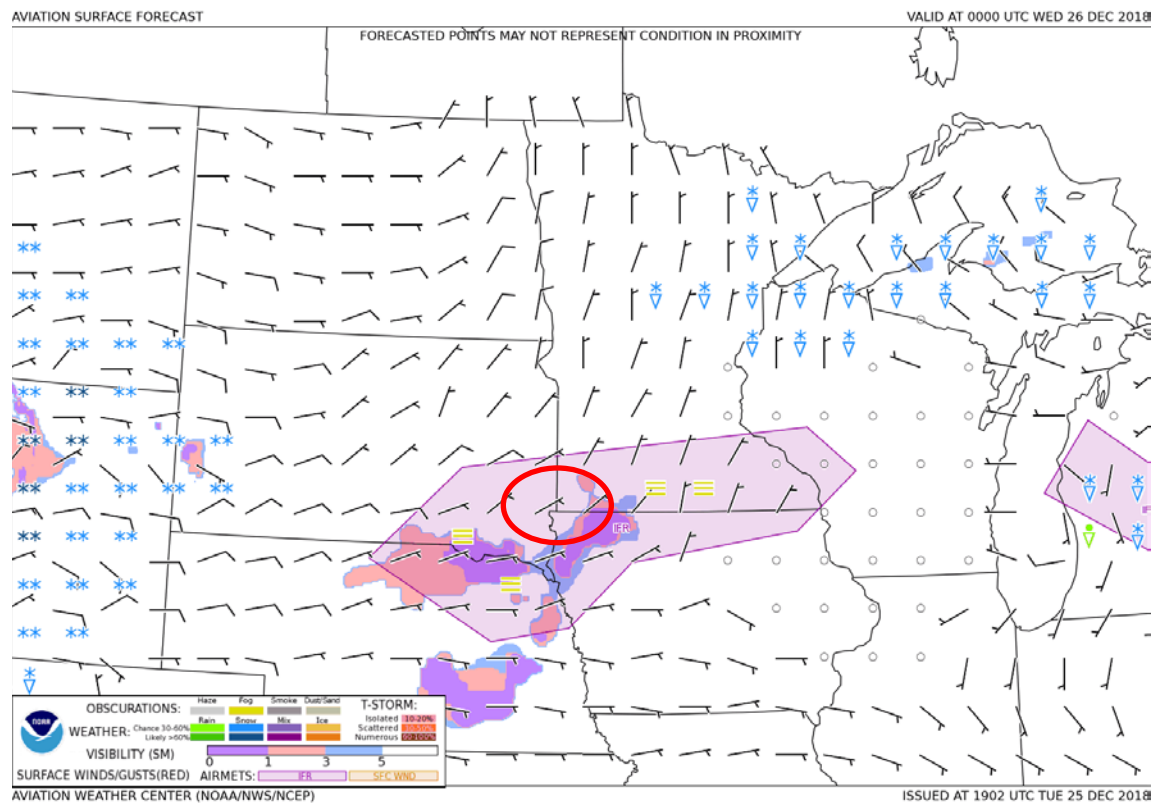


Figure 10 - GFA surface wind, visibility, weather valid for 1800 CST with AIRMET Sierra IFR conditions

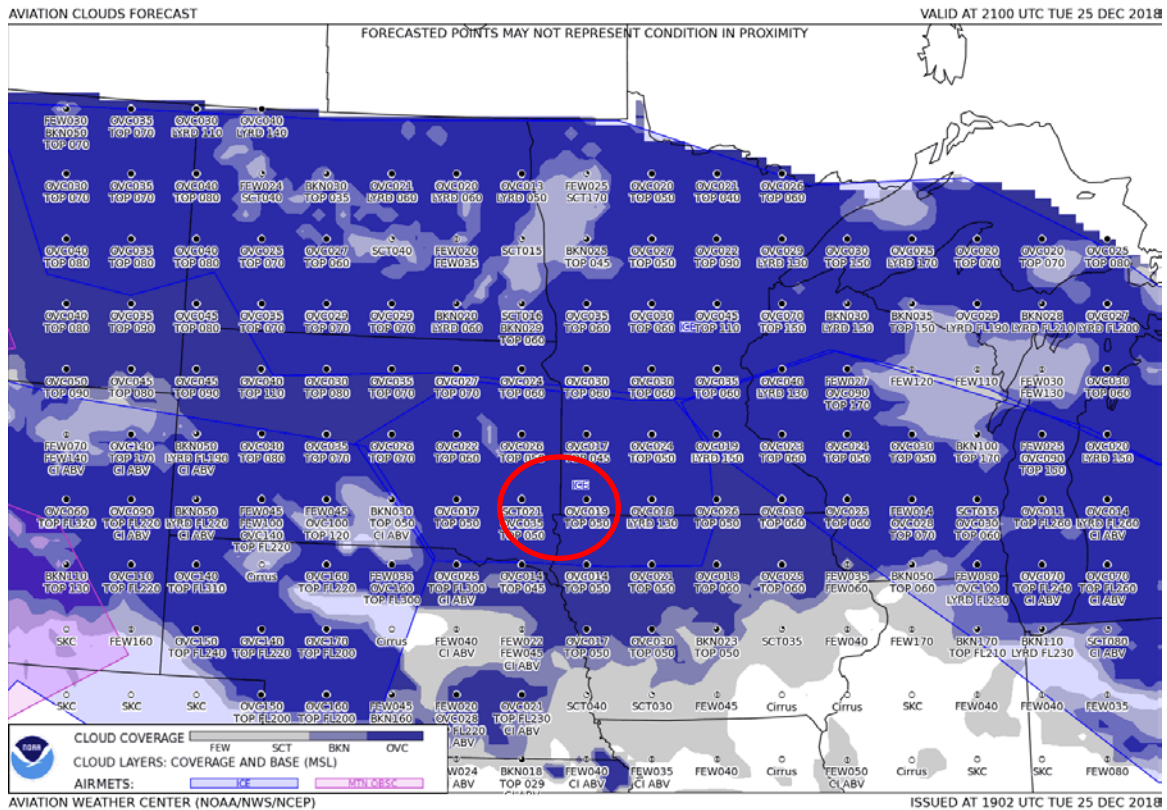


Figure 11 - GFA cloud cover forecast for 1600 CST with AIRMET Zulu for icing

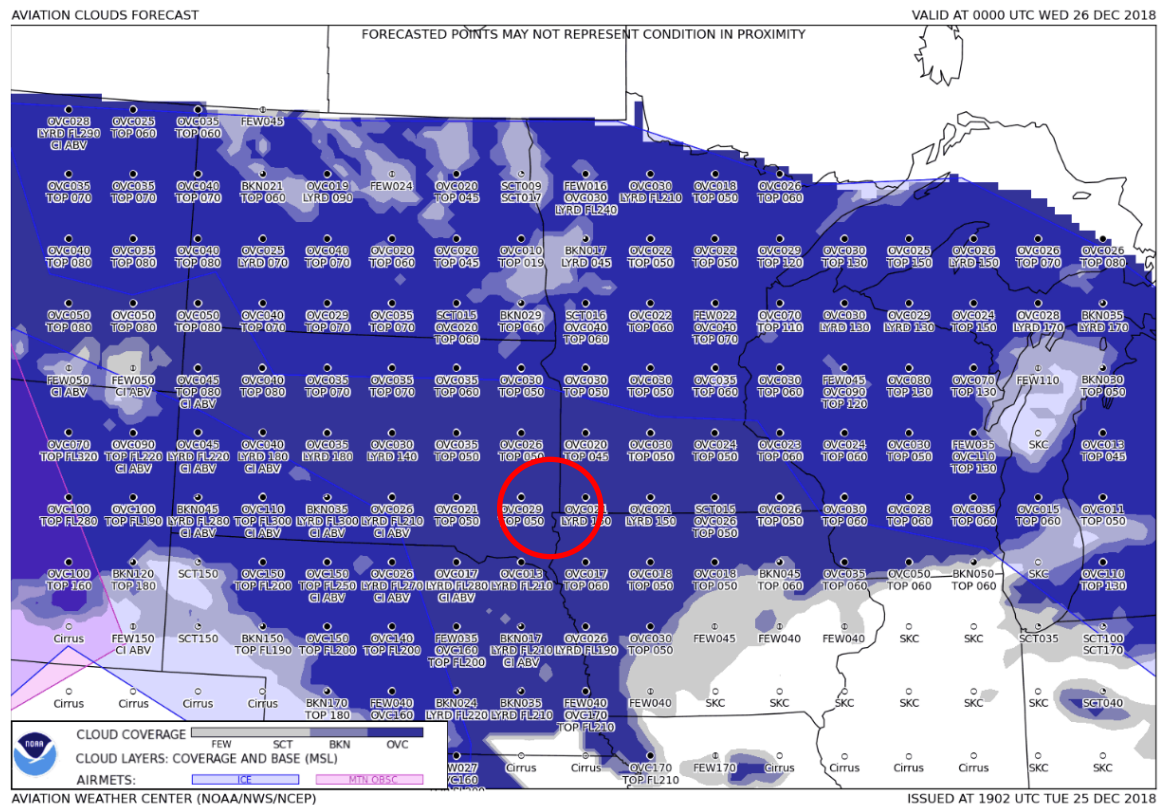


Figure 12 GFA cloud cover for 1800 CST with AIRMET Zulu for icing conditions

7.4 Winds and Temperatures Aloft Forecast

The NWS winds and temperature aloft forecast current for the period was valid from 1800 CST, and for use between 1400 and 2100 CST were as follows:

*WINDS ALOFT FORECASTS
DATA BASED ON 251800Z
VALID 260000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000*

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
MKG	2817	2927-05	2927-11	2933-17	2947-30	2960-40	298550	297553	286551
JOT	2408	2711-05	3015-09	3027-14	2954-25	2979-35	288850	780155	288455
GRB	2907	2814-07	2926-11	2933-18	2940-30	2832-40	297051	296754	285952
DBQ	2508	2913-03	3120-08	2921-15	2954-25	2872-36	288250	289255	288256
LSE	2711	2820-03	2929-09	2932-16	2845-28	2873-37	288251	287855	287154
MCW	2611	3112-02	2922-09	2831-16	2852-25	2866-36	287650	278455	287856
MSP	3107	2920-05	2932-10	2834-17	2840-30	2871-38	287551	286355	285754
FSD	1010	2105-02	2418-08	2724-15	2749-26	2758-36	277051	278156	277457

The winds aloft forecast for FSD expected a wind at 3,000 ft from 100° at 10 knots, and at 6,000 ft wind from 210° at 5 knots with a temperature of -2° C.

8.0 Inflight Weather Advisories

The NWS issues inflight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

During the period, the NWS had a series of AIRMETs current for the route and over the accident site. No SIGMETs or CWA's were current during the period.

8.1 AIRMET

The following AIRMETs were issued for the area: AIRMET Sierra for IFR conditions (figures 13 and 14) and AIRMET Zulu for icing conditions (figure 15 and 16):

*WAUS43 KPCI 251644 AAA
WA3S
-CHIS WA 251644 AMD
AIRMET SIERRA UPDT 4 FOR IFR VALID UNTIL 252100
.
AIRMET IFR...WI LM MI...UPDT
FROM 30E GRB TO 30ESE TVC TO 40WSW FNT TO 20SW GRR TO 20SE DLL
TO 40NNE DLL TO 30E GRB
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
...NEW AIRMET...*

.
AIRMET IFR...ND SD NE KS MN IA WI...UPDT
FROM 60SSW YWG TO 40SW FAR TO 20NNE RWF TO 30SW EAU TO 20SSW ODI
TO 30ENE MCW TO 20S DSM TO 20N OVR TO 20NE SLN TO 80SSW OBH TO
30SE ONL TO ANW TO 60SSE PIR TO 80ENE MOT TO 60SSW YWG
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET IFR...ND SD...UPDT
FROM 40NNW ISN TO 40WNW MOT TO 70SE BIS TO 40NE PIR TO 30NE DPR
TO 60NW RAP TO 40NNW ISN
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS ENDG 18-21Z.

....

WAUS43 KKCI 251809 AAB
WA3S
-CHIS WA 251809 AMD
AIRMET SIERRA UPDT 5 FOR IFR VALID UNTIL 252100

.
AIRMET IFR...ND SD...UPDT
FROM 40N MOT TO 30E MOT TO 20E RAP TO 50W RAP TO 40N ISN TO 40N MOT
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 15-18Z. CONDS ENDG 18-21Z.

.
AIRMET IFR...ND SD NE KS MN IA MO WI...UPDT
FROM 60SW YWG TO 30WSW FAR TO 70S FAR TO 40WSW MSP TO 30SW EAU
TO 20SSW ODI TO 50WNW IOW TO 40NNE SLN TO 50SSW OBH TO 30SE ONL
TO ANW TO 40NE DPR TO 60SW YWG
CIG BLW 010/VIS BLW 3SM BR. CONDS DVLPG 15-18Z. CONDS CONTG BYD 21Z THRU 03Z.

.
AIRMET IFR...WI LM MI...UPDT
FROM 30ESE TVC TO 50SW FNT TO 30W BAE TO 30WSW GRB TO 30ESE TVC
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 15-18Z. CONDS CONTG
BYD 21Z THRU 03Z.

....

SIERRA 2018-12-25 21:00:00

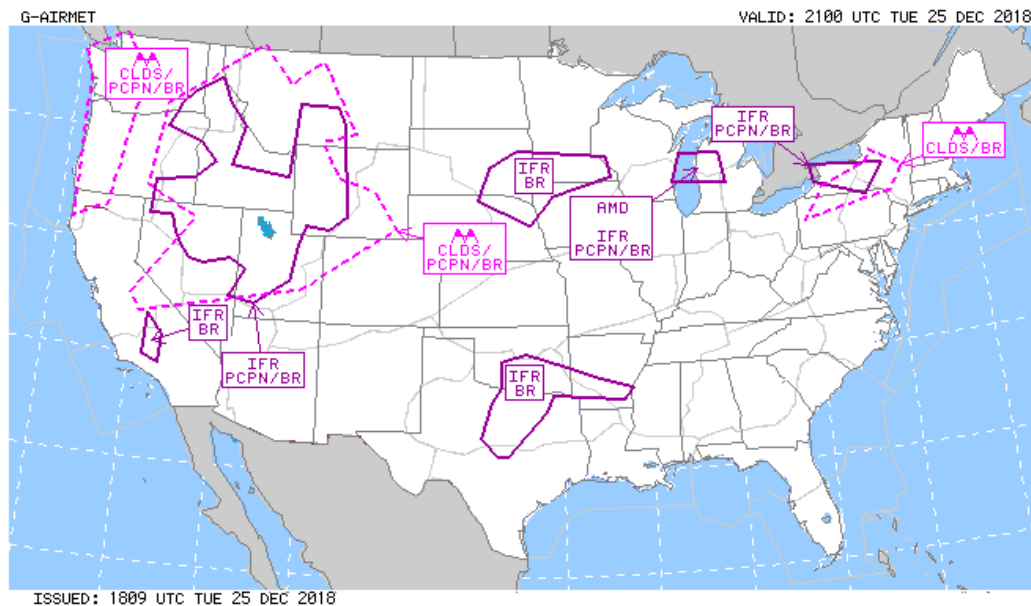


Figure 13 - G-AIRMET Sierra issued at 1209 CST and valid for the period of the accident

WAUS43 KPCI 252045

WA3S

CHIS WA 252045

AIRMET SIERRA UPDT 6 FOR IFR VALID UNTIL 260300

AIRMET IFR...ND SD

**FROM 40NW MOT TO 30NW DPR TO 80SSW DIK TO 30NNW ISN TO 40NW MOT
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z ENDG 03-06Z.**

AIRMET IFR...ND MN

**FROM 50WNW GFK TO 20NE FAR TO 60SE BIS TO 40SSE MOT TO 50WNW GFK
CIG BLW 010/VIS BLW 3SM BR. CONDS DVLPG 00-03Z. CONDS CONTG BYD
03Z THRU 09Z.**

AIRMET IFR...WI LM MI LH

**FROM 30E TVC TO 40SSE ECK TO 30SSW DXO TO 60SSE GRR TO 40ESE DLL
TO 30SW GRB TO 40WSW TVC TO 30E TVC
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.**

AIRMET IFR...ND SD NE KS MN IA MO WI

**FROM 50SSW BIS TO 40NW ABR TO 20SSW EAU TO 20SSE ODI TO 30SSW
FOD TO 50SW PWE TO 70NW SLN TO 40SSW LBF TO 50NE BFF TO 50SSW BIS
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z THRU 09Z.**

OTLK VALID 0300-0900Z

AREA 1...IFR ND SD NE KS MN IA WI

**BOUNDED BY 20NW DIK-40ESE DIK-60SSW BIS-40NW ABR-20W RWF-50N DLL-
20WNW DLL-30SSW FOD-30SSW OVR-HLC-20SW GLD-20NW AKO-70SW RAP-
60NE MLS-20NW DIK
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.**

AREA 2...IFR NE KS MO OK TX AR TN LA MS AND CSTL WTRS
BOUNDED BY 80S OBH-40NE ICT-40NW OSW-30NW ARG-20NW DYR-50WNW MSL-
20SW HRV-50SW CRP-60S SAT-70SSE DLF-DLF-70WSW DLF-20WNW FST-50NW
INK-INK-30ESE TBE-50W LBL-GLD-40NNW GLD-30NE HLC-80S OBH
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

....

SIERRA 2018-12-25 21:00:00

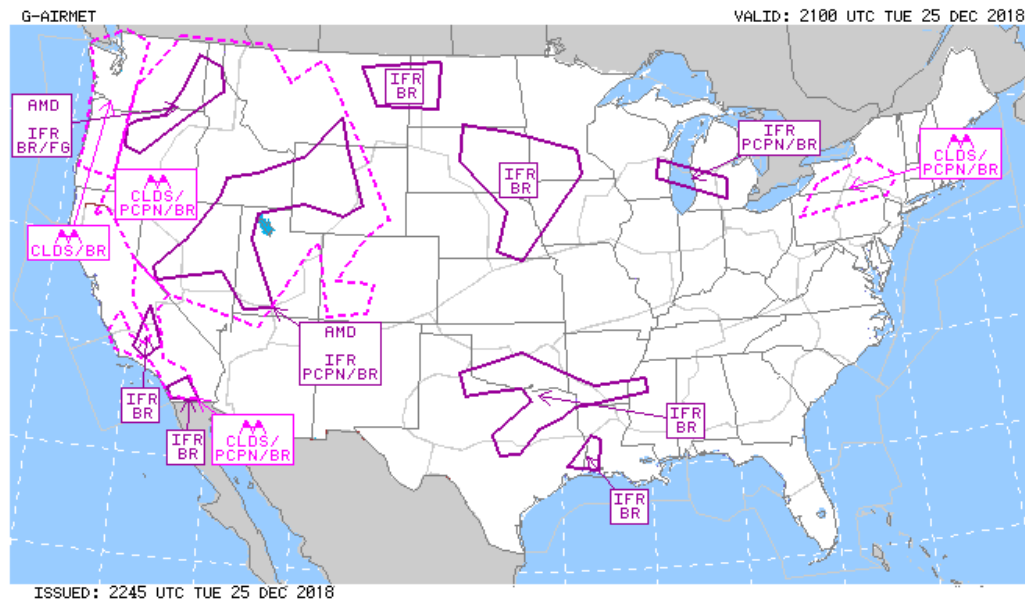


Figure 14 – Updated G-AIRMET Sierra issued at 1645 CST for IFR conditions at the time of the accident

WAUS43 KKCI 251445

WA3Z

-CHIZ WA 251445

AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 252100

AIRMET ICE...ND SD MN WI LM LS MI

FROM 40NNW INL TO YQT TO 50SE RHI TO 20SSE MSP TO 40WSW DPR TO

60WSW DIK TO 50NNW ISN TO 40NNW INL

MOD ICE BLW 130. CONDS CONTG BYD 21Z THRU 03Z.

AIRMET ICE...SD NE MN IA

FROM 40WSW DPR TO 20S MSP TO 50W DBQ TO ONL TO 70SE RAP TO 40WSW DPR

MOD ICE BTN FRZLVL AND 160. FRZLVL SFC-050. CONDS CONTG BYD 21Z ENDG 21-00Z.

ZULU 2018-12-25 21:00:00

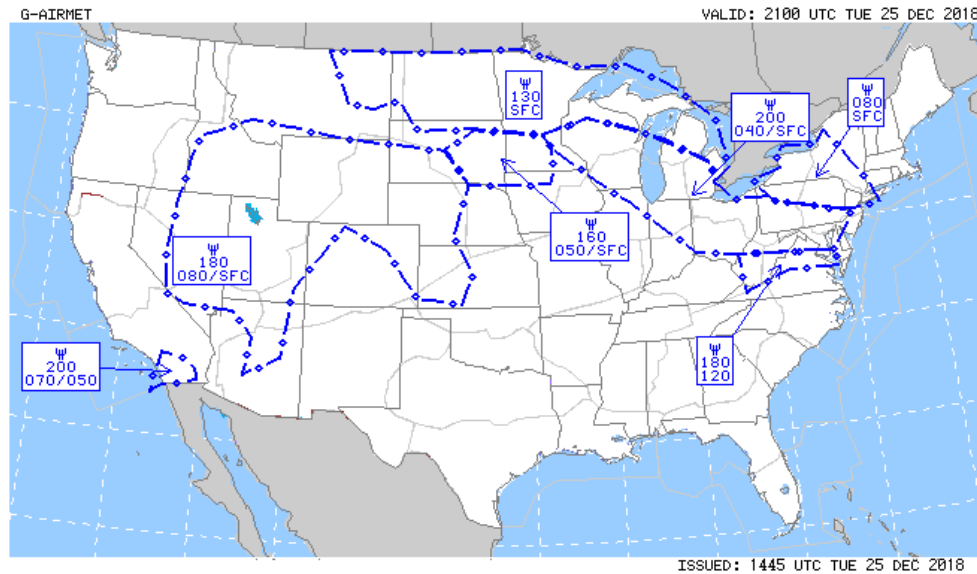


Figure 15 - G-AIRMET Zulu for icing conditions issued at 0845 CST valid at the time of the accident

WAUS43 KPCI 252045

WA3Z

-CHIZ WA 252045

AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 260300

AIRMET ICE...SD NE KS

FROM 60W RAP TO 70ESE RAP TO 30E LBF TO 60SSE OBH TO 50WSW MCI TO GLD TO BFF TO 70SW RAP TO 60W RAP

MOD ICE BTN FRZLVL AND FL200. FRZLVL SFC-060. CONDS DVLPG 21-00Z. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET ICE...MN IA WI LM MI LH

FROM 60SSW BRD TO 30SW RHI TO 40ENE GRB TO 40E ECK TO 20SE DXO TO 40WSW DXO TO 30SW MKG TO 30SSE ODI TO 30WNW MCW TO 60SSW BRD MOD ICE BLW 100. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET ICE...ND SD MN WI LM LS MI LH

FROM 30NNE INL TO YQT TO 40NW SSM TO 20SE SSM TO 60WNW YVV TO 20NE TVC TO 30NE RHI TO 50WSW RHI TO 60SSW BRD TO 80SSE FAR TO 20ENE ABR TO 30ESE BIS TO 60NE MOT TO 30NNE INL MOD ICE BLW 070. CONDS CONTG BYD 03Z THRU 09Z.

FRZLVL...RANGING FROM SFC-100 ACRS AREA

MULT FRZLVL 040-100 BOUNDED BY 40WSW IIU-20SSE IIU-20SSW LOZ-40WSW HMY-GQO-50S GQO-30SE BNA-40WSW IIU

MULT FRZLVL BLW 100 BOUNDED BY 50NNW FSD-30SW RWF-40W ODI-50SSE MCW-40SE IOW-COU-30NE SLN-40SSE SLN-40E LAA-GLD-30SSE BFF-50NW BFF-60S RAP-50NNW FSD

SFC ALG 30S GLD-40NNW IOW-30WNW MKG-MKG-40ENE BVT-30NE IND-50SW ROD 040 ALG GLD-20E HLC-60WSW PWE-30NE MCI-UIN-40N HMY 080 ALG 50SE LAA-20ENE ICT-30NW SGF-20NE DYP

....

ZULU 2018-12-25 21:00:00

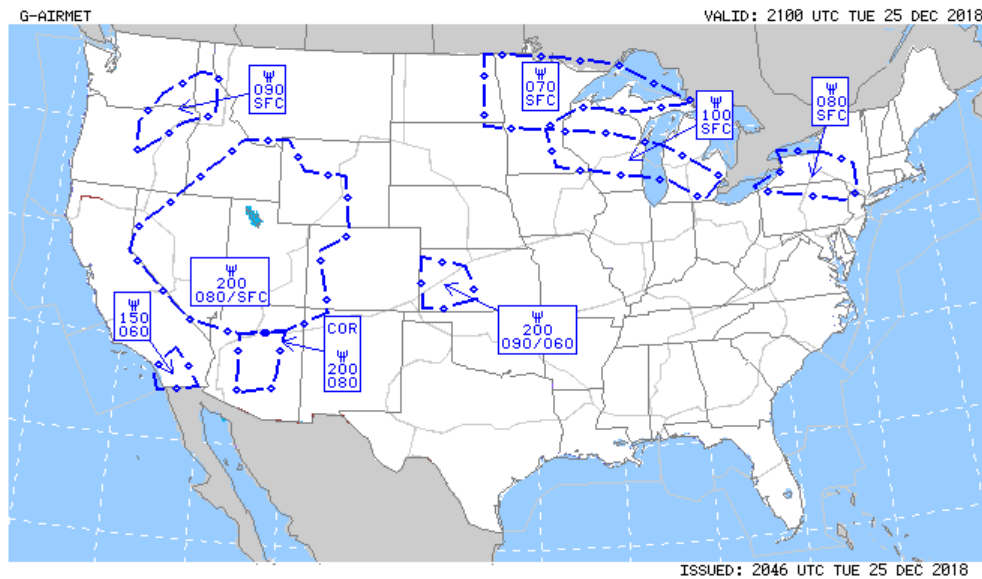


Figure 16 - Updated G-AIRMET Zulu for icing conditions valid at the time of the accident

9.0 Weather Briefing Information

The pilot obtained a route briefing through ForeFlight at 0951 CST from KGRR to KY14 and is included as attachment 1. That route briefing provided the latest inflight weather advisories⁹, decoded METARs, TAFs, PIREPs, winds aloft forecast, notice to airmen (NOTAMs) for the departure, destination, alternate airport of KFSD, and multiple enroute stations in plain language. The briefing included links to the Surface Analysis Chart, and the GFA cloud cover and surface wind, visibility, and precipitation graphics. The destination weather used the KFSD METAR and TAF. The KFSD TAF indicated that MVFR to VFR conditions were expected at the estimated time of arrival (ETA) at the time of the briefing.

A second standard route briefing was obtained at 1013 CST from KGRR to Y14 with updated METAR observations and is included as attachment 2. At that time KFSD was reporting LIFR conditions due to visibility 2 ½ miles in mist with low overcast ceilings at 300 ft agl. The TAF for KFSD continued to expect improving MVFR conditions for the ETA.

10.0 Astronomical Conditions

The United States Naval Observatory website¹⁰ was used to obtain the astronomical conditions on December 25, 2018 for Sioux Fall, South Dakota. The time of the accident has been added for reference and is in bold italic print.

⁹ AIRMET Sierra update 3 for IFR conditions and AIRMET Zulu update 2 for moderate icing valid until 1500 CST.

¹⁰ <https://aa.usno.navy.mil/index.php>

<u>Sun</u>	
Beginning of civil twilight	0726 CST
Sunrise	0758 CST
Sun transit	1227 CST
Sunset	1656 CST
<i>Accident</i>	<i>1703 CST</i>
End of civil twilight	1728 CST

At the time of the accident the Sun was 2° below the horizon at an azimuth of 239°.

F. LIST OF ATTACHMENTS

- 1 – ForeFlight standard route briefing at 0951 CST (1551Z)
- 2 – Foreflight standard route briefing at 1013 CST (1613Z)

Submitted by:

Don Eick
Senior Meteorologist