



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 28, 2020

Factual Report

METEOROLOGY

CEN20FA022

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A. ACCIDENT

Location: Chamberlain, South Dakota
Date: November 30, 2019
Time: 1233 central standard time
1833 Coordinated Universal Time (UTC)
Aircraft: Pilatus PC-12; Registration: N56KJ

B. METEOROLOGIST

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

C. DETAILS OF THE INVESTIGATION

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

The location used for the accident site was latitude 43.7656° N, longitude 99.3372° W, with an approximate elevation of 1,700 feet (ft).

D. WEATHER INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular (AC) “Aviation Weather Services”, AC 00-45H change 2¹.

1.1 Surface Analysis Chart

The northcentral section of the NWS Surface Analysis Chart for 1200 CST is provided as figure 1 with the location of the accident site located within the red circle. The chart identified a surface low pressure center located over northern Nebraska with a sea-level pressure of 988-hectopascals (hPa). The surface low pressure center was associated with a frontal system stretching from northern Nebraska southeastward into Iowa, Missouri, and further southeast. A dissipating cold frontal boundary stretched from northern Nebraska southward into Kansas, with another frontal boundary located from central Colorado to Wyoming and Montana. The accident site was located on the cold air side of the frontal systems.

The station models around the accident site depicted air temperatures ranging from 29 to 34 degrees Fahrenheit (°F), dew point temperatures between 27 and 32°F with temperature-dew point spreads of 3° F or less, a north wind of 5 to 15 knots and overcast cloud cover. Light snow was reported at the departure airport in Chamberlain, South Dakota.

1

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

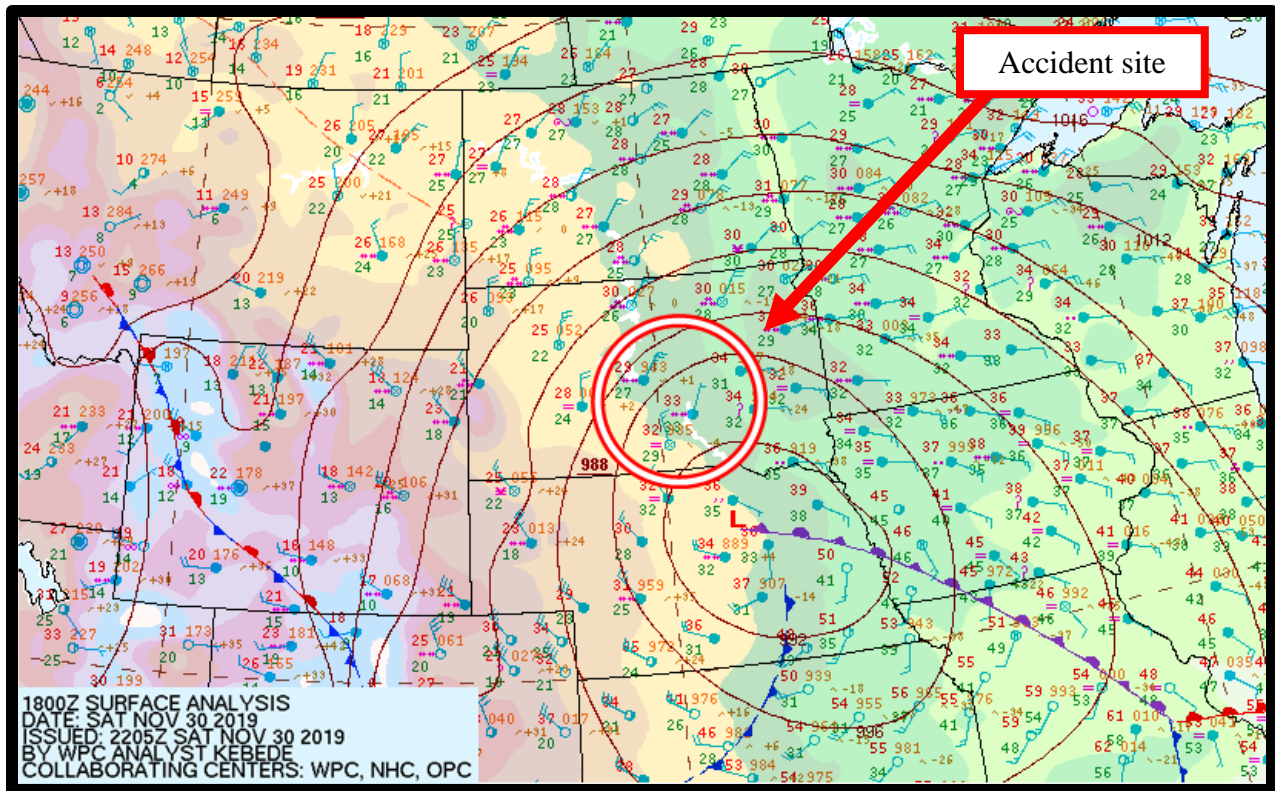


Figure 1 – NWS Surface Analysis Chart for 1200 CST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0600 CST at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There was a vertically stacked low pressure system² located over Nebraska (figures 2 through 5). Vertically stacked low pressure systems can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was an east wind to 35 knots at 925-hPa above the accident site with the wind becoming southeasterly by 700-hPa (figure 4). By 300-hPa, the wind above the accident site was from the southeast and the wind speed was around 40 knots (figure 6).

² Vertically Stacked Low Pressure System – A low-pressure system, usually a closed low or cutoff low, which is not tilted with height, i.e., located similarly at all levels of the atmosphere. Such systems typically are weakening and are slow-moving, and are less likely to produce severe weather than tilted systems. However, cold pools aloft associated with vertically-stacked systems may enhance instability enough to produce severe weather.

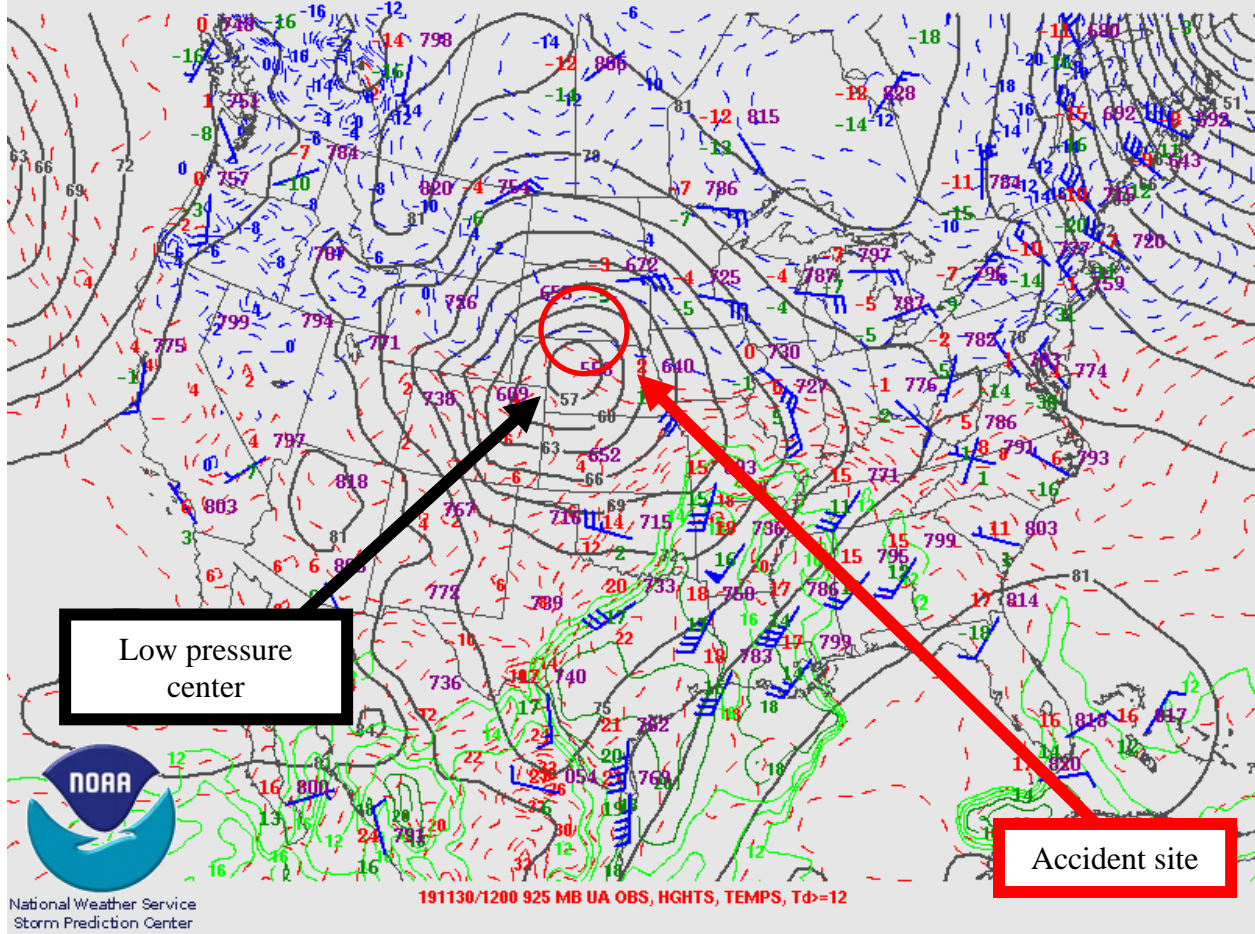


Figure 2 – 925-hPa Constant Pressure Chart for 0600 CST

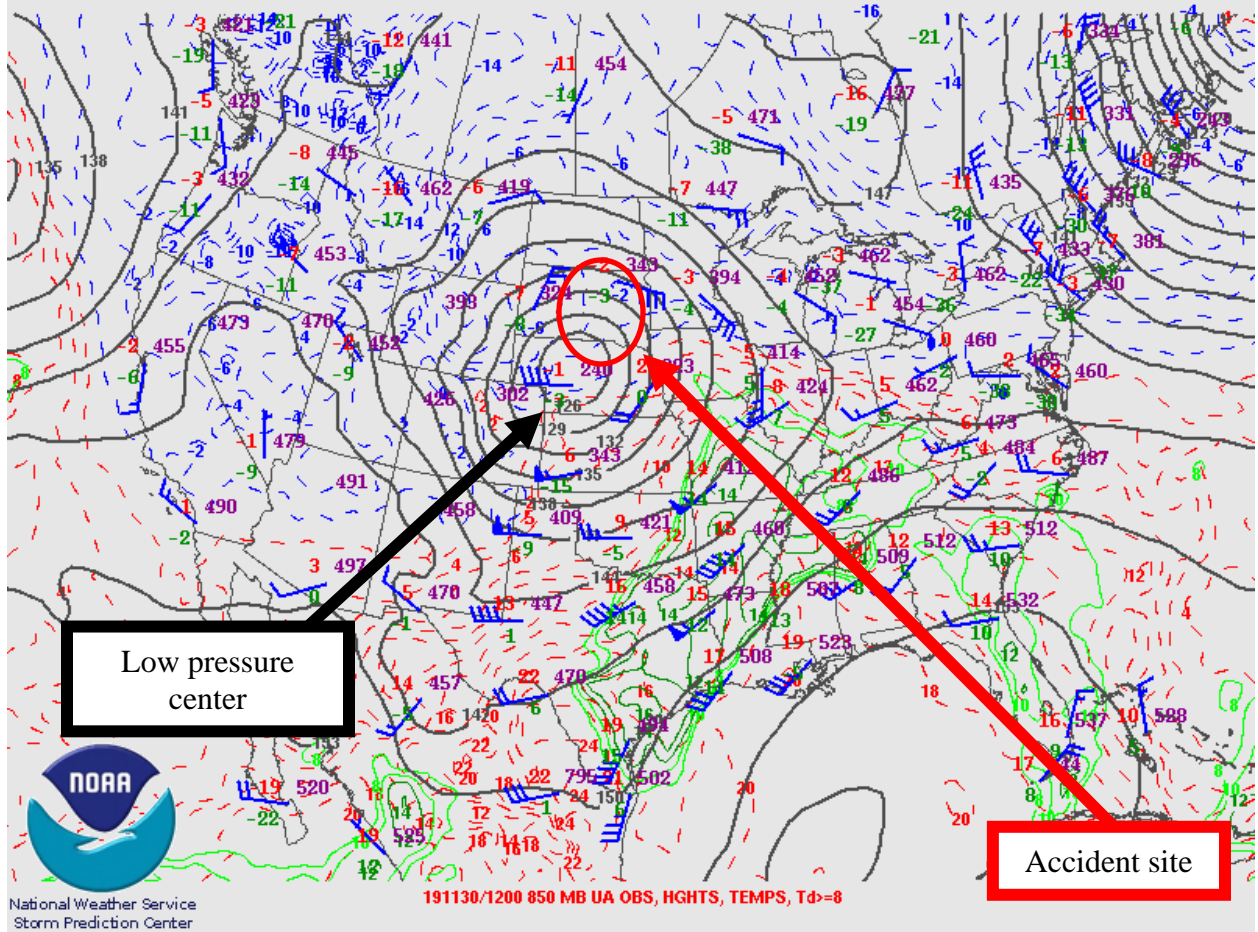


Figure 3 – 850-hPa Constant Pressure Chart for 0600 CST

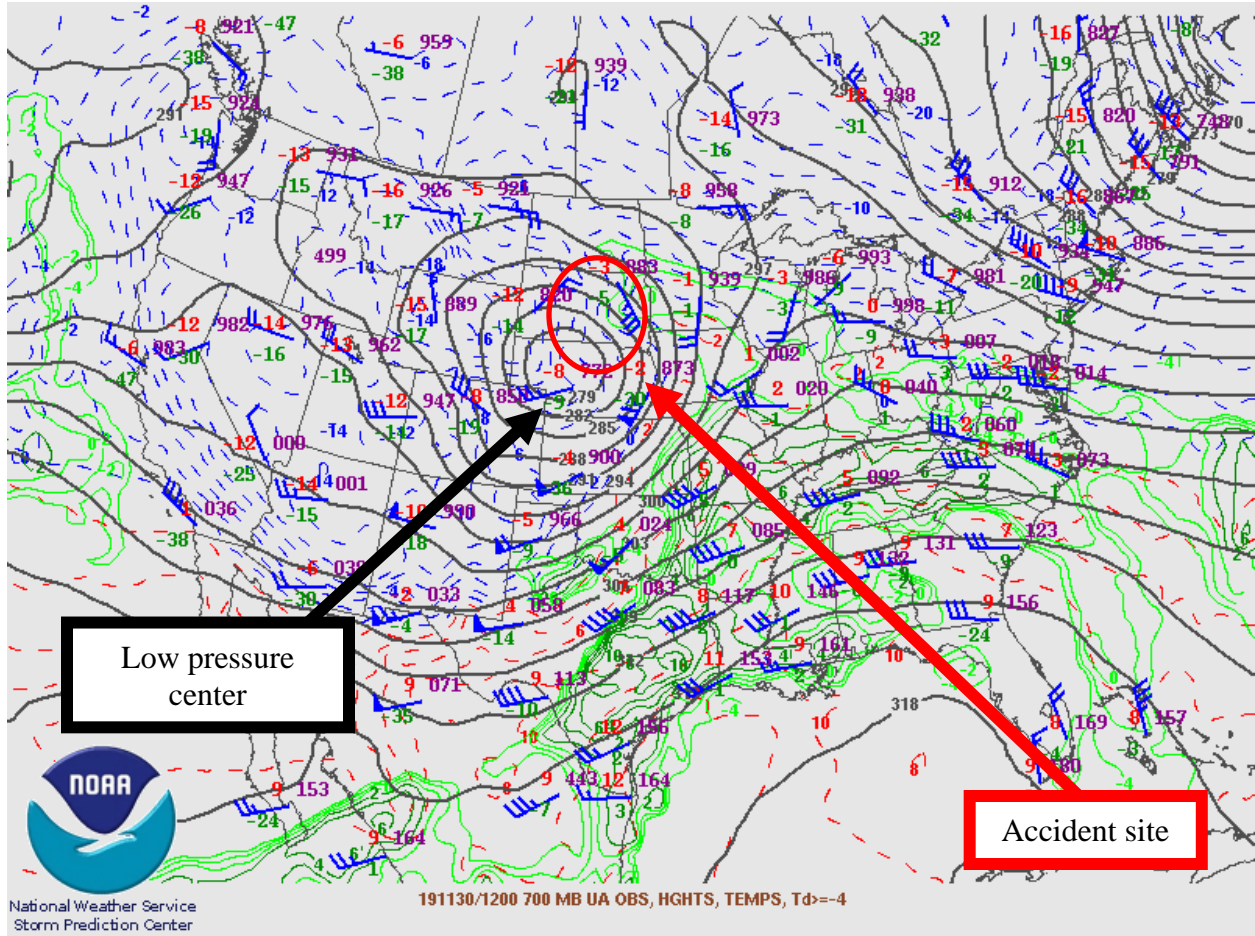


Figure 4 – 700-hPa Constant Pressure Chart for 0600 CST

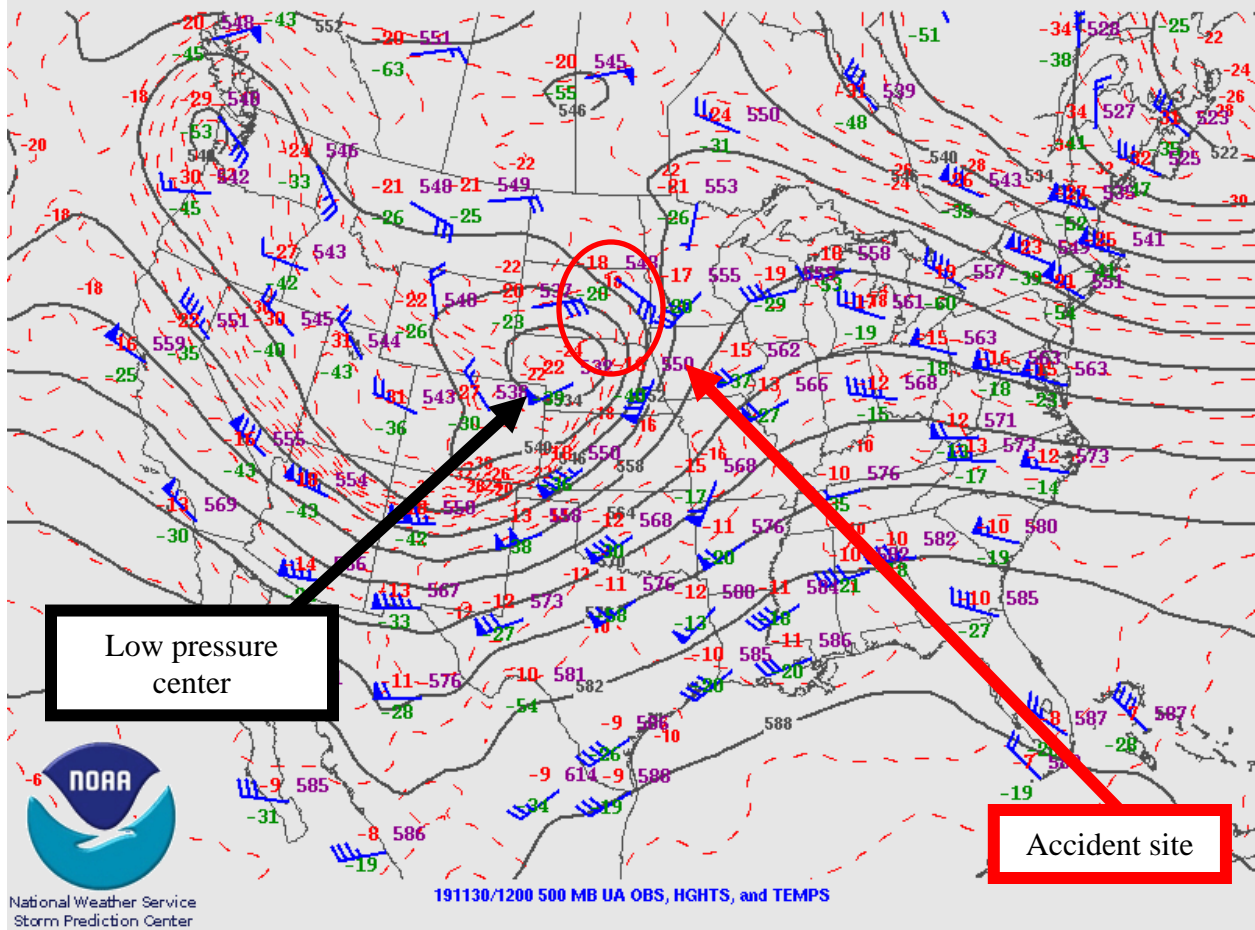


Figure 5 – 500-hPa Constant Pressure Chart for 0600 CST

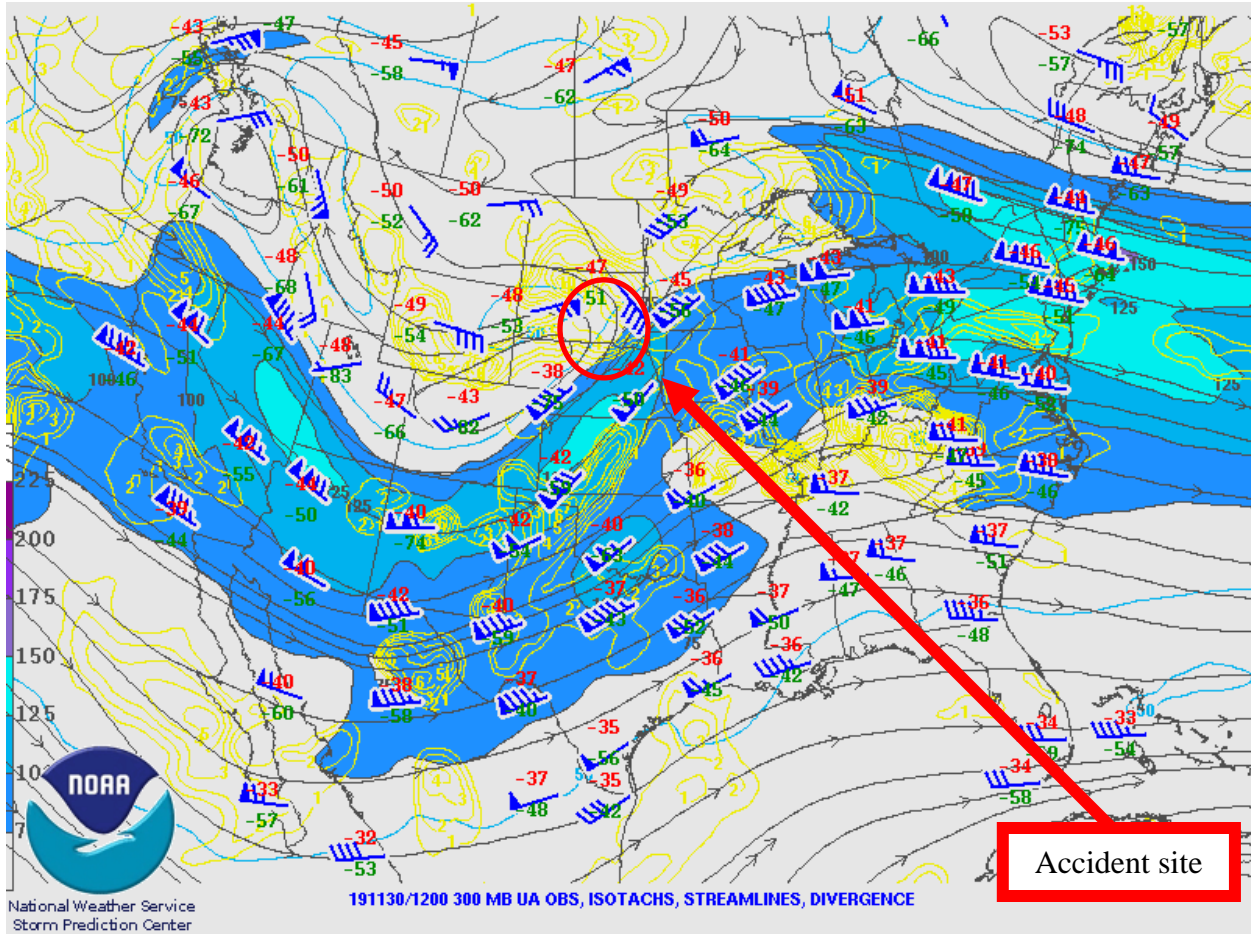


Figure 6 – 300-hPa Constant Pressure Chart for 0600 CST

2.0 Surface Observations

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



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

Chamberlain Municipal Airport (K9V9) had the closest official weather station to the accident site. K9V9 had an Automated Weather Observing System (AWOS³) whose reports were not supplemented. K9V9 was located within a mile of the accident site, at an elevation of 1,696 ft, and had a 5° easterly magnetic variation⁴ (figure 7). The following observations were taken and disseminated during the times surrounding the accident:⁵

- [0955 CST] METAR K9V9 301555Z AUTO 07006KT 1 3/4SM UP OVC005 01/01 A2933
RMK AO2 T00090009=
- [1015 CST] METAR K9V9 301615Z AUTO 06006KT 2SM UP OVC005 01/01 A2933
RMK AO2 T00080008=
- [1035 CST] METAR K9V9 301635Z AUTO 06006KT 3SM BR OVC005 01/01 A2933
RMK AO2 T00090009=
- [1055 CST] METAR K9V9 301655Z AUTO 04006KT 2SM -SN OVC005 01/01 A2933
RMK AO2 T00080008=
- [1115 CST] METAR K9V9 301715Z AUTO 03005KT 1SM -SN OVC005 01/01 A2932
RMK AO2 P0001 T00090009=

³ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting.

⁴ Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

⁵ The bold sections in this NWS product and the rest of the products in this report are intended to highlight the sections that directly reference the weather conditions that affected the accident location around the accident time. The local times in this section next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1135 CST] METAR K9V9 301735Z AUTO 03005KT 3/4SM -SN OVC005 01/01 A2931
RMK AO2 P0002 T00090009=

*[1155 CST] METAR K9V9 301755Z AUTO 02007KT 3/4SM -SN OVC005 01/01 A2930
RMK AO2 P0003 60006 T00080008 10010 20003=*

*[1215 CST] METAR K9V9 301815Z AUTO 02007KT 3/4SM -SN OVC005 01/01 A2930
RMK AO2 T00080008=*

ACCIDENT TIME 1233 CST

*[1235 CST] METAR K9V9 301835Z AUTO 02006KT 1/2SM SN OVC005 01/01 A2930
RMK AO2 T00080008=*

*[1255 CST] METAR K9V9 301855Z AUTO 01007KT 1/2SM SN OVC005 01/01 A2929
RMK AO2 P0001 T00080008=*

[1315 CST] METAR K9V9 301915Z AUTO 01007KT 1/2SM -SN OVC005 01/01 A2929
RMK AO2 T00080008=

[1335 CST] METAR K9V9 301935Z AUTO 01006KT 3/4SM -SN OVC005 01/01 A2930
RMK AO2 T00080008=

K9V9 weather at 1155 CST, automated, wind from 020° at 7 knots, 3/4 miles visibility, light snow, overcast ceiling at 500 ft above ground level (agl), temperature of 1°Celsius (C), dew point temperature of 1°C, and an altimeter setting of 29.30 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, 0.03 inches of precipitation since 1055 CST, 6-hourly precipitation of 0.06 inches of precipitation, temperature 0.8°C, dew point temperature 0.8°C, 6-hourly maximum temperature of 1.0°C, and 6-hourly minimum temperature 0.3°C.

K9V9 weather at 1215 CST, automated, wind from 020° at 7 knots, 3/4 miles visibility, light snow, overcast ceiling at 500 ft agl, temperature of 1°C, dew point temperature of 1°C, and an altimeter setting of 29.30 inHg. Remarks: automated station with a precipitation discriminator, temperature 0.8°C, dew point temperature 0.8°C.

K9V9 weather at 1235 CST, automated, wind from 020° at 6 knots, 1/2 mile visibility, moderate snow, overcast ceiling at 500 ft agl, temperature of 1°C, dew point temperature of 1°C, and an altimeter setting of 29.30 inHg. Remarks: automated station with a precipitation discriminator, temperature 0.8°C, dew point temperature 0.8°C.

K9V9 weather at 1255 CST, automated, wind from 010° at 7 knots, 1/2 mile visibility, moderate snow, overcast ceiling at 500 ft agl, temperature of 1°C, dew point temperature of 1°C, and an altimeter setting of 29.29 inHg. Remarks: automated station with a precipitation discriminator, 0.01 inches of precipitation since 1155 CST, temperature 0.8°C, dew point temperature 0.8°C.

The observations from K9V9 surrounding the accident time indicated LIFR⁶ to IFR⁶ conditions with light to moderate snow with a north to northeast wind between 5 and 10 knots. The 5 minute AWOS data from K9V9 was retrieved and they indicated that 1/2 mile visibility occurred as early as 1225 CST with moderate snow reported as early as 1230 CST (attachment 1)⁷. Snowfall information from the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) was retrieved for the area surrounding the accident site (figure 8). The CoCoRaHS points closest to the accident site indicated that 2.1 and 2.0 inches of snowfall had been observed in the 24 hours prior to 0730 CST and 0700 CST, respectively. Unknown precipitation and drizzle had also been reported at K9V9 in the 24 hours prior to the accident time in both the METARs and 5 minute AWOS data (attachment 1).

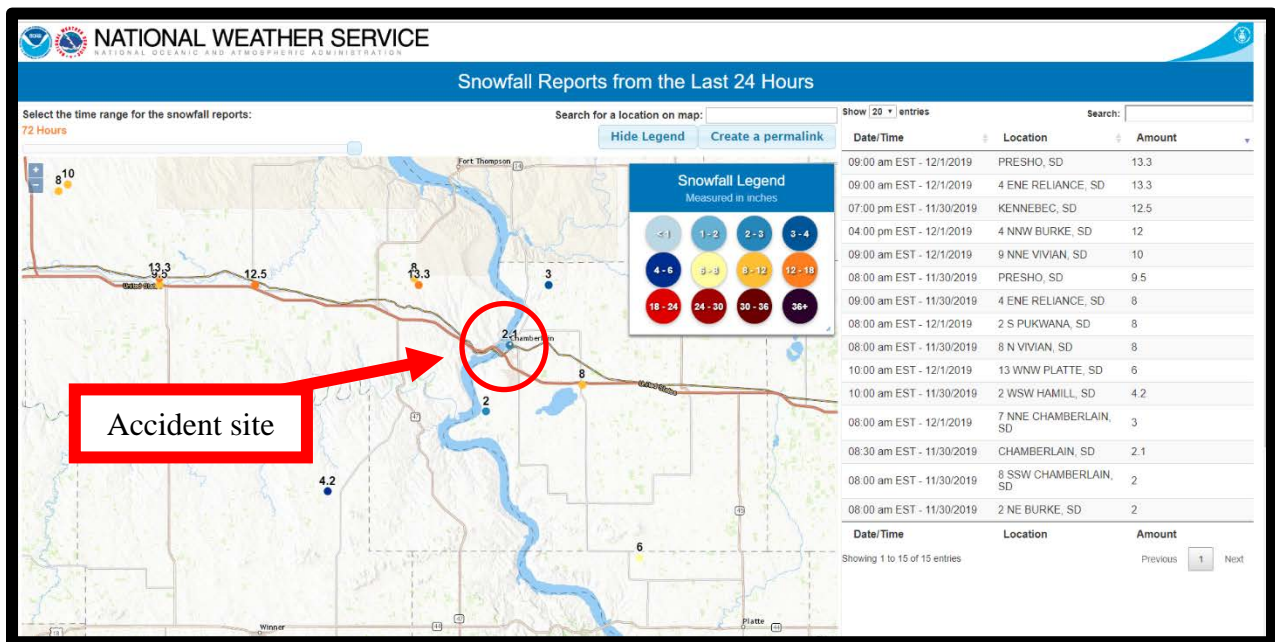


Figure 8 – CoCoRaHS snowfall map from accident area

⁶ 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.

⁷ 1-minute data was not available at this site as K9V9 is an older system and 1-minute data was not available for this model AWOS.

3.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)⁸ model sounding was created for the accident site for 1200 CST with a station elevation of 1,673 ft.⁹ The 1200 CST HRRR sounding was plotted on a standard Skew-T Log P diagram¹⁰ with the derived stability parameters included in figure 9 with data from the surface to 600-hPa (or approximately 13,000 ft msl). These data were analyzed using the RAOB¹¹ software package. The sounding depicted the lifted condensation level (LCL)¹² and the level of free convection (LFC)¹³ at 287 ft agl (1,960 ft msl) and the convective condensation level (CCL)¹⁴ at 683 ft agl (2,320 ft msl). The sounding had a greater than 90% relative humidity from the surface through 10,000 ft msl. The freezing level was located at 156 ft agl (1,829 ft msl). The precipitable water value was 0.48 inches.

⁸ The HRRR is a NOAA real-time three-kilometer (km) 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.

⁹ HRRR sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

¹⁰ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

¹¹ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹² LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹³ 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.

¹⁴ CCL – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

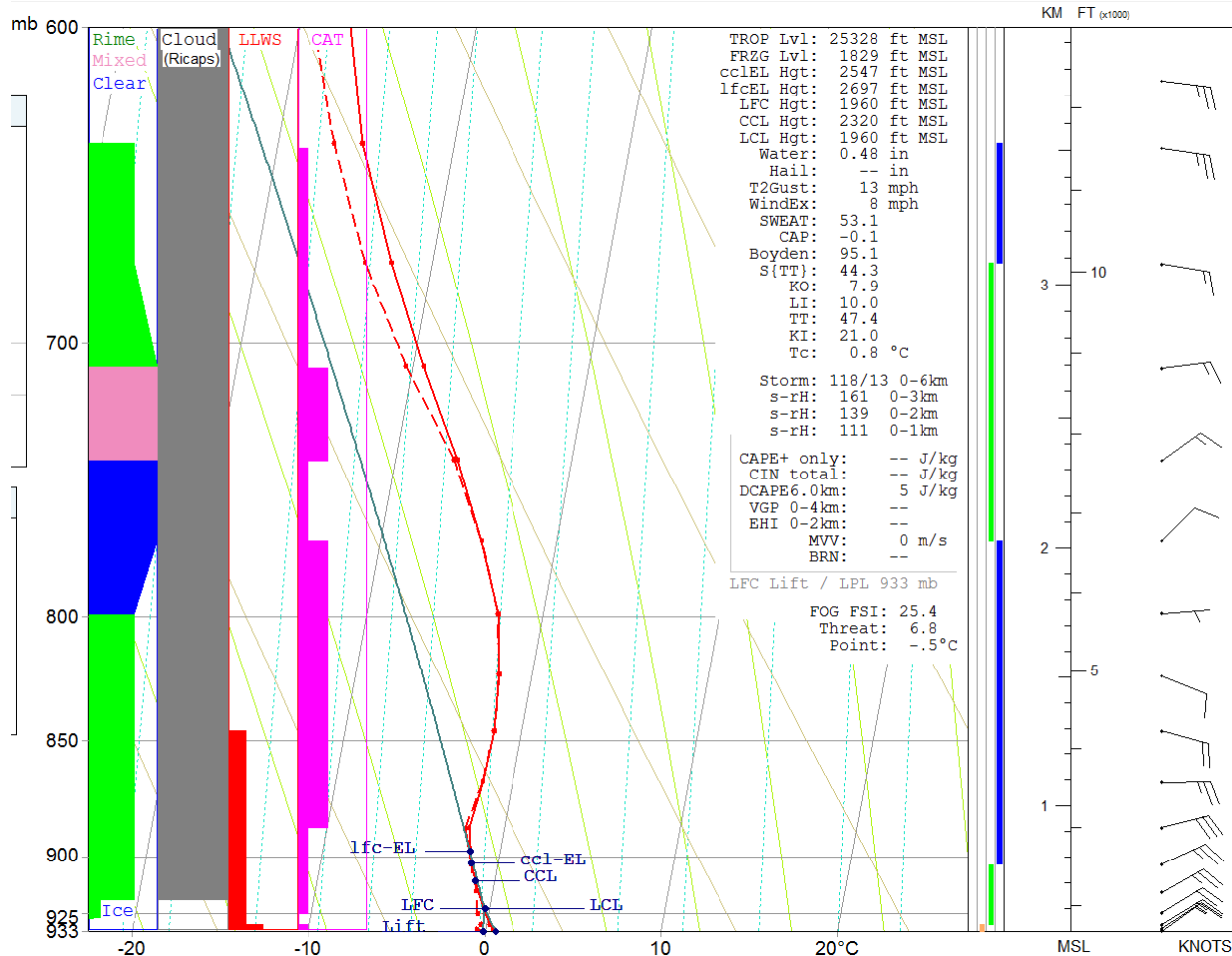


Figure 9 – 1200 CST HRRR sounding

The 1200 CST HRRR sounding indicated layers of conditional instability and instability between the surface and 10,000 ft msl. RAOB identified the possibility of clouds from ~250 ft agl (~1,900 ft msl) through 13,000 ft msl. The potential for moderate or greater rime, mixed, and clear icing was indicated by RAOB between 200 ft agl and 11,500 ft msl.

The 1200 CST HRRR sounding wind profile indicated a surface wind from 053° at 13 knots with an easterly wind through 13,000 ft msl. The wind increased in speed to 20 knots by 200 ft agl with a 30 knot easterly wind by ~1,500 ft agl. RAOB indicated the possibility of light low-level wind shear (LLWS) between the surface and 4,000 ft msl. RAOB indicated a possibility of light to moderate clear-air turbulence between the surface and 11,500 ft msl.

4.0 Satellite Data

The Geostationary Operational Environmental Satellite number 16 (GOES-16) visible and infrared data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. The GOES-16 visible (band 2) and infrared (band 13) imagery at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period from 1000 CST through 1500 CST and reviewed. The closest images to the time of the accident are documented here.

Figure 10 presents the GOES-16 visible imagery from 1230 CST at 2X magnification with the accident site highlighted with a red square. Inspection of the visible imagery indicated overcast cloud cover over the accident site. The cloud cover was relatively stationary above the accident site at the accident time (attachment 2). Figure 11 presents the GOES-16 infrared imagery from 1230 CST at 4X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated overcast cloud cover over the accident site with the lower brightness temperatures (green to yellow colors; higher cloud tops) located above the accident site. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the HRRR sounding, the approximate cloud-top heights over the accident site were 16,000 ft msl at 1230 CST (~temperature of 251 Kelvin). It should be noted these figures have not been corrected for any parallax error.

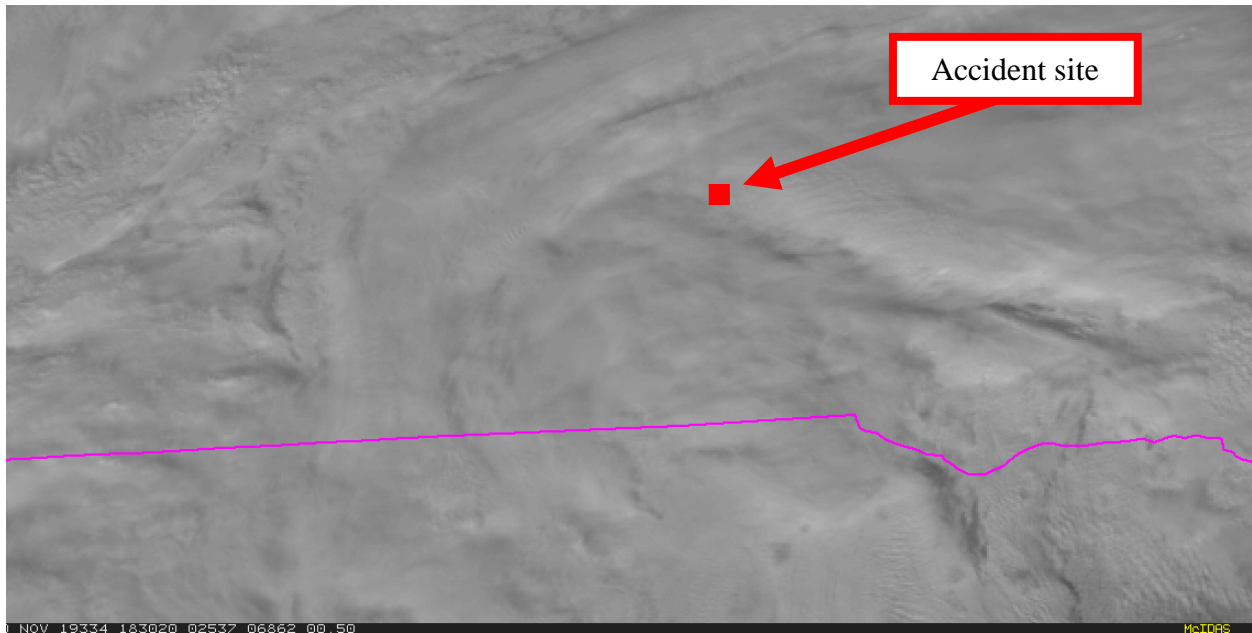


Figure 10 – GOES-16 visible image at 1230 CST

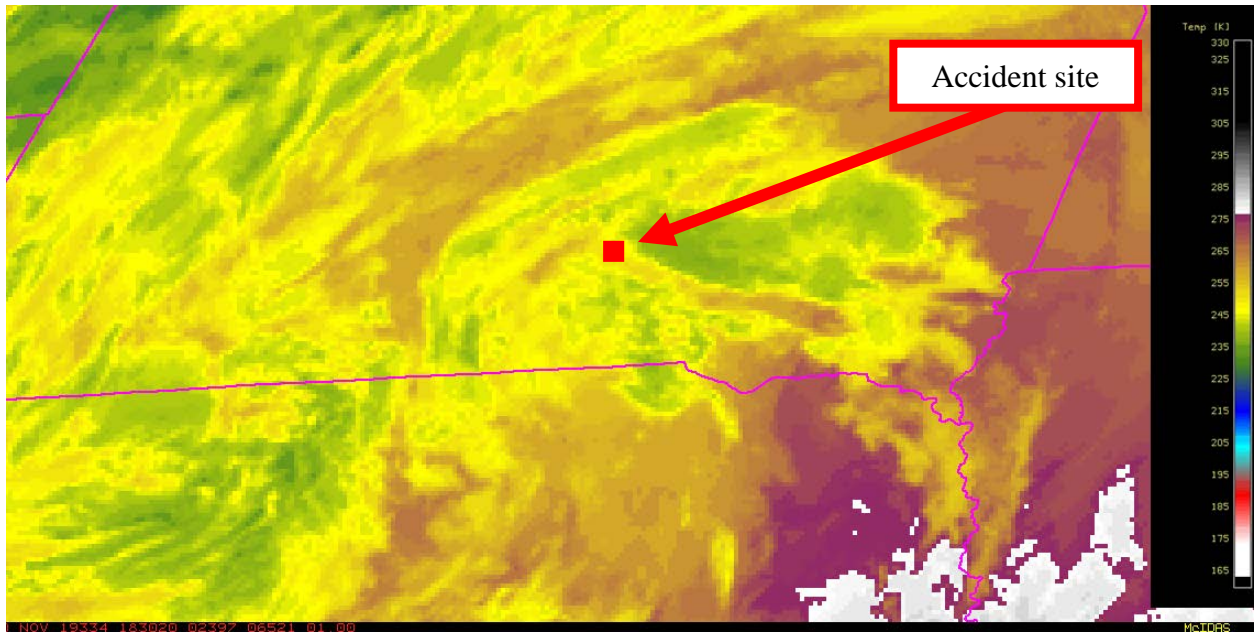


Figure 11 – GOES-16 infrared image at 1230 CST

5.0 Regional Radar Imagery Information

A regional view of the NWS National Composite Radar Mosaic is included as figure 12 for 1235 CST with the approximate location of the accident site marked by a red circle. The image depicted light (section 6.3) precipitation targets above the accident site at the accident time.

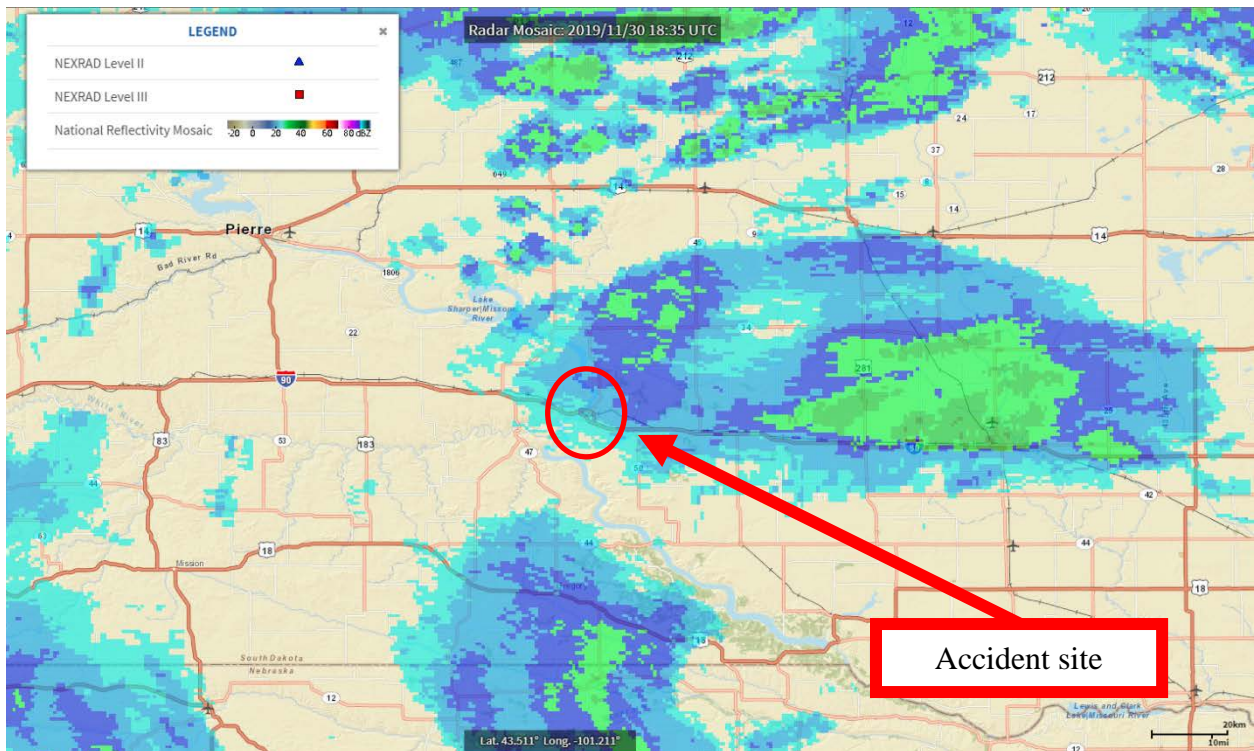


Figure 12 – Regional Composite Reflectivity image for 1235 CST

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁵ to the accident site was from Aberdeen, South Dakota, (KABR) located 108 miles northeast of the accident site. Level II archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

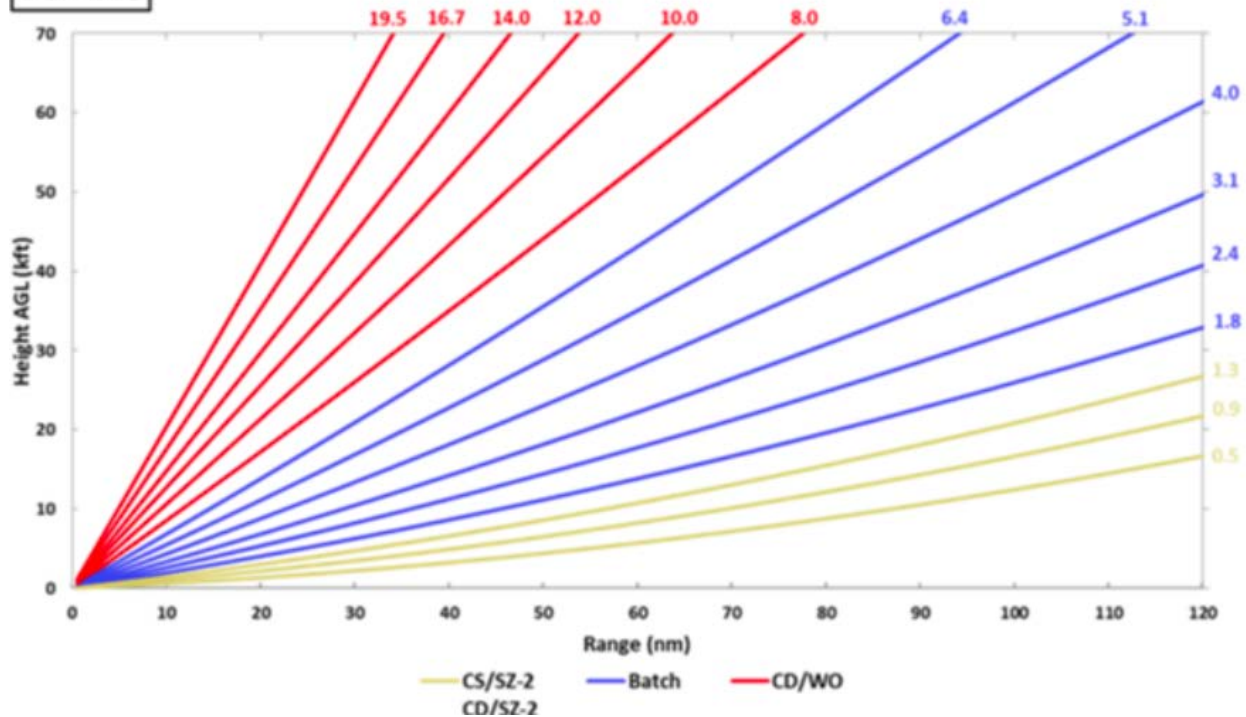
6.1 Volume Scan Strategy

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. Products that require data from multiple elevation scans are not available until the end of the five to ten-minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 215 (VCP-215). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten-minute period. During the period surrounding the accident, the KABR WSR-88D radar was operating in the precipitation mode VCP-215. The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

¹⁵ The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

VCP 215



VCP-215 Precipitation Mode Scan Strategy¹⁶

¹⁶ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured. Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values.

Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

W – With range unfolding (W)

WO – Without range unfolding (WO)

6.2 Beam Height Calculation

Assuming standard refraction¹⁷ of the WSR-88D radar beam with the antenna elevation at 1,383 ft, a distance of 108 miles from the accident location, and considering a beam width¹⁸ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KABR 0.5°	15,570 ft	10,240 ft	20,900 ft

Based on the radar height calculations, the KABR base reflectivity images from the 0.5° elevation scan depicted conditions between 10,240 ft and 20,900 ft msl over the accident site and this scan “saw” the closest altitudes to the surface.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁹ 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 decibel (dBZ²⁰) and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²¹, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

¹⁷ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁸ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

¹⁹ 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 glazed ice.

²⁰ dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

²¹

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible

6.4 Base Reflectivity and Lightning Data

Figures 13 and 14 present the KABR WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1228:56 and 1234:44 CST, respectively, with a resolution of 0.5° X 250 m. The image depicted echoes of 5 to 15 dBZ above the accident site at the accident time.

There were no lightning strikes around the accident site at the accident time.²²

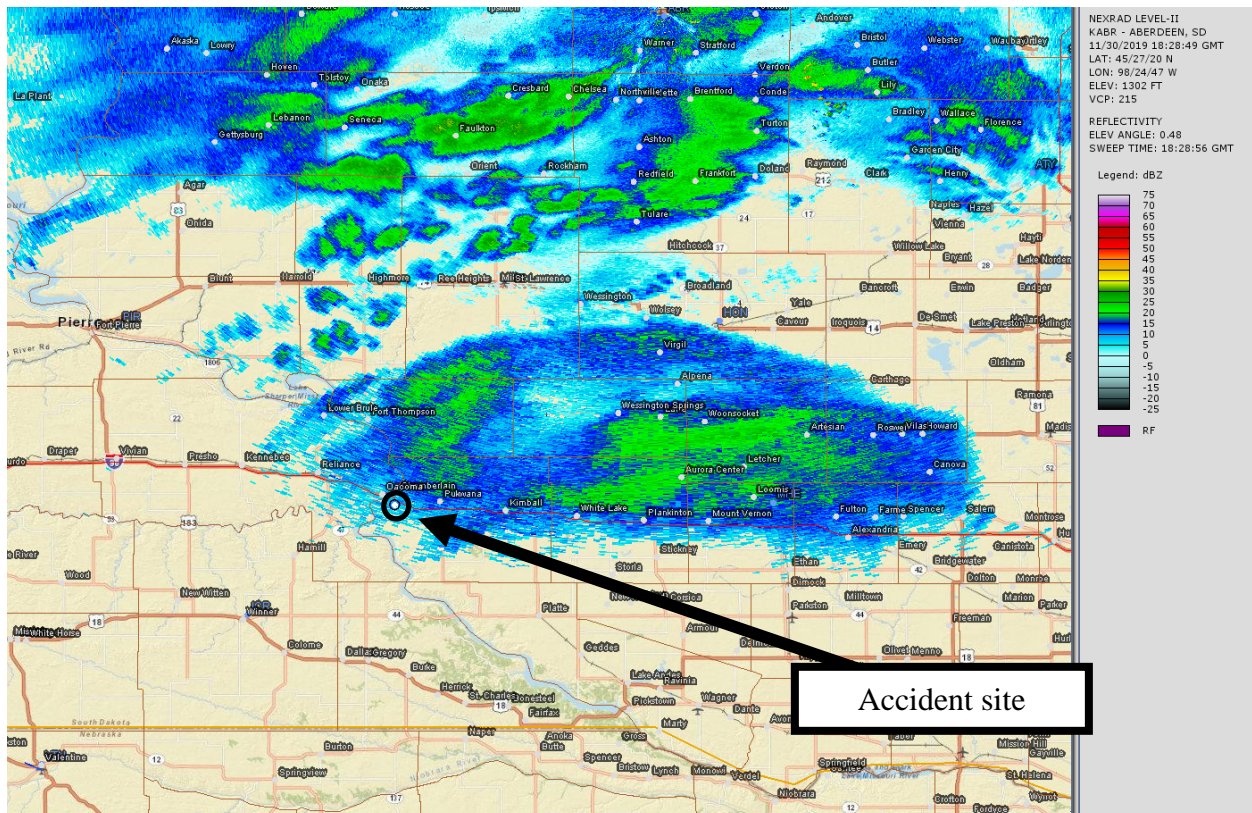


Figure 13 – KABR WSR-88D reflectivity for the 0.5° elevation scan initiated at 1228:56 CST with the accident site marked with black circle

²² A review of Earth Networks Total Lightning network was done.

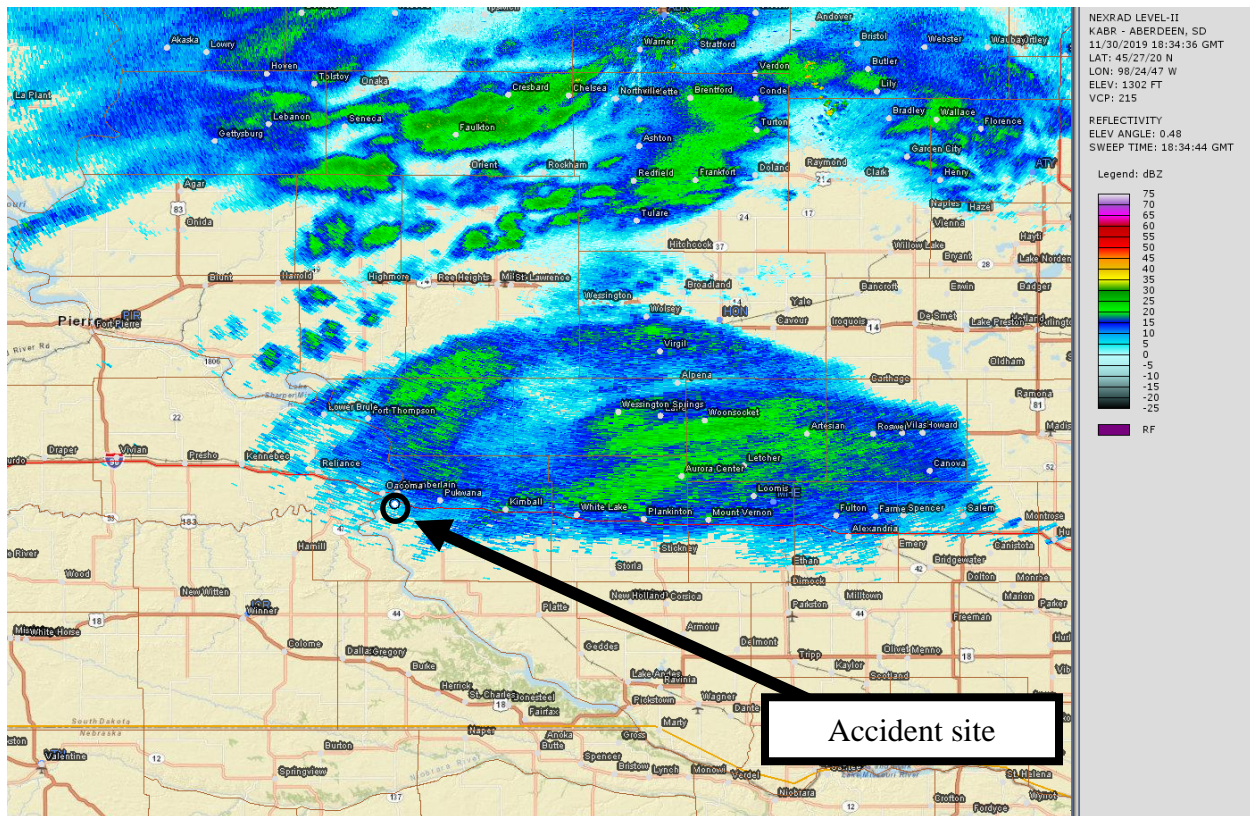


Figure 14 – KABR WSR-88D reflectivity for the 0.5° elevation scan initiated at 1234:44 CST with the accident site marked with black circle

7.0 Pilot Reports²³

There were no pilot reports (PIREPs) within 100 miles of the accident site from about four hours prior to the accident time to about four hours after the accident time

8.0 SIGMET

There were no convective or non-convective Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time.

9.0 CWSU Products

There were no Center Weather Service Unit (CWSU) Center Weather Advisories (CWA) or Meteorological Impact Statement (MIS) valid for the accident site at the accident time.

²³ Only pilot reports with the World Meteorological Organization headers UBSD** and UBNE** were considered.

10.0 AIRMETS

Airmen's Meteorological Information (AIRMET) advisories Tango and Zulu were issued at 0845 CST and an AIRMET Sierra was issued at 1022 CST. These AIRMETS were valid for the accident site at the accident time, and warned of moderate turbulence below 9,000 ft, IFR conditions due to precipitation, mist, fog, and blowing snow, and moderate icing conditions between the freezing level²⁴ and FL220²⁵:

WAUS43 KPCI 301445
WA3T
-CHIT WA 301445
AIRMET TANGO UPDT 4 FOR TURB STG WNDZ AND LLWS VALID UNTIL 302100

...SEE SIGMET WHISKEY SERIES...

AIRMET TURB...ND SD NE KS MN IA MO WI LM LS MI LH IL IN
FROM 70WNW INL TO 80ESE INL TO 30ESE YQT TO 60WNW YVV TO 30SE
ECK TO 20NNE ARG TO RZC TO OSW TO 50W LBL TO GLD TO BFF TO 70SW
RAP TO 70NW RAP TO 50SE MOT TO 70WNW INL
MOD TURB BTN FL180 AND FL400. CONDS CONTG BYD 21Z THRU 03Z.

AIRMET TURB...MI LH IN KY
FROM CVG TO HNN TO HMV TO CVG
MOD TURB BTN FL180 AND FL390. CONDS DVLPG AFT 18Z. CONDS CONTG
BYD 21Z ENDG BY 03Z.

AIRMET TURB...SD NE KS IA MO IL IN KY OK TX AR TN LA MS AL AND
CSTL WTRS
FROM 70SW RAP TO 30ENE BVT TO 30NW LOZ TO 40ENE HRV TO 120SSW
LCH TO 80E BRO TO 90W BRO TO DLF TO INK TO 20ESE TBE TO 50W LBL
TO GLD TO BFF TO 70SW RAP
MOD TURB BLW 140. CONDS CONTG BYD 21Z THRU 03Z.

**AIRMET TURB...ND SD NE MN IA WI LM LS MI IL IN
FROM 70WNW INL TO 50ESE INL TO 60WSW SSM TO FWA TO 30ENE BVT TO
70SW RAP TO 20W ISN TO 60NW MOT TO 70WNW INL
MOD TURB BLW 090. CONDS CONTG BYD 21Z THRU 03Z.**

AIRMET STG SFC WNDZ...MN WI LS MI
FROM 70WSW YQT TO 30SSE YQT TO 60NW SAW TO 70N RHI TO 20SW DLH
TO 70WSW YQT
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 18-21Z.
CONDS CONTG BYD 21Z THRU 03Z.

AIRMET STG SFC WNDZ...SD NE KS OK TX
FROM 80SW DIK TO 70S DIK TO 40S ANW TO 70ESE SLN TO 60SE ICT TO
20WSW SPS TO 40SSE LBB TO 70WSW LBB TO 30ESE TBE TO 50W LBL TO
GLD TO BFF TO 70SW RAP TO 80SW DIK
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG BYD 21Z

²⁴ Freezing level indicated between the surface and 6,000 ft msl in this AIRMET Zulu.

²⁵ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

THRU 03Z.

.
LLWS POTENTIAL...MO IL IN KY OK TX AR TN LA MS AL
BOUNDED BY 30WNW AXC-20ESE AXC-20S CVG-30SSE LOZ-30SSE BNA-40NE
HRV-20S MCB-30N LCH-20SW LCH-30NW IAH-50SE TTT-60S FSM-20NNE COU-
30WNW AXC
LLWS EXP. CONDS CONTG BYD 21Z THRU 03Z.

.
LLWS POTENTIAL...SD NE KS OK TX
BOUNDED BY BFF-40W LBF-40SW OBH-50SSE PWE-50ESE ICT-20N SPS-
40SSW TXO-30ESE TBE-50W LBL-GLD-BFF
LLWS EXP. CONDS ENDG BY 18Z.

.
OTLK VALID 2100-0300Z
AREA 1...TURB SD NE KS OK TX
BOUNDED BY 70NW RAP-40ENE MCK-MLC-SPS-70WSW LBB-30ESE TBE-50W
LBL-GLD-BFF-70SW RAP-70NW RAP
MOD TURB BTN FL180 AND FL420. CONDS DVLPG AFT 21Z. CONDS CONTG
THRU 03Z.

.
AREA 2...TURB ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY OK TX
AR TN LA MS AL
BOUNDED BY 80SE YWG-80ESE INL-40ESE YQT-60WNW YVV-30SE ECK-FWA-
CVG-HNN-HMV-GQO-40WSW MCB-40NW LCH-20NE CWK-70WSW LBB-SPS-MLC-
40ENE MCK-70NW RAP-50SE MOT-80SE YWG
MOD TURB BTN FL180 AND FL400. CONDS CONTG THRU 03Z.

.
AREA 3...TURB SD NE KS IA MO WI LM IL IN KY OK TX AR TN LA MS AL
AND CSTL WTRS
BOUNDED BY 70SW RAP-FWA-CVG-HNN-HMV-GQO-40W CEW-40ENE HRV-120SSE
LCH-120SSW LCH-30E BRO-DLF-INK-20ESE TBE-50W LBL-GLD-BFF-70SW RAP
MOD TURB BLW 140. CONDS CONTG THRU 03Z.

.
AREA 4...TURB ND SD NE MN IA WI LM LS MI LH IL IN
BOUNDED BY 70WNW INL-INL-50ESE INL-50ESE YQT-60NW YVV-40ESE ECK-
FWA-70SW RAP-20W ISN-60NW MOT-70WNW INL
MOD TURB BLW 090. CONDS CONTG THRU 03Z.

.
AREA 5...STG SFC WND S LM MI
BOUNDED BY 50SE GRB-40NNW MKG-30SSW PMM-20NE ORD-50SE GRB
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 00-03Z.
CONDS CONTG THRU 03Z.

....

WAUS43 KPCI 301622 AAA
WA3S
-CHIS WA 301622 AMD
AIRMET SIERRA UPDT 5 FOR IFR AND MTN OBSCN VALID UNTIL 302100

.
**AIRMET IFR...ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY...UPDT
FROM 40NNW INL TO 70NNE SAW TO SSM TO 50ESE SSM TO 40NNE GRB TO
FWA TO CVG TO HNN TO HMV TO 40SE VXV TO 60W ARG TO 30SW MCK TO
30ENE AKO TO BFF TO 70SW RAP TO 50NNW ISN TO 40NNW INL
CIG BLW 010/VIS BLW 3SM PCPN/BR/FG/BLSN. CONDS CONTG BYD 21Z
THRU 03Z.**

AIRMET MTN OBSCN...KY TN
FROM HNN TO HMV TO GQO TO 50WSW LOZ TO HNN
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.

....

WAUS43 KPCI 301445
WA3Z
-CHIZ WA 301445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 302100

AIRMET ICE...IL IN KY
FROM FWA TO CVG TO HNN TO HMV TO 50NE DYM TO 30E STL TO FWA
MOD ICE BTN FRZLVL AND FL220. FRZLVL 040-140. CONDS CONTG BYD 21Z
THRU 03Z.

AIRMET ICE...ND
FROM 70NE MOT TO 50W DIK TO 50NNW ISN TO 70NE MOT
MOD ICE BLW 140. CONDS ENDG 15-18Z.

**AIRMET ICE...ND SD NE KS MN IA MO WI LM LS MI LH IL IN
FROM 70NE MOT TO YQT TO 60W SSM TO 20SSE ECK TO 20S DXO TO FWA TO
30E STL TO 50W IRK TO 30NNW FOD TO 60SSE FSD TO 30NNW PWE TO 20W
SLN TO 50SSE GLD TO 70SW RAP TO 50W DIK TO 70NE MOT
MOD ICE BTN FRZLVL AND FL220. FRZLVL SFC-060. CONDS CONTG BYD 21Z
THRU 03Z.**

OTLK VALID 2100-0300Z...ICE ND SD NE KS MN IA MO WI LM LS MI LH
IL IN
BOUNDED BY 50S YWG-30WNW YQT-20NW SSM-60NW YVV-30E ECK-20SE
DXO-FWA-30SSW IND-40WNW AXC-40W MCW-50NNE MCI-60WSW MCI-50SE
HLC-GLD-70SW RAP-50NNW ISN-50S YWG
MOD ICE BTN FRZLVL AND FL220. FRZLVL SFC-100. CONDS CONTG THRU
03Z.

FRZLVL...RANGING FROM SFC-130 ACRS AREA
MULT FRZLVL BLW 060 BOUNDED BY GLD-20E HLC-30E GCK-80ESE GCK-
20SW AMA-40E TCC-40S LAA-GLD
MULT FRZLVL BLW 120 BOUNDED BY 30SSW DLH-20SW SAW-50SW YVV-
40E ECK-40NE FWA-20E FOD-60ESE LBF-20ESE ANW-40NNW ONL-
30NE FSD-30SSW DLH
MULT FRZLVL BLW 110 BOUNDED BY 20E FOD-ORD-40NE FWA-FWA-50SW
ROD-20ESE IOW-40ENE OVR-30E OBH-20E FOD
SFC ALG 20S GLD-40WNW OBH-40NNE ONL-30WNW FSD-20S MSP-50E GRB-
30E ECK
040 ALG 20S GLD-50ESE HLC-20NW SLN-20NE OVR-40S MCW-FWA
080 ALG OSW-40S BUM-50SSW IOW-40W BDF-IND-50SW ROD
120 ALG 70W ARG-60WNW ARG-30NW PXV-HMV

....

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products available before the accident flight are shown in attachment 3. The GFA surface forecast products indicated LIFR to IFR surface visibilities at the accident site for 1200 CST with G-AIRMET²⁶ Sierra forecast for the accident site. The GFA did not indicate a chance for precipitation, but a surface wind for the north was forecast with wind speeds between 10 to 20 knots. The GFA cloud forecast valid before departure (issued at 0702 and 1002 CST) indicated an overcast cloud ceiling at 1,800 ft msl and clouds tops between 9,000 and 12,000 ft msl with a G-AIRMET Zulu depicted over the accident site. For more information please see attachment 3.

12.0 Terminal Aerodrome Forecast

There were no NWS Terminal Aerodrome Forecast (TAF) located within 50 miles of the accident site.²⁷

13.0 NWS Area Forecast Discussion

The NWS office in Sioux Falls, South Dakota, issued the following Area Forecast Discussion (AFD) at 1144 CST (closest AFD to the accident time). The aviation section of the AFD discussed widespread LIFR to IFR conditions with precipitation and gusty easterly surface winds expected:

FXUS63 KFSD 301744
AFDFSD

AREA FORECAST DISCUSSION
National Weather Service Sioux Falls SD
1144 AM CST Sat Nov 30 2019

.SHORT TERM...(Today through Sunday)
Issued at 327 AM CST Sat Nov 30 2019

About as messy and complex as a forecast gets over the next 24 to 36 hours with multiple precipitation types, precipitation regimes, and winter hazards.

Pronounced upper level low and associated surface reflection responsible for all of this is currently leaking into the Nebraska Panhandle with broad DivQ and isentropic lift allowing waves of precipitation to lift through the region. This surface low will trek largely down the I-80 corridor through the day ending up somewhere near or in between Omaha and Sioux City by evening. As it does so, it will continue to deepen with NAEFS guidance pointing toward SLP approaching climatological minimums.

Dry slot will begin to wrap into the area by mid to late morning and continue into the afternoon with the DGZ drying out. This will likely switch much of the precipitation east of the James River over to more of a drizzle/freezing drizzle, although soundings hint at a

²⁶ G-AIRMET, graphical AIRMETs. May differ in space from text AIRMET product.

²⁷ <https://www.nws.noaa.gov/directives/sym/pd01008013curr.pdf>

bit of instability atop of the saturated layer and thus may see occasional showers in the mix.

Meanwhile, a pronounced trough on the 850 mb thetaE surface will pull into areas near/west of the James River keeping more bonafide precipitation alive. This feature will collapse eastward overnight, weakening as it does so. Even so, winds will be on the increase as the tighter pressure gradient on the back side of the low begins to work in to the region.

Precipitation Type: A headache to say the least trying to work through the various precipitation scenarios. Forecast soundings in many locations generally run right on or a degree or so either side of the freezing mark through the saturated layer leaving about any type of wintry precip type in play. Additionally surface temperatures have largely done the same thing, sitting a degree or so either side of the freezing mark. SREF probabilities would suggest chances of snow for locations along the I-90 corridor will be on the decrease thru the remainder of the overnight with a cold rain or freezing rain becoming more favorable. Snow is more favored for our James River and west counties. Temperatures along the Buffalo Ridge may hold just a touch colder and thus a bit more concern for icing in those locations. In fact, dProg/dt ice amounts off from the super ensemble viewer have showed a constant uptick in ice amounts for locations such Worthington up to Pipestone over the past 24 hours of model runs. Elsewhere surface temperatures may warm just above the freezing mark thru the day Saturday for any drizzle/rain that may fall. As any warm layer gets scoured out by late afternoon and evening, should see a transition to all snow.

Amounts: Again, making the distinction between the different precipitation types will likely lead to errors in overall amounts of both ice and snow but would expect a light glaze to tenth of an inch of ice to be possible for most location thru early afternoon. Areas near or along the Buffalo Ridge would stand a better chance at amounts approaching the quarter inch mark, and while confidence in its occurrence is low, some guidance even suggest this could be exceeded. Snow amounts west of the James River and north of Hwy 14 should top half a foot with generally 1 to 4 inches elsewhere.

Winds: Breezy easterly winds for the first half of today will subside for a period as the surface low works over. By this evening and overnight, will see increasing northwesterly winds with gusts in the 30 to 45+ mph range certainly possible. Forecast winds in this package are generally near or even above the 75th percentile of guidance. These will no doubt lead to issues with blowing snow and greatly reduced visibility, especially during periods of falling snow. With that said, both the blowing snow model and HREF blizzard probabilities keep the risk for reaching blizzard conditions fairly low.

Headlines: Going headlines look largely ok with western segment of the Advisory dropping off around daybreak as temperatures warm just above freezing. SW Minnesota segment will likely need to be maintained thru the day with some locations staying below the freezing mark. Have added in Charles Mix and Douglas counties to the

Warning given combination of expected snowfall and wind. The remainder of the area will likely need a Winter Weather Advisory for this evening and overnight hours with the expectation of falling snow and strong winds creating issues with reduced visibility. After coordinating with neighboring offices will hold off on issuing this advisory to keep simplicity with ongoing headlines. The one exception is from Mitchell down toward Yankton where snow may start a bit sooner and thus will go with an advisory with this forecast package.

.LONG TERM...(Sunday Night through Friday)
Issued at 327 AM CST Sat Nov 30 2019

Upper level low will have pulled into IL and WI by Sunday morning with some lingering snow showers possible thru the first half of the day across our area. Winds will remain elevated, gradually diminishing as time goes on. Temperatures will likely be stuck in the mid 20s to near 30 with a fresh snowpack on the ground.

With the active weather in the near term, minimal time was spent on the extended portions of the forecast. Upper level ridge will build to our west early in the week with no significant systems apparent as this time. Afternoon temperatures will slowly moderate back into the 30s to lower 40s.

&&

.AVIATION...(For the 18Z TAFS through 18Z Sunday afternoon)
Issued at 1144 AM CST Sat Nov 30 2019

Widespread IFR-LIFR conditions across much of the region, with low stratus, fog and drizzle to start the period. Precipitation will transition to snow as gusty easterly winds swing around to the north and increase further through the afternoon and evening. Areas of blowing snow will further reduce visibility in locations which receive appreciable snowfall. Visibility expected to slowly improve after daybreak Sunday, as the system begins to pull east, but MVFR-IFR stratus and strong northerly winds are expected to linger through the end of this TAF period.

&&

.FSD WATCHES/WARNINGS/ADVISORIES...
SD...Winter Weather Advisory from 3 PM this afternoon to noon CST Sunday for SDZ059-060-065-068-069.

Winter Storm Warning until noon CST Sunday for SDZ038>040-052>055-057-058.

Winter Weather Advisory until noon CST today for SDZ050-063-064.

Winter Storm Warning until noon CST Sunday for SDZ050-063-064.

Winter Weather Advisory until 6 PM CST this evening for SDZ056.

MN...Winter Storm Warning until noon CST Sunday for MNZ071-072.

Winter Weather Advisory until 6 PM CST this evening for MNZ080-081-089-090-097-098.

IA...NONE.
NE...NONE.
&&

\$\$

14.0 NWS Winter Weather Advisory

The NWS office in Sioux Falls, South Dakota, issued the following winter weather warnings at 0602 and 1200 CST. The winter weather warnings warned of heavy mixed precipitation at the surface with winds gusting to 40 miles per hour (mph) and these winter conditions expected to continue through 1200 CST on December 1:

MNZ071-072-SDZ038>040-052>055-057-058-010200-
/O.CON.KFSD.WS.W.0007.000000T0000Z-191201T1800Z/
Lincoln-Lyon-Beadle-Kingsbury-Brookings-Jerauld-Sanborn-Miner-
Lake-Brule-Aurora-
1200 PM CST Sat Nov 30 2019

...WINTER STORM WARNING REMAINS IN EFFECT UNTIL NOON CST SUNDAY...

- * WHAT...Heavy mixed precipitation. Additional snow accumulations of 3 to 5 inches and ice accumulations of around one tenth of an inch. Winds gusting as high as 40 mph.
- * WHERE...Portions of central, east central and south central South Dakota and southwest Minnesota.
- * WHEN...Until noon CST Sunday.
- * IMPACTS...Travel could be very difficult. Patchy blowing snow could significantly reduce visibility.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

If you must travel, keep an extra flashlight, food, and water in your vehicle in case of an emergency.

The latest road conditions for the state you are calling from can be obtained by calling 5 1 1.

&&

\$\$

MNZ071-072-SDZ038>040-052>055-057-058-302015-
/O.CON.KFSD.WS.W.0007.000000T0000Z-191201T1800Z/
Lincoln-Lyon-Beadle-Kingsbury-Brookings-Jerauld-Sanborn-Miner-
Lake-Brule-Aurora-
602 AM CST Sat Nov 30 2019

...WINTER STORM WARNING REMAINS IN EFFECT UNTIL NOON CST SUNDAY...

* WHAT...Heavy mixed precipitation. Additional snow accumulations of 3 to 5 inches and ice accumulations of around one tenth of an inch. Winds gusting as high as 40 mph.

* WHERE...Portions of central, east central and south central South Dakota and southwest Minnesota.

* WHEN...Until noon CST Sunday.

* IMPACTS...Travel could be very difficult. Patchy blowing snow could significantly reduce visibility.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

If you must travel, keep an extra flashlight, food, and water in your vehicle in case of an emergency.

The latest road conditions for the state you are calling from can be obtained by calling 5 1 1.

&&

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15.0 Winds and Temperature Aloft Forecast

The NWS 0755 CST Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

```
FBUS31 KWNO 301355
FD1US1
DATA BASED ON 301200Z
VALID 301800Z   FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT 3000    6000    9000    12000    18000    24000    30000    34000    39000
PIR      1017-06 0815-09 0816-14 0747-26 0559-35 073643 101845 180845
```

The accident site was located closest to the Pierre, South Dakota, (PIR) forecast point. The 0755 CST PIR forecast for use between 0800 CST and 1500 CST indicated a wind at 6,000 ft from 100° at 17 knots with a temperature of -6°C and a wind at 9,000 ft from 080° at 15 knots with a temperature of -9°C.

16.0 Pilot Weather Briefing

The accident pilot did not request nor receive a weather briefing from Leidos or ForeFlight.

The accident pilot requested and received flight plan and weather information at 1204 CST through FltPlan.com.²⁸ The weather information contained the latest K9V9 METAR information, TAF from KPIR, enroute PIREPs, and other nearby and enroute METARs and TAFs. For more information please see attachments 4 and 5. There is no record of the accident pilot receiving or retrieving any other weather information before or during the accident flight.

17.0 Astronomical Data

The astronomical data obtained for the accident site on November 30, 2019, indicated the following:

SUN	
Begin civil twilight	0718 CST
Sunrise	0750 CST
Sun transit	1226 CST
Accident time	1233 CST²⁹
Sunset	1702 CST
End civil twilight	1734 CST

E. LIST OF ATTACHMENTS

Attachment 1 – 5 minute AWOS dataset from K9V9

Attachment 2 – GOES-16 Visible satellite animation from 1106 to 1306 CST

Attachment 3 – GFA products valid for the accident flight

Attachment 4 – FltPlan.com correspondence

Attachment 5 – FltPlan.com pre-flight weather information

²⁸ <https://fltplan.com/>

²⁹ Inserted accident time for reference and context.

Submitted by:

Paul Suffern
Senior Meteorologist

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