NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

December 9, 2015

Group Chairman's Weather Study Report

METEOROLOGY

CEN16FA011

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A. ACCIDENT

Location: 4 miles northeast of Eaton, Colorado
Date: October 13, 2015
Time: approximately 1134 mountain daylight time (1734 UTC[1])
Aircraft: Beech G35, registration: N394CW

B. METEOROLOGY GROUP

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C. SUMMARY

For a summary of the accident, refer to the *Accident Summary* report, which is available in the docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist was not on scene for this investigation and gathered all the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are mountain daylight time (MDT) on October 13, 2015, and are 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 statute miles.

The accident site was located at latitude 40.57° N, longitude 104.65° W, elevation: 4,843 feet.

[1] UTC – is an abbreviation for Coordinated Universal Time.

E. 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 (NCEP), and the Weather Prediction Center (WPC) 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-0045G CHG 1.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1200, 1500, and 1800 MDT are provided as figures 1, 2, and 3 with the approximate location of the accident site marked. The 1200 MDT chart depicted a surface trough[2] stretched from the panhandle of Oklahoma northward into southeastern South Dakota. A cold front stretched from eastern Wyoming into eastern South Dakota. The cold front moved southward with time between 1200 and 1800 MDT (figures 1, 2, and 3) with the cold front moving into northeastern Colorado by 1800 MDT. Surface high pressure centers with pressures between of 1022-hectopascals (hPa) and 1024-hPa were located west of the accident site in western Colorado at 1200, 1500, and 1800 MDT. The station models around the accident site at 1200 MDT depicted air temperatures in the mid 70's to low 80's Fahrenheit (F), with temperature-dew point spreads of 50° F or more, a north to northwest wind between 5 and 15 knots, and clear skies. Surface conditions were similar at 1500 MDT, however, the wind near the accident site and shifted to the east to northeast (figure 2). By 1800 MDT the surface wind in the area of the accident had become light and variable around 5 knots (figure 3). With the approach of a cold front to an area one would expect an increase in wind speed, wind shear conditions near the surface, and clouds and precipitation if enough moisture was present. In this case there was not enough moisture for clouds and precipitation near the accident site at the accident time, however, the wind speed changes and wind shear conditions would still be likely.

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

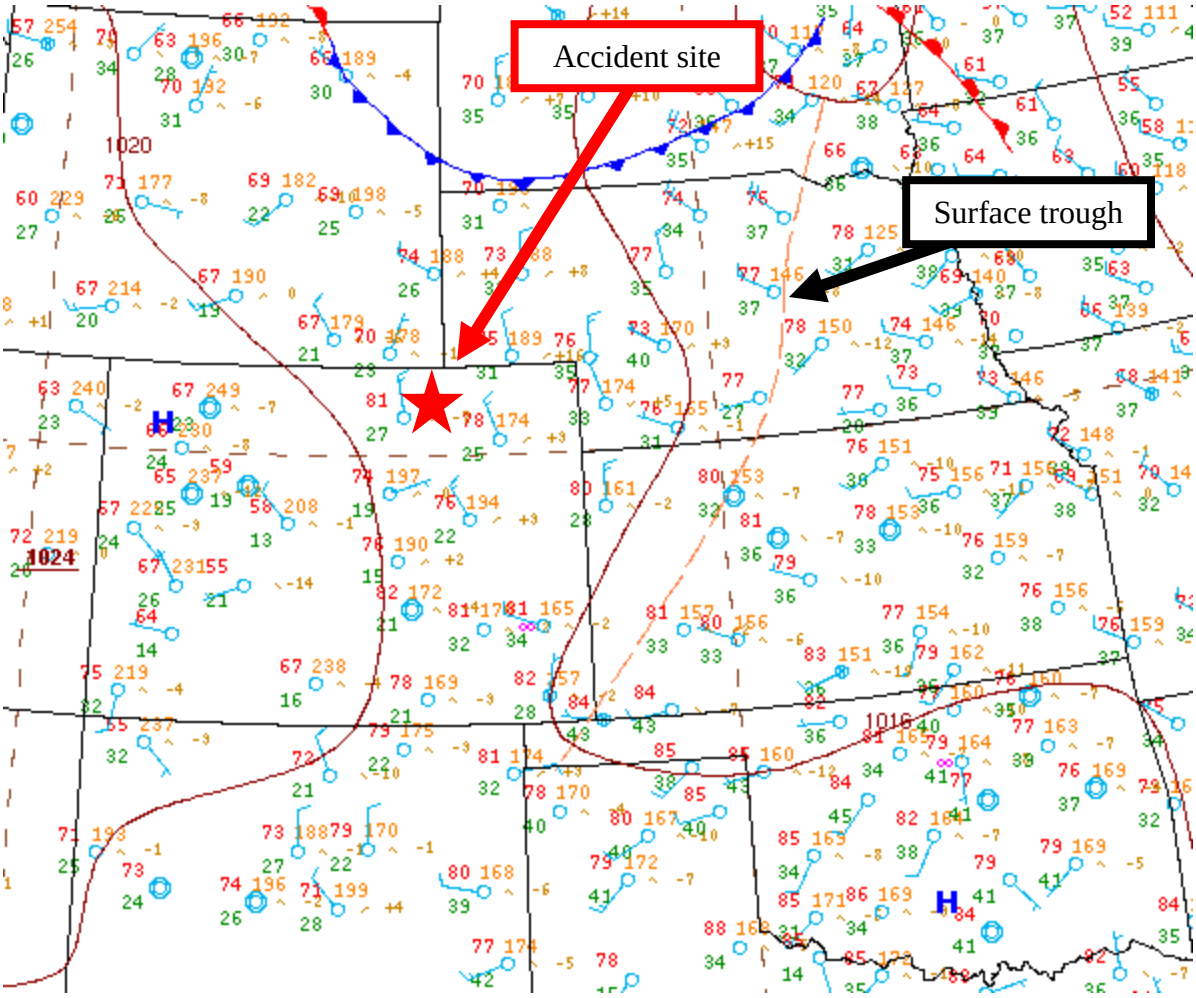


Figure 1 – NWS Surface Analysis Chart for 1200 MDT

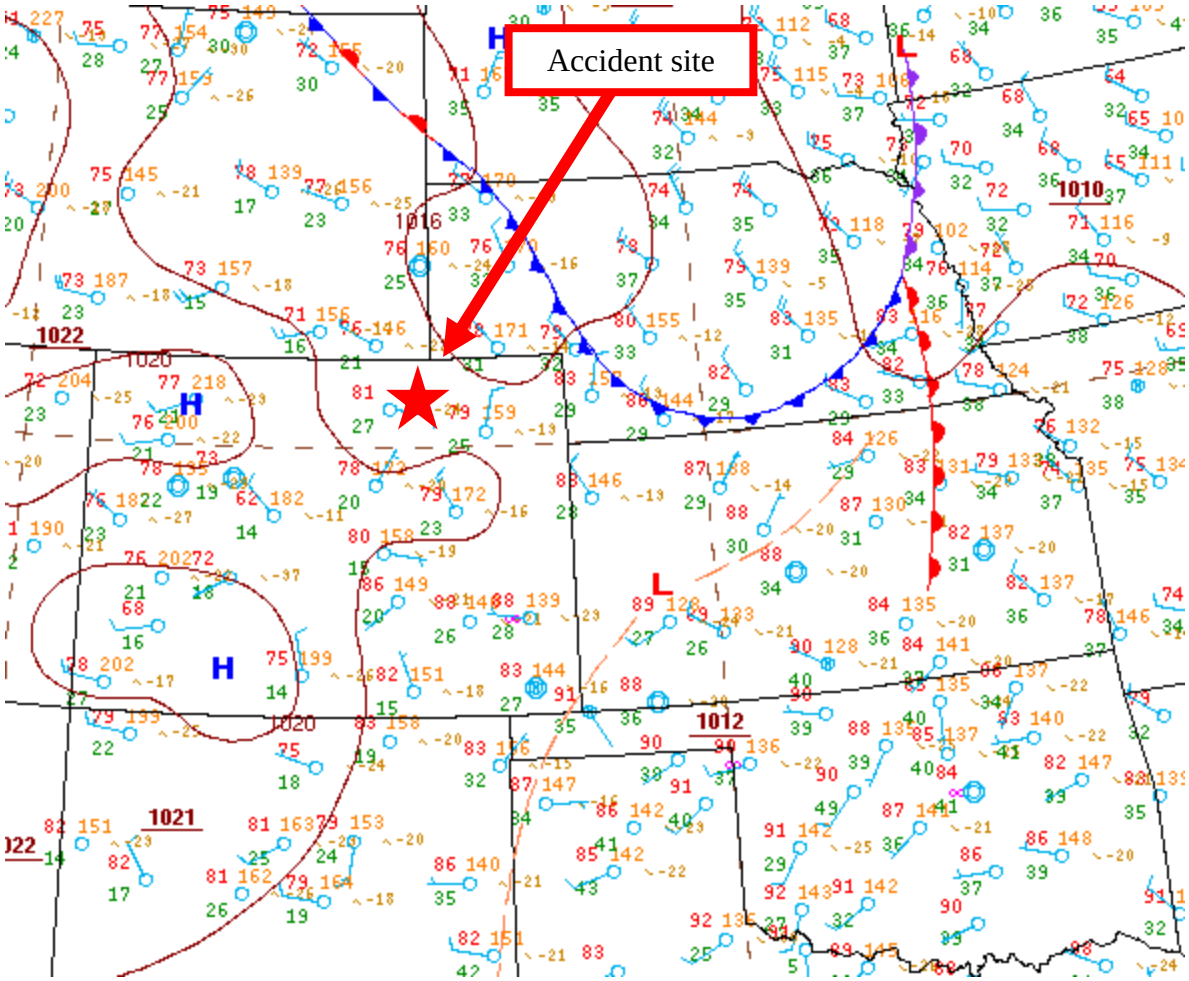


Figure 2 – NWS Surface Analysis Chart for 1500 MDT

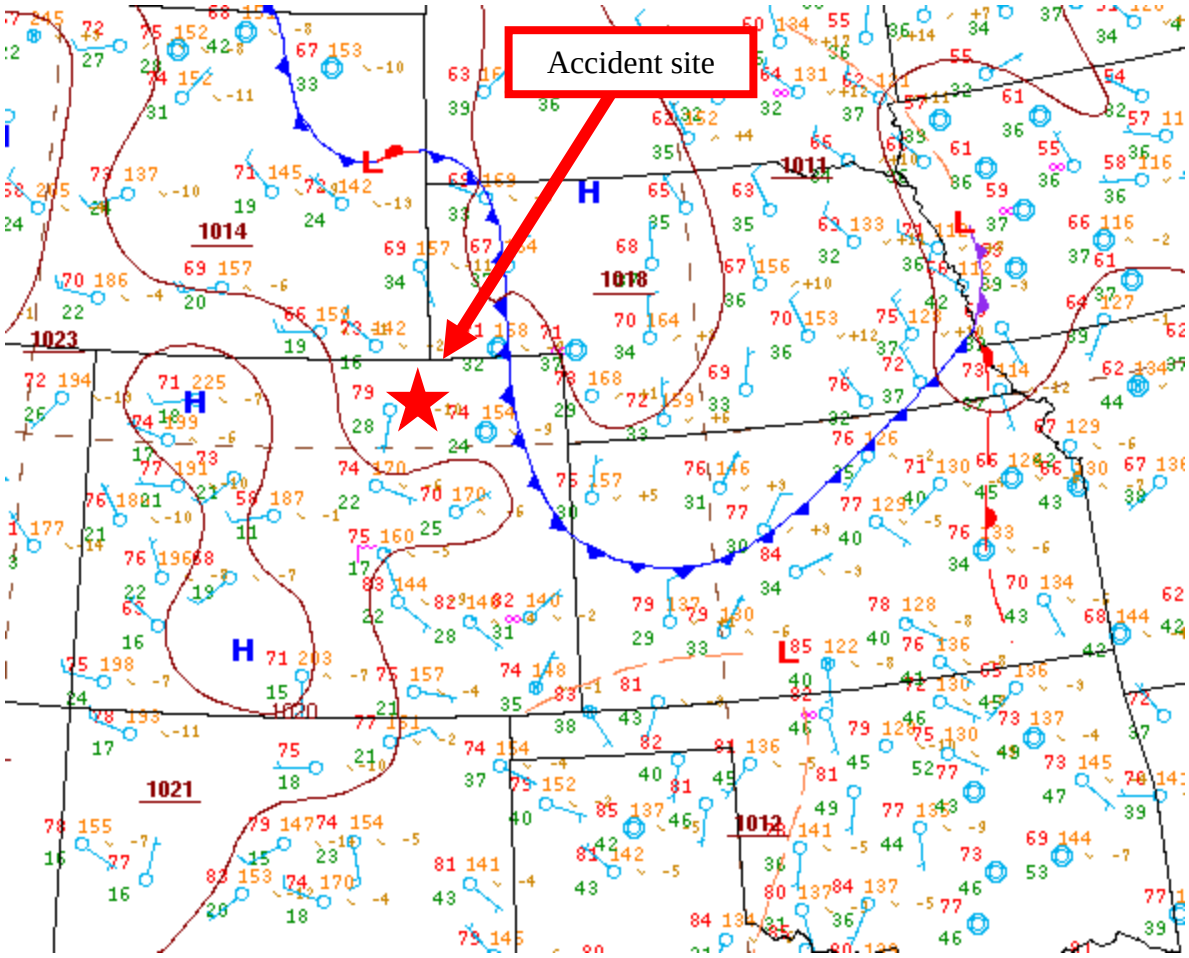


Figure 3 – NWS Surface Analysis Chart for 1800 MDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0600 MDT at 700-, 500-, and 300-hPa are presented in figures 4 through 6. The upper air charts indicated a mid-level trough to the north of the accident site at 0600 MDT likely associated with the cold front moving southward between 1200 and 1800 MDT (figures 1, 2, and 3). Areas near troughs and low pressure centers are considered favorable locations for upward motion and clouds and precipitation, especially in mountainous terrain, but enough moisture has to be present for clouds and precipitation. In this case, there was not enough moisture in the environment for clouds and precipitation near the accident site (section 4.0), however, the areas of vertical motion and wind shear associated with troughs and fronts was still present. The wind remained out of the northwest to west between 700- and 300-hPa with the wind speed increasing from 20 knots at 700-hPa to 35 knots and 300-hPa (figure 6).

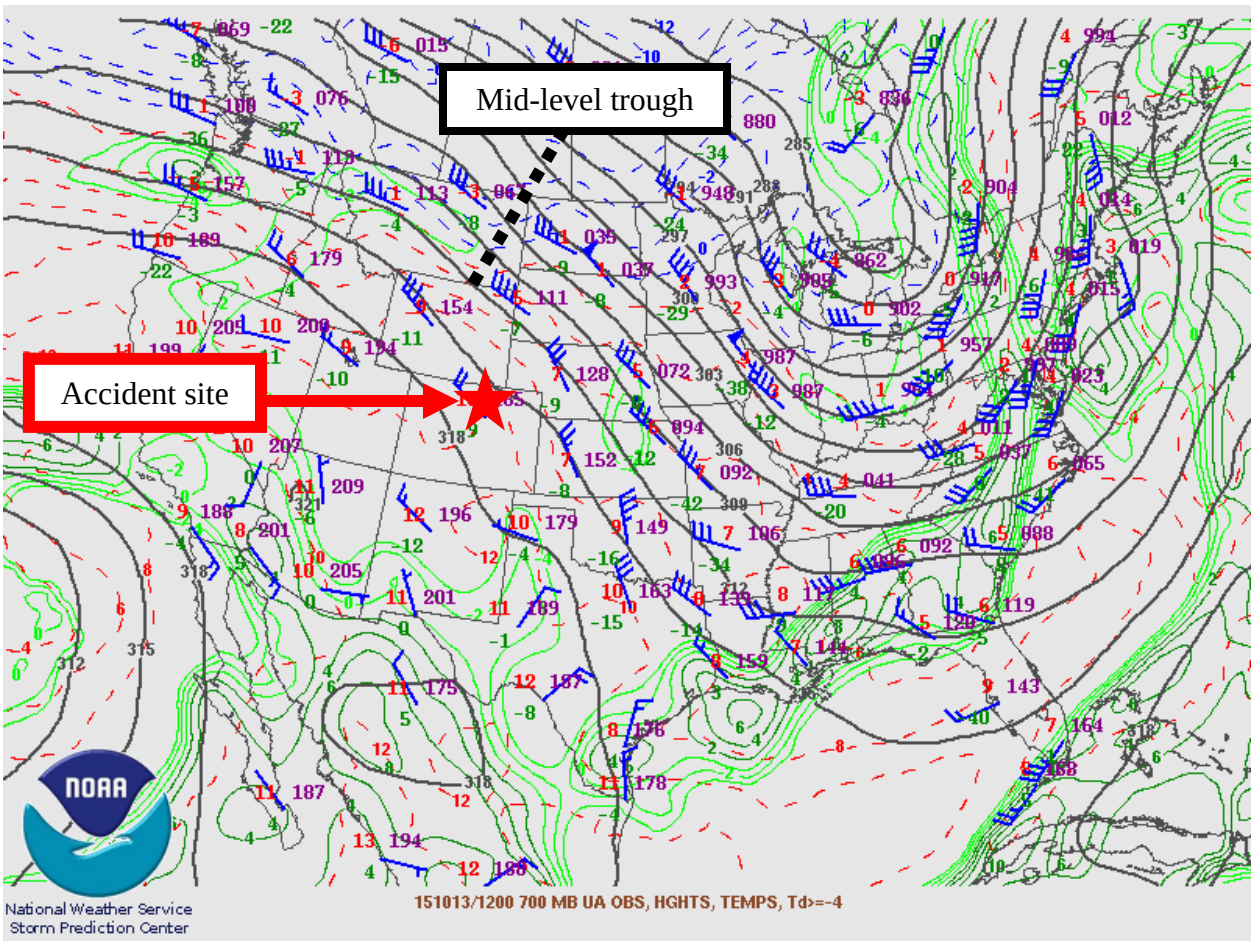


Figure 4 – 700-hPa Constant Pressure Chart for 0600 MDT

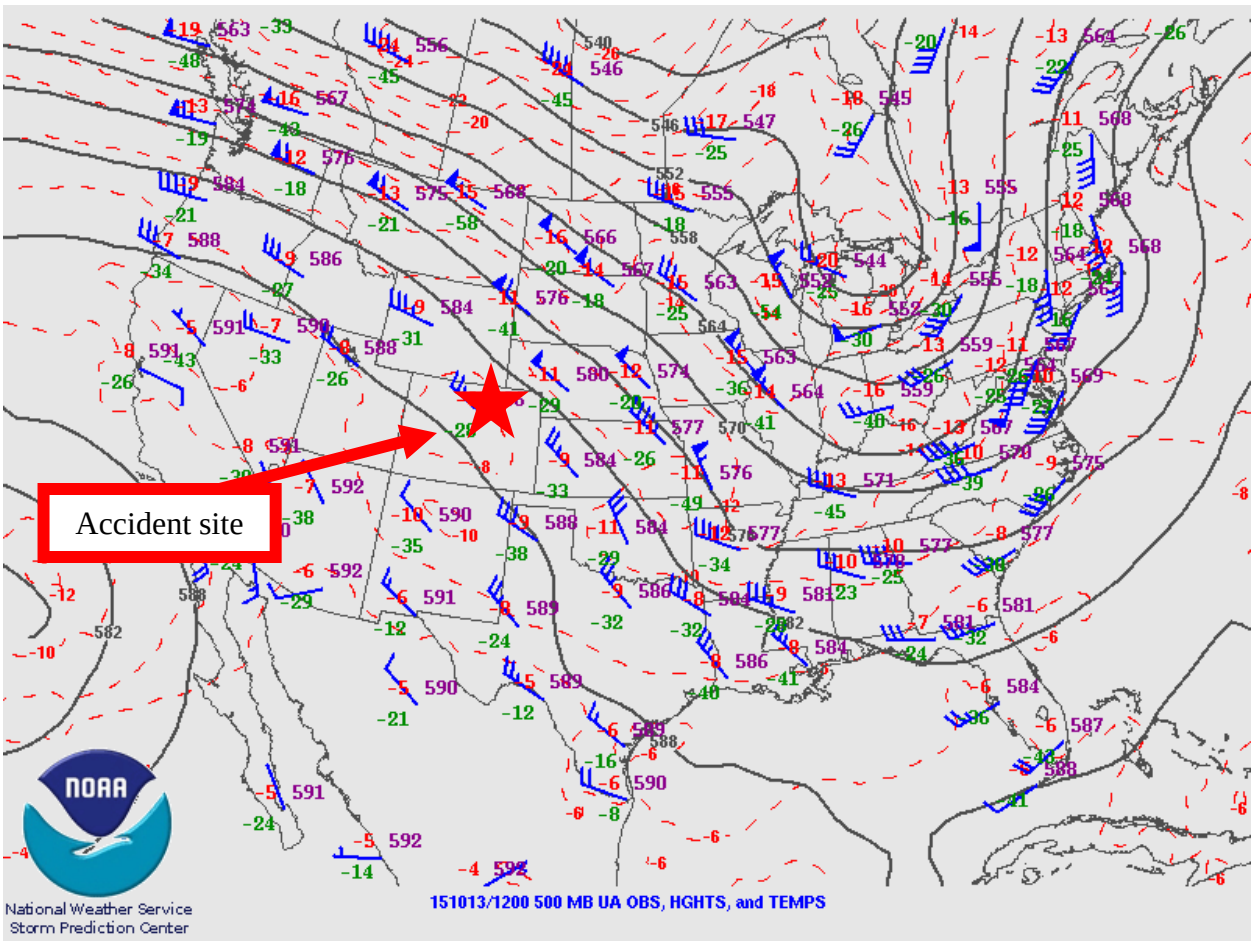


Figure 5 – 500-hPa Constant Pressure Chart for 0600 MDT

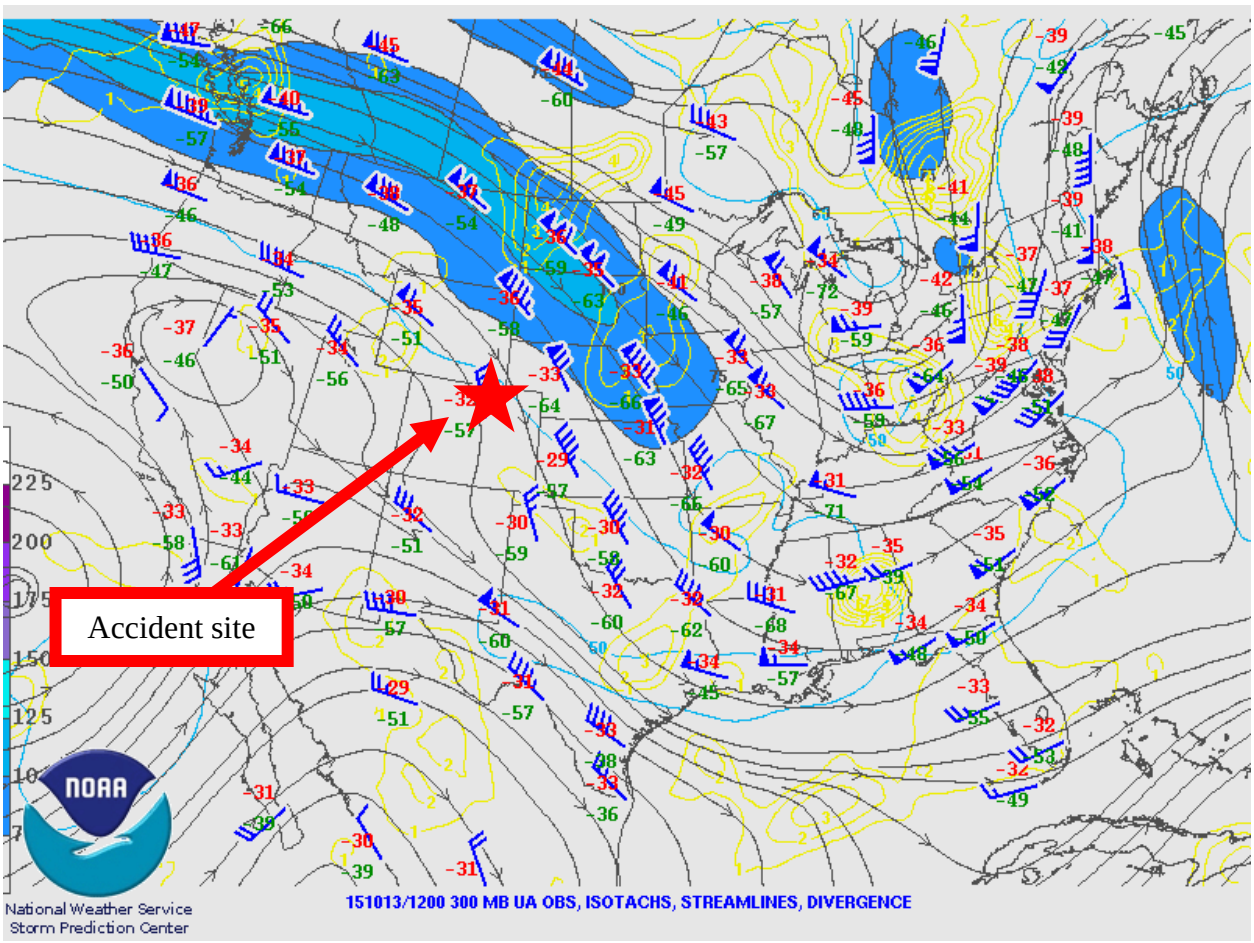


Figure 6 – 300-hPa Constant Pressure Chart for 0600 MDT

2.0 Storm Prediction Center Products

There was no convective weather forecast for the accident site from the SPC Day 1 Convective Outlook.

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language.

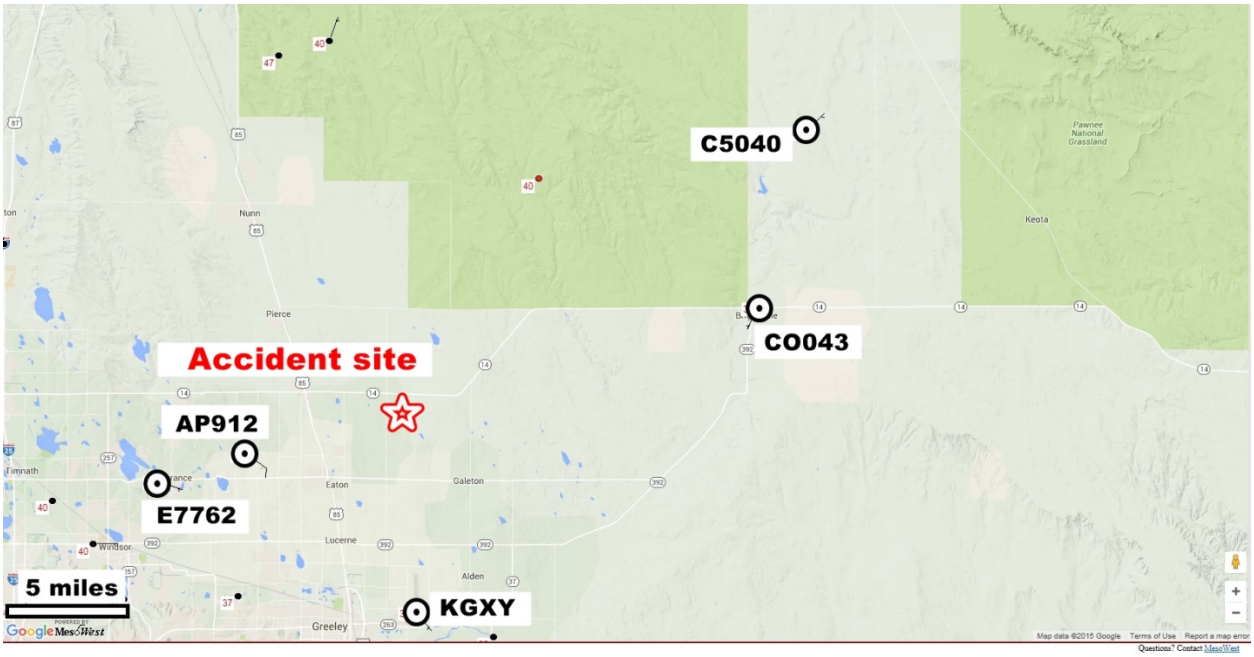


Figure 7 – Surface map with the location of the accident site and surface observation sites

Greeley-Weld County Airport (KGXY) was the closest official weather station to the accident site. KGXY was located 3 miles east of Greeley, Colorado, and had an Automated Weather Observing System (AWOS[3]) whose reports were not supplemented. KGXY was located 8 miles south of the accident site, at an elevation of 4,697 feet, and had an 8° easterly magnetic variation (figure 7). The following observations were taken and disseminated during the times surrounding the accident: [4]

[0955 MDT] KGXY 131555Z AUTO 32007KT 10SM CLR 19/03 A3022 RMK AO1=

[1015 MDT] KGXY 131615Z AUTO 31010G14KT 10SM CLR 23/M01 A3022 RMK AO1=

[1035 MDT] KGXY 131635Z AUTO 31013KT 10SM CLR 24/M02 A3022 RMK AO1=

[1055 MDT] KGXY 131655Z AUTO 33012G22KT 10SM CLR 26/M03 A3021 RMK AO1=

[1115 MDT] KGXY 131715Z AUTO 34014G19KT 10SM CLR 26/M03 A3021 RMK AO1=

ACCIDENT TIME 1134 MDT

[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 twelve thousand feet, and altimeter setting.

[4] The bold sections in this NWS product and the rest of products in the weather study report are to highlight the individual sections that directly reference the weather conditions that are or will affect the accident location around the accident time.

[1135 MDT] KGXY 131735Z AUTO 34009G16KT 10SM CLR 26/M04 A3021 RMK AO1=

[1155 MDT] KGXY 131755Z AUTO 35013G20KT 330V030 10SM CLR 27/M03 A3020 RMK AO1 10270 20030 57007=

[1215 MDT] KGXY 131815Z AUTO 34010G17KT 10SM CLR 26/M04 A3020 RMK AO1=

[1235 MDT] KGXY 131835Z AUTO 02008KT 10SM CLR 26/M04 A3019 RMK AO1=

[1255 MDT] KGXY 131855Z AUTO 02006KT 10SM CLR 27/M04 A3019 RMK AO1=

[1315 MDT] KGXY 131915Z AUTO 35005KT 10SM CLR 27/M04 A3018 RMK AO1=

[1335 MDT] KGXY 131935Z AUTO 11006KT 10SM CLR 27/M04 A3016 RMK AO1=

[1355 MDT] KGXY 131955Z AUTO 14006KT 10SM CLR 27/M04 A3015 RMK AO1=

[1415 MDT] KGXY 132015Z AUTO 00000KT 10SM CLR 27/M04 A3014 RMK AO1=

KGXY weather at 1055 MDT, wind from 330° at 12 knots with gusts to 22 knots, 10 miles visibility, clear skies below 12,000 feet above ground level (agl), temperature of 26° Celsius (C), dew point temperature of -3° C, and an altimeter setting of 30.21 inches of mercury. Remarks: automated station without a precipitation discriminator.

KGXY weather at 1115 MDT, wind from 340° at 14 knots with gusts to 19 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 26° C, dew point temperature of -3° C, and an altimeter setting of 30.21 inches of mercury. Remarks: automated station without a precipitation discriminator.

KGXY weather at 1135 MDT, wind from 340° at 9 knots with gusts to 16 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 26° C, dew point temperature of -4° C, and an altimeter setting of 30.21 inches of mercury. Remarks: automated station without a precipitation discriminator.

KGXY weather at 1155 MDT, wind from 350° at 13 knots with gusts to 20 knots, wind varying between 330° and 030°, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 27° C, dew point temperature of -3° C, and an altimeter setting of 30.20 inches of mercury. Remarks: automated station without a precipitation discriminator, 6-hourly maximum temperature of 27.0 C, 6-hourly minimum temperature of 3.0 C, 3-hourly pressure decrease of 0.7 hPa.

In addition to the official surface observation site above, there were several non-official surface observations sites reporting wind conditions around the accident site at the accident time and these sites are documented below and their locations are mapped in figure 7:

WB2JSH Eaton (AP912) was an Automatic Packet Reporting System-Weather Network/Citizen Weather Observer Program (APRSWXNET/CWOP) station and was the closest non-official surface observation site to the accident site that reported wind conditions. AP912 was located 6 miles west-southwest of the accident site at an elevation of 4,888 feet (figure 7) and figure 8 contains the observations surrounding the accident time (time in MDT):

ID = AP912	TMP ° F	RELH %	SKNT mph	GUST mph	DRCT °	QFLG	ALTI in	SOLR W/r	VSBY mil	PREC in	P01I in	P24I in	P05I in	PMID in	TSOI ° F	FT ° F	DWP °F
10-13-2015 14:30 MDT	81	14	4		207	OK	30.14	410						0			27.3
10-13-2015 14:25 MDT	81	14	4		186	OK	30.15	415						0			27.3
10-13-2015 14:20 MDT	80	15	3		149	OK	30.15	422						0			28.2
10-13-2015 14:15 MDT	80	16	5		135	OK	30.15	352						0			29.8
10-13-2015 14:10 MDT	81	14	5		136	OK	30.15	432						0			27.3
10-13-2015 14:05 MDT	81	14	3		160	OK	30.16	436						0			27.3
10-13-2015 14:00 MDT	81	14	3		355	OK	30.16	429						0			27.3
10-13-2015 13:55 MDT	81	14	4		131	OK	30.16	443						0			27.3
10-13-2015 13:50 MDT	82	15	3		89	OK	30.16	448						0			29.8
10-13-2015 13:45 MDT	82	14	2		265	OK	30.17	454						0			28.1
10-13-2015 13:40 MDT	82	13	1		259	OK	30.17	455						0			26.3
10-13-2015 13:35 MDT	82	14	2		350	OK	30.18	457						0			28.1
10-13-2015 13:30 MDT	82	13	2		346	OK	30.18	459						0			26.3
10-13-2015 13:25 MDT	82	13	1		317	OK	30.16	462						0			26.3
10-13-2015 13:20 MDT	81	14	1		338	OK	30.16	462						0			27.3
10-13-2015 13:15 MDT	80	14	2		342	OK	30.17	462						0			26.5
10-13-2015 13:10 MDT	80	14	3		342	OK	30.17	464						0			26.5
10-13-2015 13:05 MDT	80	15	2		340	OK	30.18	466						0			28.2
10-13-2015 13:00 MDT	80	14	1		253	OK	30.18	466						0			26.5
10-13-2015 12:55 MDT	79	14	4		181	OK	30.18	466						0			25.7
10-13-2015 12:50 MDT	78	15	4		55	OK	30.19	468						0			26.6
10-13-2015 12:45 MDT	79	18	3		71	OK	30.19	468						0			31.9
10-13-2015 12:40 MDT	79	16	4		57	OK	30.19	466						0			29
10-13-2015 12:35 MDT	79	14	6		19	OK	30.19	466						0			25.7
10-13-2015 12:30 MDT	79	15	6		337	OK	30.19	466						0			27.4
10-13-2015 12:25 MDT	79	16	6		0	OK	30.19	464						0			29
10-13-2015 12:20 MDT	78	15	7		342	OK	30.19	464						0			26.6
10-13-2015 12:15 MDT	78	16	5		302	OK	30.2	462						0			28.2
10-13-2015 12:10 MDT	78	15	5		318	OK	30.2	461						0			26.6
10-13-2015 12:05 MDT	78	16	6		334	OK	30.2	459						0			28.2
10-13-2015 12:00 MDT	78	16	6		50	OK	30.2	455						0			28.2
10-13-2015 11:55 MDT	77	16	7		355	OK	30.21	452						0			27.4
10-13-2015 11:50 MDT	77	15	8		340	OK	30.21	450						0			25.8
10-13-2015 11:45 MDT	77	17	8		348	OK	30.22	448						0			28.8
10-13-2015 11:40 MDT	77	16	8		348	OK	30.22	443						0			27.4
10-13-2015 11:35 MDT	77	17	9		355	OK	30.22	439						0			28.8
10-13-2015 11:30 MDT	77	18	8		329	OK	30.22	436						0			30.2
10-13-2015 11:25 MDT	77	16	7		12	OK	30.22	431						0			27.4
10-13-2015 11:20 MDT	77	16	7		348	OK	30.22	425						0			27.4
10-13-2015 11:15 MDT	77	17	9		341	OK	30.22	420						0			28.8
10-13-2015 11:10 MDT	76	16	9		321	OK	30.22	415						0			26.6
10-13-2015 11:05 MDT	76	17	9		326	OK	30.22	410						0			28
10-13-2015 11:00 MDT	76	19	9		343	OK	30.22	404						0			30.8
10-13-2015 10:55 MDT	76	19	9		346	OK	30.22	399						0			30.8
10-13-2015 10:50 MDT	76	17	10		346	OK	30.22	394						0			28
10-13-2015 10:45 MDT	75	18	12		293	OK	30.22	387						0			28.6
10-13-2015 10:40 MDT	75	17	13		286	OK	30.23	380						0			27.2

Figure 8 – List of hourly observations from AP912 surrounding the accident time with time in MDT

AP912 weather at 1130 MDT was reported as wind from 329° at 8 mph, temperature of 77° F, dew point temperature of 30.2° F.

AP912 weather at 1135 MDT was reported as wind from 355° at 9 mph, temperature of 77° F, dew point temperature of 28.8° F.

AP912 weather at 1140 MDT was reported as wind from 348° at 8 mph, temperature of 77° F, dew point temperature of 27.4° F.

AP912 weather at 1145 MDT was reported as wind from 348° at 8 mph, temperature of 77° F, dew point temperature of 28.8° F.

EW7762 Severance (E7762) was an APRSWXNET/CWOP site. E7762 was located 10 miles west-southwest of the accident site at an elevation of 4,914 feet (figure 7) and figure 9 contains the observations surrounding the accident time (time in MDT):

ID = E7762	TMP ° F	RELH %	SKNT mp	GUST mp	DRCT °	QFLG	SOLR W/r	P24I in	PMID in	DWP °F
10-13-2015 13:43 MDT	81	21	3	6	135	OK		0	0	37.4
10-13-2015 13:38 MDT	81	21	3	4	157	OK		0	0	37.4
10-13-2015 13:33 MDT	81	20	3	6	112	OK		0	0	36.1
10-13-2015 13:28 MDT	80	21	3	6	337	OK		0	0	36.5
10-13-2015 13:23 MDT	80	21	3	7	112	OK		0	0	36.5
10-13-2015 13:18 MDT	80	20	4	7	112	OK		0	0	35.3
10-13-2015 13:13 MDT	80	20	2	4	112	OK		0	0	35.3
10-13-2015 13:08 MDT	80	21	3	6	180	OK		0	0	36.5
10-13-2015 13:03 MDT	80	21	3	6	270	OK		0	0	36.5
10-13-2015 12:58 MDT	79	20	3	10	247	OK		0	0	34.5
10-13-2015 12:53 MDT	79	20	5	10	22	OK		0	0	34.5
10-13-2015 12:48 MDT	79	20	4	7	292	OK		0	0	34.5
10-13-2015 12:43 MDT	79	21	3	8	270	OK		0	0	35.7
10-13-2015 12:38 MDT	79	21	4	8	270	OK		0	0	35.7
10-13-2015 12:33 MDT	79	21	5	9	270	OK		0	0	35.7
10-13-2015 12:28 MDT	78	21	6	9	90	OK		0	0	34.9
10-13-2015 12:23 MDT	78	21	6	10	337	OK		0	0	34.9
10-13-2015 12:18 MDT	78	21	7	10	337	OK		0	0	34.9
10-13-2015 12:12 MDT	78	20	5	15	292	OK		0	0	33.7
10-13-2015 12:07 MDT	77	20	9	15	292	OK		0	0	32.8
10-13-2015 12:02 MDT	77	20	7	12	112	OK		0	0	32.8
10-13-2015 11:57 MDT	77	20	9	12	67	OK		0	0	32.8
10-13-2015 11:52 MDT	77	23	7	12	22	OK		0	0	36.3
10-13-2015 11:47 MDT	76	23	6	9	90	OK		0	0	35.5
10-13-2015 11:42 MDT	76	23	8	11	315	OK		0	0	35.5
10-13-2015 11:37 MDT	76	23	8	11	315	OK		0	0	35.5
10-13-2015 11:32 MDT	76	24	8	11	337	OK		0	0	36.6
10-13-2015 11:27 MDT	75	24	10	15	292	OK		0	0	35.7
10-13-2015 11:22 MDT	75	24	9	15	270	OK		0	0	35.7
10-13-2015 11:17 MDT	75	25	9	12	292	OK		0	0	36.8
10-13-2015 11:12 MDT	74	26	9	11	315	OK		0	0	36.9
10-13-2015 11:07 MDT	74	26	10	12	22	OK		0	0	36.9
10-13-2015 11:02 MDT	74	27	9	12	315	OK		0	0	37.9
10-13-2015 10:57 MDT	74	27	9	14	270	OK		0	0	37.9
10-13-2015 10:51 MDT	74	28	9	14	292	OK		0	0	38.8
10-13-2015 10:46 MDT	73	28	9	13	270	OK		0	0	38
10-13-2015 10:41 MDT	73	30	10	14	292	OK		0	0	39.7
10-13-2015 10:36 MDT	72	30	11	14	270	OK		0	0	38.9
10-13-2015 10:31 MDT	72	32	7	14	270	OK		0	0	40.5
10-13-2015 10:26 MDT	72	33	7	11	315	OK		0	0	41.3
10-13-2015 10:21 MDT	71	34	8	11	22	OK		0	0	41.2
10-13-2015 10:16 MDT	70	35	6	10	270	OK		0	0	41.1
10-13-2015 10:11 MDT	69	37	6	9	292	OK		0	0	41.6
10-13-2015 10:06 MDT	69	38	6	8	270	OK		0	0	42.3
10-13-2015 10:01 MDT	69	39	6	8	292	OK		0	0	43
10-13-2015 9:56 MDT	68	40	5	7	270	OK		0	0	42.8
10-13-2015 9:51 MDT	67	40	5	10	22	OK		0	0	41.9

Figure 9 – List of hourly observations from E7762 surrounding the accident time with time in MDT

E7762 weather at 1127 MDT was reported as wind from 292° at 10 mph with gusts to 15 mph, temperature of 75° F, dew point temperature of 35.7° F.

E7762 weather at 1132 MDT was reported as wind from 337° at 8 mph with gusts to 11 mph, temperature of 76° F, dew point temperature of 36.6° F.

E7762 weather at 1137 MDT was reported as wind from 315° at 8 mph with gusts to 11 mph, temperature of 76° F, dew point temperature of 35.5° F.

E7762 weather at 1142 MDT was reported as wind from 315° at 8 mph with gusts to 11 mph, temperature of 76° F, dew point temperature of 35.5° F.

E7762 weather at 1147 MDT was reported as wind from 090° at 6 mph with gusts to 9 mph, temperature of 76° F, dew point temperature of 35.5° F.

014W176 Briggsdale (CO043) was a Colorado Department of Transportation station and was located 16 miles east-northeast of the accident site at an elevation of 4,872 feet (figure 7) and figure 10 contains the observations surrounding the accident time (time in UTC):

ID = CO043	TMP ° F	RELH %	SKNT mp	GUST mp	DRCT °	QFLG	VSBY mil	TSRD ° F	TRD1 ° F	TRD2 ° F	RSS1	RSS2	DWP °F
10-13-2015 22:02 GMT	81	10	4	11	245	OK							19.3
10-13-2015 21:52 GMT	82	10	6	11	195	OK							20.1
10-13-2015 21:42 GMT	82	10	4	7	230	OK							20.1
10-13-2015 21:32 GMT	82	10	2	10	220	OK							20.1
10-13-2015 21:22 GMT	82	10	2	7	200	OK							20.1
10-13-2015 21:12 GMT	82	10	2	11	230	OK							20.1
10-13-2015 21:02 GMT	82	10	4	9	235	OK							20.1
10-13-2015 20:52 GMT	84	10	1	6	150	OK							21.6
10-13-2015 20:42 GMT	83	10	4	8	320	OK							20.8
10-13-2015 20:32 GMT	84	10	6	10	155	OK							21.6
10-13-2015 20:22 GMT	83	10	8	15	145	OK							20.8
10-13-2015 20:12 GMT	82	10	1	9	240	OK							20.1
10-13-2015 20:02 GMT	83	10	5	12	165	OK							20.8
10-13-2015 19:52 GMT	83	10	2	9	160	OK							20.8
10-13-2015 19:42 GMT	83	10	7	12	145	OK							20.8
10-13-2015 19:32 GMT	83	10	2	11	160	OK							20.8
10-13-2015 19:22 GMT	82	10	3	12	150	OK							20.1
10-13-2015 19:12 GMT	78	10	13	16	320	OK							17
10-13-2015 19:02 GMT	79	10	7	15	335	OK							17.8
10-13-2015 18:52 GMT	79	10	7	16	140	OK							17.8
10-13-2015 18:42 GMT	79	10	10	14	335	OK							17.8
10-13-2015 18:32 GMT	79	10	10	20	135	OK							17.8
10-13-2015 18:22 GMT	79	10	11	18	130	OK							17.8
10-13-2015 18:12 GMT	79	10	8	19	135	OK							17.8
10-13-2015 18:02 GMT	77	10	9	18	145	OK							16.3
10-13-2015 17:52 GMT	78	10	11	21	145	OK							17
10-13-2015 17:42 GMT	79	10	11	19	135	OK							17.8
10-13-2015 17:32 GMT	76	10	11	24	130	OK							15.5
10-13-2015 17:22 GMT	69	10	11	21	135	OK							10.2
10-13-2015 17:12 GMT	78	10	14	21	340	OK							17
10-13-2015 17:02 GMT	75	10	11	21	340	OK							14.8
10-13-2015 16:52 GMT	77	10	9	21	130	OK							16.3
10-13-2015 16:42 GMT	77	10	10	23	340	OK							16.3
10-13-2015 16:32 GMT	75	10	19	28	335	OK							14.8
10-13-2015 16:22 GMT	76	10	17	24	325	OK							15.5
10-13-2015 16:12 GMT	75	10	19	27	335	OK							14.8
10-13-2015 16:02 GMT	74	10	20	25	330	OK							14
10-13-2015 15:52 GMT	75	10	20	25	325	OK							14.8
10-13-2015 15:42 GMT	74	11	21	25	320	OK							16.2
10-13-2015 15:32 GMT	73	11	19	27	315	OK							15.4
10-13-2015 15:22 GMT	69	12	21	28	320	OK							14.3
10-13-2015 15:12 GMT	71	12	22	27	320	OK							15.9
10-13-2015 15:02 GMT	69	13	20	26	320	OK							16.1
10-13-2015 14:52 GMT	60	13	21	25	315	OK							9.1
10-13-2015 14:42 GMT	68	14	17	24	320	OK							17.1
10-13-2015 14:32 GMT	62	15	19	25	320	OK							13.9
10-13-2015 14:22 GMT	59	16	17	24	320	OK							12.9

Figure 10 – List of hourly observations from CO043 surrounding the accident time with time in UTC

CO043 weather at 1122 MDT was reported as wind from 135° at 11 mph with gusts to 21 mph, temperature of 69° F, and dew point temperature of 10.2° F.

CO043 weather at 1132 MDT was reported as wind from 130° at 11 mph with gusts to 24 mph, temperature of 76° F, and dew point temperature of 15.5° F.

CO043 weather at 1142 MDT was reported as wind from 135° at 11 mph with gusts to 19 mph, temperature of 79° F, and dew point temperature of 17.8° F.

CO043 weather at 1152 MDT was reported as wind from 145° at 11 mph with gusts to 21 mph, temperature of 78° F, and dew point temperature of 17° F.

CW5040 Briggsdale (C5040) was an APRSWXNET/CWOP station and was located 20 miles northeast of the accident site at an elevation of 5,039 feet (figure 7) and figure 11 contains the observations surrounding the accident time (time in UTC):

ID = C5040	TMP ° F	RELH %	SKNT mp	GUST mp	DRCT °	QFLG	ALTI in	SOLR W/r	WNUM	VSBY mil	TLRW ° F	PREC in	P24I in	PMID in	CHC1	CHC2	CHC3	CIG feet	FT ° F	DWP °F
10-13-2015 19:43 GMT	77	10	6	17	53	OK	30.16						0	0						16.3
10-13-2015 19:38 GMT	77	10	8	17	337	OK	30.17						0	0						16.3
10-13-2015 19:33 GMT	77	10	5	12	324	OK	30.17						0	0						16.3
10-13-2015 19:28 GMT	76	10	2	12	50	OK	30.17						0	0						15.5
10-13-2015 19:23 GMT	76	10	5	14	32	OK	30.18						0	0						15.5
10-13-2015 19:18 GMT	76	11	8	14	343	OK	30.18						0	0						17.7
10-13-2015 19:13 GMT	76	11	5	14	291	OK	30.18						0	0						17.7
10-13-2015 19:08 GMT	76	10	6	14	339	OK	30.19						0	0						15.5
10-13-2015 19:03 GMT	76	11	2	14	327	OK	30.19						0	0						17.7
10-13-2015 18:58 GMT	76	11	8	14	52	OK	30.19						0	0						17.7
10-13-2015 18:53 GMT	76	10	7	13	310	OK	30.19						0	0						15.5
10-13-2015 18:48 GMT	76	11	9	14	322	OK	30.19						0	0						17.7
10-13-2015 18:43 GMT	76	11	10	17	30	OK	30.19						0	0						17.7
10-13-2015 18:38 GMT	76	11	9	19	39	OK	30.2						0	0						17.7
10-13-2015 18:33 GMT	76	11	9	14	343	OK	30.2						0	0						17.7
10-13-2015 18:28 GMT	76	11	10	18	38	OK	30.2						0	0						17.7
10-13-2015 18:23 GMT	76	11	13	18	23	OK	30.2						0	0						17.7
10-13-2015 18:18 GMT	76	11	13	20	32	OK	30.2						0	0						17.7
10-13-2015 18:13 GMT	76	11	13	20	27	OK	30.2						0	0						17.7
10-13-2015 18:08 GMT	76	11	12	19	339	OK	30.2						0	0						17.7
10-13-2015 18:03 GMT	75	11	14	19	36	OK	30.2						0	0						16.9
10-13-2015 17:58 GMT	75	11	15	22	325	OK	30.2						0	0						16.9
10-13-2015 17:53 GMT	75	12	16	22	44	OK	30.2						0	0						19
10-13-2015 17:48 GMT	75	12	15	21	343	OK	30.2						0	0						19
10-13-2015 17:43 GMT	75	12	15	22	337	OK	30.2						0	0						19
10-13-2015 17:38 GMT	75	11	16	23	29	OK	30.2						0	0						16.9
10-13-2015 17:33 GMT	75	12	16	23	340	OK	30.2						0	0						19
10-13-2015 17:28 GMT	75	12	17	23	337	OK	30.2						0	0						19
10-13-2015 17:23 GMT	75	12	17	23	18	OK	30.2						0	0						19
10-13-2015 17:18 GMT	75	12	17	21	23	OK	30.2						0	0						19
10-13-2015 17:13 GMT	75	12	16	21	18	OK	30.2						0	0						19
10-13-2015 17:08 GMT	75	12	15	22	23	OK	30.2						0	0						19
10-13-2015 17:03 GMT	75	12	16	22	342	OK	30.2						0	0						19
10-13-2015 16:58 GMT	74	11	15	24	343	OK	30.2						0	0						16.2
10-13-2015 16:53 GMT	74	11	19	24	343	OK	30.2						0	0						16.2
10-13-2015 16:48 GMT	74	12	19	24	324	OK	30.2						0	0						18.2
10-13-2015 16:43 GMT	74	11	17	27	327	OK	30.2						0	0						16.2
10-13-2015 16:38 GMT	74	11	20	27	343	OK	30.21						0	0						16.2
10-13-2015 16:33 GMT	74	11	19	25	330	OK	30.21						0	0						16.2
10-13-2015 16:28 GMT	74	12	13	23	343	OK	30.21						0	0						18.2
10-13-2015 16:23 GMT	74	11	20	23	343	OK	30.2						0	0						16.2
10-13-2015 16:18 GMT	74	11	15	22	311	OK	30.2						0	0						16.2
10-13-2015 16:13 GMT	73	11	16	23	327	OK	30.2						0	0						15.4
10-13-2015 16:08 GMT	74	11	15	24	315	OK	30.2						0	0						16.2
10-13-2015 16:03 GMT	73	11	16	24	319	OK	30.2						0	0						15.4
10-13-2015 15:58 GMT	73	11	18	23	319	OK	30.2						0	0						15.4
10-13-2015 15:53 GMT	73	12	17	23	23	OK	30.2						0	0						17.4

Figure 11 – List of hourly observations from C5040 surrounding the accident time with time in UTC

C5040 weather at 1128 MDT was reported as wind from 337° at 17 mph with gusts to 23 mph, temperature of 75° F, and dew point temperature of 19° F.

C5040 weather at 1133 MDT was reported as wind from 340° at 16 mph with gusts to 23 mph, temperature of 75° F, and dew point temperature of 19° F.

C5040 weather at 1138 MDT was reported as wind from 029° at 16 mph with gusts to 23 mph, temperature of 75° F, and dew point temperature of 16.9° F.

C5040 weather at 1143 MDT was reported as wind from 337° at 15 mph with gusts to 22 mph, temperature of 75° F, and dew point temperature of 19° F.

The observations from KGXY indicated VFR[5] ceilings at the surface at the time of the accident with no visibility restrictions. The surface wind was rather gusty at KGXY around the accident time with winds between 10 and 20 knots and a varying wind direction switching from a surface wind from the northwest to a surface wind from the northeast (and even to the east by 1335 MDT). There was a frontal boundary at the surface moving southwestward across the accident area at the accident time (section 6.4) and this frontal boundary likely caused the change in wind direction. This frontal boundary would have also been a focus area for low-level wind shear (LLWS) and turbulence. The same pattern in the change in surface wind direction can be seen at all the non-official observations sites surrounding the accident area. At a few of the non-official observation stations the switch from the northwest to northeast wind only occurs for a few observations, but at every station there is a pronounced switch of surface wind direction to the northeast to east (from the northwest). This change in wind direction occurred at the stations to the east of the accident site first, CO043 and C5040, and then occurred at the stations west of the accident site around the same time as the accident or shortly afterwards, AP912 and E7762. So the accident aircraft likely experienced LLWS and turbulence during this wind shift around the accident time (section 14.0). In addition, the accident flight likely went from having a gusty headwind to having a gusty tailwind in a short amount of time.

4.0 Upper Air Data

The closest official upper air sounding to the accident site that was located behind the southward moving cold front (figures 1, 2, and 3) was from Rapid City, South Dakota, (KRAP), located 220 miles north-northeast of the accident site, with a site number 72662, at an elevation of 3,169 feet. The 0600 MDT KRAP sounding was plotted on a standard Skew-T log P diagram[6] with the derived stability parameters included in figure 12 (with the chart plotted from the surface to 600-hPa, or 14,000 feet msl). This data was analyzed utilizing the RAOB[7] software package. The sounding depicted the Lifted Condensation Level (LCL)[8] at 11,830 feet msl and a Convective Condensation Level (CCL)[9] of 16,827 feet. The freezing level was located at 11,953 feet. The precipitable water value was 0.43 inches.

[5] Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 6 miles visibility.
[6] 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.
[7] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.
[8] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.
[9] 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.

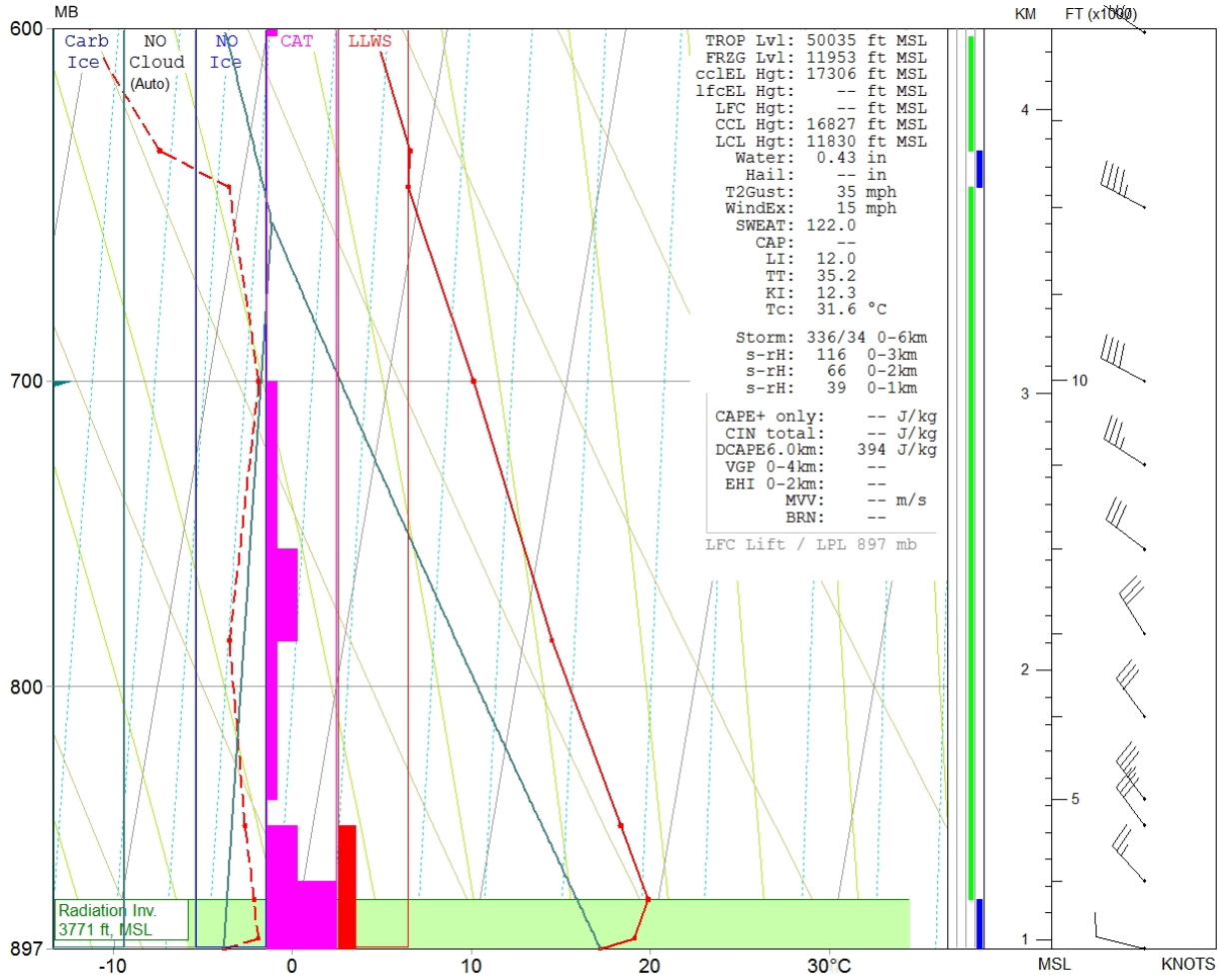


Figure 12 – 0600 MDT KRAP sounding

The 0600 MDT KRAP sounding indicated a conditionally unstable environment from 4,000 feet msl through 12,000 feet msl. This environment would have been supportive of vertical motion and the mixing of momentum (wind speed or magnitude) from 4,000 feet through 12,000 feet. RAOB did not identify the possibility of clouds and no clouds would have been likely given how dry the vertical environment was. No areas of icing were likely below 14,000 feet.

The sounding wind profile indicated a surface wind from 285° at 9 knots with the wind remaining out of the west to northwest through 14,000 feet msl. The wind speed increased up to 40 knots by 10,000 feet msl. With the conditionally unstable environment, winds at the surface could have increased up to 40 knots with vertical momentum being transferred between layers and the observations at KGXY indicated a gusty surface winds. In addition, around the accident time the surface observations site all switch their wind direction to northeast or easterly and this would have likely increased the LLWS and clear air turbulence conditions for the accident flight. The possibility of LLWS was indicated by RAOB along with layers of possible clear-air turbulence through 10,000 feet msl. Given the background vertical wind environment and easterly surface wind conditions the accident aircraft would have likely encountered LLWS and areas of clear air turbulence around the accident time at the accident location.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from the NCDC and processed with the NTSB's Man-computer Interactive Data Access System (McIDAS) workstation. Visible and infrared imagery (GOES-13 band 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm retrieved brightness temperatures for the scene. Satellite imagery surrounding the time of the accident, from 0900 MDT through 1400 MDT at approximately 15-minute intervals, was reviewed and the closest images to the time of the accident are documented here.

Figure 13 presents the GOES-13 visible imagery from 1130 MDT at 3X magnification with the accident site marked by a red square. The visible imagery indicated no cloud cover over and around the accident site at the accident time.

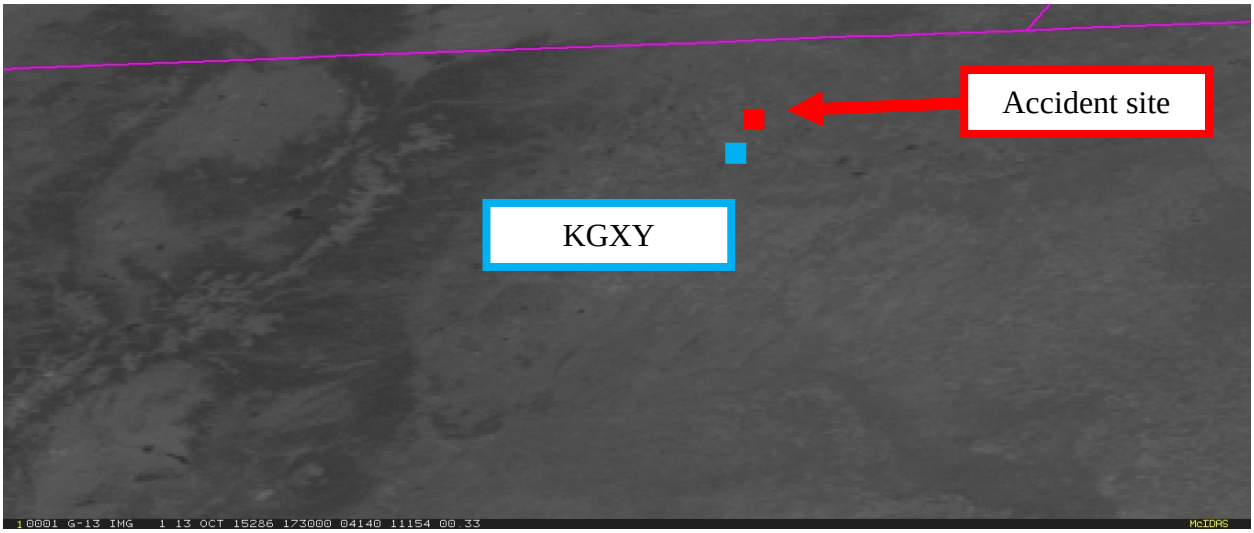


Figure 13 – GOES-13 visible image at 1130 MDT

6.0 Radar Imagery Information

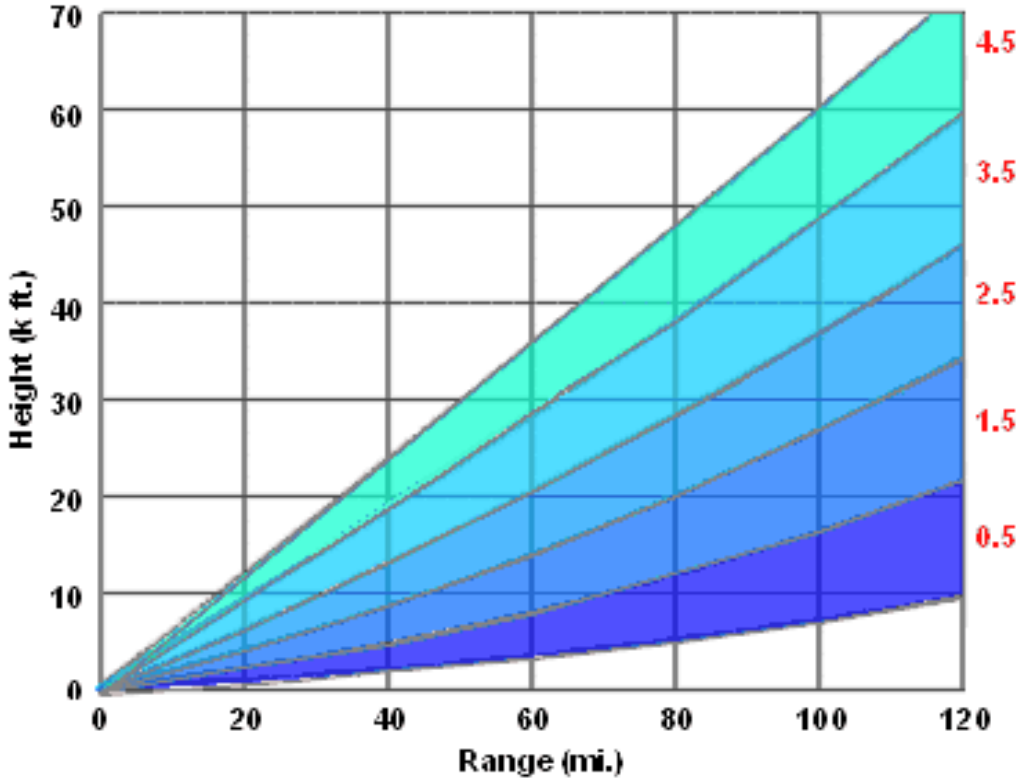
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[10] was from Cheyenne, Wyoming, (KCYS) located 36 miles north-northwest of the accident site with an elevation of 6,128 feet. Level II and III archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

[10] 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.

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 on the WSR-88D's Principle Users Processor (PUP). 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 two common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° about every four minutes. This particular scanning strategy is documented as volume coverage pattern 12 (VCP-12). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period (VCP-32). During the period surrounding the accident, the KCYS WSR-88D radar was operating in the clear-air mode (Mode B, VCP-31). 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.



VCP-31 Clear air Mode Scan Strategy

6.2 Beam Height Calculation

Assuming standard refraction[11] of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width[12] information[13] of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	8,980 feet	7,200 feet	10,750 feet	3,550 feet

Based on the beam heights, the 0.5° elevation scan depicted the conditions between 7,180 feet and 10,760 feet msl over the accident site and these are the closest altitudes to the ground before the accident occurred.[14]

[11] Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.
[12] Beam width – A measure of the angular width of a radar beam.
[13] Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.
[14] For more information see the ATC data contained in the docket for this accident.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[15] 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 decibels (dBZ[16]), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0 1 2	< 5 5 to 9 10 to 14	
1 Very Light	3 4 5	15 to 19 20 to 24 25 to 29	.01 in/hr .02 in/hr .04 in/hr
2 Light to Moderate	6 7	30 to 34 35 to 39	.09 in/hr .21 in/hr
3 Strong	8	40 to 44	.48 in/hr
4 Very Strong	9	45 to 49	1.10 in/hr
5 Intense	10	50 to 54	2.49 in/hr
6 Extreme	11 12 13 14 15	55 to 59 60 to 64 65 to 69 70 to 74 > 75	>5.67 in/hr

[15] 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.

[16] 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.

The Federal Aviation Administration (FAA) Advisory Circular AC 00-24B titled "Thunderstorms" dated January 2, 1983, also defines the echo intensity levels and potential weather phenomena associated with those levels. If the maximum VIP Level is 1 "weak" and 2 "moderate", then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very heavy" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts and turbulence.

6.4 Base Reflectivity

Figures 14, 15, and 16 present the KCYS WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1129, 1140, and 1150 MDT with a resolution of 0.5° X 250 m with the ATC flight track overlaid as a red line. The base reflectivity imagery indicated no precipitation targets over the accident site at the accident time. However, on the base reflectivity image a radar-depicted boundary is apparent in northeastern Colorado as early as 1048 MDT (attachment 1). The pink line on figures 14 through 18 highlight and approximate the radar-depicted boundary and its movement with time southwestward toward the accident site. The likely cold frontal boundary moved southwestward towards the accident site at the accident time and ahead of this boundary is when the surface observation sites wind directions switched around to the northeast to east. The boundary was not directly overhead of the surface observations sites when the wind shifted to the east as clearly indicated by figures 17 and 18, where the boundary was still to the northeast of KGXY, but the winds had shifted around to the east (section 3.0) at 1235 MDT. The difference in the surface wind shift and the location of the boundary on the base reflectivity was likely due to the base reflectivity imagery only detecting targets above 7,000 feet msl (section 6.2). Turbulence and LLWS associated with frontal boundaries will be further discussed in section 14.0. It is likely that the turbulence and LLWS associated with this frontal boundary affected the accident flight at the accident time. There were no lightning strikes near the accident site at the accident time.

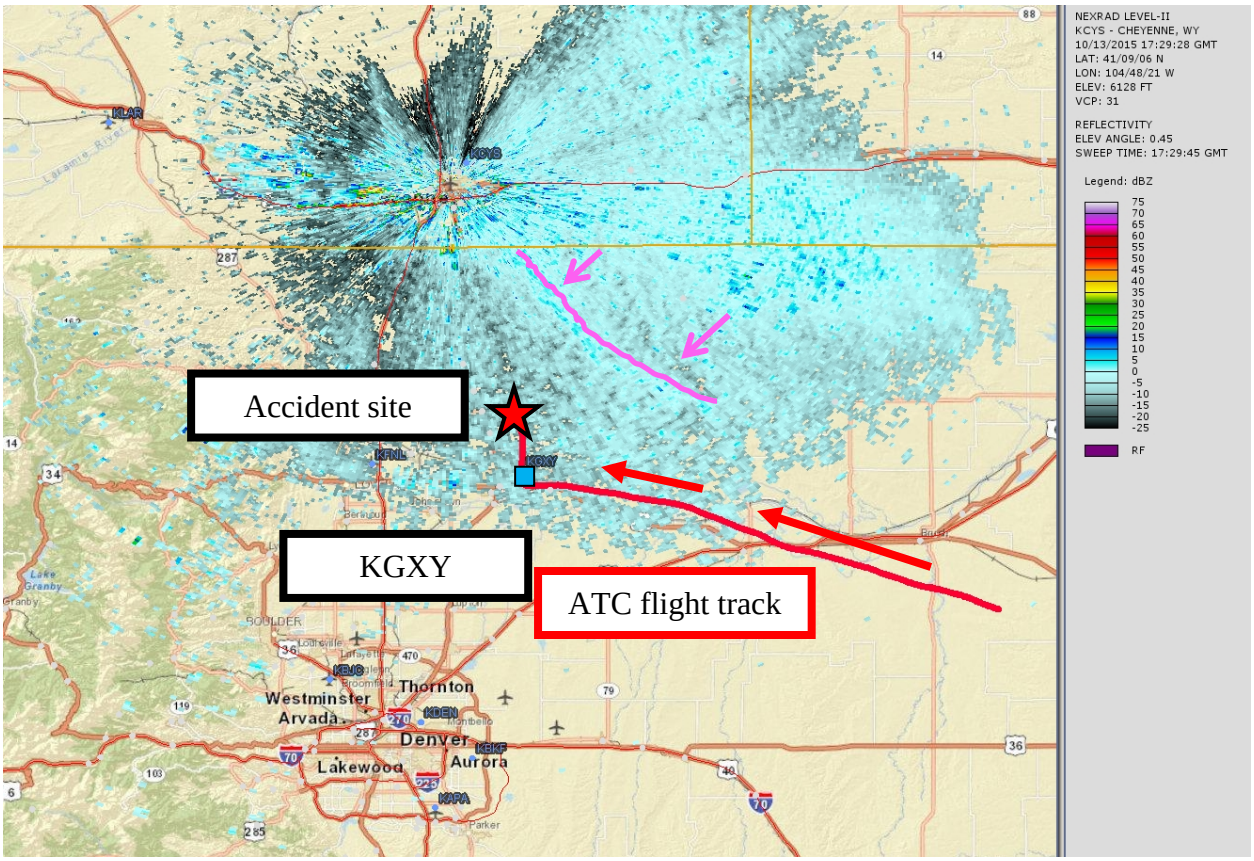


Figure 14 – KCYS WSR-88D reflectivity for the 0.5° elevation scan initiated at 1129 MDT with the ATC track data. Pink line highlights and approximate radar-depicted boundaries.

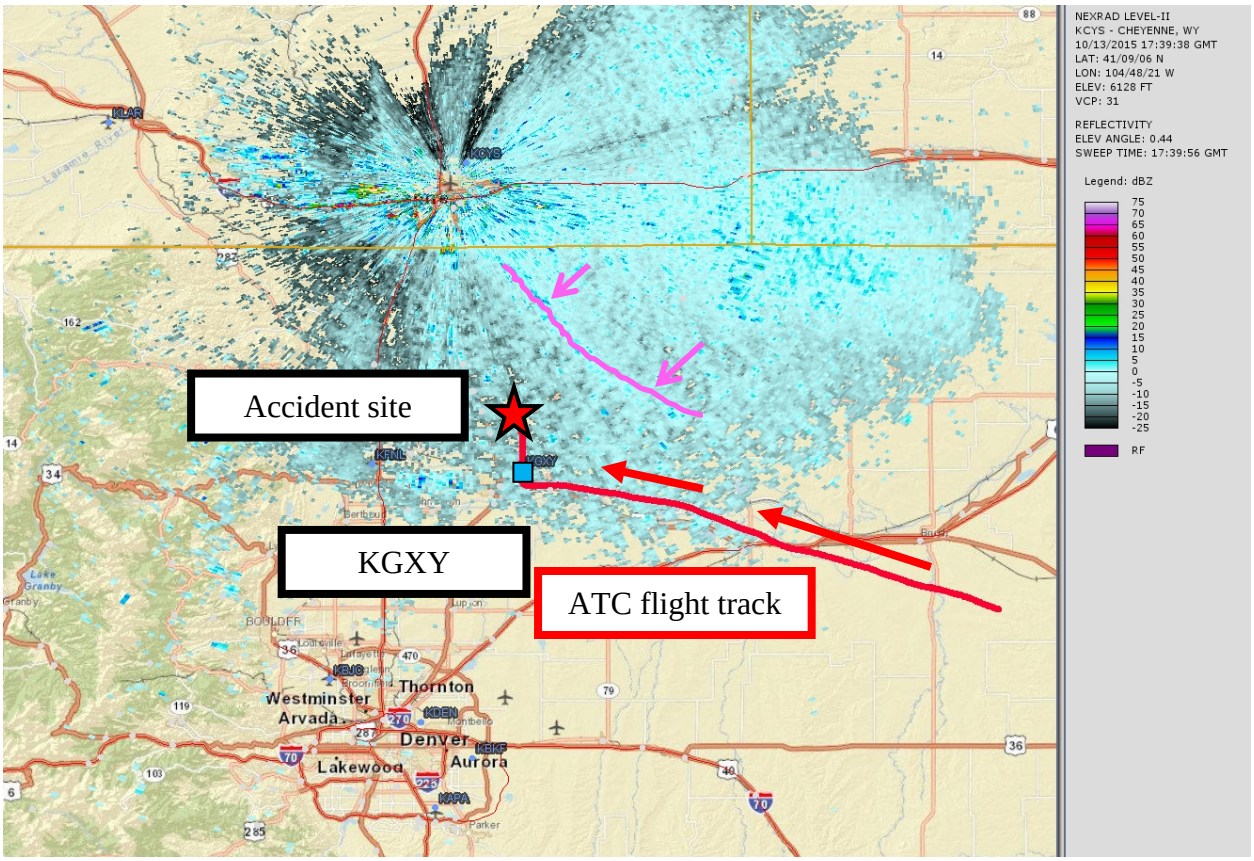


Figure 15 – KCYS WSR-88D reflectivity for the 0.5° elevation scan initiated at 1140 MDT with the ATC track data. Pink line highlights and approximate radar-depicted boundaries.

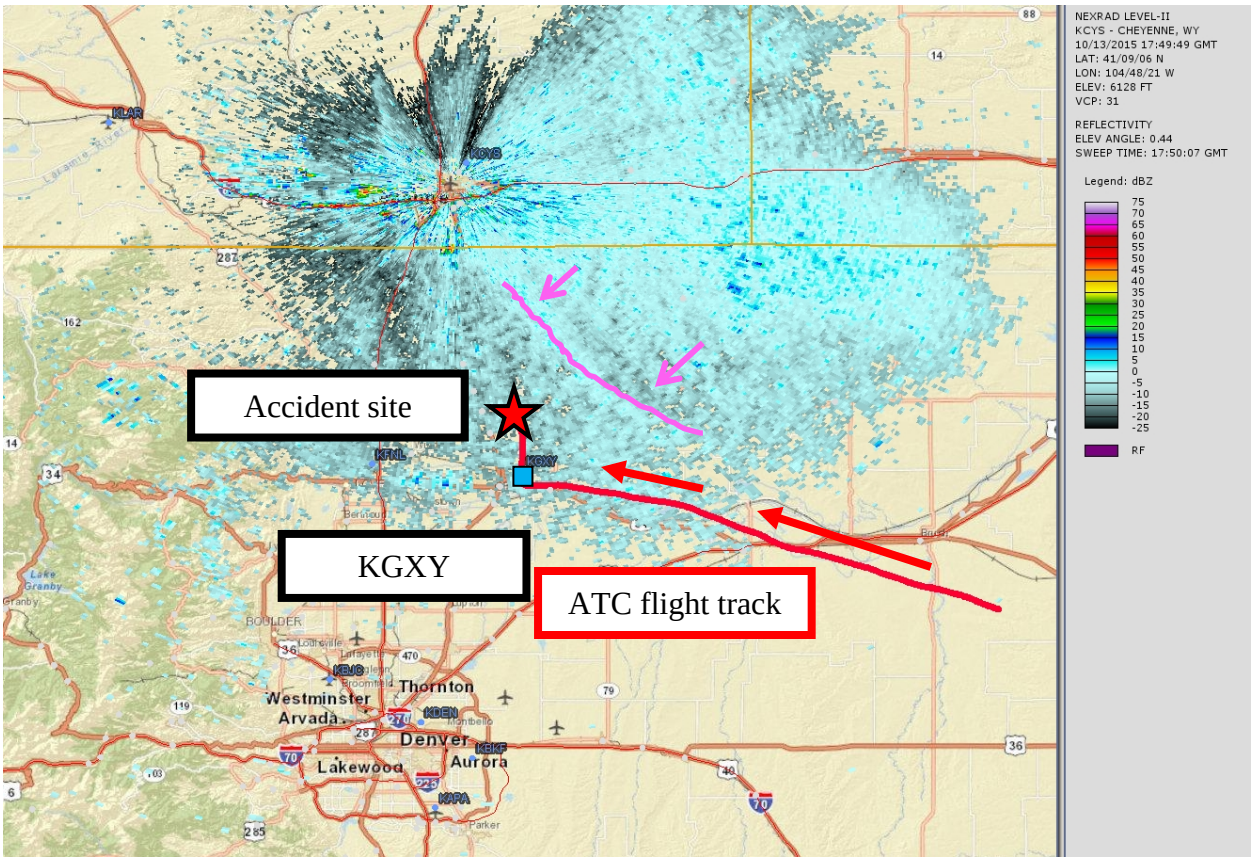


Figure 16 – KCYS WSR-88D reflectivity for the 0.5° elevation scan initiated at 1150 MDT with the ATC track data. Pink line highlights and approximate radar-depicted boundaries.

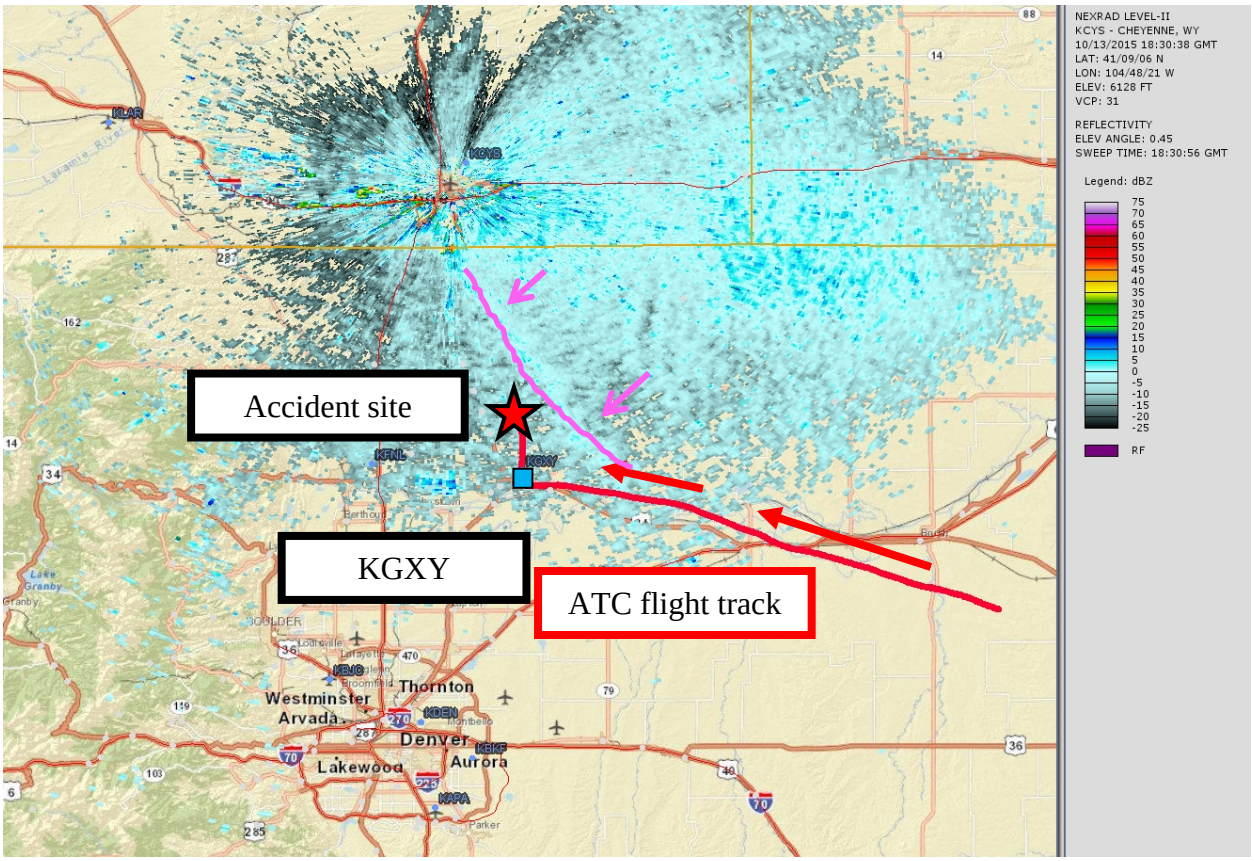


Figure 17 – KCYS WSR-88D reflectivity for the 0.5° elevation scan initiated at 1231 MDT with the ATC track data. Pink line highlights and approximate radar-depicted boundaries.

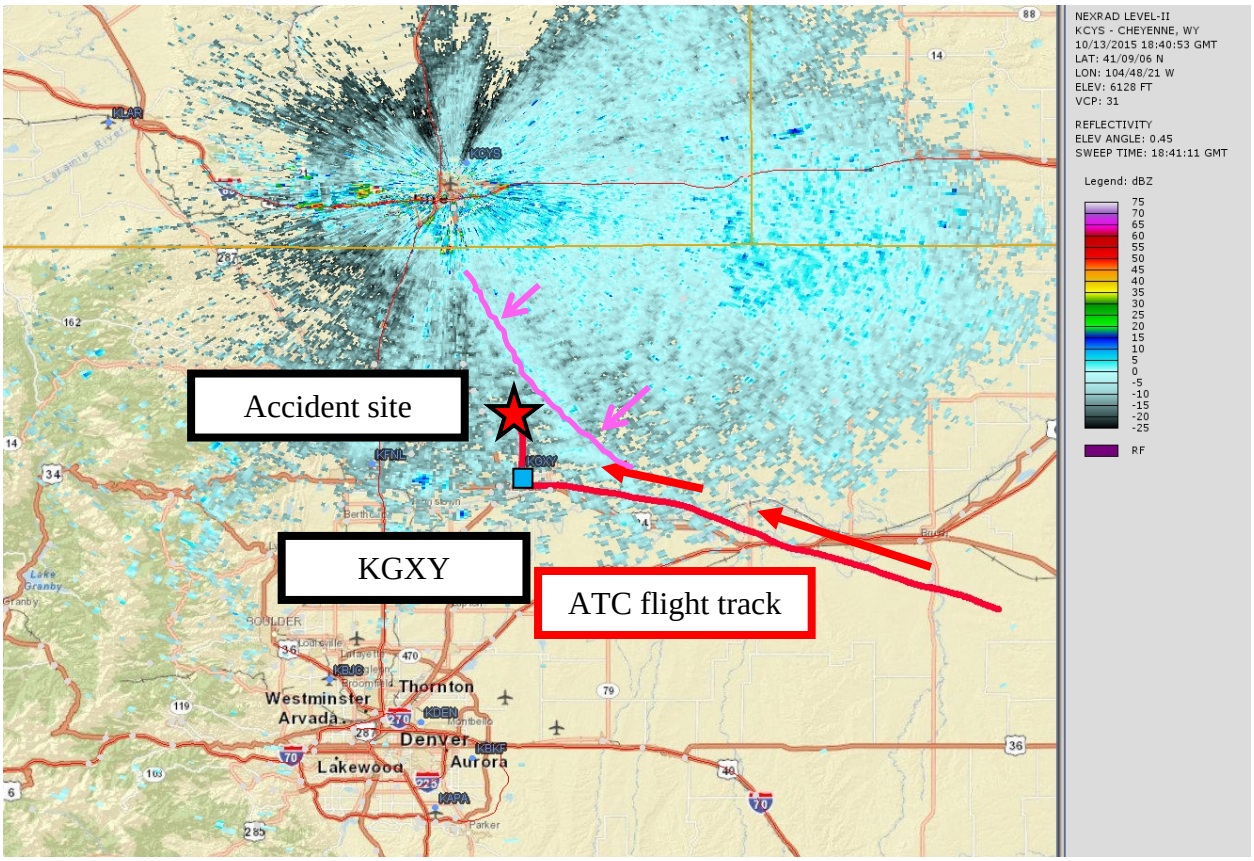


Figure 18 – KCYS WSR-88D reflectivity for the 0.5° elevation scan initiated at 1241 MDT with the ATC track data. Pink line highlights and approximate radar-depicted boundaries.

7.0 Pilot Reports

All pilot reports (PIREPs) were reviewed close to the accident site from around three hours prior to the accident time to around four hours after the accident time and PIREPs for 13,000 feet and below are displayed below:

EIK UUA /OV BJC045016/TM 1702/FL065/TP R44/TB EXTRM CAT/RM COR AC TYPE

LMO UA /OV BJC360012/TM 1715/FL068/TP C172/TB NEG/RM SMTH

GXY UUA /OV GLL360010/TM 1917/FL095/TP C172/TB MOD-SEV 065-075/RM DURC WIND SHEER +/-15KT

GXY UUA /OV GLL360010/TM 1917/FL095/TP C172/TB MOD BLO 075/RM LLWS +/-15KTS DURC CORRECTION TO PREV UA=

BJC UUA /OV BJC /TM 2122 /FL002 /TP M20P /RM LLWS +20KT SFC-200AGL DURD RY12L=

Urgent pilot report (UA); 16 miles from Rocky Mountain Metropolitan Airport, Colorado, on the 045° radial; Time – 1102 MDT (1702Z); Altitude – 6,500 feet msl; Type aircraft – Robinson R44; Turbulence – Extreme clear air turbulence; Remarks – Corrected for aircraft type.

Routine pilot report (UA); 12 miles from Rocky Mountain Metropolitan Airport, Colorado, on the 360° radial; Time – 1115 MDT (1715Z); Altitude – 6,800 feet msl; Type aircraft – Cessna 172; Turbulence – Negative; Remarks – Smooth.

Urgent pilot report (UA); 10 miles from Gill, Colorado, on the 360° radial; Time – 1317 MDT (1917Z); Altitude – 9,500 feet msl; Type aircraft – Cessna 172; Turbulence – Moderate to severe between 6,500 and 7,500 feet msl; Remarks – During climb wind shear +/- 15 knots.

Urgent pilot report (UA); 10 miles from Gill, Colorado, on the 360° radial; Time – 1317 MDT (1917Z); Altitude – 9,500 feet msl; Type aircraft – Cessna 172; Turbulence – Moderate below 7,500 feet msl; Remarks – LLWS +/- 15 knots during climb, correction to previous pilot report.

Urgent pilot report (UA); Over Rocky Mountain Metropolitan Airport, Colorado; Time – 1522 MDT (2122Z); Altitude – 200 feet agl; Type aircraft – Mooney M20; Remarks – LLWS +20 knots from the surface to 200 feet agl during descent into runway 12L.

The PIREPs characterized the turbulence at and around the accident site at the accident time as extreme to severe and moderate in some cases. The one PIREP from 1115 MDT was west of turbulence air and frontal boundary (figures 14 through 18, section 6.4), hence the negative turbulence report.

8.0 SIGMET and CWSU Advisory

No SIGMET was valid for the accident site at the accident time.

No meteorological impact statement (MIS) or Center Weather Advisory (CWA) was valid for the accident site at the accident time.

9.0 AIRMETs

AIRMET Tango issued at 0845 MDT was valid for the accident site at the accident time. The AIRMET forecasted moderate turbulence below FL180[17]. Figures 19 and 20 contain a graphic view of AIRMET Tango overlaid with PIREPs valid at 1100 and 1200 MDT (figures 21 and 22 contain AIRMET valid 1000 and 0900 MDT). The extreme PIREP from 1102 MDT (section 7.0) is plotted on the 1200 MDT valid map time (figure 20):

WAUS45 KKCI 131445
WA5T
_SLCT WA 131445
AIRMET TANGO UPDT 2 FOR TURB VALID UNTIL 132100
.
AIRMET TURB...ID MT
FROM 30NNE HVR TO 20E BIL TO 30W HLN TO 60SW YXC TO 30NNE HVR

[17] Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. 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.

MOD TURB BTN FL240 AND FL380. CONDS DVLPG 15-18Z. CONDS CONTG
BYD 21Z THRU 03Z.
.
AIRMET TURB...MT
FROM 30SSE YXC TO 50SE YQL TO 50SSW LWT TO 40WSW HLN TO 30E MLP
TO 30SSE YXC
MOD TURB BLW 160. CONDS DVLPG 15-18Z. CONDS CONTG BYD 21Z ENDG
00-03Z.
.
AIRMET TURB...WY CO
FROM 20SSW DDY TO 50SSW BFF TO 40NNE PUB TO 30E HBU TO 40ENE OCS
TO 20SSW DDY
MOD TURB BLW FL180. CONDS CONTG BYD 21Z ENDG 00-03Z.
.
OTLK VALID 2100-0300Z...TURB ID MT WY
BOUNDED BY 50NNW ISN-70SW RAP-60WSW SHR-30W HLN-60SW YXC-50NNW
ISN
MOD TURB BTN FL240 AND FL380. CONDS CONTG THRU 03Z.
....

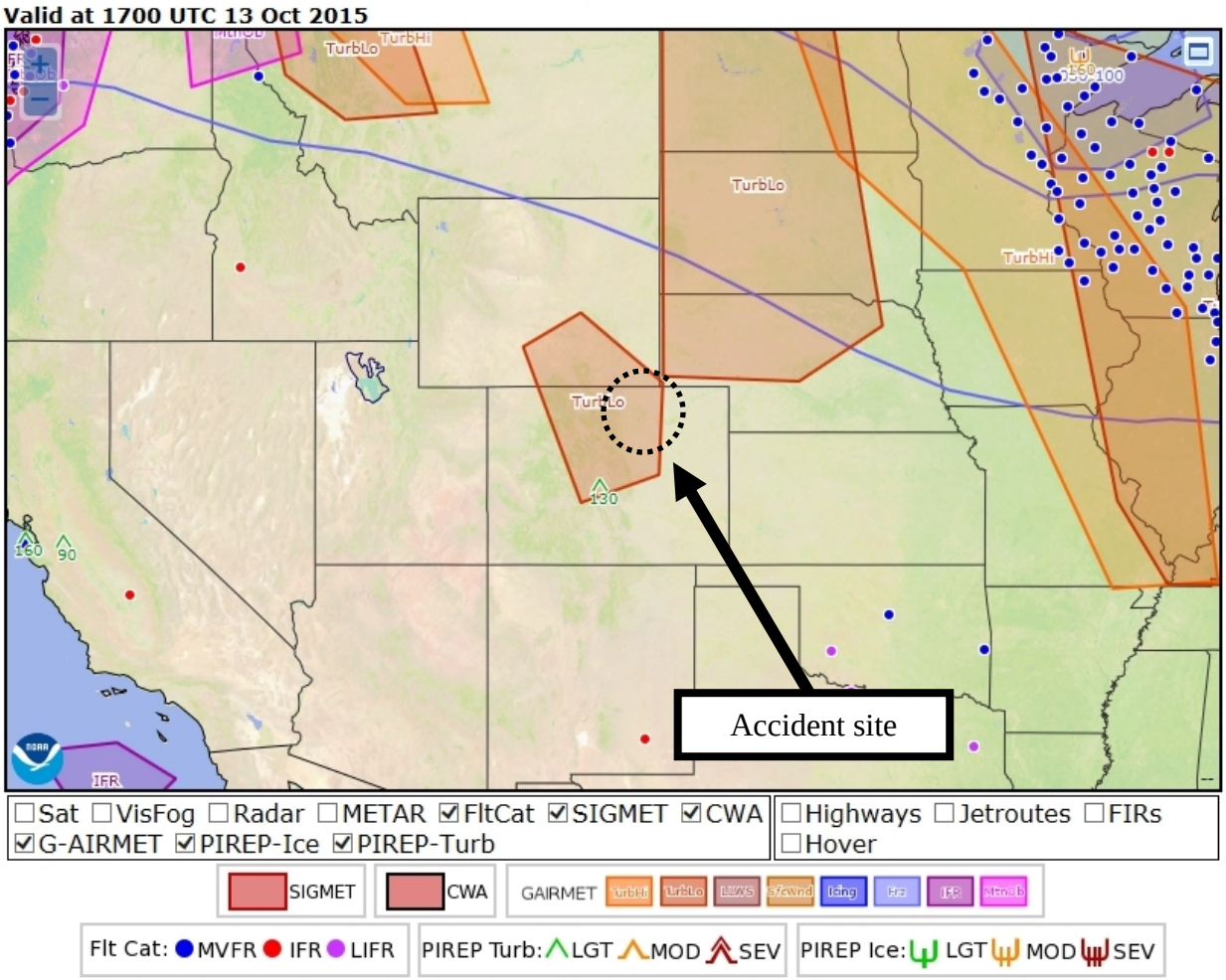


Figure 19 – AIRMETs valid at 1100 MDT with recent PIREPs overlaid and the accident site marked

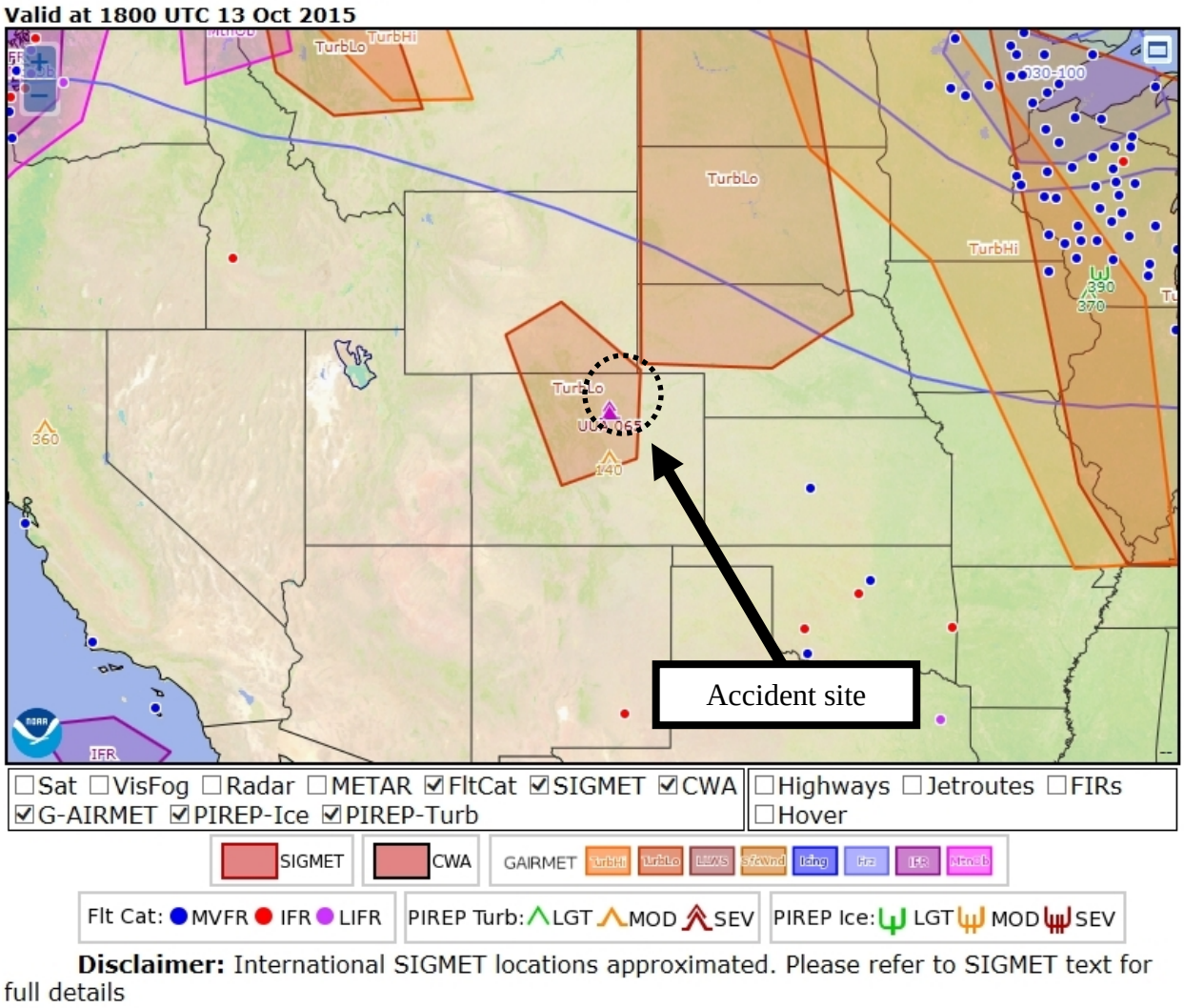


Figure 20 – AIRMETs valid at 1200 MDT with recent PIREPs overlaid and the accident site marked

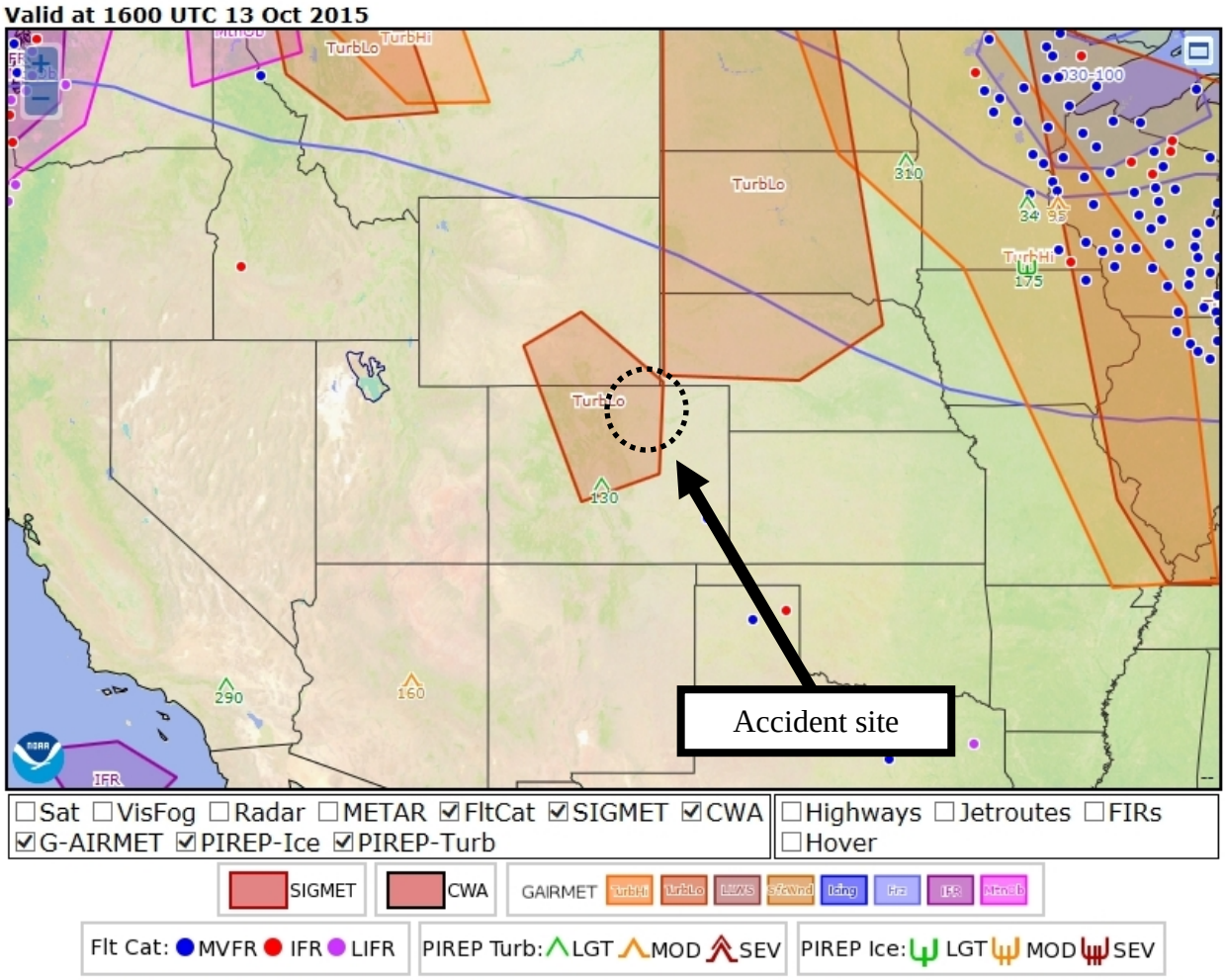


Figure 21 – AIRMETs valid at 1000 MDT with recent PIREPs overlaid and the accident site marked

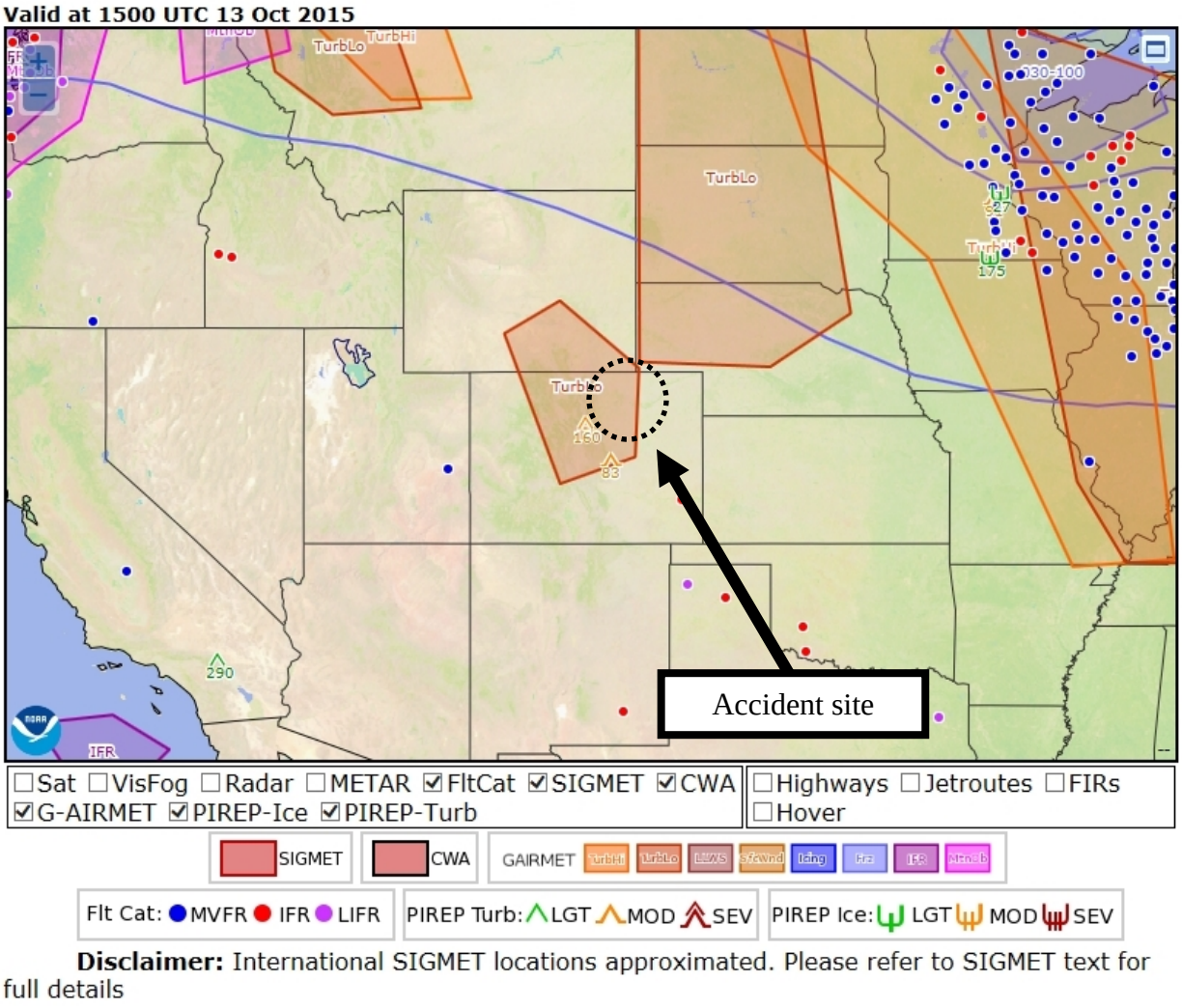


Figure 22 – AIRMETs valid at 0900 MDT with recent PIREPs overlaid and the accident site marked

10.0 Area Forecast

The Area Forecast issued at 0445 MDT, valid at the accident time, forecasted clear skies over all of Colorado at the accident time. At 1200 MDT occasional scattered cirrus clouds were forecast in the vicinity of the Front Range:

FAUS45 KKCI 131045
FA5W
_SLCC FA 131045
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 140500
CLDS/WX VALID UNTIL 132300...OTLK VALID 132300-140500
ID MT WY NV UT CO AZ NM
.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.

NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS...ALF...11Z BROAD RDG OVR THE WRN U.S. MOD-STG WLY-NWLY WND FLOW ACRS NRN ID AND MT. LTLCG EXPD DURG THE PD. AT THE SFC...11Z RDG OF HIGH PRES OVR THE RCKYS. WK CDFNT FM CNTRL ND TO N CNTRL MT. 05Z RDG OF HIGH PRES OVR THE RCKYS.
.
ID
NRN...SCT080-100 SCT150. 19Z SCT080 SCT120 SCT-BKN CI.
OTLK...VFR.
CNTRL MTNS...SKC. OTLK...VFR.
SWRN...SKC. TIL 19Z OCNL VIS 3SM FU. WRN SNAKE VLY. OTLK...VFR THRUT.
SERN...SKC. OTLK...VFR.
.
MT
W OF CONTDVD...SCT-BKN110 TOPS 130. 20Z SCT-BKN090 TOPS 110.
OTLK...VFR.
SWRN MTNS...SKC. 19Z SCT130-150. OTLK...VFR.
E SLPS CONTDVD...SKC. BECMG 1618 WND SWLY 20G30KT. OTLK...VFR WND 01Z VFR.
RMNDR CNTRL...SKC. 19Z SCT130 SCT CI. OTLK...VFR.
NERN...SCT130 SCT170. 18Z SCT-BKN100 TOPS 130. OTLK...VFR.
SERN...SKC. OCNL SCT170. OTLK...VFR.
.
WY
SERN QTR...SKC. 15Z WND WLY-NWLY G25-30KT SRN SXNS. OTLK...VFR WND 02Z VFR.
RMNDR...SKC. BECMG 1719 OCNL SCT CI. BECMG 1517 SCT CI.
OTLK...VFR.
.
NV
SRN QTR...SKC. OCNL SCT CI 21Z SCT120 SCT-KN CI. OTLK...VFR.
RMNDR...SKC. BECMG 1820 OCNL SCT CI SRN SXNS. OTLK...VFR.
.
UT
SKC. OTLK...VFR.
.
CO
SKC. 18Z OCNL SCT CI VCNTY FRONT RANGE. OTLK...VFR.
.
AZ
N HLF...SKC. OCNL SCT CI. OTLK...VFR.
S HLF...SCT CI. OCNL SCT150. OTLK...VFR.
.
NM
N HLF...SKC. OTLK...VFR.
S HLF...SKC. OCNL SCT CI. OTLK...VFR.
....

11.0 Terminal Aerodrome Forecast

KCYS was the closest site with a NWS TAF. The TAF valid at the time of the accident was issued at 1121 MDT and was valid for a 24-hour period beginning at 1200 MDT. The TAF for KCYS was as follows:

TAF KCYS 131721Z 1318/1418 **01010G17KT P6SM SKC**
FM132300 28009KT P6SM SKC=

The forecast expected wind from 010° at 10 knots with gusts to 17 knots, greater than 6 miles visibility, and clear skies.

12.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Boulder, Colorado (National Weather Service office responsible for surface forecast for the accident area), issued the following Area Forecast Discussion at 1007 MDT (closest AFD to the accident time), which discussed the surface wind becoming northeasterly by 1200 MDT across most of the area with drainage winds setting up overnight:

FXUS65 KBOU 131607
AFDBOU
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE DENVER/BOULDER CO
1007 AM MDT TUE OCT 13 2015
.UPDATE...
ISSUED AT 1007 AM MDT TUE OCT 13 2015
NO CHANGES TO THE FORECAST EXPECTED. WILL WATCH THE WINDS AND
RELATIVE HUMIDITY OVER THE NORTHEAST PLAINS WHERE CONDITIONS WILL
APPROACH RED FLAG CRITERIA. APPEARS THE STRONGEST WINDS WILL OCCUR
LATE THIS MORNING AND EARLY AFTERNOON WHILE THE LOWEST RELATIVE
HUMIDITIES ARE EXPECTED LATE THIS AFTERNOON. BRIEF RED FLAG
CONDITIONS MAY BE MET BUT NOT LAST THE REQUIRED THREE HOURS.
&&
.SHORT TERM...(TODAY THROUGH TONIGHT)
ISSUED AT 335 AM MDT TUE OCT 13 2015
ANOTHER WARM AND DRY DAY IS IN STORE AS NORTHWESTERLY FLOW ALOFT
CONTINUES OVER THE STATE. UNDER CLEAR SKIES...TEMPERATURES WILL
REMAIN ABOVE NORMAL FOR THIS TIME OF YEAR...WITH READINGS IN THE
UPPER 70S TO LOWER 80S OVER THE PLAINS AND UPPER 50S TO LOWER 70S
FOR THE MOUNTAINS. GUSTY WESTERLY WINDS WILL OCCUR OVER THE
MOUNTAINS AGAIN...WITH NORTHERLY WINDS OVER THE PLAINS TODAY.
TONIGHTS MINIMUM TEMPERATURES WILL BE SIMILAR TO A FEW DEGREES
WARMER THAN THIS MORNINGS READINGS.
.LONG TERM...(WEDNESDAY THROUGH MONDAY)
ISSUED AT 335 AM MDT TUE OCT 13 2015
WEATHER PATTERN WILL REMAIN RELATIVELY UNCHANGED THROUGH FRIDAY
WITH A BLOCKING RIDGE DOMINATING OUR WEATHER. THIS RIDGE IS CAUGHT
IN BETWEEN THE STRONGER NORTHERN BRANCH AND CUTOFF LOW OFF THE
CALIFORNIA COAST. THE RIDGE IS EXPECTED TO SHIFT ONLY SLOWLY
NORTHWARD THROUGH FRIDAY AND SATURDAY.
IN THE MEANTIME...DRY WEATHER WILL PERSIST. THE ONLY WEATHER
FEATURE WILL BE A BACK DOOR COLD FRONT STILL ON TRACK TO PUSH

ACROSS THE PLAINS THURSDAY MORNING WITH GUSTY WINDS BUT COOLER TEMPERATURES BEHIND IT. AS A RESULT...THE MUCH ABOVE NORMAL HIGHS ON WEDNESDAY WILL RETREAT TO CLOSER TO NORMAL LEVELS FOR THURSDAY.
BY THURSDAY NIGHT...MUCH COOLER AIR WILL FILTER IN BEHIND THE FRONT. THIS WILL BRING A THREAT OF PATCHY FROST TO PORTIONS OF THE PLAINS. SLIGHTLY COOLER AIR WILL LIKELY HOLD OVER THE PLAINS FRIDAY...BEFORE TEMPERATURES RETURN TO ABOVE NORMAL LEVELS OVER THE WEEKEND AS DEEPER SOUTHWEST FLOW DEVELOPS.
THERE IS SOME HOPE OF PRECIPITATION...ALBEIT LIGHT...BY LATE IN THE WEEKEND INTO EARLY NEXT WEEK AS THE CUTOFF LOW IS ANTICIPATED TO GET CAUGHT UP IN THE DEEPER ENERGY REACH THE WEST COAST. MODELS HAVE STRUGGLED WITH THE TIMING OF THIS FEATURE...SO WILL KEEP THE FORECAST CONSISTENT WITH A SLIGHT CHANCE OF SHOWERS/STORMS IN THE MOUNTAINS FOR SATURDAY AND SUNDAY...AND THEN POSSIBLY SPILLING ONTO THE PLAINS BY MONDAY.
&&
.AVIATION...(FOR THE TAFS THROUGH 18Z WEDNESDAY MORNING)
ISSUED AT 1007 AM MDT TUE OCT 13 2015
VFR CONDITIONS TO CONTINUE THROUGH WEDNESDAY. WINDS WILL BECOME NORTHEASTERLY BY 18Z. NORMAL DRAINAGE WINDS WILL SET UP BY 03Z IF NOT SOONER AND CONTINUE INTO WEDNESDAY MORNING.
&&
.FIRE WEATHER...
ISSUED AT 335 AM MDT TUE OCT 13 2015
A VERY DRY AIRMASS CONTINUES OVER THE STATE TODAY WITH MINIMUM RH VALUES IN THE LOW TO MID TEENS. WIND SPEEDS MAY APPROACH CRITERIA ALONG THE NORTHERN STATE BORDER ALONG AND WEST OF I25...HOWEVER NOT ENOUGH COVERAGE OR LENGTH OF TIME TO NEED A HIGHLIGHT.
GRASSLAND FIRE DANGER WILL INCREASE THURSDAY WITH THE GUSTY WINDS ASSOCIATED WITH A COLD FRONTAL PASSAGE...BUT HUMIDITIES WILL BE A LITTLE HIGHER THAN THIS PAST SUNDAYS EVENT.
&&
.BOU WATCHES/WARNINGS/ADVISORIES...
NONE.
&&
$$

13.0 Pilot Weather Briefing

The accident pilot requested and received a Lockheed Martin Flight Services (LMFS) online weather briefing at 1630 MDT on October 12. The LMFS online weather briefing contained all the standard weather information and forecast valid from 1630 MDT on October 12. The weather forecast products such as AIRMETs and Area Forecast were only valid through 2100 MDT on October 12 (AIRMET) or 0100 MDT on October 13 (Area Forecast). The accident pilot did not take a flight on October 12 and no further updated weather briefing from LMFS or Direct User Access Terminal Service (DUATS) was requested nor received. For more information please see attachment 2. There is no record of the accident pilot receiving or retrieving any other weather information before or during the accident flight.

14.0 Fronts and LLWS Information

The Federal Aviation Administration's (FAA) Advisory Circular AC 00-06A titled "Aviation Weather for Pilots and Flight Operations Personnel" issued in January 1975 is the primary basic pilot training guide on aviation weather used for flight training guidance. Figure 23 is taken from AC 00-06A and is a cross section of wind shear that occurs across air currents of differing velocities and/or directions. These type of conditions were likely present and occurring at and around the accident site at the accident time with a northeast to east gusty surface wind and a west to northwest wind above the low-level northeast wind layer right near the surface.

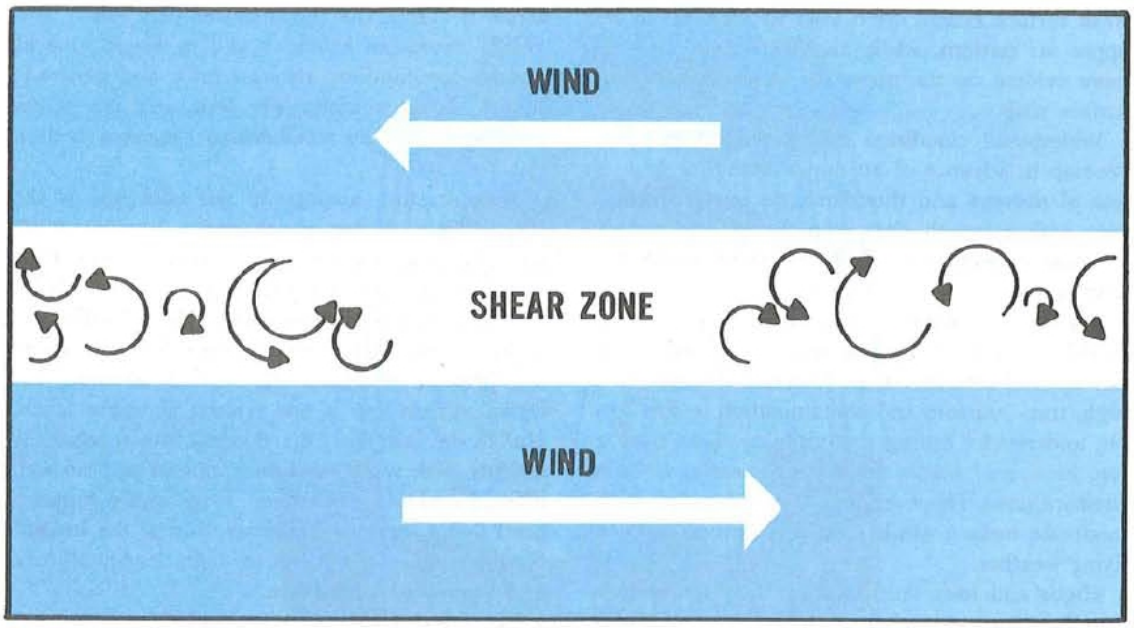


FIGURE 31. Wind shear. Air currents of differing velocities create friction or "shear" between them. Mixing in the shear zone results in a snarl of eddies and whirls.

Figure 23 – Cross section of wind shear and differing air currents

Chapters 8 and 9 from AC 00-06A also discuss the hazards associated with fronts, air masses, and turbulence. Figure 24 is a series of images from a research weather computer model simulating the turbulence flow created by the density differences in a front and the creation of Kelvin-Helmholtz instability[18] along the boundary of the air mass. The turbulence noted along and in the front is a common location of loss of aircraft control. These types of LLWS conditions were likely near the accident site at the accident time. If there had been enough moisture present for clouds, they likely would have provided visible proof of the turbulent LLWS conditions located within the frontal boundary at and around the accident site at the accident time.

[18] Kelvin-Helmholtz instability – Instability caused by air masses with different densities moving at different speeds that create turbulence and wave-like patterns in the clouds when visible.

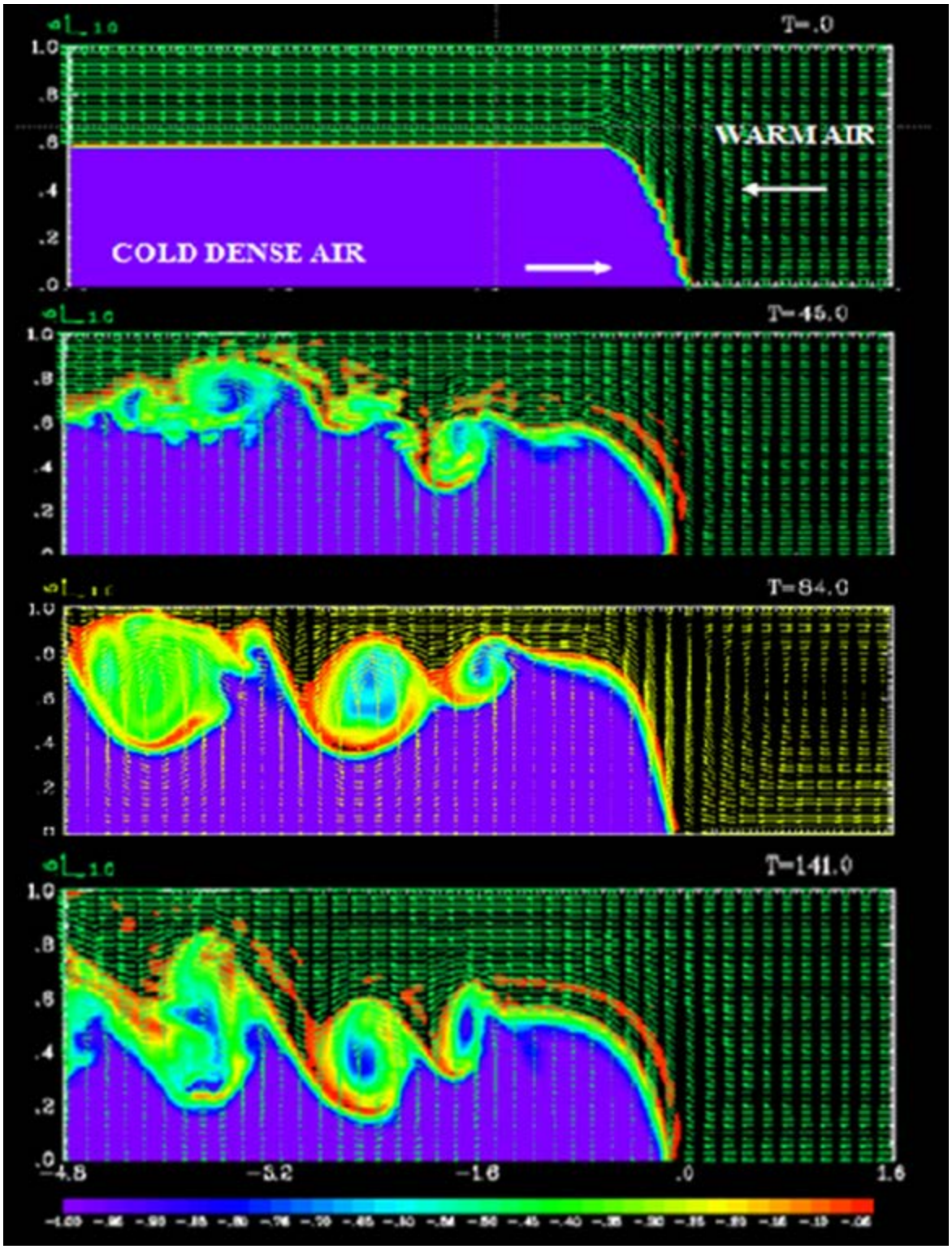


Figure 24 – Computer modeling of the turbulence flow created by the density differences in a front

15.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on October 13, 2015, indicated the following:

SUN	
Begin civil twilight	0640 MDT
Sunrise	0707 MDT
Sun transit	1245 MDT
Sunset	1822 MDT
End civil twilight	1849 MDT

F. LIST OF ATTACHMENTS

Attachment 1 – KCYS base reflectivity imagery loop for the 0.5° elevation scans initiated from 1048 MDT through 1251 MDT

Attachment 2 – LMFS online weather briefing requested by the accident pilot at 1630 MDT on October 12

Paul Suffern
NTSB, AS-30