

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



CEN23FA391

METEOROLOGY

Specialist's Factual Report

October 16, 2023

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A. ACCIDENT

Location: Wellington, Colorado
Date: August 31, 2023
Time: 1339 mountain daylight time (MDT)
1939 coordinated universal time (UTC)
Airplane: Schleicher Alexander GMBH ASH 26E motor glider; Registration: N50FU

B. METEOROLOGY SPECIALIST

Donald Eick
NTSB Senior Meteorologist
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C. SUMMARY

On August 31, 2023, about 1339 mountain daylight time, a Schleicher Alexander GMBH & Co ASH 26E motor glider, N50FU, was substantially damaged when it was involved in an accident near Wellington, Colorado. The pilot sustained fatal injuries. The motor glider was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

The self-launching motor glider departed from the Owl Canyon Gliderport (4CO2) at 1320 MDT and reached a maximum altitude of 7,800 ft at 1330 MDT prior to the accident.

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 remotely, collecting data from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). This report documents the general weather products and forecasts over the region during the period and the pertinent meteorological parameters related to the accident. All times are reported as MDT based upon the 24-hour clock, local time is -6 hours from UTC, and UTC=Z. NWS airport and weather 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 located at latitude 40.86484° North and longitude 105.07827° West at an elevation of about 5,697 ft in a relatively flat agricultural field.

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) and the WPC 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 Federal Aviation Administration (FAA) "Aviation Weather Handbook", FAA-H-8083-28¹.

1.1 Surface Analysis Chart

The NWS Surface Analysis chart for 1200 MDT centered over the region depicted a low-pressure system at 1009-hectopascal (hPa)² over western Wyoming associated with a frontal wave with a stationary front extending eastward across the state with another low at 1007-hPa over the Wyoming (WY) and Nebraska (NE) border. A trough³ extended southward from the low into central Colorado. A thermal low-pressure system⁴ at 1008-hPa was located over southeast Colorado, with troughs extending southward. Two high pressure systems at 1013-hPa were located over western Colorado with a ridge⁵ extending northward into Wyoming. The accident site was located in the vicinity of the trough and to the east of the ridge axis.

The station models on the chart depicted general southerly winds immediately east of the higher terrain and clear to scattered clouds. Temperatures were in the upper 80's degrees Fahrenheit (°F) with cooler temperatures in the higher elevations

¹ <https://www.faa.gov/regulationspolicies/handbooksmanuals/aviation/faq-h-8083-28-aviation-weather-handbook>

² Hectopascal (hPa) is the standard unit for reporting pressure and is interchangeable with the former term millibar (mb) with the same units. The International Standard Atmosphere (ISA) is based on a sea-level pressure of 1013.25-hPa at 15° Celsius (C) or 59° Fahrenheit (F).

³ Trough (abbreviated as "TROF") is an elongated area of relatively low atmospheric pressure, usually not associated with a closed circulation, and thus used to distinguish from a closed low. The opposite of ridge. Troughs are a general area of convergence, a wind shift, and often as associated with clouds and precipitation depending on the availability of moisture, unstable atmosphere, and forceful lifting.

⁴ Thermal Low is an area of low pressure that is shallow in vertical extent and produced primarily by warm surface temperatures.

⁵ Ridge is an elongated area of relatively high atmospheric pressure and is often associated with light winds, clear skies and subsiding motion. Opposite of a trough.

west of the accident site. Dew point temperatures were in the 20's °F, with an approximately 25° to 30°F temperature-dew point spread. No significant weather was depicted over the area of the accident.

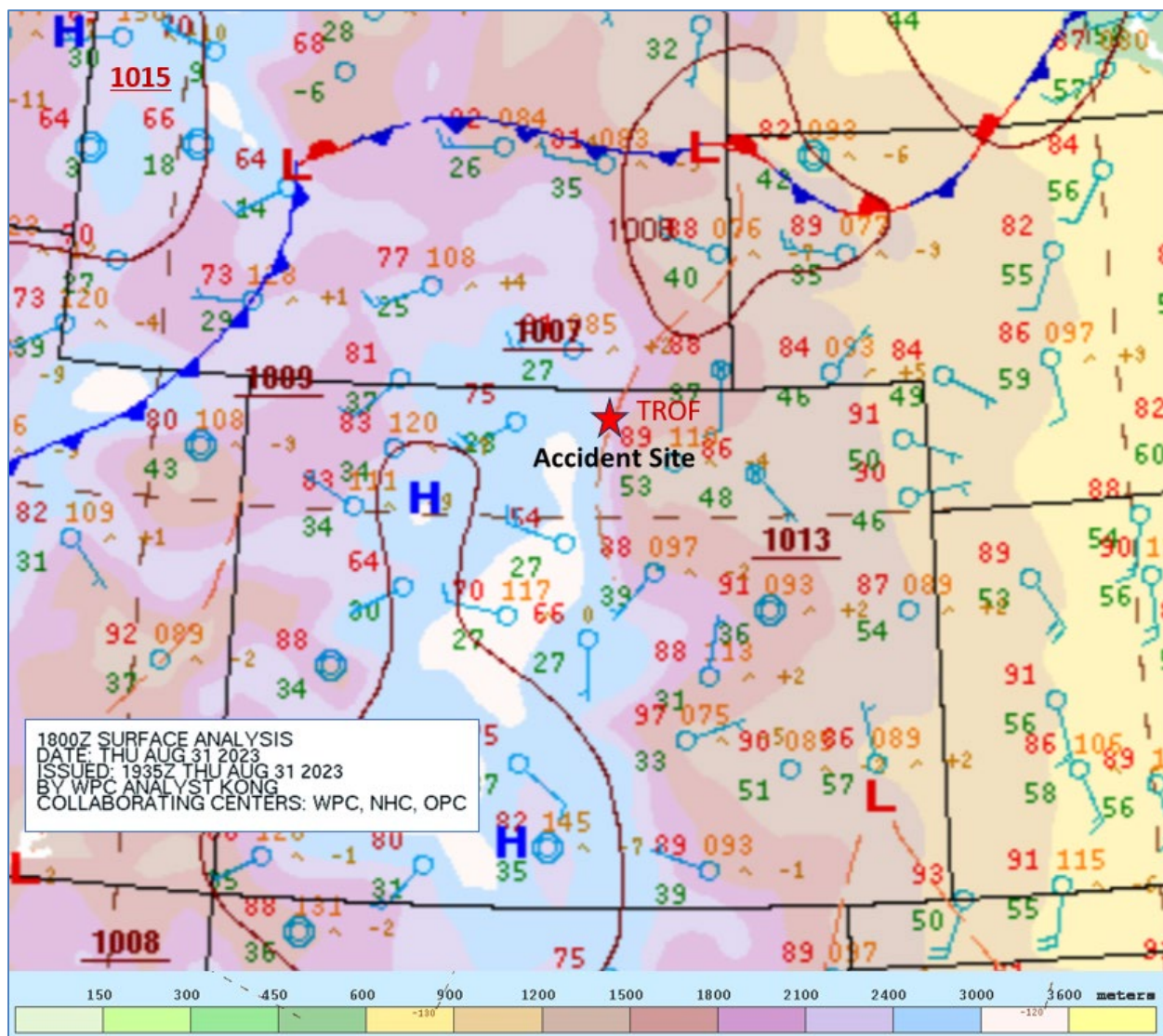


Figure 1 - Regional view of the NWS Surface Analysis Chart for 1200 MDT with the terrain and approximate accident site marked by the red star.

1.2 Regional Radar Composite

The NWS National Composite Radar Mosaic over the region for 1340 MDT is included as figure 2 with the approximate accident site marked by the red star. The image depicted two areas of echoes west of Fort Collins, CO, and another larger region west through northeast of Cheyenne, WY, with no echoes observed over the accident site. The echoes over WY were noted in the vicinity of a large wind farm and further

identified as associated with false returns. While the echoes west and southwest of Fort Collins were located in the vicinity of high terrain and also not associated with precipitation echoes.

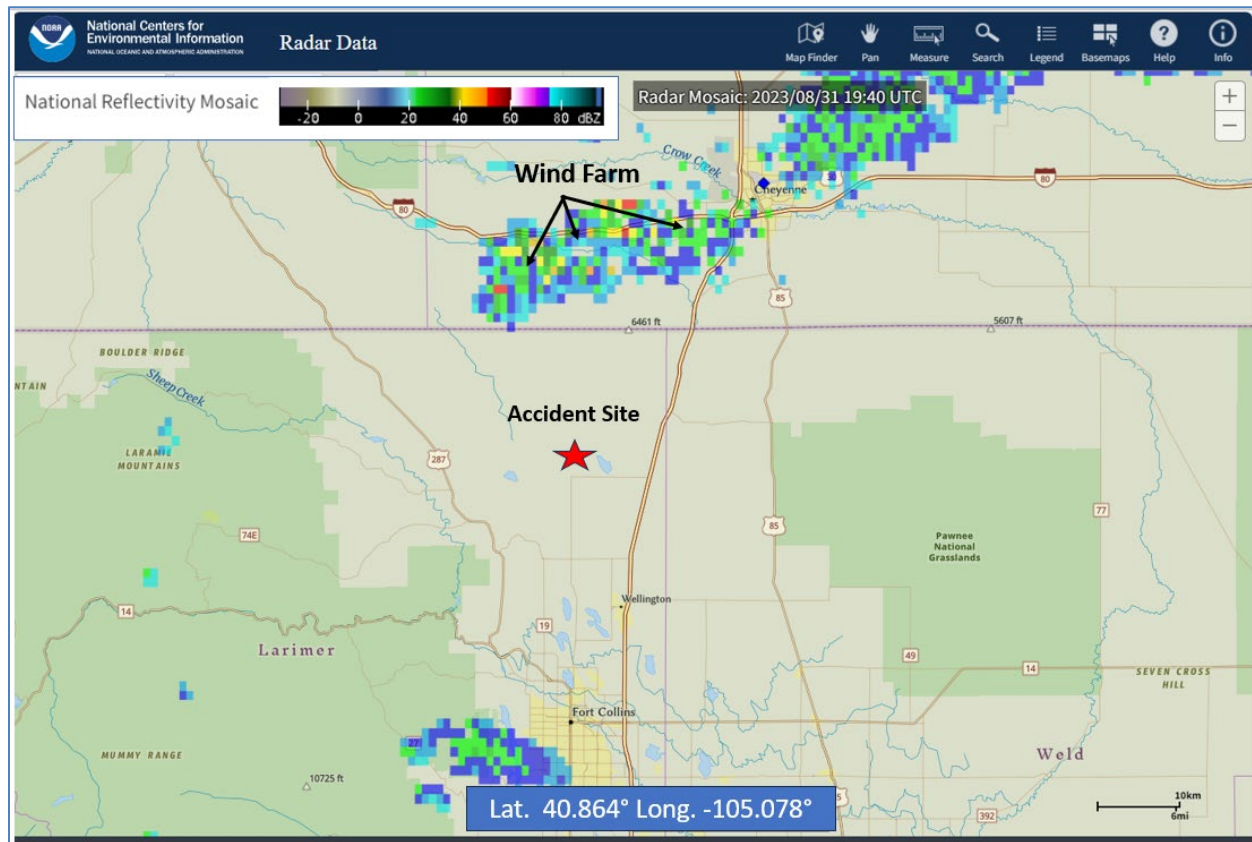


Figure 2 - Regional view of the National Composite Mosaic for 1340 MDT with the accident site marked by the red star. No weather echoes were identified in the vicinity of the accident site.

2.0 Surface Observations

The official observations issued surrounding the accident site were documented using Aviation Routine Weather Reports (METAR⁶) and Aviation Select Special Weather Reports (SPECI). Cloud heights are reported above ground level (agl) in the following section, and the magnetic variation was estimated at 8° east based on the latest sectional chart for the area.

⁶ METAR - is an abbreviation for METeorological Aerodrome Report and is the international standard for reporting weather for aviation.

2.1 Wellington, CO

The accident motor glider departed from Owl Canyon Gliderport (4CO2), Wellington, CO, located about 6 miles southeast of the accident site at an elevation of 5,546 ft. The airport is a privately-owned airport and has multiple asphalt/turf runways. The airport had only a wind indicator, and no other weather reporting capability.

2.2 Cheyenne, WY

The closest official weather reporting site to the accident site was from Cheyenne Regional Airport/Jerry Olson Field (KCYS), Cheyenne, WY, located 24 miles northeast at an elevation of 6,160 ft. The airport had an Automated Surface Observation System (ASOS) and which was not augmented by any human observers during the period and broadcasted locally on 134.425 Megahertz (MHz) and disseminated observations longline⁷ to users every hour with specials as required.

KCYS weather at 1353 MDT, automated, wind from 190° at 10 knots gusting to 16 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 31° Celsius (C), dew point temperature minus 1°C, altimeter setting 30.05 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, peak wind from 210 at 30 knots occurred at 1300 MDT, sea-level pressure 1007.7-hPa, temperature 30.6°C, dew point -0.6°C.

The raw observations disseminated surrounding the period from 1053 through 1753 MDT were as follows.

METAR KCYS 311653Z AUTO 29011G22KT 9SM CLR 29/M01 A3009 RMK AO2 SLP083 T02941011=

METAR KCYS 311753Z AUTO 25007G25KT 9SM CLR 31/M01 A3008 RMK AO2 PK WND 25026/1705 SLP078 T03111006 10311 20133 50002=

METAR KCYS 311853Z AUTO 10SM CLR 32/M01 A3007 RMK AO2 SLP079 T03171011=

Accident 1939Z

METAR KCYS 311953Z AUTO 19010G16KT 10SM CLR 31/M01 A3005 RMK AO2 PK WND 21030/1900 SLP077 T03061006=

METAR KCYS 312053Z AUTO 9SM CLR 32/00 A3004 RMK AO2 PK WND 22027/2045 SLP073 T03170000 56011=

METAR KCYS 312153Z AUTO 25006KT 10SM CLR 30/01 A3003 RMK AO2 PK WND 20030/2104 SLP072 T03000006=

METAR KCYS 312253Z AUTO 24014G19KT 10SM CLR 31/01 A3003 RMK AO2 SLP070 T03110006=

⁷ Longline - refers to the dissemination of the observation through the FAA and NWS using standard communication protocols in near real-time to users.

METAR KCYS 312353Z AUTO 18012KT 8SM CLR 31/02 A3003 RMK AO2 SLP076 T03060017 10328
20294 55002=

The observations indicated a westerly wind backing⁸ to the south with gusts from 19 to 30 knots during the period, visibility 10 miles or more, clear skies below 12,000 ft agl, with the maximum temperature reaching 31°C (89° F).

2.3 Ft. Collins/Loveland, CO

The next closest weather reporting station was from Northern Colorado Regional Airport (KFNL), Fort Collins/Loveland, CO, located about 29 miles south of the accident site at an elevation of 5,020 ft. The airport had an Automated Weather Observation System (AWOS) which was augmented by tower personnel through a LAWRS⁹ program. Observations were broadcast locally on 135.075 MHz and disseminated hourly with specials as needed when the tower was in operation. At the time of the accident the following conditions were reported.

KFNL weather at 1356 MDT, wind from 170° at 11 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 34° C, dew point temperature 6°C, altimeter setting 29.98 inHg. Remarks: automated station with a precipitation discriminator, sea-level pressure 1007.6-hPa, temperature 34.4°C, dew point 6.1°C.

The observations issued from 1056 through 1756 MDT were as follows.

METAR KFNL 311656Z 18006KT 10SM CLR 28/10 A3003 RMK AO2 SLP094 T02830100=

METAR KFNL 311756Z 16008KT 9SM CLR 32/08 A3002 RMK AO2 SLP088 T03170078 10317 20144
58004=

METAR KFNL 311856Z 19010KT 8SM CLR 33/07 A3000 RMK AO2 SLP089 T03330072=

Accident 1939Z

METAR KFNL 311956Z 17011KT 10SM CLR 34/06 A2998 RMK AO2 SLP076 T03440061=

METAR KFNL 312056Z 15009KT 10SM CLR 36/04 A2996 RMK AO2 SLP072 T03560044 56017=

METAR KFNL 312156Z 16008G18KT 10SM CLR 36/03 A2995 RMK AO2 SLP064 T03560033=

METAR KFNL 312256Z 15010G17KT 10SM CLR 35/04 A2994 RMK AO2 SLP066 T03500044=

⁸ Backing - refers to a counter-clockwise change in wind flow.

⁹ Limited Aviation Weather Reporting Station - is a facility where observations are taken, prepared, and transited by NWS certified control tower personnel on a limited basis to support aviation requirements.

METAR KFNL 312356Z 13011KT 8SM CLR 34/06 A2994 RMK AO2 SLP065 T03440061 10361 20317
55004=

The observations from KFNL reported southerly winds backing to the southeast with wind gusts to 18 knots after the accident, with visibility 10 miles or more and clear skies below 12,000 ft agl. The maximum temperature of 36°C (97°F) occurred after the accident.

2.4 Buckeye, CO

A Remote Automated Weather Station (RAWS) site operated by the Bureau of Land Management was located at Buckeye (BEYC2), CO, at latitude 40.8115° N and longitude -105.0367° W, or approximately 3 miles southeast of the accident site at an elevation of 5,591 ft. At 1335 MDT, the following conditions were reported.

Weather Conditions

Temperature	88 °F
Dew point temperature	36 °F
Relative humidity	16%
Wind	SE 10 kt
Peak Gust	17 kts

2.5 NWS METAR Display

A display of the conditions for 1400 MDT from the NWS Aviation Weather Center's METAR display with the lowest elevation scan of the regional radar display overlaid is included as figure 3 with a red star over the approximate accident site. The pilot reports recorded within 3-hours are also overlaid. The METAR display temperature and dew point temperatures are presented in °F. The chart depicted generally visual flight rule (VFR) conditions¹⁰ over the region with southerly winds over the area with clear to scattered clouds, visibilities unrestricted at 10 miles or more, with temperatures in the 90's °F, with dew point temperatures in the 40's °F.

¹⁰ Regarding the general flight conditions, VFR conditions are defined as visibility greater than 5 statute and no ceiling or ceilings above 3,000 ft agl.

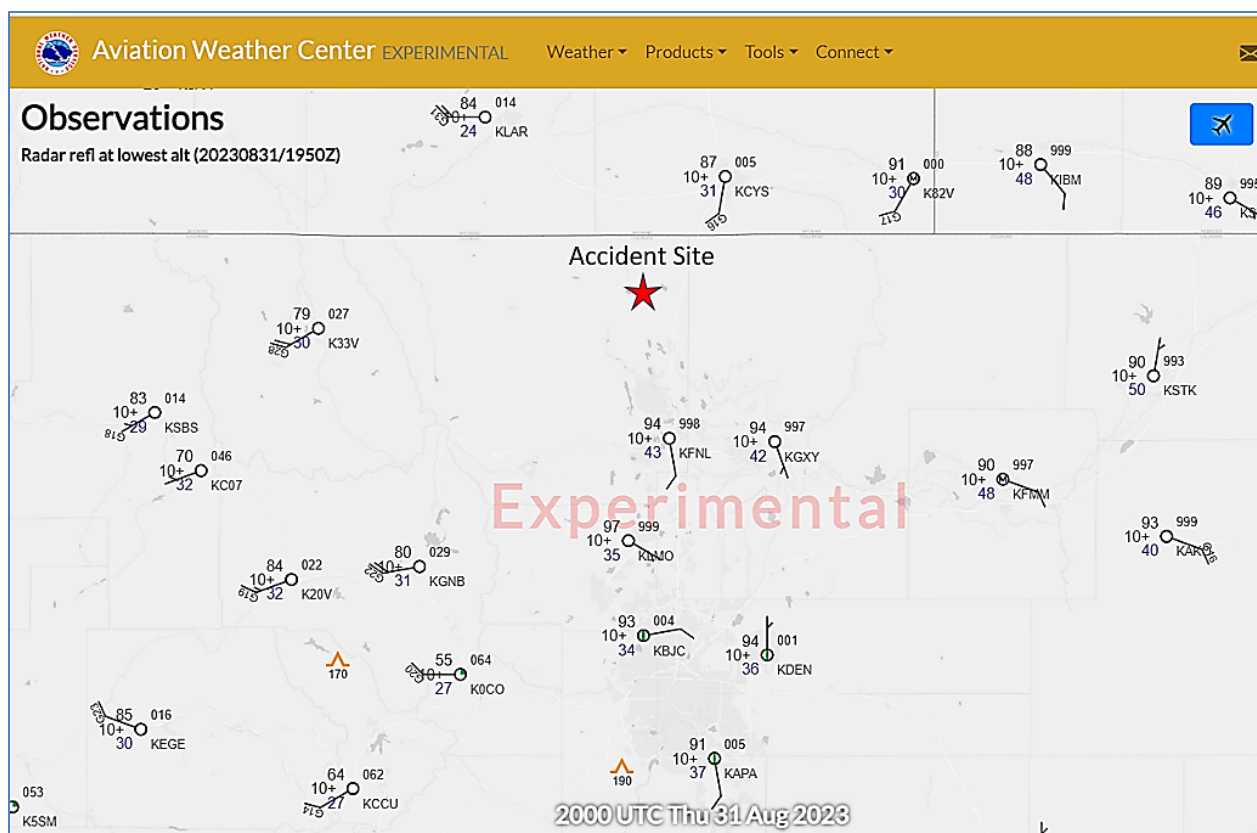


Figure 3 - NWS Aviation Weather Center's METAR display and weather radar image for 1400 MDT with the approximate accident site marked by the red star. Pilot reports of turbulence are also noted on the image.

2.6 Streamline Analysis

A streamline analysis¹¹ obtained from archive data from Plymouth State University¹² for 1400 MDT based on the surface observations over the region is included as figure 4 with the approximate accident site marked by the red star. The chart depicted a region of general confluence¹³ in the wind flow with southerly winds in the vicinity of the accident site.

¹¹ Streamline - arrows on a weather chart showing wind speed and direction. The head of the arrow points toward where the wind is blowing and the length of the arrow is proportional to the wind speed. Sometimes shows wind direction and trajectory only.

¹² <https://vortex.plymouth.edu/myowxp/>

¹³ Confluence - is a pattern of wind flow in which air flows inward toward an axis oriented parallel to the general direction of flow. It is the opposite of diffluence. Confluence is not the same as convergence. Winds often accelerate as they enter a confluent zone, resulting in speed divergence which offsets the (apparent) converging effect of the confluent flow.

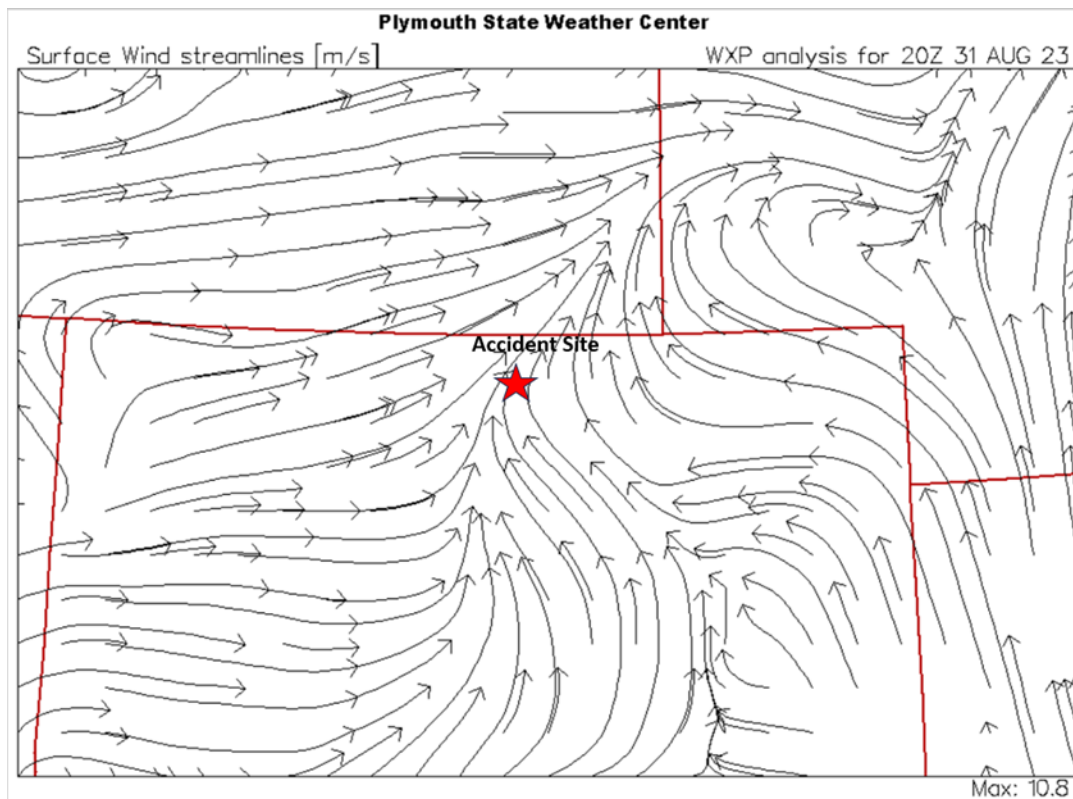


Figure 4 - Streamlines for 1400 MDT over the region with the approximate accident site marked by the red star.

3.0 Sounding

A High-Resolution Rapid Refresh (HRRR) numerical model¹⁴ data was obtained from the NOAA Air Resource Laboratory for the closest grid point¹⁵ to the accident site for 1400 MDT. The data was then plotted on a standard Skew T Log P diagram¹⁶ using the RAOB Analysis software¹⁷ from the surface to 450-hPa or approximately 22,000 ft. The resultant HRRR sounding plot for 1400 MDT is included as figure 5.

¹⁴ The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

¹⁵ Grid point was latitude 40.86°N and longitude 105.08°W.

¹⁶ 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.

¹⁷ RAOB -The Universal RAOwinsonde OBservation program is an interactive sounding analysis program developed by Eosonde Research Services (ERS) previously known as Environmental Research Services, The Villages, Florida.

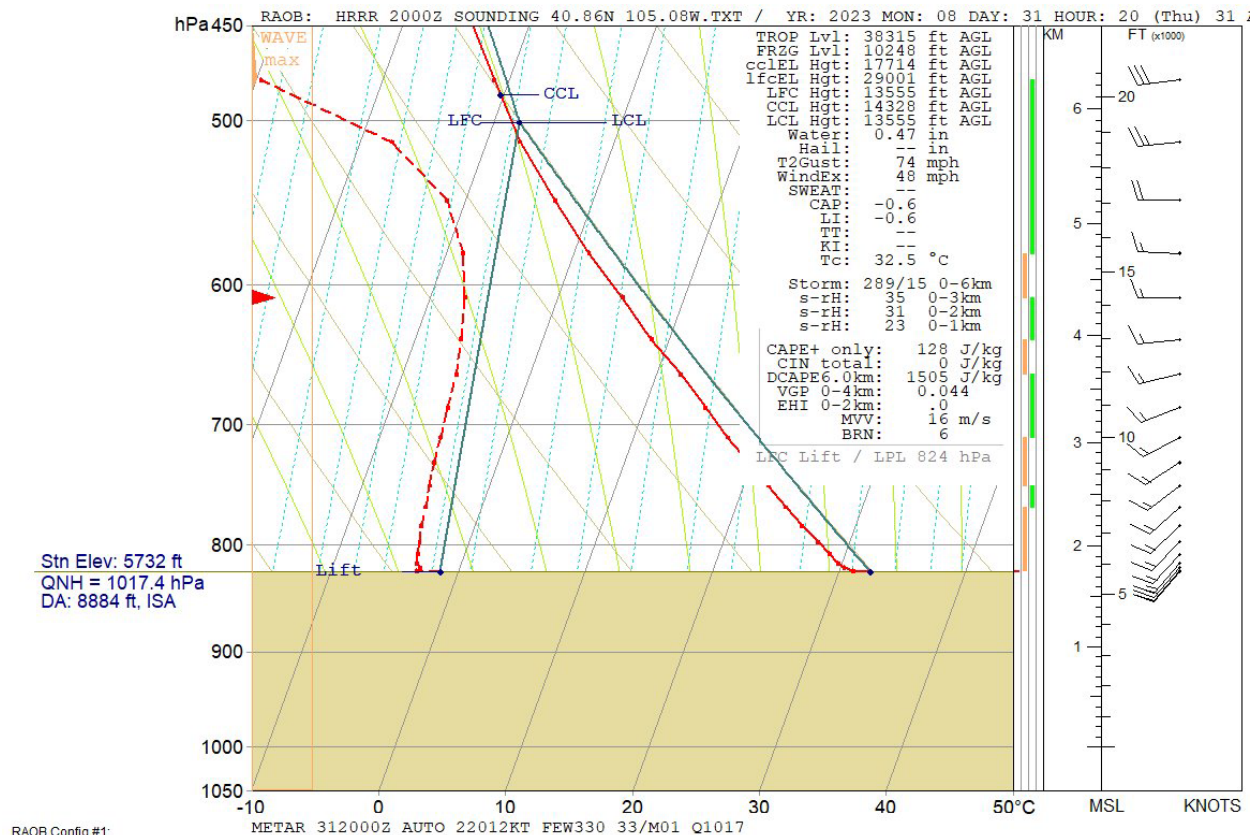


Figure 5 - High-Resolution Rapid Refresh (HRRR) numerical model over the closest grid point to the accident site for 1400 MDT.

The sounding depicted an elevation of 5,732 ft over the grid point with a near surface wind from 220° at 12 knots, a temperature of 33°C (91°F), a dew point temperature of -1°C (30°F), a relative humidity of 11%, which resulted in a density altitude near 8,884 ft. The sounding depicted the lifted condensation level (LCL)¹⁸ and level of free convection (LFC)¹⁹ at 13,555 ft agl (19,283 ft msl), and a convective condensation level (CCL)²⁰ at 14,328 ft agl, with the precipitable water content of 0.47 inches. The freezing level was identified above 10,000 ft. The sounding depicted temperatures decreasing with height with no defined inversions or stable layers depicted below 22,000 ft. The Lifted Index (LI)²¹ was -0.6 and the convective available

¹⁸ Lifted Condensation Level (LCL) - the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

¹⁹ Level of Free Convection (LFC) - the height at which a parcel of air lifted dry adiabatically until saturated, then lifted moist-adiabatically thereafter would first become warmer than the surrounding air. The parcel will then continue to rise freely above the LFC until it becomes colder than the temperature profile.

²⁰ Convective Condensation Level (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.

²¹ Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate

potential energy (CAPE)²² was 286 J/kg, both of which indicated a conditionally unstable atmosphere with a weak potential for thunderstorm development. The RAOB Analysis program indicated no clouds below 22,000 ft during the period; however, any high-based cumulus clouds with precipitation that did develop had a potential for dry type microbursts with the maximum convective outflow winds up to 42 knots as indicated by the WindEx index and the DCAPE²³ of 1,505 J/kg.

The sounding wind profile indicated surface wind from the southwest and veering²⁴ to the west with height, with the mean 0 to 6 km or 18,000 ft wind from 260° at 20 knots. The sounding vertical wind profile did not indicate any significant vertical wind shears with height over the region. The wind profile did support the development of a mountain wave activity with a predominate wave near 14,000 ft with the potential for light-to-moderate turbulence, based on the worst case terrain scenario.

A table of the sounding parameters of height, pressure temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and magnitude, and RAOB derived Clear Air Turbulence (CAT), Low-Level Wind Shear (LLWS), and mountain wave potential²⁵ from the surface through 18,000 ft were as follows.

Height (ft-msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (deg/kts)	CAT (FAA)	LLWS (FAA)	Mountain Wave nm - fpm - max
5732	824	32.5	-1.4	11	219/ 12			
5768	823	31.1	-3.3	11	218/ 12			
5875	820	30.3	-3.1	11	219/ 13			
6018	816	29.7	-3.5	11	219/ 13			
6305	808	28.8	-3.7	12	220/ 14			
6703	797	27.5	-3.9	12	222/ 15			
7215	783	25.8	-4.2	13	224/ 15			
7808	767	24.0	-4.4	15	227/ 16			
8485	749	22.0	-4.7	16	230/ 16			
9213	730	19.8	-5.0	18	234/ 16			
9994	710	17.4	-5.2	21	240/ 16			
10911	687	14.8	-5.5	24	248/ 16			
11934	662	11.9	-5.8	28	256/ 15			
12985	637	8.6	-6.4	34	264/ 16			
14241	608	5.1	-7.3	40	269/ 16		14.09	1053 LT-MD
15541	579	1.2	-8.7	48	272/ 17			

instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

²² Convective Available Potential Energy (CAPE) - A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft thus, higher values indicate greater potential for severe weather.

²³ DCAPE - Downdraft CAPE. DCAPE can be used to estimate the potential strength of rain-cooled downdrafts with thunderstorms convection and is similar to CAPE. Larger DCAPE values are associated with stronger downdrafts.

²⁴ Veering - is a clockwise turning of the wind direction with height, and often indicates warm air advection over the region. Opposite of backing.

²⁵ The mountain wave algorithm used is the worst case scenario and not tailored to the local terrain.

17079	546	-3.0	-11.5	52	271/ 19
18737	512	-7.4	-17.5	44	264/ 23

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 18 (GOES-18) imagery were obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared band 13 at a wavelength of 10.3 microns (μm) provided a resolution of 2 kilometers (km) with radiative cloud top temperatures. The low-level water vapor (band 10) at a wavelength of 7.3 μm and the mid-level water vapor (band 9) at a wavelength of 6.9 μm also had a resolution of 2 km and sampled the atmosphere from 750-500-hPa. The visible band 2 at a wavelength of 0.64 μm with a resolution of 0.5 km provided the highest resolution over the area. The infrared, low and mid-level water vapor, and visible imagery were reviewed surrounding the period, and the closest images to the accident time documented.

Figure 6 is the GOES-18 visible image for 1341 MDT at 2X magnification with the approximate accident noted by the red square. The image depicted a band of scattered cumulus clouds over and west of the accident site. An animation of the visible and GeoColor²⁶ imagery (Attachment 1) between 1300 through 1500 MDT showed the clouds develop, propagate eastward and dissipate in the immediately vicinity of the accident site. While some clouds remained stationary over high terrain immediately west of the accident site similar to altocumulus standing lenticular clouds (ACSL)²⁷.

Figures 7 and 8 are the GOES-18 Low-Level and Mid-Level Tropospheric Water Vapor images respectively for 1341 MDT respectively at 6X magnification. The images depicted a transverse banding²⁸ pattern, with mid-level drying or moisture channel darkening over the region at the time of the accident. The strong brightness temperature variations imply the presence of vertical motions or updrafts and downdrafts.

²⁶ The GeoColor was developed by the Cooperative Institute for Research in the Atmosphere (CIRA) and the Regional and Mesoscale Meteorology Branch (RAMMBA) of NOAA's Center for Satellite Applications and research (STAR).

²⁷ Lenticular Clouds - a very smooth, round or oval, lens-shaped cloud that is often seen, singly or stacked in groups, near or in the lee of a mountain ridge.

²⁸ Transverse Bands - are bands of clouds oriented perpendicular to the flow in which they are embedded. They often are seen best on satellite photographs. When observed at high levels (i.e., in cirrus formations), they may indicate severe or extreme turbulence. Transverse bands observed at low levels (called transverse rolls or T rolls) often indicate the presence of a temperature inversion (or cap) as well as directional shear in the low- to mid-level winds.

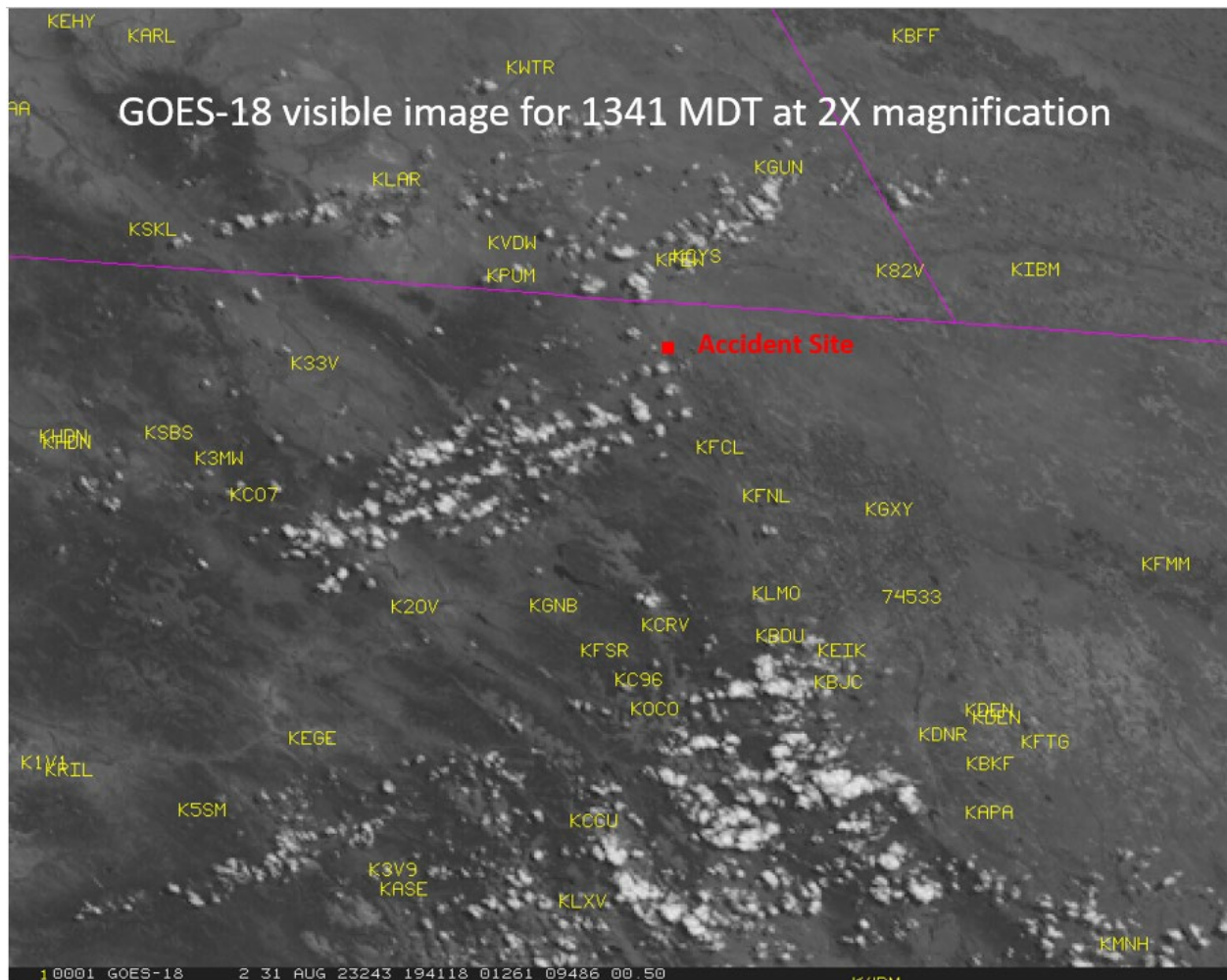


Figure 6 - GOES-18 visible image for 1341 MDT at 2X magnification with the accident noted by the red square.

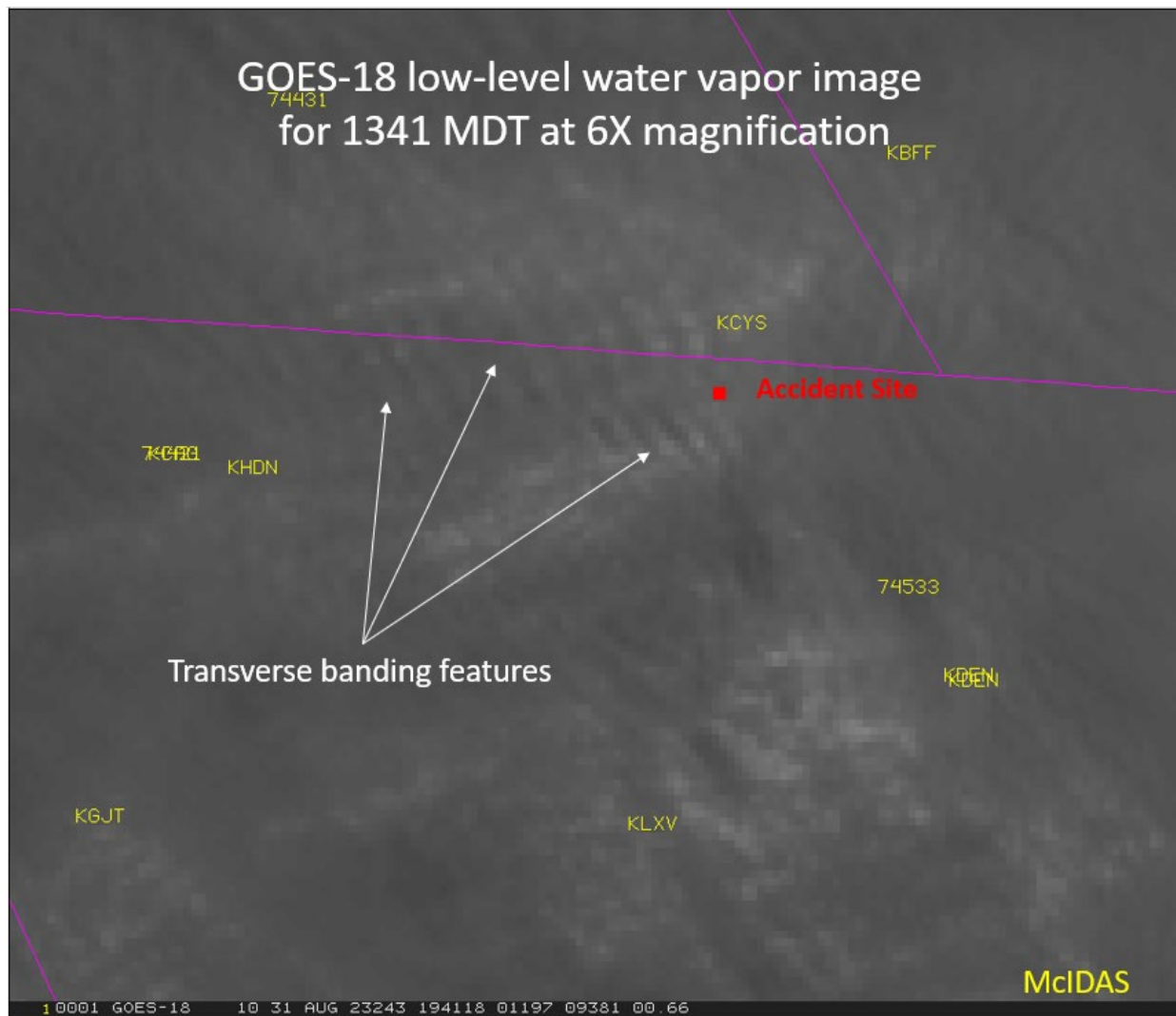


Figure 7 - GOES-18 low-level water vapor image for 1341 MDT at 6X magnification with the accident site marked by the red square.

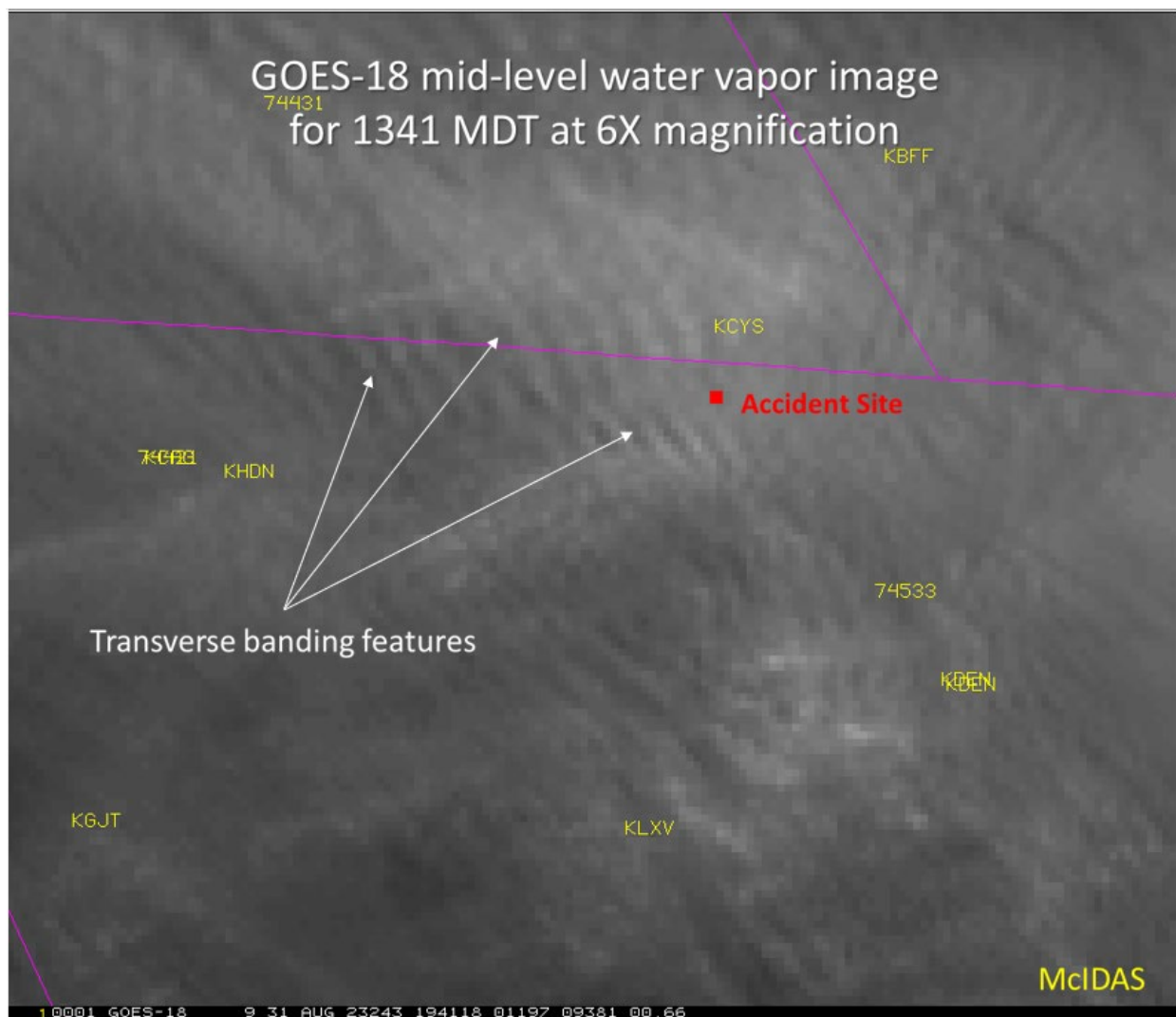


Figure 8 - GOES-18 mid-level water vapor image for 1341 MDT at 6X magnification with the accident site marked by the red square.

5.0 Pilot Reports

The following pilot reports or PIREPs were reported²⁹ in the national database within 50 miles of KFNL from 1200 through 1600 MDT. The reports in standard code and abbreviations were as follows:

EGE UA /OV 20V235015-EGE335010/TM 1831/FL125/TP CH7A/TB NEG/RM SMOOTH

CPR UA /OV CPR180010/TM 1838/FL090/TP B190/TB LGT CHOP/RM BTW 090-100

²⁹ Includes only the reports official recorded and disseminated as a PIREP and may not include "ride reports" broadcasted or other conditions solicited by air traffic controllers and not entered in the formal PIREP format coding. These reports are available to users in near real-time.

DEN UA /OV 35 SE/TM 1850/FL100/TP BE20/TB LGT/MOD/RM DURC 100-140

COS UA /OV OVER FCS/TM 1852/FL124/TP C206/TB MODERATE TURBULENCE BTW 110-124

ASE UA /OV ASE/TM 1931/FL090/TP PRM1/TB LGT OCNL MOD/RM +/- 10KTS DURD

EGE UA /OV RLG120015/TM 1938/FL170/TP GLF4/TB MOD CHOP/RM ZDV

PUB UA /OV PUB100030/TM 1939/FL410/TP E55P/RM MTN WAVE -500FPM-ZDV

ARP UAL327 3932N 10511W 1957 F190 TB MODERATE SK IC RM B738 OV TLRID LT TO MOD CHOP

Of the 8 reports, there were 7 that reported light to moderate turbulence over the area, with 1 report of encountering mountain wave activity at 41,000 ft with 500 fpm vertical altitude deviations. There were no urgent reports of any severe turbulence or other hazards over the area surrounding the period.

6.0 NWS Forecasts

The NWS Denver Weather Forecast Office (WFO), located in Boulder, CO (KBOU), was responsible for issuing the local forecasts and warnings for the Wellington area, and are documented below in addition to the general aviation weather products issued by the NWS AWC located in Kansas City, MO.

6.1 Terminal Aerodrome Forecast

The closest Terminal Aerodrome Forecast (TAF)³⁰ to the accident site was from KCYS³¹. TAFs are a concise statement of the expected meteorological conditions significant to aviation for a specific period typically 24-hours and are valid for 5 statute miles from the airport's runway complex (terminal). The closest TAF is often used by various flight planning systems and briefers to provide pilots reference to the local conditions. The TAF issued for KCYS surrounding the period at 1120 MDT was as follows:

TAF KCYS 311720Z 3118/0118 29012G22KT P6SM SKC
FM312300 20010KT P6SM SKC
FM010400 22005KT P6SM FEW250=

³⁰ www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

³¹ The NWS Cheyenne, WY, WFO issued the TAF.

6.2 Soaring Forecast

The NWS KBOU WFO issued a soaring forecast at 0655 MDT which was as follows:

UXUS97 KBOU 311256
SRGBOU

Soaring Forecast
National Weather Service Denver/Boulder, Colorado
0655 MDT Thursday, August 31, 2023

This forecast is for Thursday, August 31, 2023:

If the trigger temperature of 87.0 F/30.5 C is reached...then

Thermal Soaring Index..... Excellent
Maximum rate of lift..... 1557 ft/min (7.9 m/s)
Maximum height of thermals..... 21283 ft MSL (15990 ft AGL)

Forecast maximum temperature..... 97.0 F/36.6 C
Time of trigger temperature..... 1045 MDT
Time of overdevelopment..... None
Middle/high clouds during soaring window..... None
Surface winds during soaring window..... 20 mph or less
Height of the -3 thermal index..... 16527 ft MSL (11234 ft AGL)
Thermal soaring outlook for Friday 09/01..... Excellent

Wave Soaring Index..... Poor
Wave Soaring Index trend (to 1800 MDT)..... No change
Height of stable layer (12-18K ft MSL)..... None
Weak PVA/NVA (through 1800 MDT)..... Weak PVA
Potential height of wave..... 14410 ft MSL (9117 ft AGL)
Wave soaring outlook for Friday 09/01..... Poor

Remarks...

Sunrise/Sunset..... 06:26:43 / 19:32:53 MDT
Total possible sunshine..... 13 hr 6 min 10 sec (786 min 10 sec)
Altitude of sun at 12:59:48 MDT... 58.76 degrees

* * * * * Numerical weather prediction model forecast data valid * * * * *

08/31/2023 at 0900 MDT								08/31/2023 at 1200 MDT							
CAPE...	+13.1	LI...	+2.2					CAPE...	+101.5	LI...	+1.3				
CINH...	-93.5	K Index...	+14.2'					CINH...	-25.2	K Index...	+15.5'				
Height	Temperature	Wnd	WndSpd	Lapse Rate				Temperature	Wnd	WndSpd	Lapse Rate				
ft MSL	deg C deg F	Dir	kt m/s	C/km F/kft				deg C deg F	Dir	kt m/s	C/km F/kft				

50000	-62.5 -80.5	265	40 21	-nan.n -nan.n				-62.4 -80.3	265	40 20	-nan.n -nan.n				

45000	-58.5	-73.3	270	50	26	-nan.n	-nan.n	-58.3	-72.9	270	48	24	-nan.n	-nan.n
40000	-54.9	-66.8	275	44	22	-nan.n	-nan.n	-55.1	-67.2	275	42	22	-nan.n	-nan.n
38000	-50.9	-59.6	275	42	22	-nan.n	-nan.n	-50.7	-59.3	275	41	21	-nan.n	-nan.n
36000	-47.0	-52.6	280	40	21	-nan.n	-nan.n	-45.8	-50.4	280	40	21	-nan.n	-nan.n
34000	-41.8	-43.2	280	37	19	-nan.n	-nan.n	-41.4	-42.5	280	37	19	-nan.n	-nan.n
32000	-37.1	-34.8	275	35	18	-nan.n	-nan.n	-37.1	-34.8	280	34	18	-nan.n	-nan.n
30000	-32.2	-26.0	275	34	18	-nan.n	-nan.n	-32.0	-25.6	280	33	17	-nan.n	-nan.n
29000	-29.7	-21.5	270	34	18	-nan.n	-nan.n	-29.4	-20.9	280	32	16	-nan.n	-nan.n
28000	-27.2	-17.0	270	34	17	-nan.n	-nan.n	-26.8	-16.2	280	31	16	-nan.n	-nan.n
27000	-25.1	-13.2	270	33	17	-nan.n	-nan.n	-24.7	-12.5	275	31	16	-nan.n	-nan.n
26000	-22.9	-9.2	265	32	17	-nan.n	-nan.n	-22.6	-8.7	270	31	16	-nan.n	-nan.n
25000	-20.8	-5.4	265	31	16	-nan.n	-nan.n	-20.5	-4.9	270	31	16	-nan.n	-nan.n
24000	-18.4	-1.1	260	29	15	-nan.n	-nan.n	-18.1	-0.6	265	29	15	-nan.n	-nan.n
23000	-16.0	3.2	255	27	14	-nan.n	-nan.n	-15.6	3.9	260	26	14	-nan.n	-nan.n
22000	-13.5	7.7	250	25	13	-nan.n	-nan.n	-13.1	8.4	255	24	13	-nan.n	-nan.n
21000	-11.3	11.7	245	21	11	-nan.n	-nan.n	-10.9	12.4	250	23	12	-nan.n	-nan.n
20000	-9.1	15.6	240	18	9	-nan.n	-nan.n	-8.7	16.3	240	22	11	-nan.n	-nan.n
19500	-8.0	17.6	235	16	8	-nan.n	-nan.n	-7.6	18.3	240	21	11	-nan.n	-nan.n
19000	-7.0	19.4	230	15	8	-nan.n	-nan.n	-6.0	21.2	235	20	10	-nan.n	-nan.n
18500	-6.0	21.2	230	13	7	-nan.n	-nan.n	-5.0	23.0	230	18	10	-nan.n	-nan.n
18000	-4.5	23.9	225	11	6	-nan.n	-nan.n	-4.0	24.8	230	17	9	-nan.n	-nan.n
17500	-3.3	26.1	225	10	5	-nan.n	-nan.n	-3.1	26.4	230	16	8	-nan.n	-nan.n
17000	-2.1	28.2	220	9	5	-nan.n	-nan.n	-2.1	28.2	230	15	8	-nan.n	-nan.n
16500	-0.8	30.6	225	9	4	-nan.n	-nan.n	-0.8	30.6	230	15	8	-nan.n	-nan.n
16000	0.4	32.7	225	8	4	-nan.n	-nan.n	0.5	32.9	230	14	7	-nan.n	-nan.n
15500	1.7	35.1	230	8	4	-nan.n	-nan.n	1.8	35.2	225	13	7	-nan.n	-nan.n
15000	3.0	37.4	240	8	4	-nan.n	-nan.n	3.2	37.8	225	12	6	-nan.n	-nan.n
14500	4.4	39.9	245	8	4	-nan.n	-nan.n	4.5	40.1	225	11	6	-nan.n	-nan.n
14000	5.8	42.4	255	9	4	-nan.n	-nan.n	5.9	42.6	230	11	6	-nan.n	-nan.n
13500	7.1	44.8	260	9	5	-nan.n	-nan.n	7.2	45.0	235	10	5	-nan.n	-nan.n
13000	8.5	47.3	265	10	5	-nan.n	-nan.n	8.5	47.3	240	10	5	-nan.n	-nan.n
12500	9.8	49.6	270	11	6	-nan.n	-nan.n	9.9	49.8	245	10	5	-nan.n	-nan.n
12000	11.2	52.2	275	12	6	-nan.n	-nan.n	11.2	52.2	250	9	5	-nan.n	-nan.n
11500	12.5	54.5	275	12	6	-nan.n	-nan.n	12.6	54.7	255	9	5	-nan.n	-nan.n
11000	13.9	57.0	280	12	6	-nan.n	-nan.n	14.0	57.2	255	8	4	-nan.n	-nan.n
10500	15.2	59.4	280	12	6	-nan.n	-nan.n	15.3	59.5	255	8	4	-nan.n	-nan.n
10250	15.4	59.7	280	11	6	-nan.n	-nan.n	15.4	59.7	255	8	4	-nan.n	-nan.n
10000	16.2	61.2	280	11	6	-nan.n	-nan.n	16.3	61.3	255	7	4	-nan.n	-nan.n
9750	17.0	62.6	280	11	6	-nan.n	-nan.n	17.1	62.8	255	6	3	-nan.n	-nan.n
9500	17.9	64.2	280	11	6	-nan.n	-nan.n	17.9	64.2	255	6	3	-nan.n	-nan.n
9250	18.5	65.3	280	10	5	-nan.n	-nan.n	18.5	65.3	250	5	2	-nan.n	-nan.n
9000	19.0	66.2	280	9	4	-nan.n	-nan.n	19.2	66.6	245	4	2	-nan.n	-nan.n
8750	19.8	67.6	280	9	4	-nan.n	-nan.n	20.0	68.0	240	3	2	-nan.n	-nan.n
8500	20.5	68.9	275	9	5	-nan.n	-nan.n	20.7	69.3	230	3	1	-nan.n	-nan.n
8250	21.2	70.2	275	8	4	-nan.n	-nan.n	21.4	70.5	215	2	1	-nan.n	-nan.n
8000	21.7	71.1	275	8	4	-nan.n	-nan.n	22.1	71.8	195	2	1	-nan.n	-nan.n
7750	22.3	72.1	275	8	4	-nan.n	-nan.n	22.8	73.0	185	2	1	-nan.n	-nan.n
7500	22.9	73.2	275	8	4	-nan.n	-nan.n	23.5	74.3	175	1	1	-nan.n	-nan.n
7250	23.3	73.9	275	7	4	-nan.n	-nan.n	24.2	75.6	160	2	1	-nan.n	-nan.n
7000	23.8	74.8	270	6	3	-nan.n	-nan.n	24.9	76.8	155	2	1	-nan.n	-nan.n
6750	24.2	75.6	265	5	3	-nan.n	-nan.n	25.6	78.1	145	2	1	-nan.n	-nan.n
6500	24.5	76.1	260	4	2	-nan.n	-nan.n	26.5	79.7	135	2	1	-nan.n	-nan.n
6250	24.6	76.3	245	4	2	-nan.n	-nan.n	27.3	81.1	135	2	1	-nan.n	-nan.n
6000	24.6	76.3	235	4	2	-nan.n	-nan.n	28.2	82.8	130	2	1	-nan.n	-nan.n
5750	24.6	76.3	225	4	2	-nan.n	-nan.n	28.9	84.0	125	2	1	-nan.n	-nan.n

5500 24.6 76.3 225 4 2 -nan.n -nan.n | 30.3 86.5 120 2 1 -nan.n -nan.n

08/31/2023 at 1500 MDT

CAPE... +88.8 LI... -0.0
CINH... -26.8 K Index... +22.8'

Height ft	Temperature MSL deg C deg F	Wnd Dir	WndSpd kt m/s	Lapse Rate C/km F/kft
32000	-36.5 -33.7	285	35 18	-nan.n -nan.n
30000	-31.5 -24.7	280	32 16	-nan.n -nan.n
29000	-29.0 -20.2	275	30 15	-nan.n -nan.n
28000	-26.5 -15.7	275	28 15	-nan.n -nan.n
27000	-24.4 -11.9	275	29 15	-nan.n -nan.n
26000	-22.3 -8.1	270	29 15	-nan.n -nan.n
25000	-20.1 -4.2	270	30 15	-nan.n -nan.n
24000	-18.0 -0.4	265	29 15	-nan.n -nan.n
23000	-15.9 3.4	265	28 14	-nan.n -nan.n
22000	-13.7 7.3	260	27 14	-nan.n -nan.n
21000	-11.6 11.1	255	25 13	-nan.n -nan.n
20000	-9.4 15.1	255	23 12	-nan.n -nan.n
19500	-8.3 17.1	255	22 11	-nan.n -nan.n
19000	-6.6 20.1	250	20 11	-nan.n -nan.n
18500	-5.3 22.5	250	19 10	-nan.n -nan.n
18000	-4.1 24.6	250	18 9	-nan.n -nan.n
17500	-2.8 27.0	245	17 9	-nan.n -nan.n
17000	-1.5 29.3	245	15 8	-nan.n -nan.n
16500	-0.2 31.6	240	14 7	-nan.n -nan.n
16000	1.2 34.2	235	13 7	-nan.n -nan.n
15500	2.5 36.5	230	13 6	-nan.n -nan.n
15000	3.9 39.0	225	12 6	-nan.n -nan.n
14500	5.3 41.5	220	11 6	-nan.n -nan.n
14000	6.7 44.1	220	10 5	-nan.n -nan.n
13500	8.2 46.8	215	10 5	-nan.n -nan.n
13000	9.5 49.1	205	9 5	-nan.n -nan.n
12500	10.9 51.6	200	9 4	-nan.n -nan.n
12000	12.3 54.1	195	8 4	-nan.n -nan.n
11500	13.7 56.7	185	8 4	-nan.n -nan.n
11000	14.9 58.8	180	7 4	-nan.n -nan.n
10500	16.1 61.0	175	7 4	-nan.n -nan.n
10250	17.2 63.0	170	7 4	-nan.n -nan.n
10000	17.9 64.2	170	7 4	-nan.n -nan.n
9750	18.7 65.7	165	7 3	-nan.n -nan.n
9500	19.4 66.9	165	7 3	-nan.n -nan.n
9250	20.0 68.0	160	7 4	-nan.n -nan.n
9000	20.7 69.3	160	7 4	-nan.n -nan.n
8750	21.5 70.7	160	7 4	-nan.n -nan.n
8500	22.3 72.1	155	7 3	-nan.n -nan.n
8250	23.1 73.6	155	7 4	-nan.n -nan.n
8000	23.8 74.8	155	7 4	-nan.n -nan.n
7750	24.6 76.3	155	7 4	-nan.n -nan.n
7500	25.3 77.5	150	6 3	-nan.n -nan.n
7250	26.0 78.8	150	7 3	-nan.n -nan.n
7000	26.6 79.9	150	7 4	-nan.n -nan.n

6750	27.4	81.3	150	7	3	-nan.n	-nan.n
6500	28.3	82.9	150	6	3	-nan.n	-nan.n
6250	29.1	84.4	150	6	3	-nan.n	-nan.n
6000	29.9	85.8	150	6	3	-nan.n	-nan.n
5750	30.7	87.3	150	6	3	-nan.n	-nan.n
5500	31.9	89.4	145	6	3	-nan.n	-nan.n

6.3 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short-term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF and provide some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The AFD issued by KBOU at 1154 MDT was as follows.

*FXUS65 KBOU 311754
AFDBOU*

*Area Forecast Discussion
National Weather Service Denver/Boulder CO
1154 AM MDT Thu Aug 31 2023*

*.UPDATE...
Issued at 1146 AM MDT Thu Aug 31 2023*

The forecast is performing well with only minor updates this morning.

The 12Z synoptic analysis shows a trough to our north with a shortwave coming in behind it and a ridge to our south and southwest, with weak southwesterly flow aloft over Colorado between them. It will be hot and dry, forecast high temperatures are in the mid to upper 90s across the plains, and 60s (mountains) to 80s (valleys) across the high country. These are about 10 degrees above normal across the plains and mountain valleys. The Denver record daily high temperature of 98 F, most recently occurred in 2011, though the current forecast is for the record to stand.

Afternoon minimum humidity is forecast near and just below 15 percent across much of northeast Colorado this afternoon. In North and Middle Parks, it may be coincident with peak gusts of 25 to 30 mph, leading to patchy elevated fire weather conditions. These should be limited in time and zone coverage so we will continue to refrain from issuing products, while monitoring the situation closely.

CAMs show little to no convection for northeast Colorado this afternoon and evening, there may be a few very weak storms and showers for the high country, focused around Park County, but not much else.

*.SHORT TERM...(Today and tonight)
Issued at 419 AM MDT Thu Aug 31 2023*

A hot and dry airmass will remain over the region with the center of the upper ridge over NM/AZ and light to moderate southwesterly flow aloft over CO. The models keep mid-level temperatures

around 5.5C in the 500-700 mb layer, similar to yesterday, so went with a max of 97, only a degree away from the record high of 98 for this date. *The models keep the area void of thunderstorms this afternoon, but weak cumulus buildups late this afternoon, could result in a brief period of gusty outflow winds in the 20-30 mph range around Denver and the Palmer Divide, mainly between 4-7 pm. Gusty winds 25-30 mph coupled with relative humidities in the mid teens will produce elevated fire conditions in the valleys of Jackson and Grand counties this afternoon. No fire weather highlights at this time as but this will be an area to keep an eye on. Mild and dry tonight with lows again in the low to mid 60s.*

.AVIATION...(For the 18Z TAFS through 18Z Friday afternoon)

Issued at 1146 AM MDT Thu Aug 31 2023

Expect VFR conditions through the TAF period. Cloud bases are expected to remain above 6000 feet through the period. Some weak cumulus may build over the high country this afternoon and evening, none are expected near the terminals. A few modest gusts are possible but not probable enough to include in the current TAF. Southwesterly drainage winds this morning have become light and variable, and should soon come around southeasterly while increasing early this afternoon. Winds should continue to come around easterly and increase into the late afternoon and early evening, then turn back around southeasterly before drainage sets back in overnight.

.BOU WATCHES/WARNINGS/ADVISORIES...

None.

6.4 Graphic Area Forecast

The NWS Graphic Forecast for Aviation (GFA) is a graphical depiction of surface wind, thunderstorms, precipitation, color-coded general flight categories, and cloud cover bases and tops reported in msl heights, from graphical output from the NWS National Digital Forecast Database (NDFD) with the Graphic-Airmen's Meteorological Information (G-AIRMET) for IFR conditions, mountain obscuration, icing conditions, and strong surface wind overlaid. The GFA provides a forecast for the enroute phase of flight and for locations without a TAF. The GFA is available at the NWS AWC website and through other weather briefing services.

The 3-hour GFA Surface and Cloud Forecasts based on data from 0900³² and valid for 1200 MDT are included as figures 9 and 10, with the Surface Forecast enlarged over Colorado to show the expected surface winds. The GFA forecasts depicted confluent southerly winds over the region at 15 knots with clear skies. No G-AIRMETs were depicted over the area for any IFR conditions, strong surface winds, icing, or mountain obscuration conditions during the period.

³² Based on model data for 0900 MDT and issued at about 1000 MDT, and valid for 1200 MDT, i.e. 3-hour forecast.

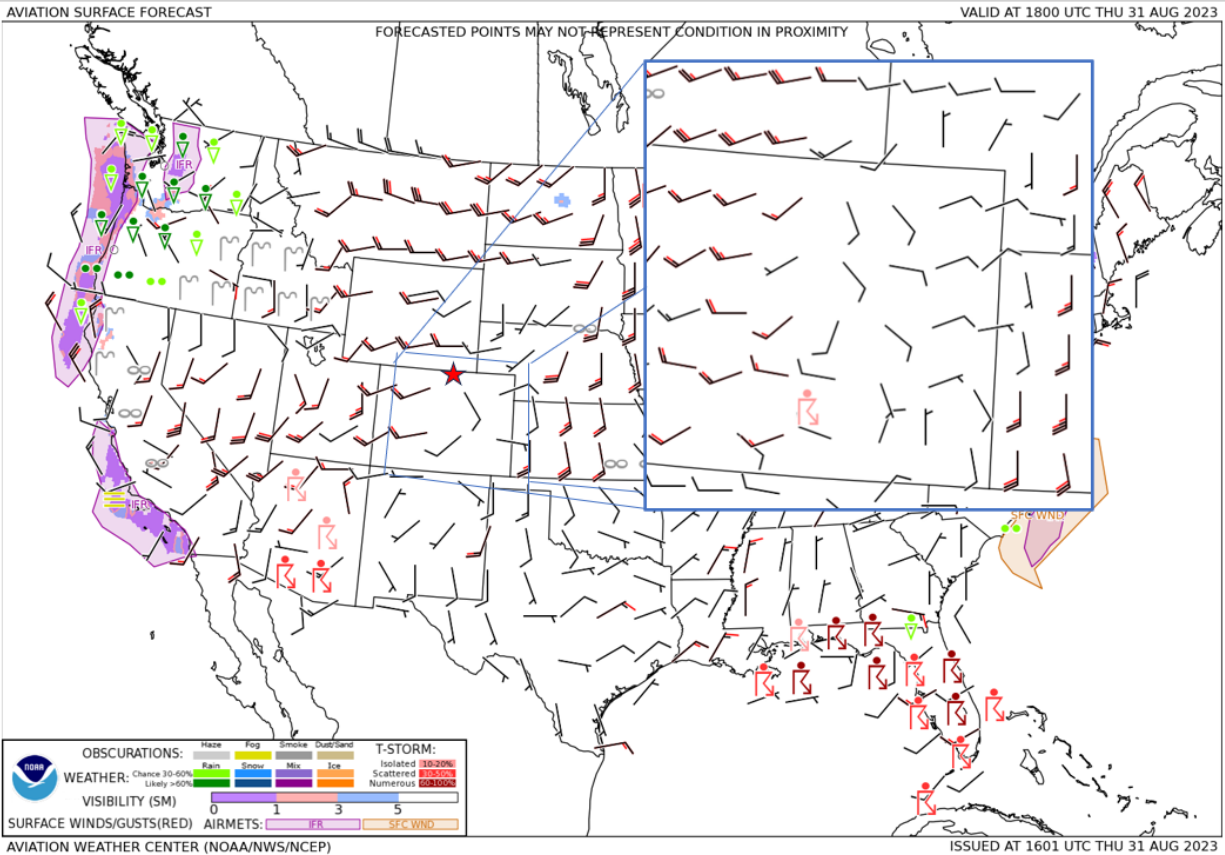


Figure 9 - Graphic Forecast for Aviation (GFA) 3-hour Surface Forecast valid for 1200 MDT with the approximate accident site marked by the red star and includes an enlarge view of Colorado.

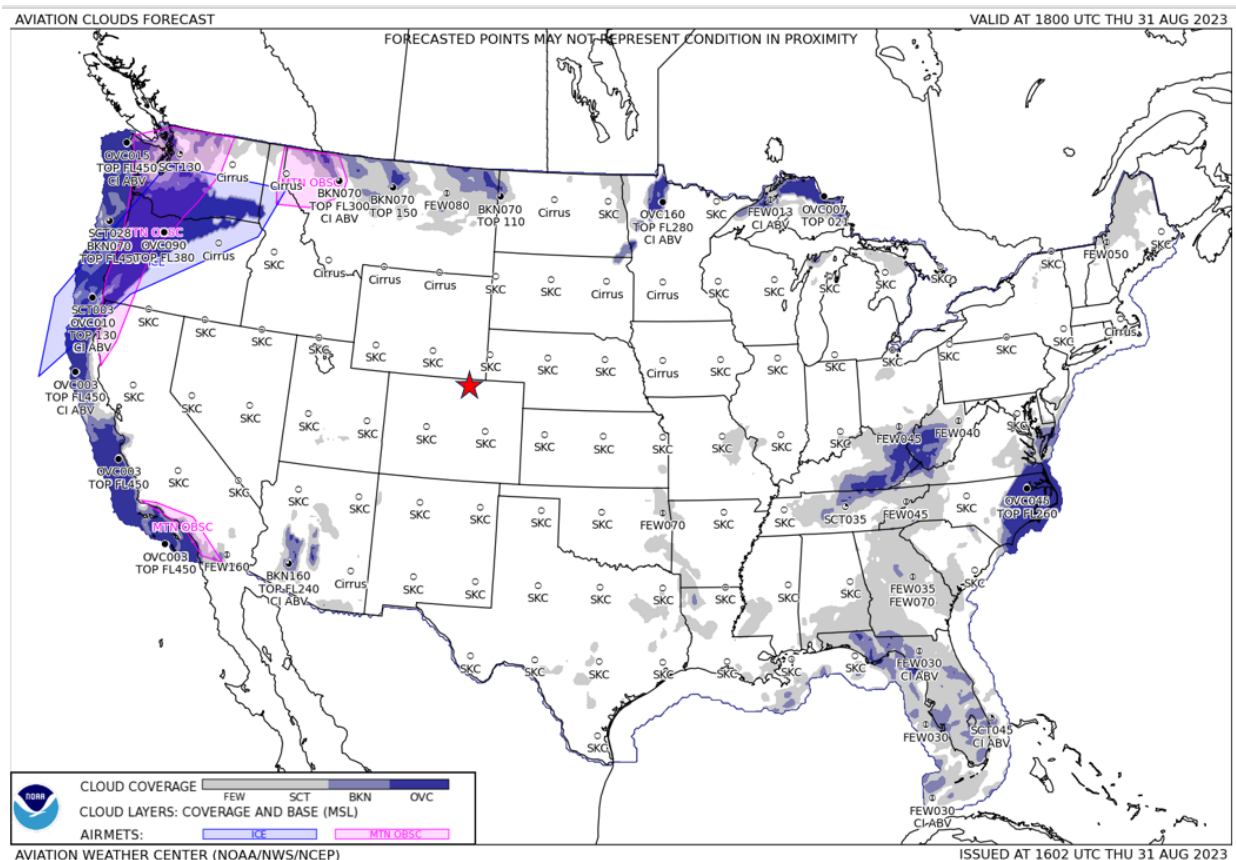


Figure 10 - Graphic Forecast for Aviation (GFA) 3-hour Cloud Forecast valid for 1200 MDT with the approximate accident site marked by the red star. Depicting clear skies over the area.

6.5 Winds and Temperatures Aloft Forecast

The NWS Winds and Temperatures Aloft forecast current during the period was as follows for the 3 stations the surrounded the accident site (BFF - Scottsbluff, NE; DEN - Denver, CO; and MBW - Medicine Bow, WY).

FBUS31 KWN0 311359
 FD1US1
 _DATA BASED ON 311200Z
 VALID 311800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
_BFF	2912	2519+18	2729+09	2533-08	2534-21	274837	275547	285655	
_DEN		2506+20	2709+11	2418-07	2729-19	283636	284346	284556	
_MBW		2515	2733+09	2642-08	2739-19	275137	275446	276157	

The forecast for Denver for 9,000 at expected a wind from 250° at 6 knots with a temperature of 20°C, and at 12,000 ft a wind from 270° at 9 knots with a temperature of 11°C.

6.6 Graphic Turbulence Guidance

The NWS Graphic Turbulence Guidance (GTG) product depiction of the maximum expected eddy dissipation rate (EDR)³³ for a lightweight class aircraft³⁴ for 1400 MDT below 18,000 ft is included as figure 11. The GTG image for 1400 MDT depicted EDR values between 16 to 30 over the area consistent with light to moderate turbulence.

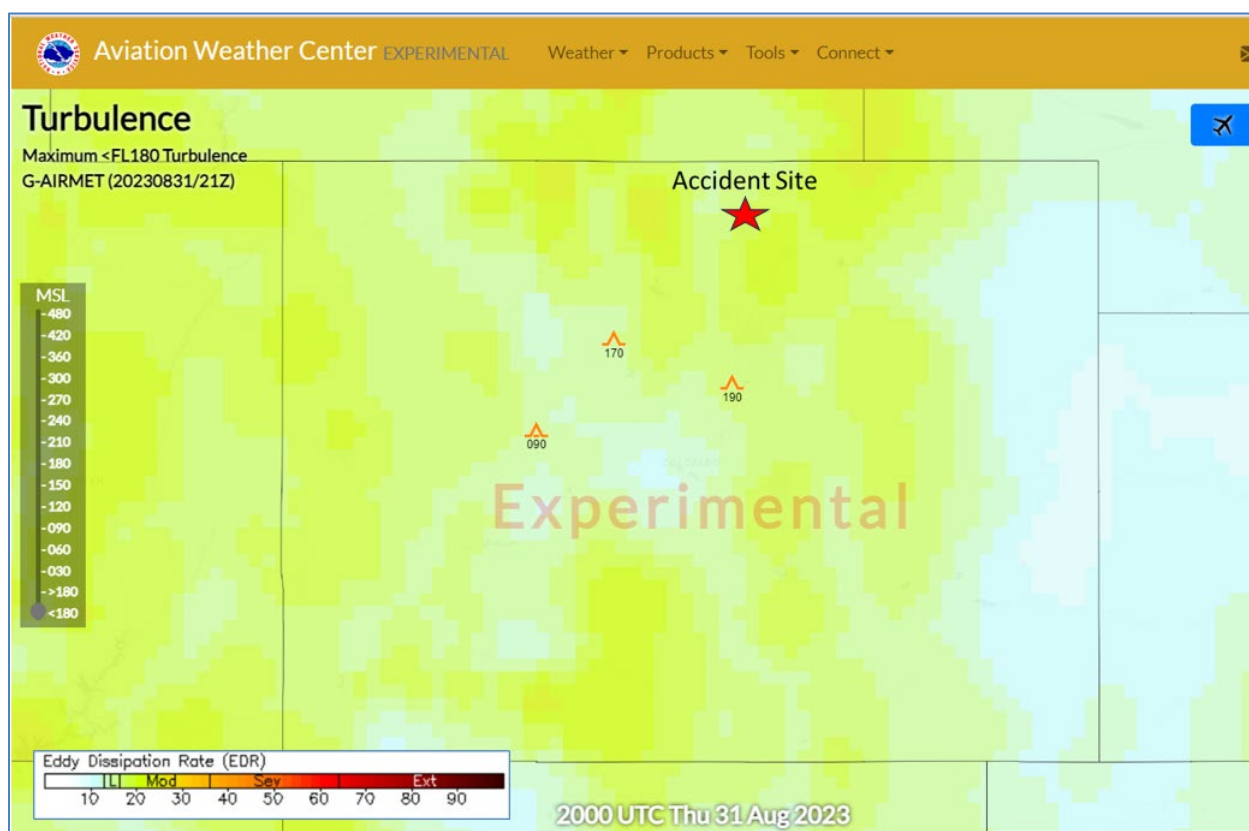


Figure 11 - NWS Graphic Turbulence Guidance (GTG) for a light weight category aircraft for 1400 MDT with PIREPs reported for the previous several hours.

7.0 Inflight Weather Advisories

In-flight Aviation Weather Advisories are forecasts that advise en route aircraft of the development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) at the various Air Route Traffic Control Centers

³³ The EDR is an aircraft-independent measure of turbulence, which is the cube root of the dissipation rate of turbulent kinetic energy and measured in m^2/s^3 . However, the relationship between the EDR value and the perception of turbulence is a function of aircraft type, and the mass, altitude, configuration and airspeed of the aircraft.

³⁴ Light weight is based on a takeoff weight less than 15,500 pounds.

(ARTCCs). There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the G-AIRMET, and the Center Weather Advisory (CWA). Inflight advisories serve to notify en-route pilots of the possibility of encountering hazardous flying conditions that 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 based on experience and the operational limits of the aircraft. Once issued they are broadcast by FAA air traffic controllers upon issuance and available on inflight weather broadcasts.

There were no NWS inflight weather advisories current over the area at the time of the accident for any significant convection, turbulence, icing, or low-level wind shear, instrument flight rule conditions or mountain obscuration conditions.

E. ATTACHMENTS

Attachment 1 - GOES-18 GeoColor satellite imagery from 1100-1500 MDT.

Attachment 2 - GOES-18 mid-level water vapor imagery 1100-1500 MDT.

Submitted by:

Donald Eick
NTSB Senior Meteorologist