



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 25, 2019

Weather Study

METEOROLOGY

CEN20FA010

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A. ACCIDENT

Location: Aberdeen, South Dakota
Date: October 9, 2019
Time: 2235 central daylight time
0335 Coordinated Universal Time (UTC) October 10, 2019
Aircraft: Cessna 172; Registration: N6483B

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 daylight time (CDT) based upon the 24-hour clock, where local time is -5 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. 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.

The accident site was located at latitude 45.5617° N, longitude 98.4603° W at an approximate elevation of 1,329 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction 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 "Aviation Weather Services", AC 00-45H.¹

¹

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030

1.1 Surface Analysis Chart

The northcentral United States section of the NWS Surface Analysis Chart for 2200 CDT is provided as figure 1 with the location of the accident site marked within the red circle. The chart indicated a low pressure system over northern Minnesota with a pressure of 1009-hectopascals (hPa). A cold frontal boundary stretched from the low pressure center southward into southeastern South Dakota and continued southward into Nebraska and Kansas. The accident site was located west of the cold front on the cold side of the frontal boundary.

The station models around the accident site depicted air temperatures in the low 40's degrees Fahrenheit (°F), dew point temperatures in the low 40's °F with a temperature-dew point spread of 3° or less, a north wind at 15 knots, overcast cloud cover and light rain.

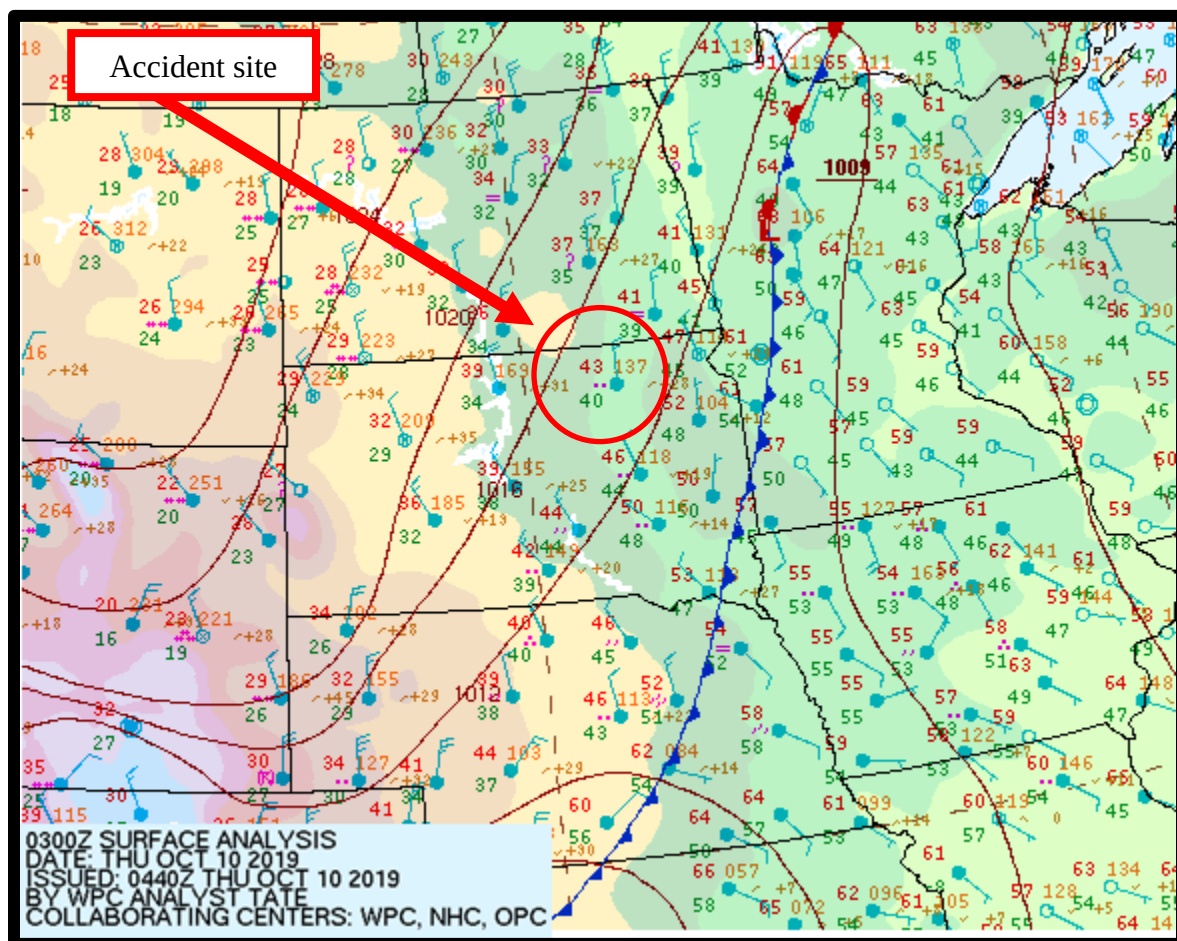


Figure 1 – NWS Surface Analysis Chart for 2200 CDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1900 CDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There was a low- and mid-level trough² located near and above the accident site at 925-, 850-, 700-, and 500-hPa. Upper level troughs are the support for the surface pressure system and fronts aloft, and can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. The wind was from the north at 15 knots at 925-hPa (figure 2) with the wind becoming southerly at 20 knots by 700-hPa (figure 4). At 300-hPa, the wind was from the southwest at 45 knots (figure 6).

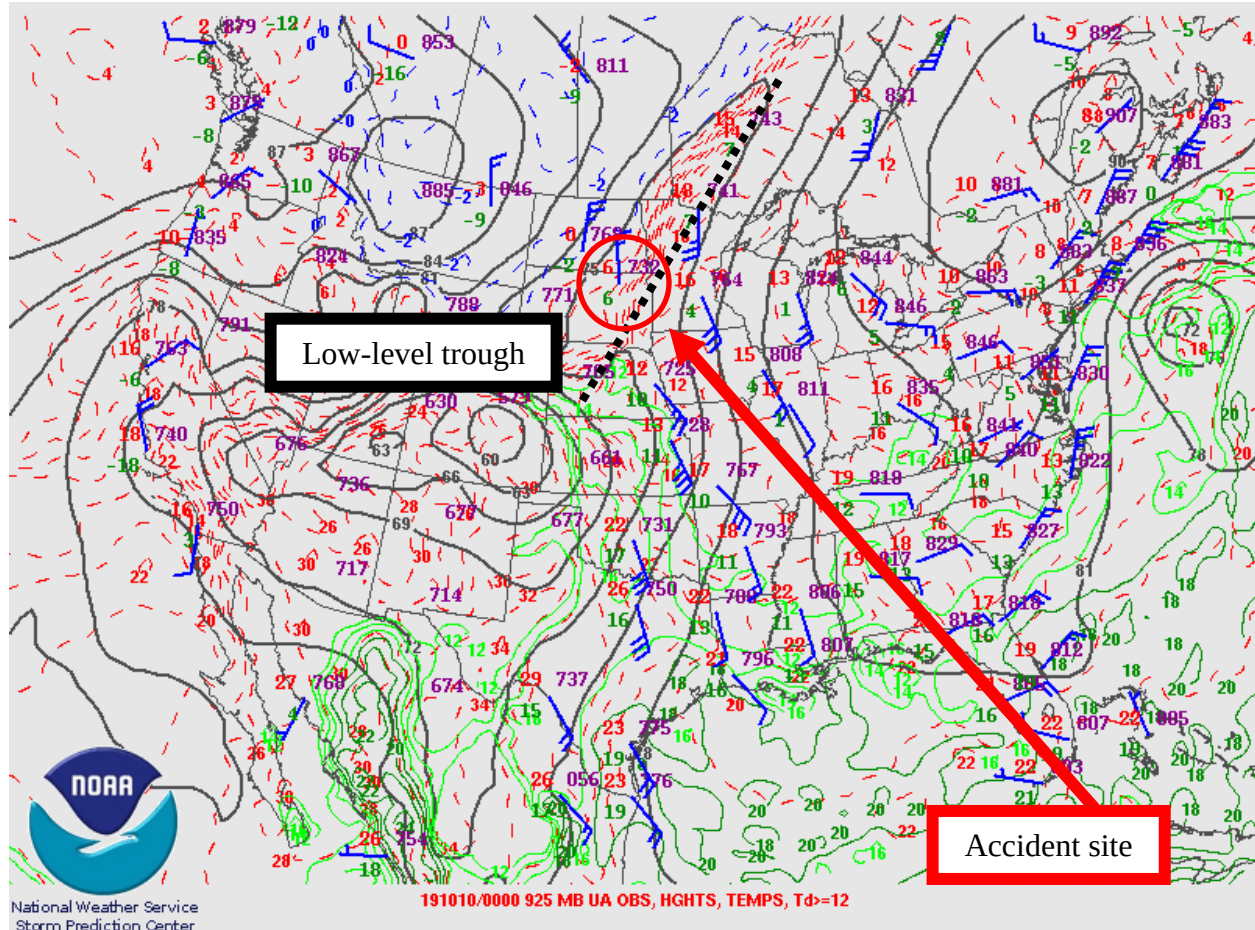


Figure 2 – 925-hPa Constant Pressure Chart for 1900 CDT

² Trough – An elongated area of relatively low atmospheric pressure or heights.

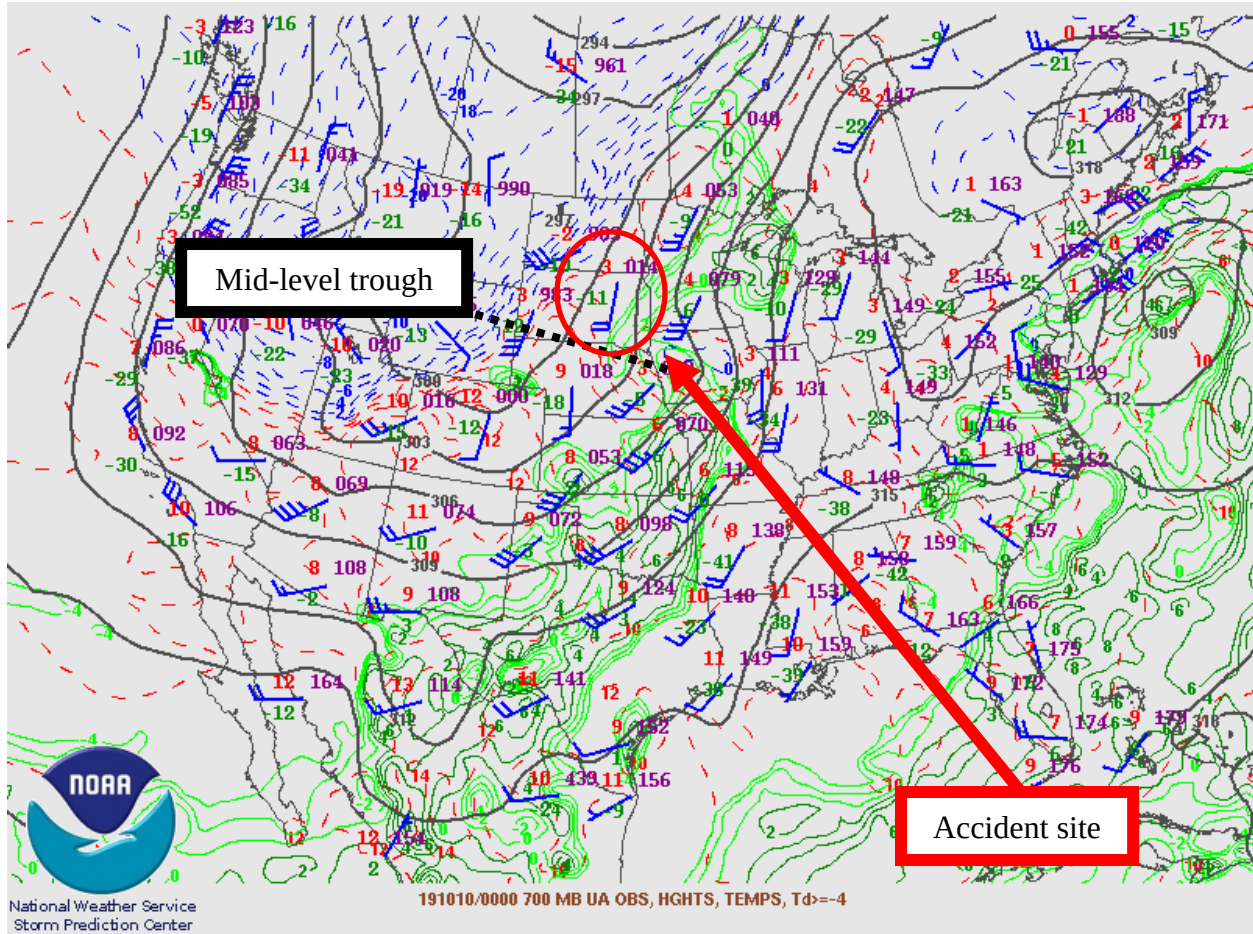


Figure 4 – 700-hPa Constant Pressure Chart for 1900 CDT

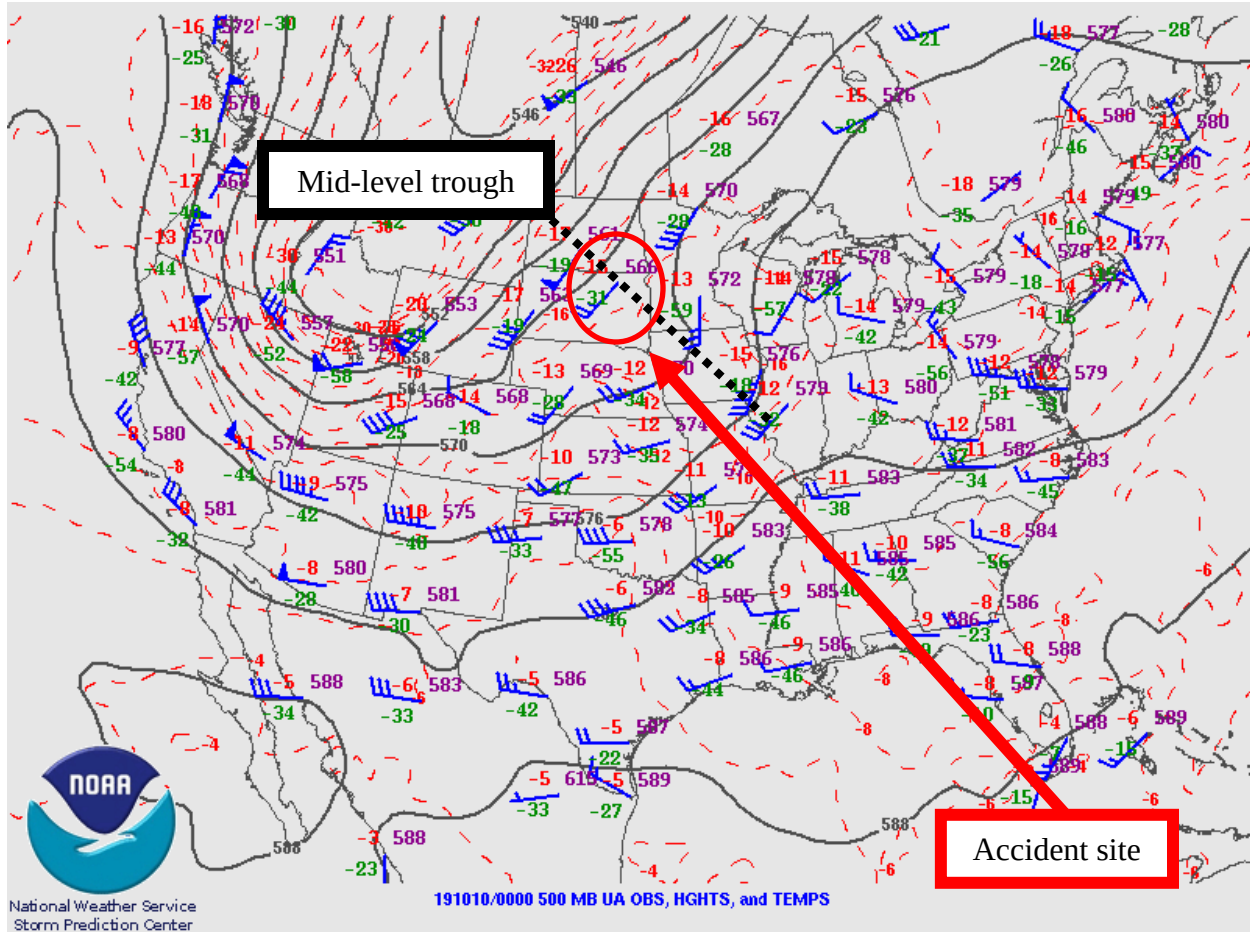


Figure 5 – 500-hPa Constant Pressure Chart for 1900 CDT

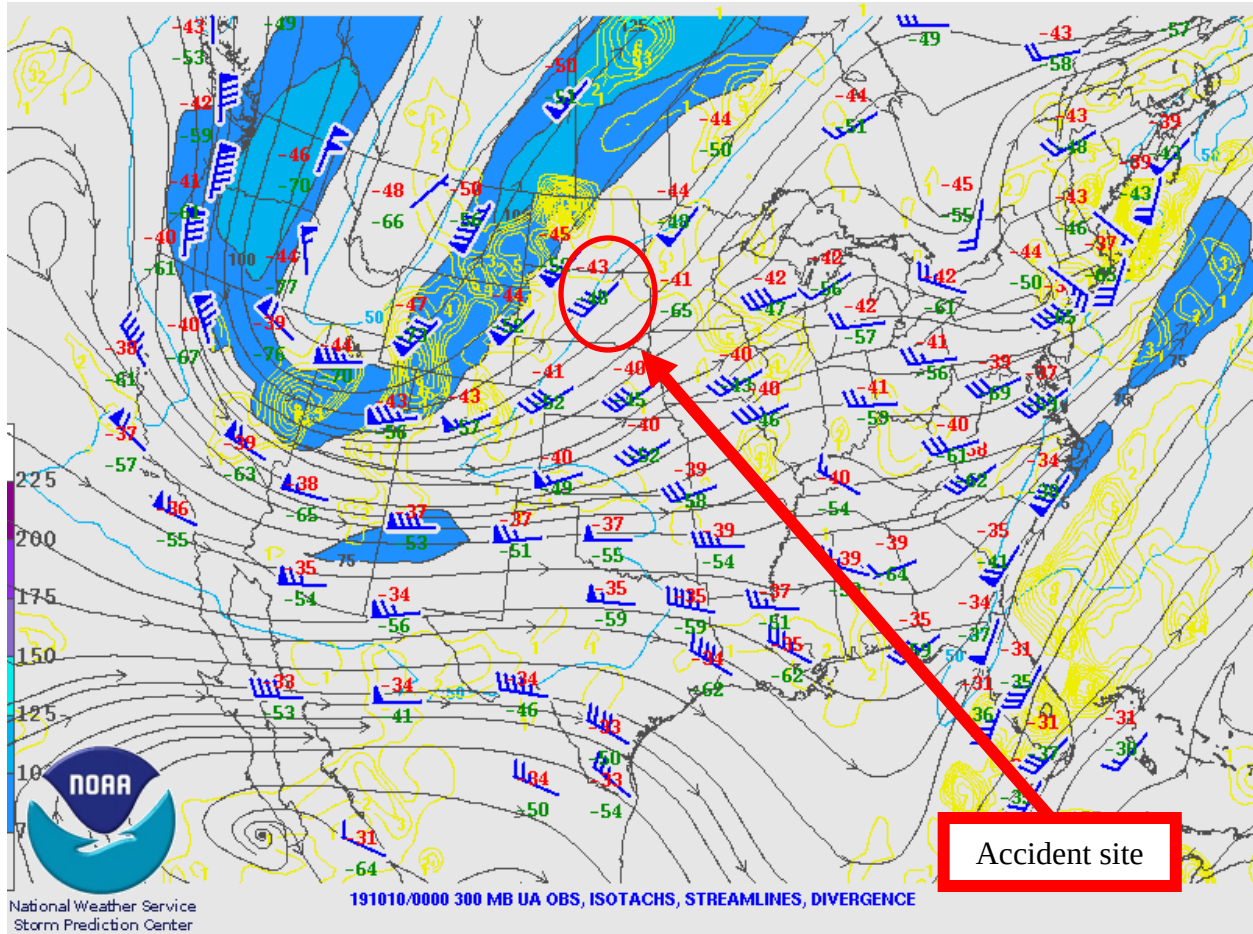


Figure 6 – 300-hPa Constant Pressure Chart for 1900 CDT

2.0 SPC Products

SPC issued the following Day 1 Convective Outlook at 1958 CDT (figure 7) with areas of general thunderstorms forecast for the accident site. SPC defines the “TSTM” area as an area that encloses where a 10% or higher probability of thunderstorms is forecast during the valid period. The SPC Day 1 Convective Outlook text follows figure 7:

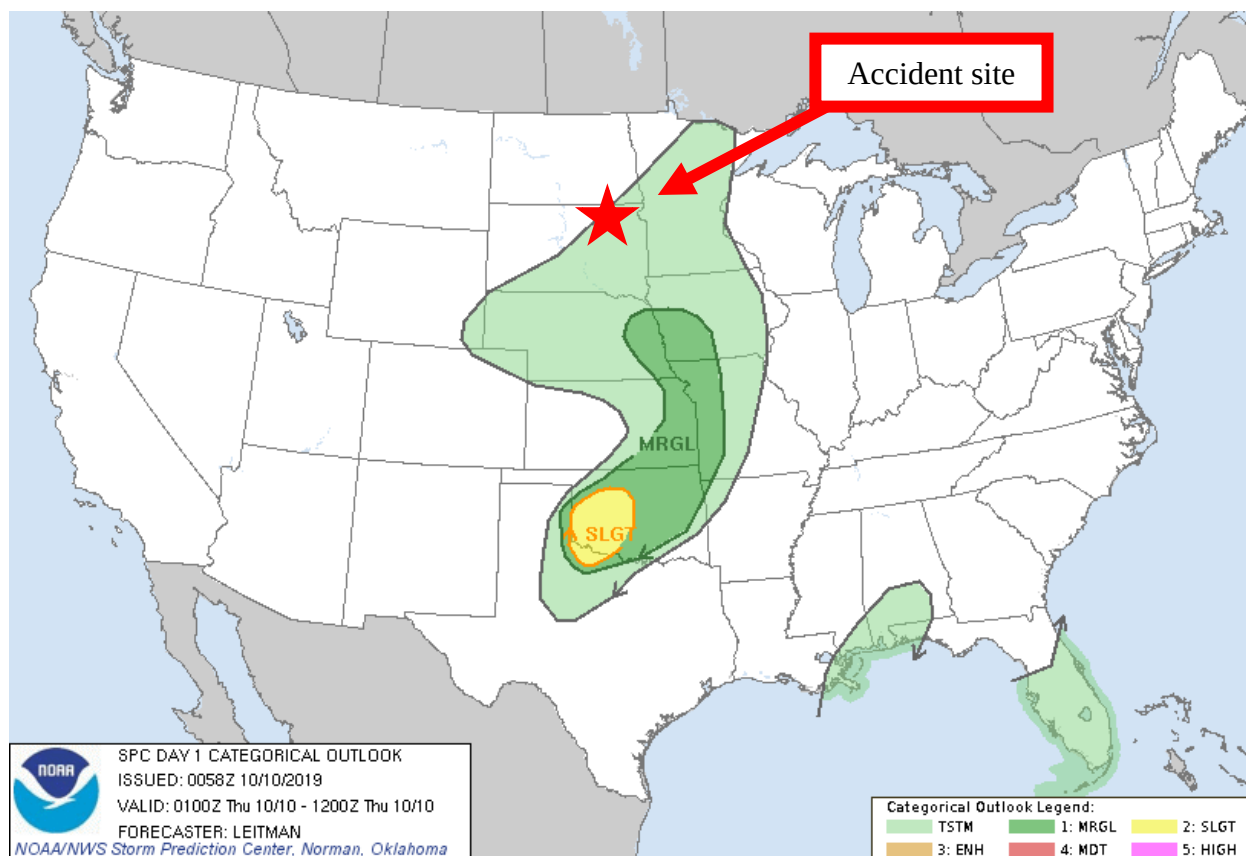


Figure 7 – SPC day 1 Convective Outlook valid at the time of the accident

SPC AC 100058

Day 1 Convective Outlook
 NWS Storm Prediction Center Norman OK
 0758 PM CDT Wed Oct 09 2019

Valid 100100Z - 101200Z

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS ACROSS PARTS OF
 SOUTHWEST AND CENTRAL OK AND VICINITY THROUGH LATE EVENING...

...SUMMARY...

Supercells capable of large hail and isolated damaging winds will be possible for several more hours tonight, mainly across western into central Oklahoma. More isolated large hail may occur overnight into the middle Missouri Valley.

...Western/Central OK Vicinity...

Widely scattered strong to severe thunderstorms are ongoing this evening across the extreme eastern TX Panhandle into southwest OK. The 00z OUN RAOB showed steep lapse rates above a weak capping inversion around 850 mb, with another warm layer around 500 mb. While there have been a few severe thunderstorm warnings across the region within Severe Thunderstorm Watch 672, these warm layers may be inhibiting more robust, sustained updrafts and hence, a lack of

reports greater than 1 inch so far this evening. Nevertheless, favorable shear and MLCAPE approaching 2000 J/kg will support potential for large hail and isolated damaging winds for a few more hours this evening as storms track northeast. As storms approach the I-35 corridor toward 04-05z, weakening is expected.

Elsewhere, the Marginal risk has been slightly adjusted based on latest hi-res guidance and observed data, but overall forecast philosophy remains unchanged. As warm advection and a southerly low level jet increases across the mid-MO Valley overnight, isolated hail will be possible from elevated thunderstorms.

..Leitman.. 10/10/2019

[CLICK TO GET WUUS01 PTSDY1 PRODUCT](#)

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 0600Z

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 8 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked.

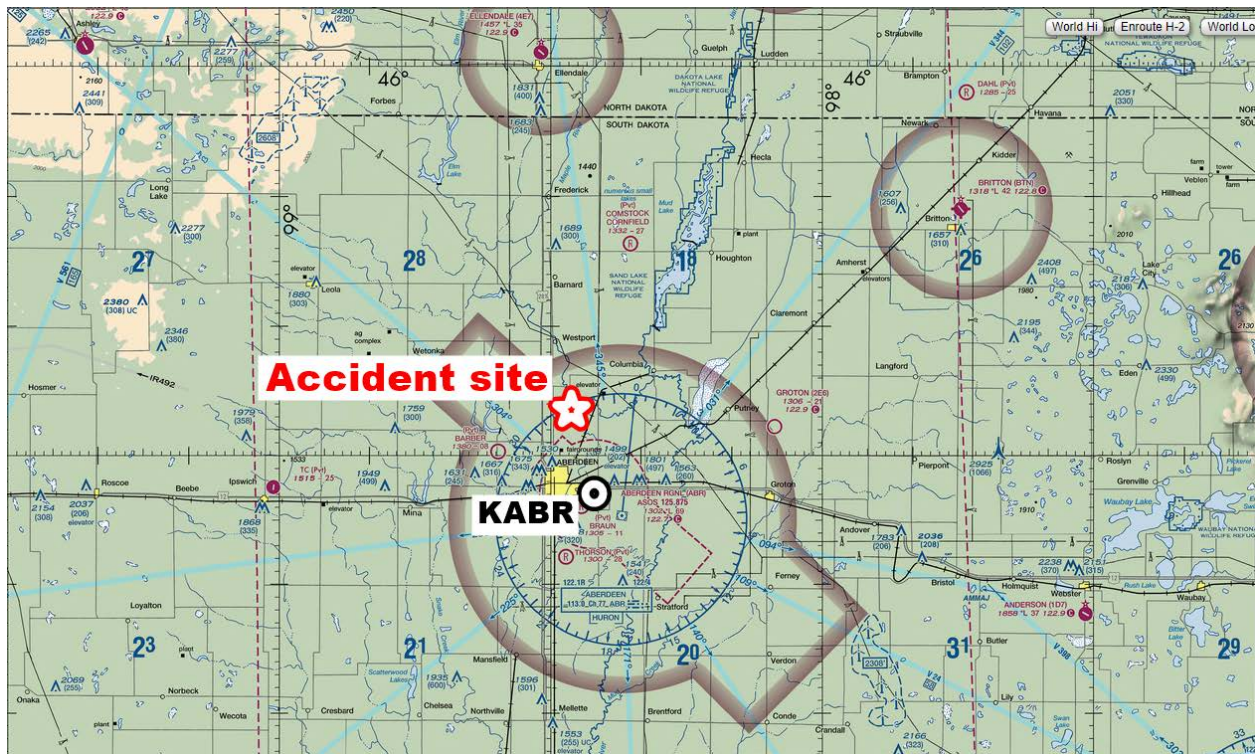


Figure 8 – Sectional chart of accident area with the location of the accident site and the closest surface observation site

The closest official weather reporting facility to the accident site was from Aberdeen Regional Airport equipment (KABR), at an elevation of 1,302 ft, and was 7 miles south-southeast of the accident site (figure 8). KABR had an Automated Surface Observing System (ASOS³) whose reports were not supplemented and had a 5° easterly magnetic variation⁴. The following observations were taken and disseminated during the times surrounding the accident:⁵

[1744 CDT] SPECI KABR 092244Z AUTO 33014KT 9SM OVC009 10/08 A2980 RMK AO2 T01000078=
[1753 CDT] METAR KABR 092253Z AUTO 34014KT 8SM OVC009 10/08 A2981 RMK AO2 SLP096 T01000078=
[1853 CDT] METAR KABR 092353Z AUTO 34018G22KT 5SM -RA BR OVC006 08/07 A2984 RMK AO2 RAB27 SLP107 P0000 60000 T00780067 10144 20078 52035=
[1953 CDT] METAR KABR 100053Z AUTO 36014G22KT 10SM OVC009 07/05 A2987 RMK AO2 RAE11 SLP119 P0000 T00720050=
[2053 CDT] METAR KABR 100153Z AUTO 36015G25KT 5SM -RA BR OVC008 07/05 A2990 RMK AO2 RAB46 SLP130 P0000 T00670050=
[2153 CDT] METAR KABR 100253Z AUTO 36015G24KT 4SM -RA BR BKN008 OVC012 06/04 A2992 RMK AO2 SLP137 P0001 60001 T00610044 51028=

ACCIDENT TIME 2235 CDT

[2253 CDT] METAR KABR 100353Z AUTO 35019G27KT 7SM -RA BKN007 OVC014 05/03 A2994 RMK AO2 PK WND 34027/0352 SLP144 P0001 T00500033 \$=
[2300 CDT] SPECI KABR 100400Z AUTO 36014G27KT 9SM -RA SCT007 OVC014 05/03 A2995 RMK AO2 P0000 T00500033 \$=
[2307 CDT] SPECI KABR 100407Z AUTO 36012G22KT 7SM BKN007 OVC014 05/03 A2995 RMK AO2 RAE03 P0000 T00500033 \$=

KABR weather at 2153 CDT, automated, wind from 360° at 15 knots with gusts to 24 knots, 4 miles visibility, light rain, mist, a broken ceiling at 800 ft above ground level (agl), overcast skies at 1,200 ft agl, temperature of 6°Celsius (C), dew point temperature of 4°C, and an altimeter setting of 29.92 inches of mercury (inHg). Remarks: station with a precipitation discriminator, sea level

³ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

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

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

pressure 1013.7 hPa, 0.01 inches of precipitation since 2053 CDT, 6-hourly precipitation of 0.01 inches, temperature 6.1°C, dew point temperature 4.4°C, 3-hourly pressure increase of 2.8 hPa.

KABR weather at 2253 CDT, automated, wind from 350° at 19 knots with gusts to 27 knots, 7 miles visibility, light rain, a broken ceiling at 700 ft agl, overcast skies at 1,400 ft agl, temperature of 5°C, dew point temperature of 3°C, and an altimeter setting of 29.94 inHg. Remarks: station with a precipitation discriminator, peak wind from 340° at 27 knots at 2252 CDT, sea level pressure 1014.4 hPa, 0.01 inches of precipitation since 2153 CDT, temperature 5.0°C, dew point temperature 3.3°C, maintenance is needed on the system.

The observations for KABR surrounding the period from 1744 through 2300 CDT indicated IFR⁶ ceiling conditions with gusty surface winds from the northwest to north and light rain.

4.0 Upper Air Data

KABR was the closest site with an upper air sounding and had a station ID of 72659. The 1900 CDT KABR sounding was plotted on a standard Skew-T Log P diagram⁷ with the derived stability parameters included in figure 9 with data from the surface to 700-hPa (or approximately 10,000 ft msl). This data was analyzed using the RAOB⁸ software package. The sounding depicted the lifted condensation level (LCL)⁹ and the level of free convection (LFC)¹⁰ at 372 ft agl (1,674 ft msl) and the convective condensation level (CCL)¹¹ at 658 ft agl (1,960 ft msl). The sounding had a greater than 90% relative humidity from the surface through 5,000 ft msl. The freezing level was located at 12,543 ft msl. The precipitable water value was 0.82 inches.

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 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.

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

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

¹⁰ LFC – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

¹¹ 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.

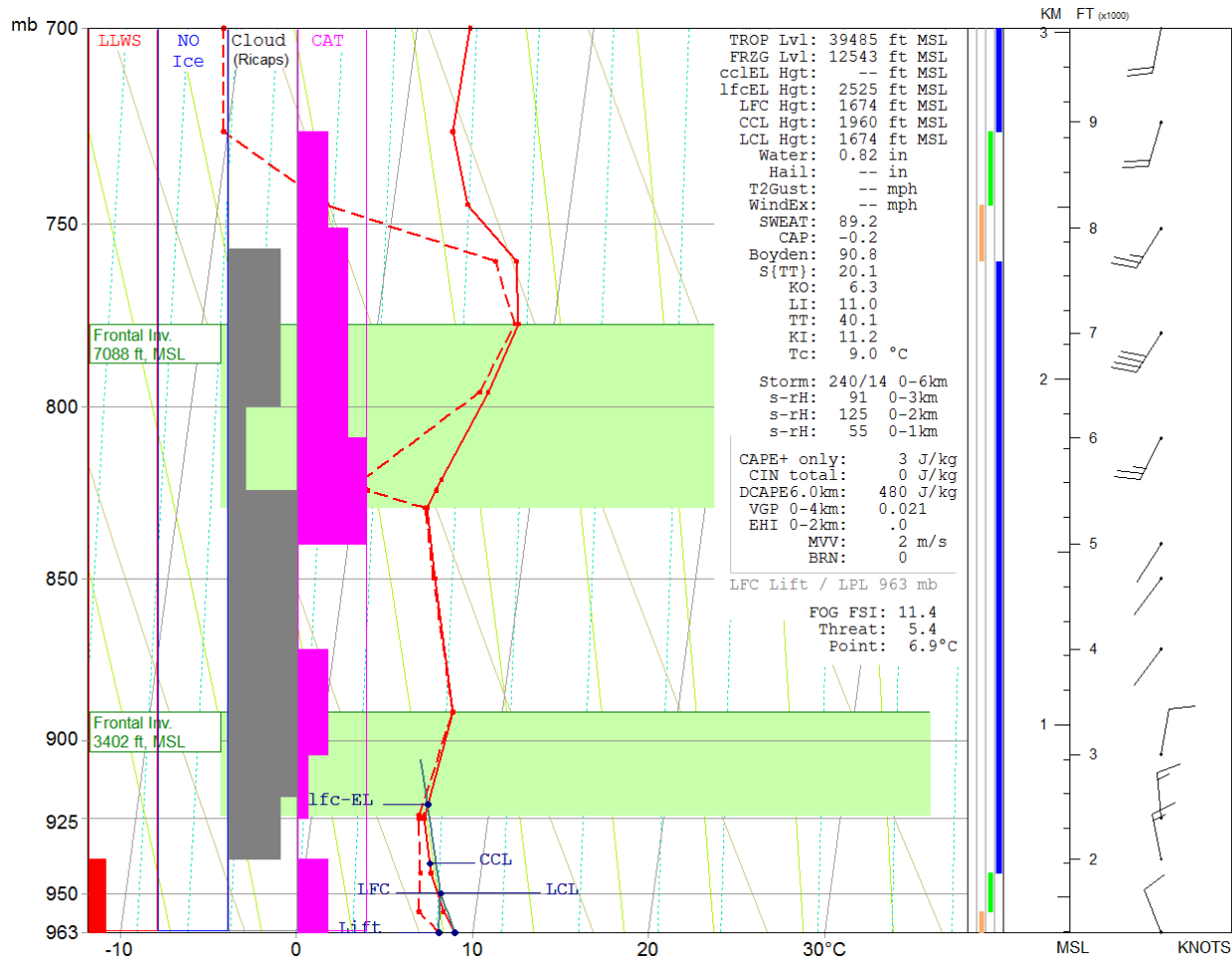


Figure 9 – 1900 CDT KABR sounding

The 1900 CDT KABR sounding for the accident site indicated a conditionally unstable layer from the surface through ~2,000 ft msl and then a stable layer from ~2,000 ft msl through 7,500 ft msl. RAOB identified the possibility of clouds from ~700 ft agl through ~8,000 ft msl. RAOB did not indicate the possibility of icing conditions below 10,000 ft msl. RAOB indicated frontal inversions¹² were in place above the accident site at 3,402 ft and 7,088 ft msl with clouds indicated below those inversion layers (figure 9).

The 1900 CDT KABR sounding wind profile indicated a surface wind from 340° at 9 knots with the wind veering¹³ to the southwest by 6,000 ft msl. The wind speed increased to 25 knots by 6,000 ft. RAOB indicated the possibility of light low-level wind shear (LLWS) between the surface and ~700 ft agl (~2,000 ft msl). RAOB indicated light to moderate clear-air turbulence (CAT) existed in several layers between the surface and 9,000 ft msl.

¹² Inversion – A departure from the usual decrease of the value of an atmospheric property with increasing altitude; also, the layer through which this departure occurs (the "inversion layer"), or the lowest altitude at which the departure is found (the "base of the inversion").

¹³ A clockwise turning of the wind with height in the northern hemisphere.

5.0 Satellite Data

Data from 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 software. Infrared (bands 13) imagery at a wavelength of 10.3 microns (μm) were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1600 CDT through 2330 CDT at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here. The visible imagery was not conducive for viewing at the accident time due to low light levels and were not obtained for this case.

Figures 10 and 11 present the GOES-16 infrared imagery from 2230 and 2240 CDT at 4X magnification and with a temperature enhancement curve applied with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site at the accident time with the cloud cover moving from southwest to northeast and with the lowest brightness temperatures (blue and green colors, higher clouds) located above western South Dakota and western North Dakota. Based on the brightness temperatures above the accident site (259 Kelvin) and the vertical temperature profile provided by the 1900 CDT KABR sounding, the approximate cloud-top heights over the accident site were 18,000 ft at 2240 CDT. It should be noted these figures have not been corrected for any parallax error.

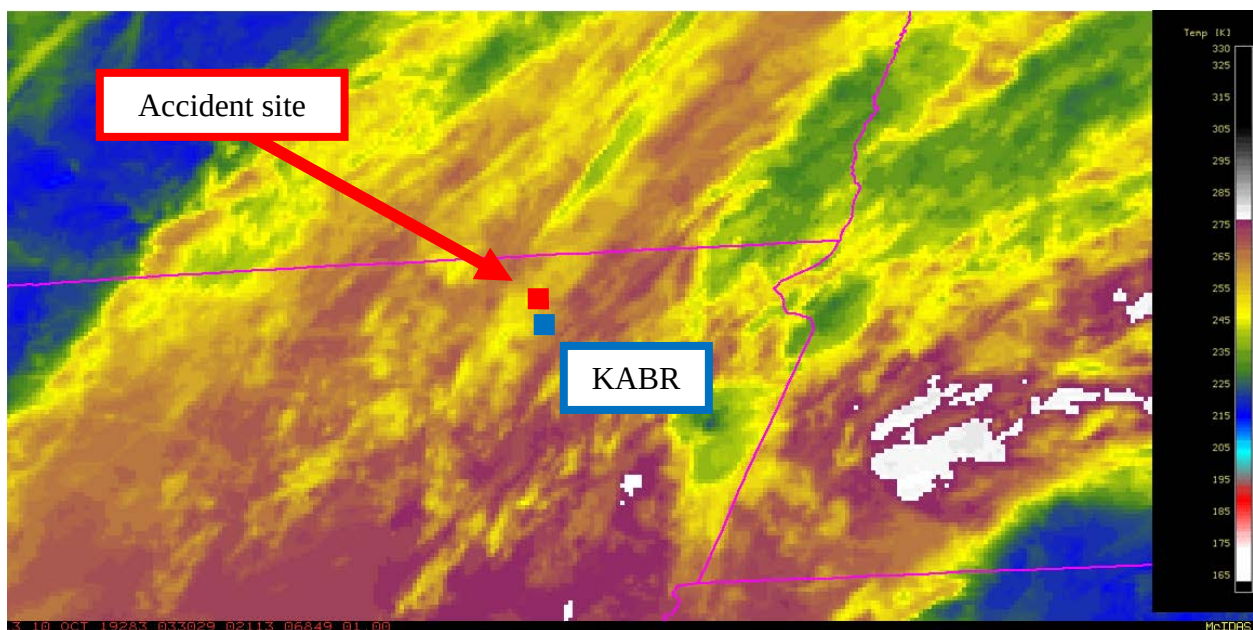


Figure 10 – GOES-16 visible image at 2230 CDT

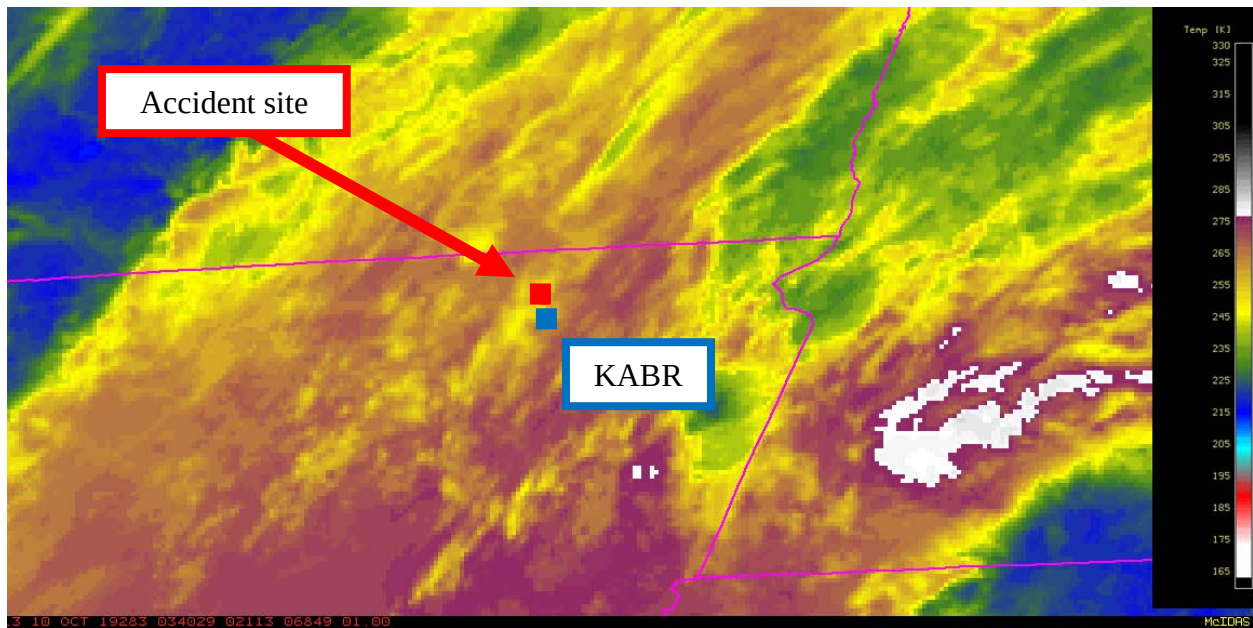


Figure 11 – GOES-16 infrared image at 2240 CDT

6.0 Weather Radar Imagery

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁴ to the accident site was KABR. 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

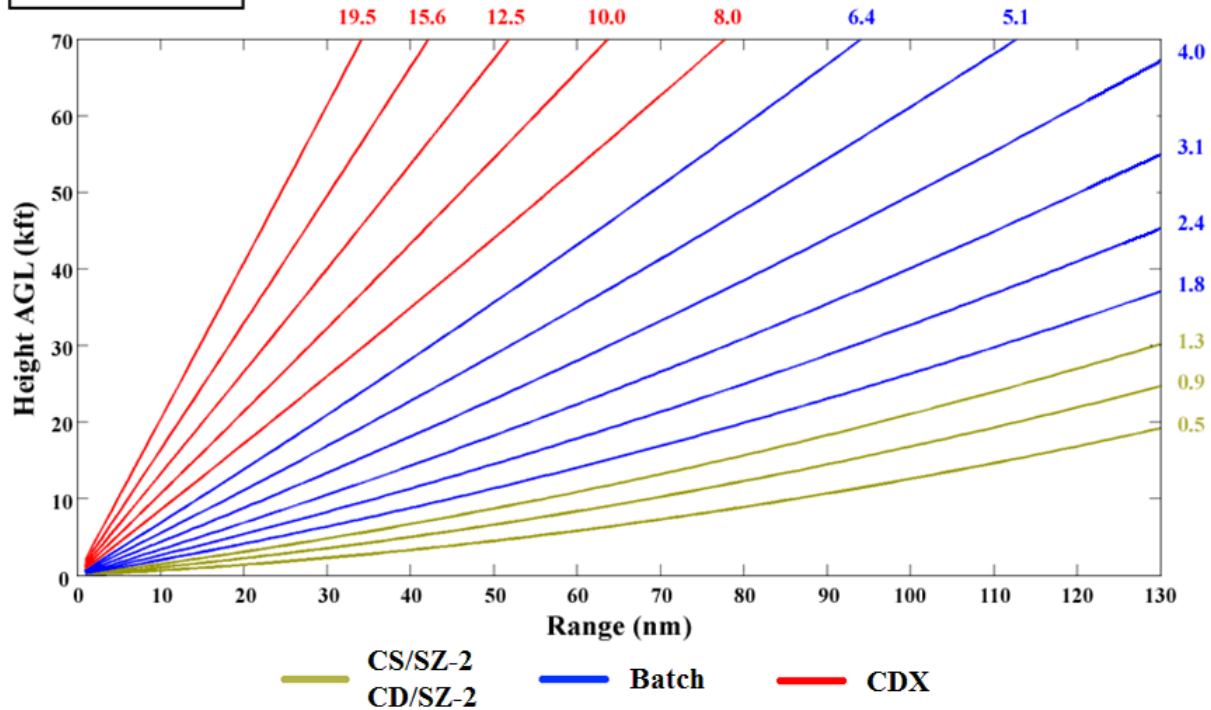
6.1 Volume Scan Strategy

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 15 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 212 (VCP-212). 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-212. 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.

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

VCP 212



VCP-212 Precipitation Mode Scan Strategy¹⁵

6.2 Beam Height Calculation

Assuming standard refraction¹⁶ of the WSR-88D radar beam with the antenna elevation at 1,383 ft (KABR), and considering a beamwidth¹⁷ 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°	1,790 ft	1,440 ft	2,140 ft

¹⁵ 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)

¹⁶ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁷ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

Based on the radar height calculations, the elevation scans from KABR listed in the above table depicted the conditions between 1,440 ft and 2,140 ft msl over the accident site and these scans “saw” the closest altitudes to the surface at the accident time.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁸ 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 dBZ, and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C¹⁹, “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 list below:

- 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 Data

Figures 12 and 13 present the KABR WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 2232:41 and 2236:20 CDT, respectively, with a resolution of 0.5° X 250 m. Reflectivity values between 15 and 25 dBZ were located above the accident site at the accident time indicative of very light precipitation (section 6.3). The reflectivity bands were moving from north to south near the accident site and south to north in eastern South Dakota (attachment 1).

¹⁸ 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.

¹⁹

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

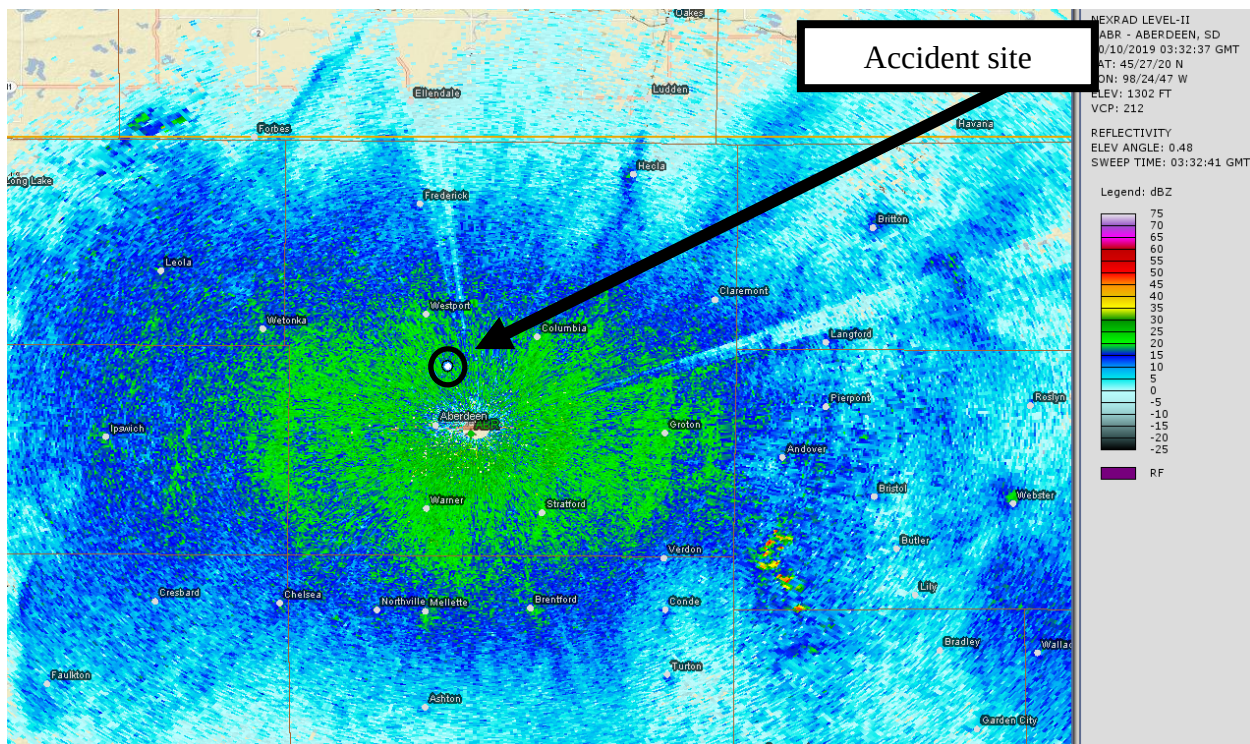


Figure 12 – KABR WSR-88D reflectivity for the 0.5° elevation scan initiated at 2232:41 CDT with the accident site marked with black circle

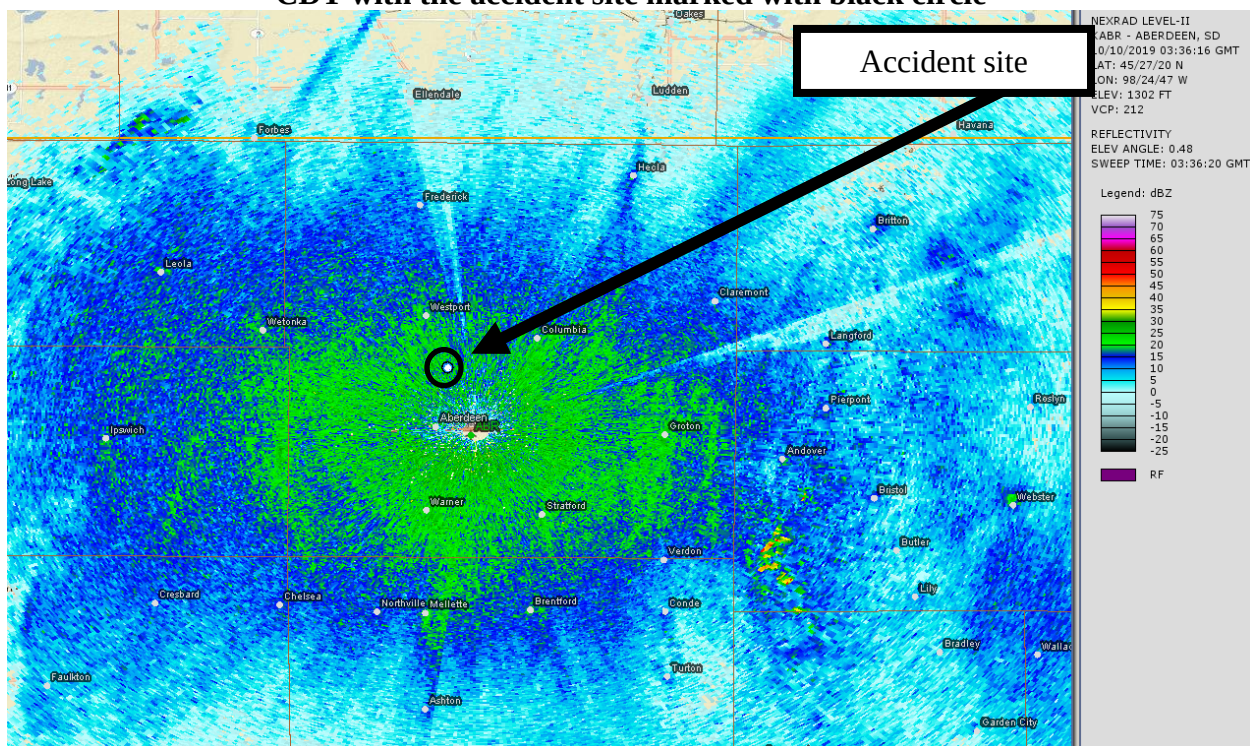


Figure 13 – KABR WSR-88D reflectivity for the 0.5° elevation scan initiated at 2236:20 CDT with the accident site marked with black circle

7.0 Pilot Reports

All pilot reports (PIREPs)²⁰ within 150 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time for below FL180²¹ were reviewed and there were no PIREPs provided into the national airspace system.

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 Advisories

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

10.0 AIRMETs

Airmen's Meteorological Information (AIRMET) advisories Sierra and Zulu were issued at 2145 CDT valid for the accident site at the accident time. AIRMET Sierra and Zulu warned of IFR conditions due to precipitation and mist and moderate icing conditions between the freezing level²² and FL200:

WAUS43 KKCI 100245

WA3S

-CHIS WA 100245

AIRMET SIERRA FOR IFR VALID UNTIL 100900

.

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

FROM 60NNE ISN TO 50N MOT TO 40NW INL TO 40WNW BRD TO DSM TO 40SE ICT TO 60NNE MMB TO 50SW HLC TO GLD TO BFF TO 70SW RAP TO 30NW ISN TO 60NNE ISN

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.

.

OTLK VALID 0900-1500Z...IFR ND SD NE KS MN IA MO WI

BOUNDED BY 60N MOT-30N INL-MSP-IRK-20NW MCI-20SW OSW-50SSW ICT-

60NNE MMB-GLD-BFF-70SW RAP-20WSW ISN-60N MOT

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 15Z.

....

WAUS43 KKCI 100245

WA3Z

²⁰ Only pilot reports with the World Meteorological Organization (WMO) header UBSD** and UBND** identifier were considered.

²¹ 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.

²² The freezing level ranged from the surface to 8,000 ft msl in the AIRMET Zulu box.

-CHIZ WA 100245

AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 100900

.

AIRMET ICE...ND SD

FROM 50NNW MOT TO 50WNW RAP TO 50NNW ISN TO 50NNW MOT
MOD ICE BLW 160. CONDS DVLPG AFT 06Z. CONDS CONTG BYD 09Z THRU
15Z.

.

AIRMET ICE...ND SD NE KS MN

**FROM 40NE INL TO 70S FAR TO 70ESE PIR TO 40E LBF TO GLD TO BFF TO
70SW RAP TO 50W RAP TO 50NNW MOT TO 40NE INL
MOD ICE BTN FRZLVL AND FL200. FRZLVL SFC-080. CONDS CONTG BYD 09Z
THRU 15Z.**

.

AIRMET ICE...MN IA MO WI LM LS IL IN KY

FROM 50SE INL TO 20SE RHI TO 30ESE ORD TO PXV TO 30NE ARG TO
70WSW ARG TO 40SE BUM TO DSM TO 50ESE FSD TO 20SE RWF TO 60SSW
BJI TO 50SE INL
MOD ICE BTN 130 AND FL240. CONDS CONTG BYD 09Z THRU 15Z.

.

OTLK VALID 0900-1500Z

AREA 1...ICE NE KS MN IA MO WI LM LS MI IL IN KY OK TX AR
BOUNDED BY 40NE INL-50WNW YQT-40WNW SAW-40ESE BAE-30ESE
ORD-PXV-40ESE FAM-20ESE ARG-50WNW TXK-30NNE MLC-20N BUM-50NNW
OVR-40NE RWF-60SSW BJI-40NE INL
MOD ICE BTN 130 AND FL240. CONDS CONTG THRU 15Z.

.

AREA 2...ICE ND SD NE

BOUNDED BY 50NNW MOT-40NE DIK-20NW DPR-BFF-70SW RAP-50NNW
ISN-50NNW MOT
MOD ICE BLW 160. CONDS CONTG THRU 15Z.

.

FRZLVL...RANGING FROM SFC-145 ACRS AREA

MULT FRZLVL BLW 130 BOUNDED BY 100WSW YWG-50NW INL-40WNW BJI-
70ESE ABR-80S ABR-20NNE ONL-50SSE GLD-GLD-BFF-40SW RAP-
20NW BIS-100WSW YWG
SFC ALG 20SE SNY-70ESE RAP-40NE DPR-60ENE MOT-70NE MOT
040 ALG 70W ANW-20WSW ABR-60SSE YWG
080 ALG GLD-60SSE FAR-30N BJI-30NNW INL
120 ALG 40WNW LBL-60SE LAA-70S RWF-40SSW BDF-40WSW TVC-30S
TVC-DXO

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11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident flight are shown in attachment 2. The GFA surface forecast products indicated VFR conditions would be likely for 2200 CDT with a surface wind from the north at 10 to 15 knots. The GFA cloud forecast products indicated an overcast cloud ceiling at 2,800 ft msl with layered clouds through 10,000 ft msl. For more information please see attachment 2.

12.0 Terminal Aerodrome Forecast

KABR was the closest site with a NWS Terminal Aerodrome Forecast (TAF) and the KABR TAF valid at the accident time was issued at 2107 CDT and was valid for a 22-hour period beginning at 2100 CDT. The 2107 CDT TAF for KABR was as follows:

KABR 100207Z 1002/1024 **36017G25KT 5SM -RA BR OVC006**
FM101500 35016G26KT 1 1/2SM RA BR OVC008
FM101700 35019G31KT 3/4SM RASNPL BR OVC005
FM102200 34022G34KT 1SM -SN OVC008=

The TAF expected a wind from 360° at 17 knots with gusts to 25 knots, 5 miles visibility, light rain, mist, and an overcast ceiling at 600 ft agl.

13.0 NWS Area Forecast Discussion

The NWS Office in Aberdeen, South Dakota, issued the following Area Forecast Discussion (AFD) at 2055 CDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed continued MVFR/IFR conditions with north surface winds between 20 to 35 knots:

FXUS63 KABR 100155 AAA
AFDABR

Area Forecast Discussion...UPDATED
National Weather Service Aberdeen SD
855 PM CDT Wed Oct 9 2019

.UPDATE...
Issued at 855 PM CDT Wed Oct 9 2019

Already getting some light rain/drizzle showing up on obs this evening along with a few cells on radar across the far east. Expect radar echoes to expand through the night across the cwa. Updated forecast earlier to make some adjustments to pops.

UPDATE Issued at 655 PM CDT Wed Oct 9 2019

00z aviation discussion updated below.

&&

.SHORT TERM...(This Evening through Friday Night)
Issued at 337 PM CDT Wed Oct 9 2019

The inverted trough has set up between the Missouri Valley and the Sisseton Hills this afternoon. Temps on the front side climbed to around 70 while temps behind the trough have fallen into the 40s. Light rain/mist has also developed in the lower clouds on the west side of the trough. As this system gets going tonight and the low moves north, wrap around precip will slowly push from west to east. Would not be surprised if the winter storm warning needs an upgrade on Thursday to a blizzard warning given the expected northwest winds

gusting to 50 to 60 mph. While the snow is still expected to be heavy and wet, falling snow will blow around and severely restrict visibilities.

Models are all coalescing on a rain/sleet (cold aloft, thin layer of just above freezing temps at the sfc)/snow transition from the James Valley east Thursday afternoon and evening. Getting that into the grids was challenging and does not reflect forecaster thought as much as it should since it defaulted to more freezing rain accumulations than sleet. However, there is also some indication that some drier air will feed in Thursday evening, so some freezing drizzle is not out of the question. Given the trouble at the transition zone, decided to punt the watch to the mid shift, though it looks like southern areas in the watch may be more likely to transition to an advisory while counties like Brown/Marshall/Day will end up meeting warning criteria.

Lows tonight will also be the highs for Thursday as temps fall in the afternoon. By Friday, all areas will have changed over to snow. Upslope areas in Marshall county will see locally higher amounts than much of northeastern SD. Snow/snow showers will taper off Friday night from west to east.

The main impacts of this storm will center around the winds and any ice/snow accumulations on trees and powerlines, as well as the restricted vsby in falling/blowing snow. The main challenge is still pinpointing exact amounts. A temperature shift of two degrees will change precip from snow to rain. Snow rates will not exceed an inch an hour except across Corson and northern Dewey counties, and that will only be for a short time. Daytime accumulations may be considerably less than what actually falls given ground temp and time of year. Much of the wet snow will also compact quickly or become slushy.

.LONG TERM...(Saturday through Wednesday)
Issued at 337 PM CDT Wed Oct 9 2019

A wrapped-up, deep low pressure system will be positioned across north central Minnesota on Saturday morning. Snow showers will linger but lessen through the afternoon hours, and northwest winds will continue gusting to 30+ mph through the afternoon as well. Both the snow and wind will reduce gradually from west to east. Beyond this storm system, there's not a return of precipitation chances through at least the middle of the week. The main story in the extended is the colder than average temperatures. High temperatures will be in the low to mid-30s Saturday, and look only to moderate into the low 40 to mid-40 range by mid-next week. Low temperatures meanwhile will remain in the mid to upper 20s.

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.AVIATION...(For the 00Z TAFS through 00Z Thursday Evening)
Issued at 655 PM CDT Wed Oct 9 2019

A deepening upper level low pressure trough over the region will bring increasing coverage of rain and snow to the region through the

night into Thursday. The changeover to snow will occur from west to east from late tonight through Thursday afternoon affecting ABR by evening. There may be some freezing precipitation at ABR on Thursday. Otherwise, IFR/MVFR ceilings and vsbys are expected at all airports through Thursday. North winds will also become an issue at 20 to 35 knots at all locations.

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.ABR WATCHES/WARNINGS/ADVISORIES...

SD...Winter Storm Warning from 1 AM CDT /midnight MDT/ Thursday to 7 PM CDT /6 PM MDT/ Friday for SDZ003>005-009-010-015-016-033>035-045.

Winter Storm Watch from Thursday afternoon through late Friday night for SDZ006>008-011-017>019-036-037-048-051.

MN...None.

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14.0 Winds and Temperature Aloft Forecast

The NWS 2057 CDT Winds and Temperature Aloft forecast valid for 0100 CDT on October 10 for the closest point to the accident site is included below:

FBUS31 KWN0 100157

FD1US1

DATA BASED ON 100000Z

VALID 100600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
ABR	0130	9900+05	1917+03	1619-01	2025-16	2136-28	225043	215453	226161

The accident site was closest to the ABR forecast point. The ABR forecast for use between 2100 CDT October 9 and 0400 CDT October 10 indicated a wind at 3,000 ft from 010° at 30 knots and at 6,000 ft a calm wind with a temperature of 5°C.

15.0 Pilot Weather Briefing

The accident pilot did not request nor receive a weather briefing through The FAA contract Automated Flight Service Station provider Leidos or filed any flight plan.

A check of ForeFlight was done and revealed that the accident pilot did not request a weather briefing through ForeFlight. It is unknown if the accident pilot checked or received any additional weather information before or during the accident flight.

16.0 Astronomical Data

The astronomical data obtained for the accident site on October 9, 2019, indicated the following with the sun and Moon at the accident time:

SUN

Begin civil twilight	0712 CDT
Sunrise	0742 CDT
Sun transit	1321 CDT
Sunset	1900 CDT
End civil twilight	1929 CDT
<i>Accident</i>	<i>2235 CDT²³</i>

MOON

Moonrise	1746 CDT
<i>Accident</i>	<i>2235 CDT²⁴</i>
Moon transit	2257 CDT
Moonset	0313 CDT on the following day

The phase of the Moon was a Waxing Gibbous with 87.8% of the Moon's visible disk was illuminated. The overcast cloud cover over the area however would have prevented the Moon's illumination from reaching the surface.

E. LIST OF ATTACHMENTS

Attachment 1 – KABR WSR-88D animation from 2214 CDT to 2243 CDT

Attachment 2 – GFA products available before the accident flight for around the accident time

Submitted by:

Paul Suffern
Senior Meteorologist

²³ Inserted accident time for reference and context.

²⁴ Inserted accident time for reference and context.

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