NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

August 11, 2016

Group Chairman's Factual Report

METEOROLOGY

CEN15MA290

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A. ACCIDENT

Location: 1 mile east-southeast of Frisco, Colorado
Date: July 3, 2015
Time: approximately 1340 mountain daylight time (1940 UTC[1])
Aircraft: Eurocopter AS350B3E, registration: N390LG

B. METEOROLOGY GROUP

Paul Suffern
Senior Meteorologist
National Transportation Safety Board
Operational Factors Division, AS-30
Washington, D.C. 20594-2000

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 did not travel for this investigation and gathered 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 July 3, 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 location was located at latitude 39.57° N, longitude 106.08° W, elevation 9,176 feet.

E. FACTUAL INFORMATION

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

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 1500 MDT is provided as figure 1, with the approximate location of the accident site marked. The chart depicted a surface trough[2] east of the accident site stretching from north central Colorado southward into the western panhandle of Texas. A surface low pressure center with a pressure of 1010-hectopascals (hPa) was located in southeastern Colorado. A surface high pressure center with a pressure of 1015-hPa was located in southern Colorado. The station models around the accident site depicted air temperatures in the mid 60's to low 80's Fahrenheit (F), with temperature-dew point spreads of 19° F or more, a west to northwest wind between 10 and 15 knots in the Rocky Mountains, with light and variable winds east of the mountains in Colorado, and partly cloudy skies. A thunderstorm was reported in western Colorado at 1500 MDT.

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

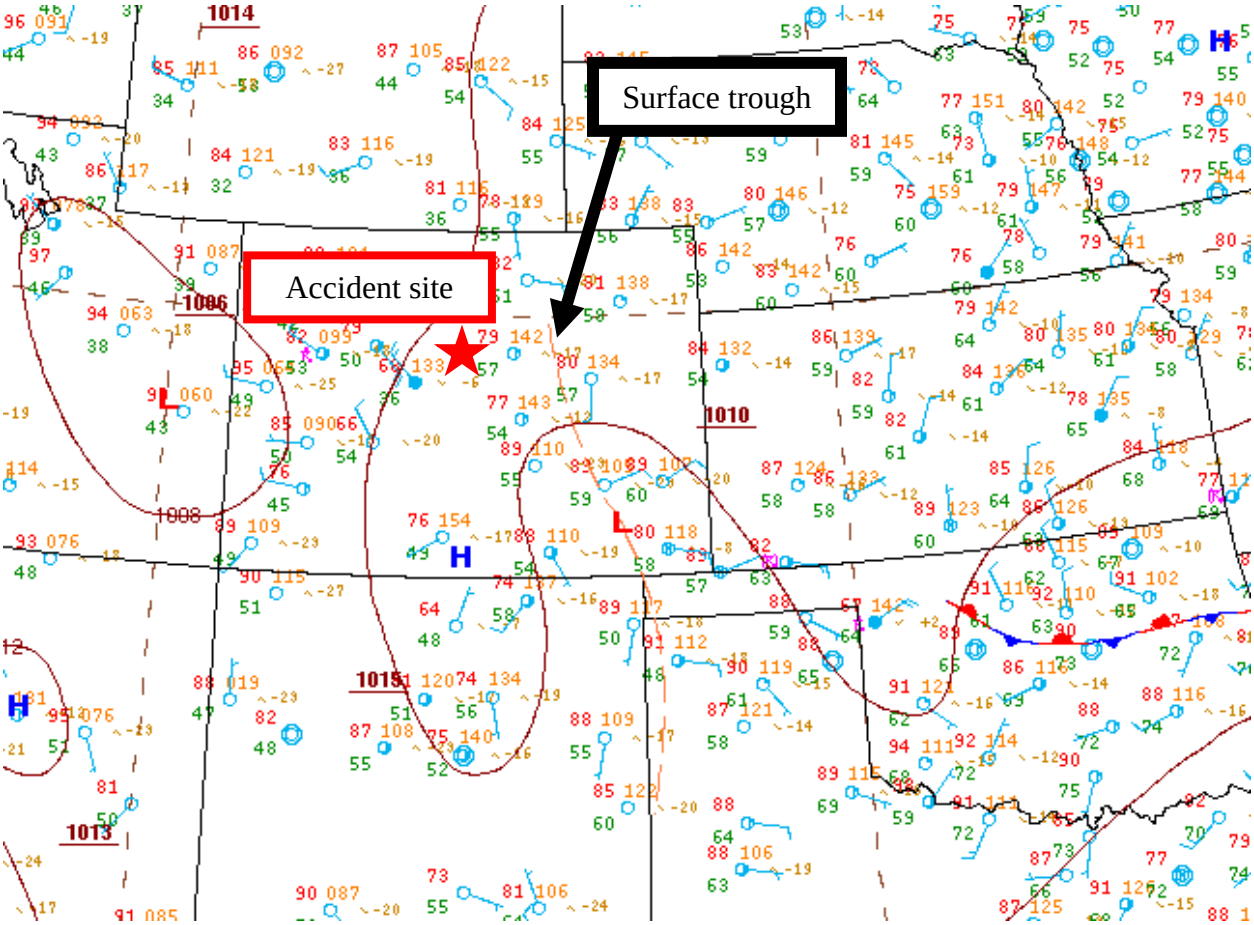


Figure 1 – NWS Surface Analysis Chart for 1500 MDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1800 MDT at 700-, 500-, and 300-hPa are presented in figures 2, 4 and 5 with the 500-hPa chart for 0600 MDT as figure 3. The 500-hPa charts at 0600 and 1800 MDT depicted a mid-level trough just east of the accident site continuing to move southeastward through 1800 MDT with a northwest wind between 20 and 35 knots. Areas near and ahead of troughs are typically areas where enhanced lift, clouds, and precipitation can occur. Clouds and precipitation can occur in mountainous terrain with strong enough wind flow over the terrain and abundant moisture and the 700-hPa chart depicted dew point temperatures near and above 8° Celsius (C) at 1800 MDT (figure 3) near the accident site in the mountainous terrain, and this will be further discussed in section 4.0. The wind remained out of the west to northwest from 500- through 300-hPa with the strongest wind at 300-hPa, near 45 knots.

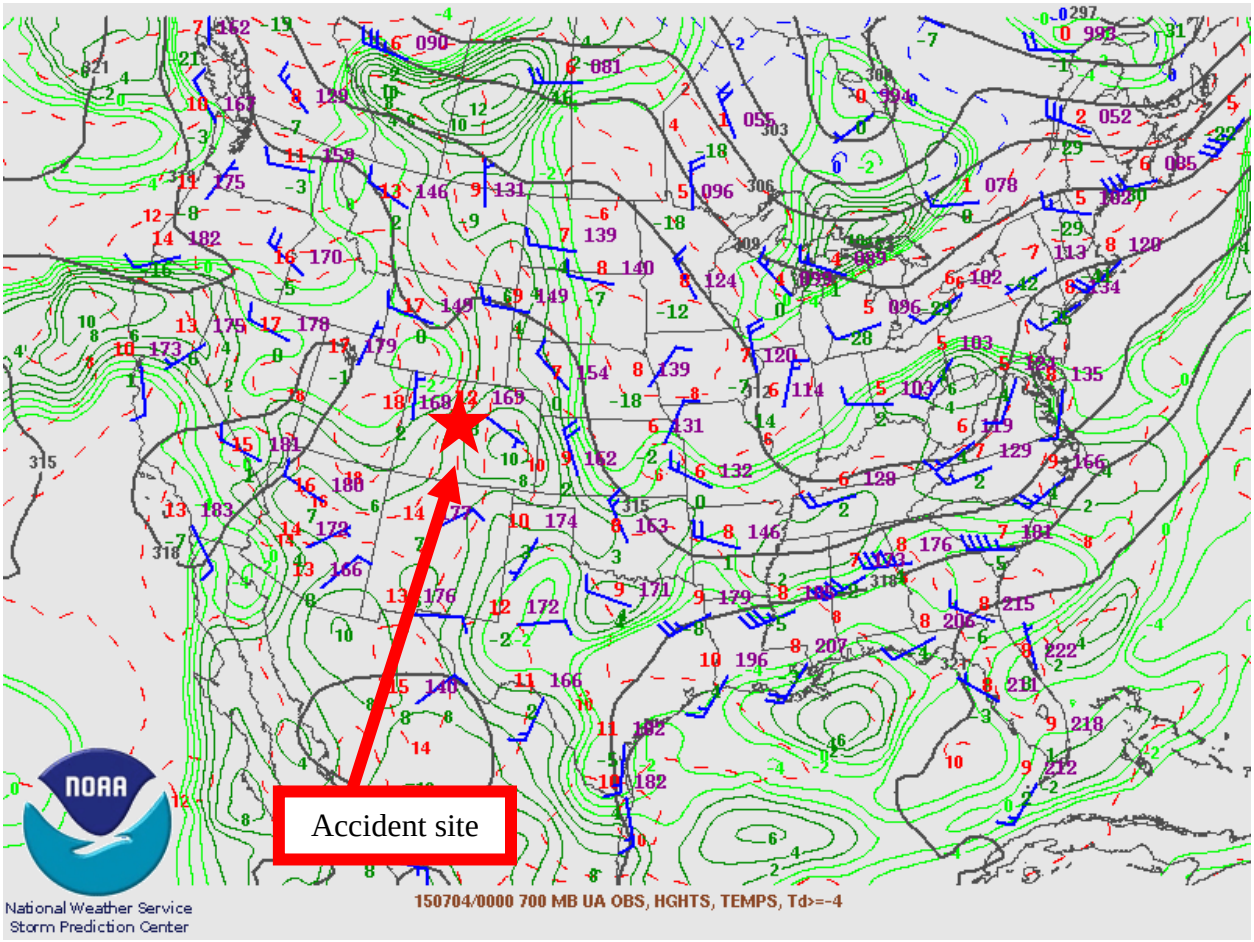


Figure 2 – 700-hPa Constant Pressure Chart for 1800 MDT

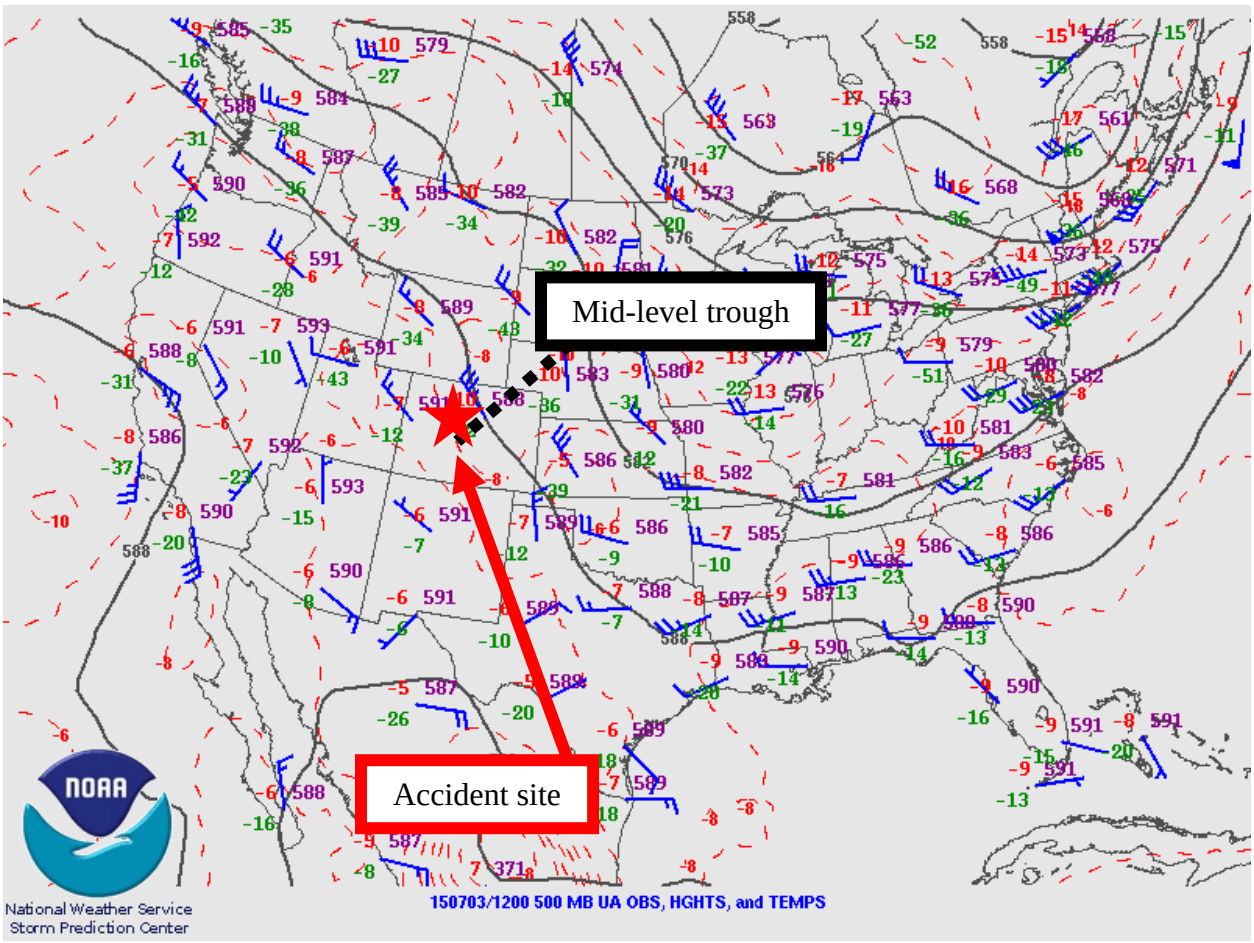


Figure 3 – 500-hPa Constant Pressure Chart for 0600 MDT

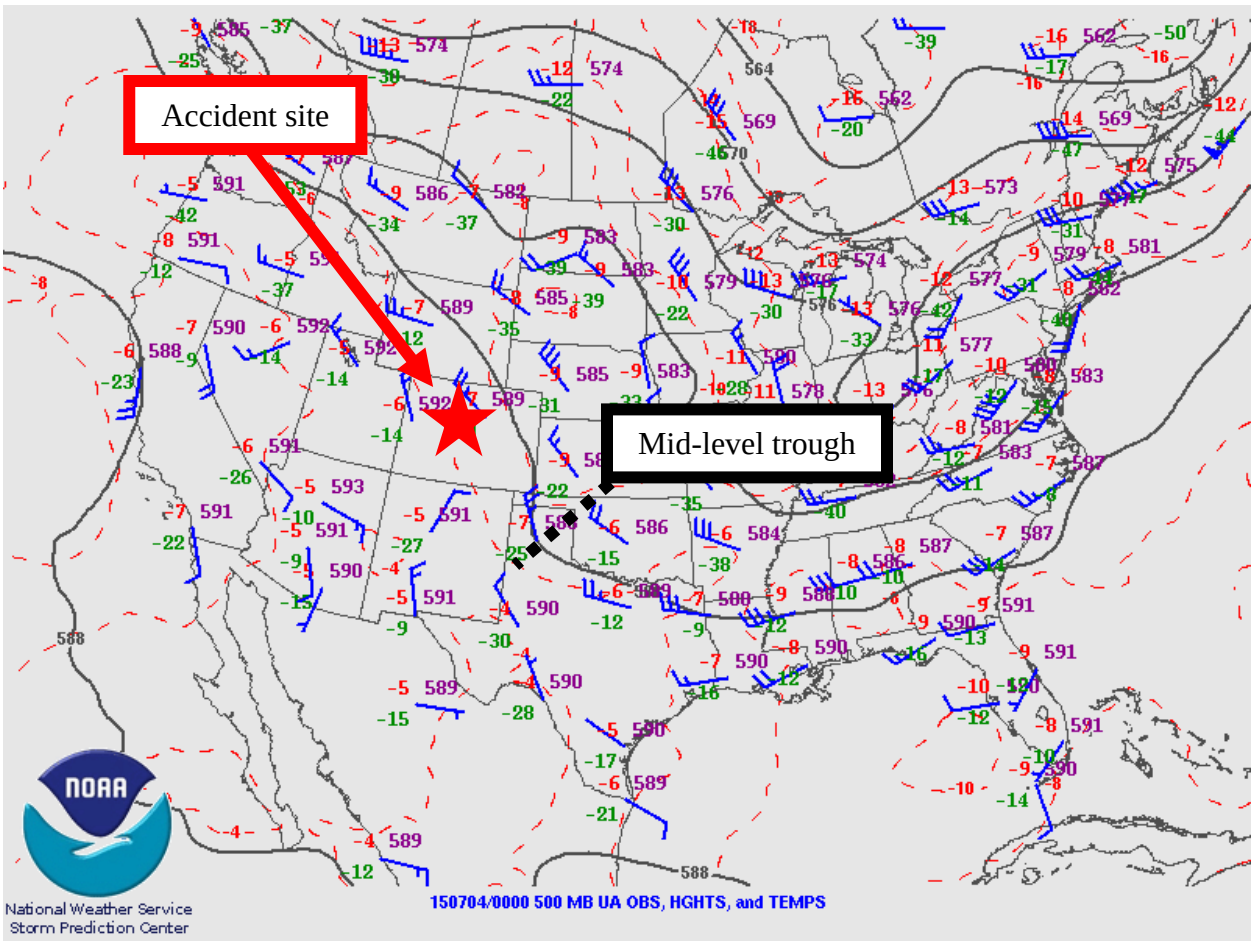


Figure 4 – 500-hPa Constant Pressure Chart for 1800 MDT

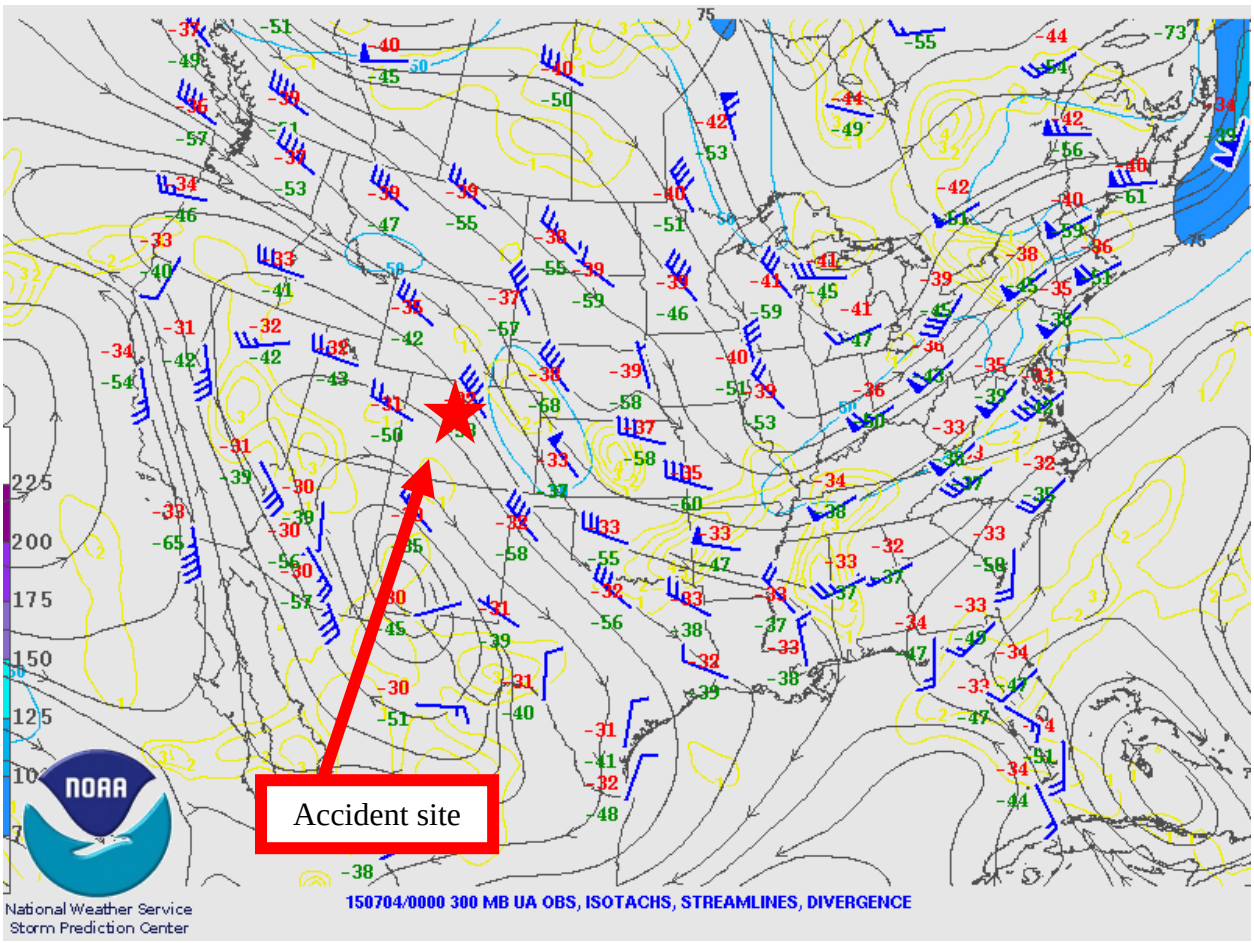


Figure 5 – 300-hPa Constant Pressure Chart for 1800 MDT

2.0 Storm Prediction Center Products

SPC issued the following Day 1 Convective Outlook at 1023 MDT (figure 6) with areas of thunderstorms and a marginal risk for severe thunderstorm forecast for the accident site. The accident site was located in an area where SPC forecasted a 5 percent chance of damaging thunderstorm winds or wind gusts 50 knots or greater within 25 miles of a point and a 5 percent chance of one inch diameter hail or larger within 25 miles of a point (figures 7 and 8). These severe weather chances are relatively high given that on a normal summer day only a small chance of general thunderstorms would be forecast for the accident area:[3]

SPC AC 031623

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1123 AM CDT FRI JUL 03 2015

VALID 031630Z - 041200Z

[3] 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.

...THERE IS AN ENH RISK OF SVR TSTMS OVER PARTS OF GA AND SC...

...THERE IS A SLGT RISK OF SVR TSTMS FROM A PART OF THE SRN PLAINS TO SERN ATLANTIC COAST...

...THERE IS A SLGT RISK OF SVR TSTMS OVER A PART OF THE CNTRL HIGH PLAINS...

...THERE IS A MRGL RISK OF SVR TSTMS FROM THE HIGH PLAINS TO SERN ATLANTIC COAST...

...SUMMARY...
SCATTERED STRONG TO SEVERE THUNDERSTORMS ARE EXPECTED THIS AFTERNOON AND EVENING OVER THE CENTRAL HIGH PLAINS...AND FROM THE SOUTHERN PLAINS TO THE CAROLINAS.

...SYNOPSIS...

LITTLE CHANGE TO THE LARGE-SCALE PATTERN IS ANTICIPATED OVER THE NEXT 24 HRS WITH A REX BLOCK OVER THE FAR NERN PACIFIC...DOWNSTREAM RIDGING FROM NRN MEXICO INTO THE GREAT BASIN...AND A LONG-WAVE TROUGH PERSISTING EAST OF THE ROCKIES. WITHIN THIS UPPER-AIR REGIME...SEVERAL VORTICITY MAXIMA PRESENT FROM THE MID MS VALLEY TO CNTRL PLAINS WILL PROGRESS SEWD...CONTRIBUTING TO WEAK HEIGHT FALLS AND A GENERAL INCREASE IN TSTM ACTIVITY FROM THE ARKLATEX EWD THROUGH THE GULF COAST STATES INTO SOUTHEAST. OTHER MID-LEVEL PERTURBATIONS WILL TRANSLATE SEWD FROM THE NRN HIGH PLAINS INTO THE NRN AND CNTRL PLAINS...AHEAD OF A MORE SUBSTANTIAL SHORT-WAVE TROUGH DIGGING SEWD THROUGH THE CANADIAN ROCKIES.

AT THE SURFACE...AN AREA OF LOW PRESSURE OVER CNTRL KY AS OF MID MORNING WILL DEVELOP NEWD INTO THE UPPER OH VALLEY WHILE A SECONDARY CYCLONE FORMS OVER THE VA PIEDMONT PRIOR TO MOVING INTO THE TIDEWATER REGION. MEANWHILE...A TRAILING COLD FRONT WILL SETTLE SLOWLY SWD THROUGH THE OZARK PLATEAU AND LOWER OH AND TN VALLEYS INTO THE ARKLATEX AND LOWER MS VALLEY. AHEAD OF THIS FRONT...AN OUTFLOW BOUNDARY STRETCHING FROM THE ARKLATEX THROUGH NRN PARTS OF MS...AL AND GA INTO UPSTATE SC WILL BE THE PRIMARY FOCUS FOR STRONG TO SEVERE STORMS THIS AFTERNOON INTO EVENING.

...ARKLATEX TO SERN ATLANTIC COAST THIS AFTERNOON AND EVENING...

12Z RAOBS FROM BMX AND FFC INDICATED THAT A MOIST AND ALREADY MODERATELY UNSTABLE AIR MASS WAS FAVORABLY ALIGNED WITH A BELT OF 40-50 KT WLY WINDS AT AROUND 3 KM AGL...A SETUP WHICH HAS ALREADY SUPPORTED THE INTENSIFICATION OF STORMS OVER CNTRL GA AS OF LATE MORNING. EXPECT THIS ACTIVITY TO MOVE/DEVELOP ESEWD TOWARD THE SC COAST TODAY WITH THE PRIMARY HAZARD BEING DAMAGING OUTFLOW WINDS. FOR ADDITIONAL GUIDANCE ON THIS AREA...SEE MCD 1288 AND SEVERE THUNDERSTORM WATCH 387.

ADDITIONAL STORMS WILL LIKELY DEVELOP THIS AFTERNOON ON THE PERIPHERY OF THE EARLY-DAY CLOUDS AND LINGERING PRECIPITATION FROM THE OZARK PLATEAU AND ARKLATEX EWD INTO CNTRL PARTS OF MS AND AL. WHILE THE PHASING OF THE STRONGER FLOW IN THE 700-MB LAYER AND WHERE

THE GREATEST AIR MASS DESTABILIZATION WILL OCCUR IS NOT AS FAVORABLE AS POINTS TO THE EAST...A SUFFICIENT OVERLAP SHOULD EXIST TO PROMOTE INTENSE STORM CLUSTERS CAPABLE OF DAMAGING WIND GUSTS INTO THIS EVENING. SLIGHTLY STRONGER DEEP-LAYER SHEAR OVER ERN OK INTO WRN AR MAY PROMOTE SOME MARGINAL SUPERCELL STRUCTURES AND AN ASSOCIATED RISK FOR SEVERE HAIL IN ADDITION TO GUSTY WINDS.

...HIGH PLAINS THIS AFTERNOON AND EVENING...

BOUNDARY-LAYER DEWPOINTS IN THE 50S BENEATH THE ERN REACHES OF A STEEP MID-LEVEL LAPSE RATE PLUME WILL YIELD A MODERATELY UNSTABLE AIR MASS BY AFTERNOON. OROGRAPHIC FORCING COUPLED WITH THE INFLUENCE OF WEAK MID-LEVEL PERTURBATIONS EMBEDDED WITHIN THE PREVAILING NWLY FLOW REGIME WILL FOSTER ISOLATED TO WIDELY SCATTERED STORMS LATER TODAY. A FEW SUPERCELLS CAPABLE OF LARGE HAIL ARE POSSIBLE OVER PARTS OF ERN CO WHERE A FAVORABLE OVERLAP OF MODERATE INSTABILITY AND 40-50 KT OF DEEP-LAYER SHEAR IS FORECAST. ELSEWHERE...ISOLATED OCCURRENCES OF STRONG WIND GUSTS AND/OR HAIL WILL BE POSSIBLE WITH THE MOST INTENSE STORMS INTO THIS EVENING.

..MEAD/MOSIER.. 07/03/2015

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 2000Z

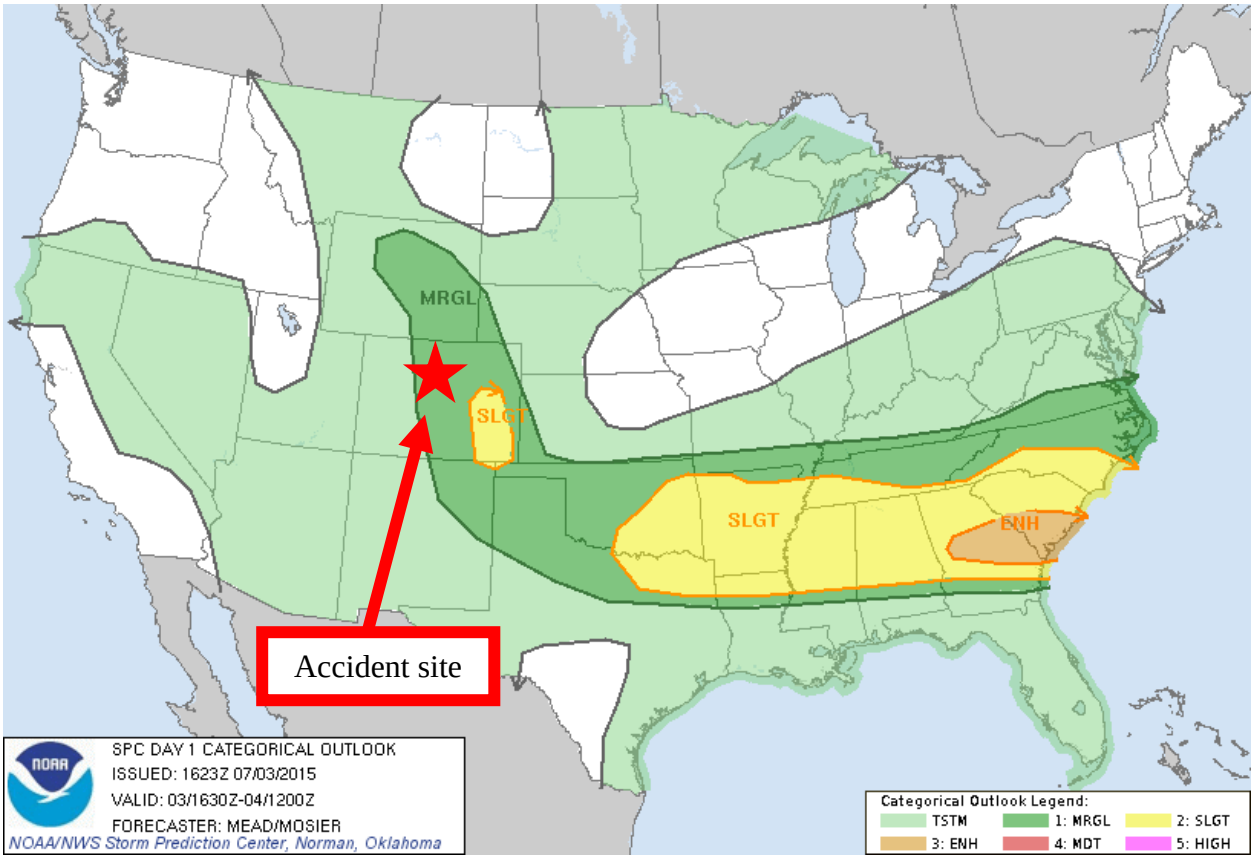


Figure 6 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

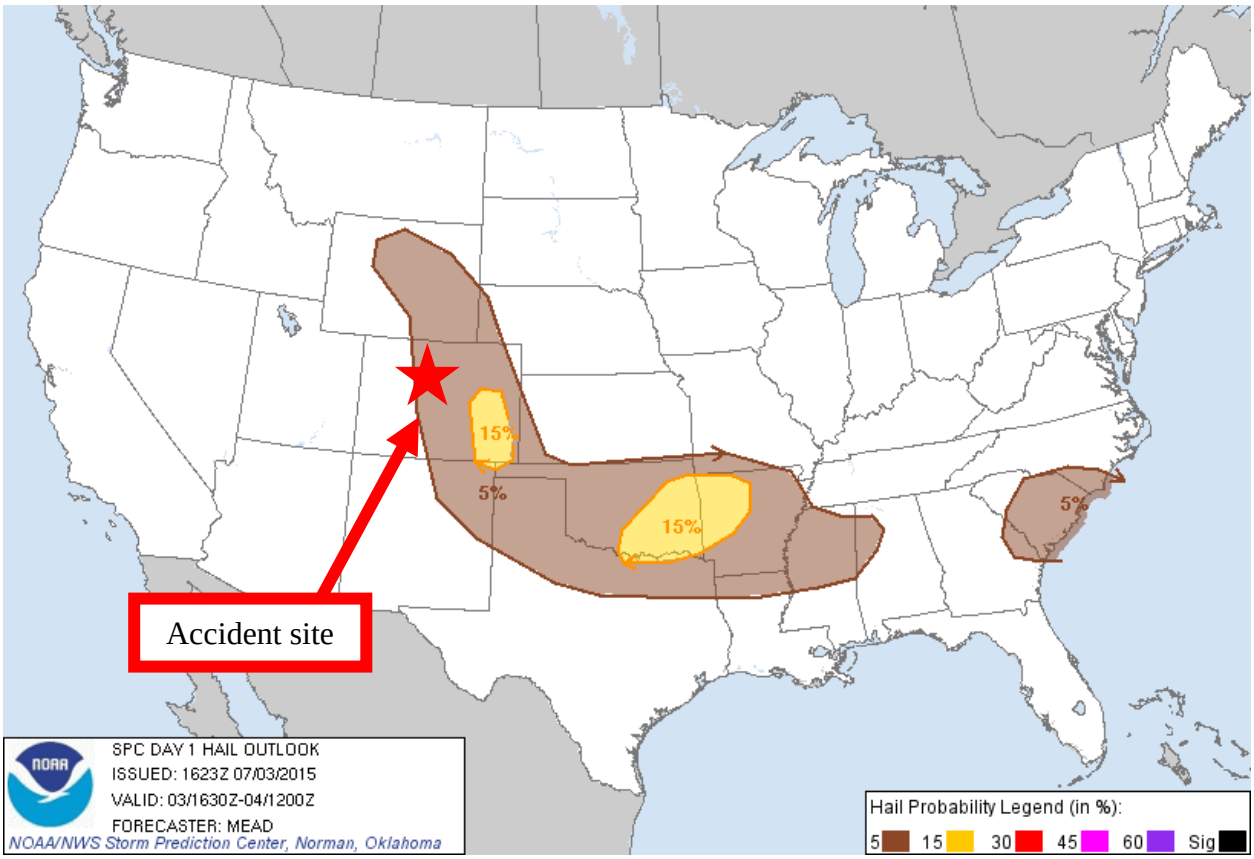


Figure 7 – Storm Prediction Center day 1 Hail Outlook valid at the time of the accident

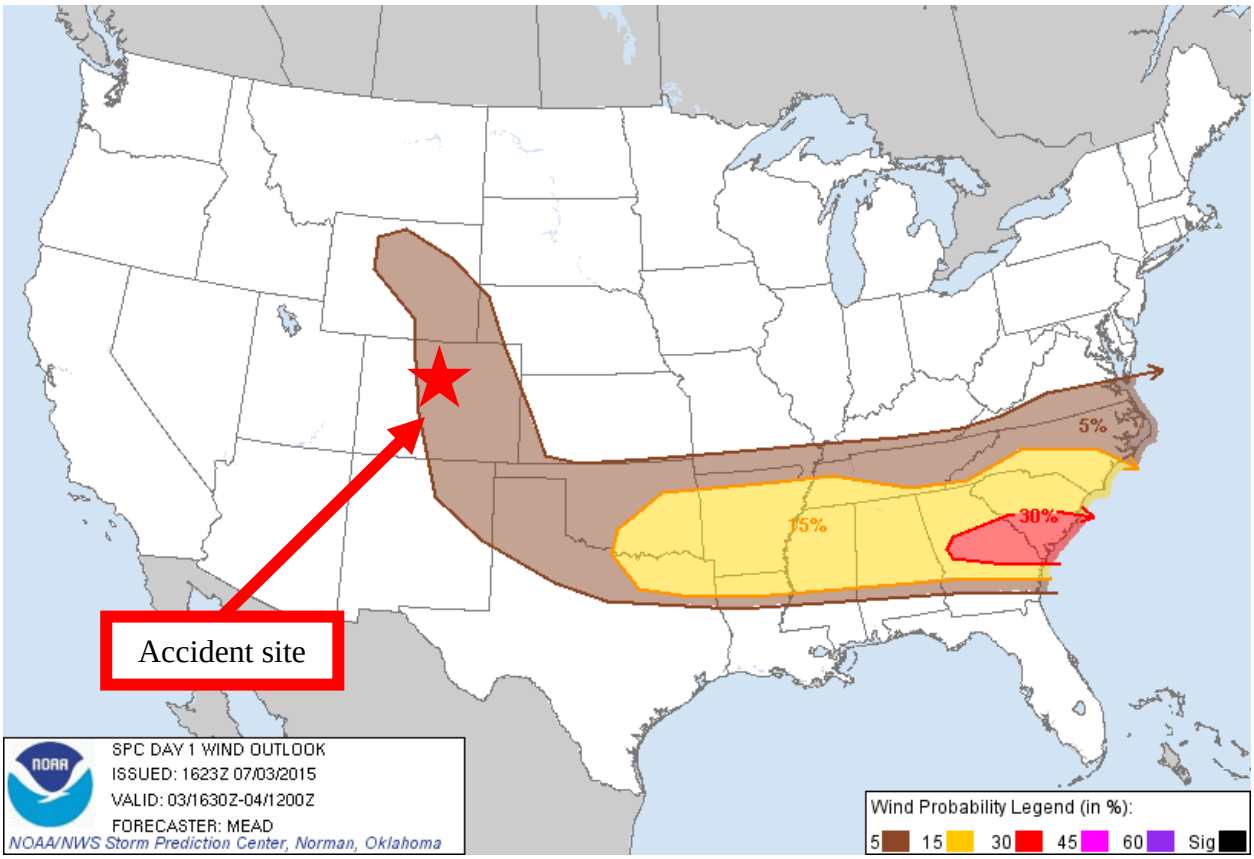


Figure 8 – Storm Prediction Center day 1 Wind Outlook valid at the time of the accident

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.

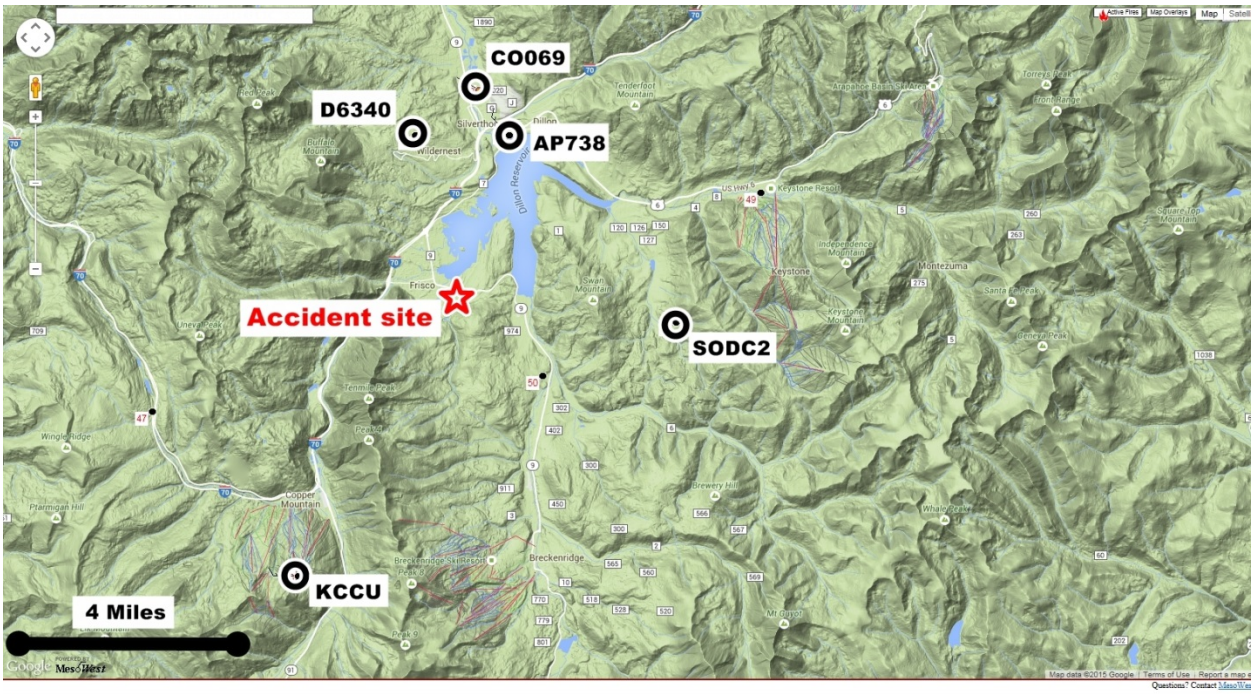


Figure 9 – Map of Colorado with the location of the accident site and surface observation sites

Copper Mountain – Red Cliff Pass (KCCU) was the closest official weather station to the accident site located 7 miles south-southwest of the accident site (figure 9). KCCU had an Automated Weather Observing System (AWOS[4]) whose reports were not supplemented. KCCU was located at an elevation of 12,028 feet. The following observations were taken and disseminated during the times surrounding the accident:

[1155 MDT] KCCU 031755Z AUTO 29023G32KT 10SM SCT055 18/00 A3063 RMK AO2=

[1215 MDT] KCCU 031815Z AUTO 29022G29KT 10SM SCT055 SCT070 18/00 A3064 RMK AO2=

[1235 MDT] KCCU 031835Z AUTO 29022G30KT 10SM SCT060 SCT070 SCT110 18/00 A3062 RMK AO2 LTG DSNT W=

[1255 MDT] KCCU 031855Z AUTO 29022G29KT 10SM SCT060 18/M01 A3062 RMK AO2 LTG DSNT W=

[1315 MDT] KCCU 031915Z AUTO 28017G28KT 10SM SCT060 18/M02 A3062 RMK AO2=

[1335 MDT] KCCU 031935Z AUTO 28019G24KT 10SM SCT060 SCT070 BKN120 18/M01 A3062 RMK AO2=

ACCIDENT TIME 1340 MDT

[1355 MDT] KCCU 031955Z AUTO 29020G27KT 10SM SCT060 SCT080 SCT090 19/M02 A3062 RMK AO2 LTG DSNT W=

[1415 MDT] KCCU 032015Z AUTO 29020G26KT 10SM SCT060 20/M03 A3061 RMK AO2=

[1435 MDT] KCCU 032035Z AUTO 28019G27KT 10SM SCT070 SCT085 BKN100 18/M02 A3062 RMK AO2 LTG DSNT SE=

[1455 MDT] KCCU 032055Z AUTO 26019G32KT 10SM -RA BKN060 BKN070 OVC100 15/M04 A3062 RMK AO2 LTG DSNT NW=

[1515 MDT] KCCU 032115Z AUTO 25013G16KT 10SM SCT046 BKN060 BKN075 16/00 A3062 RMK AO2 LTG DSNT E SE AND W=

[1535 MDT] KCCU 032135Z AUTO 26009G19KT 10SM BKN060 BKN095 18/00 A3062 RMK AO2 LTG DSNT E S AND W=

[4] 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.

KCCU weather at 1315 MDT was reported as wind from 280° at 17 knots with gusts to 28 knots, 10 miles visibility, scattered clouds at 6,000 above ground level (agl), temperature of 18° C, dew point temperature of -2° C, and an altimeter setting of 30.62 inches of mercury. Remarks: automated station with precipitation discriminator.

KCCU weather at 1335 MDT was reported as wind from 280° at 19 knots with gusts to 24 knots, 10 miles visibility, scattered clouds at 6,000 agl, scattered clouds at 7,000 feet agl, a broken ceiling at 12,000 feet agl, temperature of 18° C, dew point temperature of -1° C, and an altimeter setting of 30.62 inches of mercury. Remarks: automated station with precipitation discriminator.

KCCU weather at 1355 MDT was reported as wind from 290° at 20 knots with gusts to 27 knots, 10 miles visibility, scattered clouds at 6,000 agl, scattered clouds at 8,000 feet agl, scattered clouds 9,000 feet agl, temperature of 19° C, dew point temperature of -2° C, and an altimeter setting of 30.62 inches of mercury. Remarks: automated station with precipitation discriminator, lightning distant[5] west.

KCCU weather at 1415 MDT was reported as wind from 290° at 20 knots with gusts to 26 knots, 10 miles visibility, scattered clouds at 6,000 agl, temperature of 20° C, dew point temperature of -3° C, and an altimeter setting of 30.61 inches of mercury. Remarks: automated station with precipitation discriminator.

In addition to the official surface observation site above, there were a few non-official surface observations sites reporting around the accident site at the accident time and these sites are documented below:

DW6340 Silverthorne (D6340) was an APRSWXNET/CWOP station and was the closest non-official surface observation site to the accident site. D6340 was located 3 miles north-northwest of the accident site at an elevation of 9,685 feet (figure 9) and figure 10 contains the observations surrounding the accident time:

[5] Distant indicated that the lightning was beyond 10 miles but less than 30 miles from the center of the airport (or airport location point, ALP).

ID = D6340	TMP ° F	RELH %	SKNT mph	GUST mph	DRCT °	QFLG	ALTI in	PREC in	P24I in	CHC3	DWP °F
7-3-2015 16:40 MDT	73	35	0	8		OK	29.63		0		43.7
7-3-2015 16:25 MDT	74	31	3	11	254	OK	29.63		0		41.4
7-3-2015 16:09 MDT	72	32	1	8	259	OK	29.64		0		40.5
7-3-2015 15:54 MDT	68	36	2	8	274	OK	29.65		0		40
7-3-2015 15:39 MDT	67	42	3	9	259	OK	29.65		0		43.1
7-3-2015 15:24 MDT	66	45	3	11	247	OK	29.65		0		44
7-3-2015 15:09 MDT	66	42	2	9	275	OK	29.66		0		42.2
7-3-2015 14:54 MDT	69	32	0	4		OK	29.66		0		37.9
7-3-2015 14:39 MDT	72	31	0	2		OK	29.66		0		39.7
7-3-2015 14:24 MDT	75	26	1	7	329	OK	29.66		0		37.8
7-3-2015 14:09 MDT	75	30	1	10	49	OK	29.66		0		41.4
7-3-2015 13:54 MDT	73	31	1	7	53	OK	29.67		0		40.6
7-3-2015 13:39 MDT	73	29	2	8	338	OK	29.66		0		38.9
7-3-2015 13:24 MDT	75	33	1	8	283	OK	29.67		0		43.9
7-3-2015 13:09 MDT	75	33	1	10	58	OK	29.67		0		43.9
7-3-2015 12:54 MDT	74	32	1	7	128	OK	29.67		0		42.3
7-3-2015 12:39 MDT	74	34	2	14	78	OK	29.67		0		43.8
7-3-2015 12:24 MDT	73	34	3	11	298	OK	29.68		0		43
7-3-2015 12:09 MDT	72	38	1	7	136	OK	29.69		0		45
7-3-2015 11:54 MDT	72	38	1	10	57	OK	29.7		0		45
7-3-2015 11:39 MDT	72	39	1	8	283	OK	29.69		0		45.7
7-3-2015 11:24 MDT	71	35	2	9	14	OK	29.7		0		42
7-3-2015 11:09 MDT	71	36	2	7	93	OK	29.69		0		42.7
7-3-2015 10:54 MDT	70	41	0	6		OK	29.7		0		45.2
7-3-2015 10:39 MDT	70	39	0	5		OK	29.7		0		43.9
7-3-2015 10:24 MDT	69	47	0	3		OK	29.7		0		47.9
7-3-2015 10:09 MDT	68	46	0	2		OK	29.71		0		46.4
7-3-2015 9:54 MDT	67	49	0	2		OK	29.72		0		47.2
7-3-2015 9:39 MDT	66	51	1	4	158	OK	29.72		0		47.3
7-3-2015 9:24 MDT	64	50	0	2		OK	29.72		0		45
7-3-2015 9:08 MDT	62	59	0	2		OK	29.73		0		47.5
7-3-2015 8:53 MDT	60	60	0	3		OK	29.73		0		46.1
7-3-2015 8:38 MDT	59	67	0	3		OK	29.73		0		48.1
7-3-2015 8:23 MDT	57	67	0	2		OK	29.73		0		46.2
7-3-2015 8:08 MDT	56	72	0	2		OK	29.73		0		47.1

Figure 10 – List of hourly observations from D6340 surrounding the accident time

D6340 weather at 1324 MDT was reported as wind from 283° at 1 mph with gusts to 8 mph, temperature of 75° F, dew point temperature of 43.9° F, and an altimeter setting of 29.67 inches of mercury. The density altitude was calculated as 13,264 feet.

D6340 weather at 1339 MDT was reported as wind from 338° at 2 mph with gusts to 8 mph, temperature of 73° F, dew point temperature of 38.9° F, and an altimeter setting of 29.66 inches of mercury. The density altitude was calculated as 13,130 feet.

D6340 weather at 1354 MDT was reported as wind from 53° at 1 mph with gusts to 7 mph, temperature of 73° F, dew point temperature of 40.6° F, and an altimeter setting of 29.67 inches of mercury. The density altitude was calculated as 13,128 feet.

D6340 weather at 1409 MDT was reported as wind from 49° at 1 mph with gusts to 10 mph, temperature of 75° F, dew point temperature of 41.4° F, and an altimeter setting of 29.66 inches of mercury. The density altitude was calculated as 13,260 feet.

Soda Creek (SODC2) was a Remote Automated Weather Station (RAWS) site. SODC2 was located 4 miles east of the accident site at an elevation of 9,578 feet (figure 9) and figure 11 contains the observations surrounding the accident time:

ID = SODC2	TMP ° F	RELH %	SKNT mph	GUST mph	DRCT °	QFLG	SOLR W/m*m	TLKE ° F	PREC in	SINT in	FT ° F	PEAK mph	PDIR °	VOLT volt	DWP °F
7-4-2015 7:56 MDT	53	72	2	5	50	OK	66		9.02			5	126	12.9	44.2
7-4-2015 6:56 MDT	45	83	2	4	131	OK	25		9.02			4	124	12.8	40.2
7-4-2015 5:56 MDT	46	74	2	5	90	OK	2		9.02			5	149	12.7	38.2
7-4-2015 4:56 MDT	46	78	0	5		OK	0		9.02			5	135	12.8	39.5
7-4-2015 3:56 MDT	48	73	2	5	104	OK	0		9.02			5	33	12.8	39.8
7-4-2015 2:56 MDT	47	71	2	7	115	OK	0		9.02			7	73	12.9	38.1
7-4-2015 1:56 MDT	48	65	1	5	124	OK	0		9.02			5	61	12.9	36.8
7-4-2015 0:56 MDT	49	60	3	5	42	OK	0		9.02			5	64	13	35.7
7-3-2015 23:56 MDT	52	67	1	6	76	OK	0		9.02			6	133	13	41.4
7-3-2015 22:56 MDT	55	62	4	14	329	OK	0		9.02			14	136	13.1	42.2
7-3-2015 21:56 MDT	58	60	8	15	119	OK	0		9.02			15	130	13.2	44.2
7-3-2015 20:56 MDT	60	57	11	19	126	OK	11		9.02			19	124	13.3	44.7
7-3-2015 19:56 MDT	62	52	11	20	136	OK	72		9.02			20	123	13.5	44.2
7-3-2015 18:56 MDT	69	39	7	16	168	OK	357		9.02			16	150	13.7	43
7-3-2015 17:56 MDT	75	23	9	16	291	OK	603		9.02			16	269	14	34.7
7-3-2015 16:56 MDT	74	27	4	11	122	OK	712		9.02			11	281	13.4	37.9
7-3-2015 15:56 MDT	68	30	4	17	248	OK	240		9.02			17	292	13.7	35.4
7-3-2015 14:56 MDT	74	17	9	20	290	OK	928		9.02			20	262	13.4	26.4
7-3-2015 13:56 MDT	75	21	11	21	311	OK	1062		9.02			21	284	13.4	32.4
7-3-2015 12:56 MDT	73	27	11	20	313	OK	1019		9.02			20	298	13.4	37
7-3-2015 11:56 MDT	72	30	9	16	309	OK	934		9.02			16	294	13.4	38.9
7-3-2015 10:56 MDT	70	32	7	13	324	OK	795		9.02			13	309	13.4	38.8
7-3-2015 9:56 MDT	68	39	4	6	327	OK	627		9.02			6	305	13.5	42.1
7-3-2015 8:56 MDT	65	48	1	2	106	OK	434		9.02			2	70	13.4	44.8
MesoWest Disclaimer															
Data provided by: Bureau of Land Management & USDA Forest Service															
Contact MesoWest															

Figure 11 – List of hourly observations from SODC2 surrounding the accident time

SODC2 weather at 1156 MDT was reported as wind from 309° at 9 mph with gusts to 16 mph, temperature of 72° F, dew point temperature of 38.9° F, peak wind gust direction from 294°.

SODC2 weather at 1256 MDT was reported as wind from 313° at 11 mph with gusts to 20 mph, temperature of 73° F, dew point temperature of 37° F, peak wind gust direction from 298°.

SODC2 weather at 1356 MDT was reported as wind from 311° at 11 mph with gusts to 21 mph, temperature of 75° F, dew point temperature of 32.4° F, peak wind gust direction from 284°.

SODC2 weather at 1456 MDT was reported as wind from 290° at 9 mph with gusts to 20 mph, temperature of 74° F, dew point temperature of 26.4° F, peak wind gust direction from 262°.

KB0VBZ Silverthorne (AP738) was an APRSWXNET/CWOP station and was located 4 miles east-northeast of the accident site at an elevation of 8,976 feet (figure 9) and figure 12 contains the observations surrounding the accident time:

ID = AP738	TMP ° F	RELH %	SKNT mph	GUST mph	DRCT °	QFLG	ALTI in	P24I in	DWP °F
7-3-2015 15:57 MDT	85	49	7	10	135	OK			63.7
7-3-2015 15:53 MDT	88	47	7	10	135	OK			65.2
7-3-2015 15:52 MDT	88	47	7	10	135	OK			65.2
7-3-2015 15:48 MDT	89	45	6	11	315	OK			64.9
7-3-2015 15:47 MDT	89	45	6	11	315	OK			64.9
7-3-2015 15:28 MDT	85	50	6	11	135	OK			64.2
7-3-2015 15:27 MDT	85	50	6	11	135	OK			64.2
7-3-2015 15:17 MDT	83	50	5	7	135	OK			62.4
7-3-2015 15:12 MDT	85	48	3	8	135	OK			63.1
7-3-2015 15:07 MDT	86	47	3	8	135	OK			63.4
7-3-2015 15:02 MDT	85	49	4	8	135	OK			63.7
7-3-2015 14:52 MDT	83	52				OK			63.5
7-3-2015 14:28 MDT	84	50	6	10	135	OK			63.3
7-3-2015 14:27 MDT	84	50	6	10	135	OK			63.3
7-3-2015 14:22 MDT	83	50	4	10	135	OK			62.4
7-3-2015 14:17 MDT	83	50	5	8	135	OK			62.4
7-3-2015 14:12 MDT	83	50	5	8	135	OK			62.4
7-3-2015 14:07 MDT	83	51	5	8	135	OK			63
7-3-2015 14:02 MDT	83	52	5	9	135	OK			63.5
7-3-2015 13:57 MDT	82	53	4	7	135	OK			63.2
7-3-2015 13:52 MDT	81	54	2	5	315	OK			62.8
7-3-2015 13:47 MDT	80	57	3	6	135	OK			63.4
7-3-2015 13:42 MDT	79	57	5	8	135	OK			62.4
7-3-2015 13:37 MDT	82	52	4	7	135	OK			62.6
7-3-2015 13:32 MDT	83	52	2	3	135	OK			63.5
7-3-2015 13:27 MDT	83	50	5	8	135	OK			62.4
7-3-2015 13:22 MDT	83	49	5	8	135	OK			61.8
7-3-2015 13:03 MDT	81	54	2	6	135	OK			62.8
7-3-2015 13:02 MDT	81	54	2	6	135	OK			62.8
7-3-2015 12:57 MDT	81	54	6	10	135	OK			62.8
7-3-2015 12:52 MDT	82	54	4	6	135	OK			63.7
7-3-2015 12:43 MDT	80	56	5	8	135	OK			62.9
7-3-2015 12:42 MDT	80	56	5	8	135	OK			62.9
7-3-2015 12:28 MDT	81	55	3	7	135	OK			63.3
7-3-2015 12:27 MDT	81	55	3	7	135	OK			63.3
7-3-2015 12:12 MDT	80	60	4	6	135	OK			64.8
7-3-2015 11:57 MDT	80	63	3	6	135	OK			66.2
7-3-2015 11:47 MDT	79	68	5	10	135	OK			67.5
7-3-2015 11:38 MDT	78	68	4	7	135	OK			66.6
7-3-2015 11:37 MDT	78	68	4	7	135	OK			66.6
7-3-2015 11:27 MDT	78	67	5	8	135	OK			66.1
7-3-2015 11:22 MDT	77	67	5	9	135	OK			65.2
7-3-2015 11:17 MDT	77	67	4	11	135	OK			65.2
7-3-2015 11:07 MDT	77	66	4	8	135	OK			64.8
7-3-2015 10:57 MDT	77	66	4	5	135	OK			64.8
7-3-2015 10:53 MDT	77	63	4	7	135	OK			63.4
7-3-2015 10:52 MDT	77	63	4	7	135	OK			63.4

Figure 12 – List of hourly observations from AP738 surrounding the accident time

AP738 weather at 1332 MDT was reported as wind from 135° at 2 mph with gusts to 3 mph, temperature of 83° F, and dew point temperature of 63.5° F.

AP738 weather at 1337 MDT was reported as wind from 135° at 4 mph with gusts to 7 mph, temperature of 82° F, and dew point temperature of 62.6° F.

AP738 weather at 1342 MDT was reported as wind from 135° at 5 mph with gusts to 8 mph, temperature of 79° F, and dew point temperature of 62.4° F.

AP738 weather at 1347 MDT was reported as wind from 135° at 3 mph with gusts to 6 mph, temperature of 80° F, and dew point temperature of 63.4° F.

Silverthorne (CO069) was a CDOT station 5 miles north of the accident site (figure 9), but its observations were quality controlled and had a caution flag around the accident time. Therefore CO069 observations were not included in this report.

4.0 Upper Air Data

A North American Mesoscale (NAM) computer model upper air sounding for the accident site was generated for 1200 MDT with the surface elevation at 10,823 feet. The 1200 MDT sounding was plotted on a standard Skew-T log P diagram[6] with the derived stability parameters included in figure 13 (with data from the surface to 400-hPa, or 24,000 feet msl.) This data was analyzed utilizing the RAOB[7] software package. The sounding depicted the Lifted Condensation Level (LCL)[8] at 16,981 feet msl, a Convective Condensation Level (CCL)[9] of 16,355 feet, and a Level of Free Convection (LFC)[10] at 16,981 feet. The freezing level was located at 16,182 feet. The precipitable water value was 0.49 inches.

[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.

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

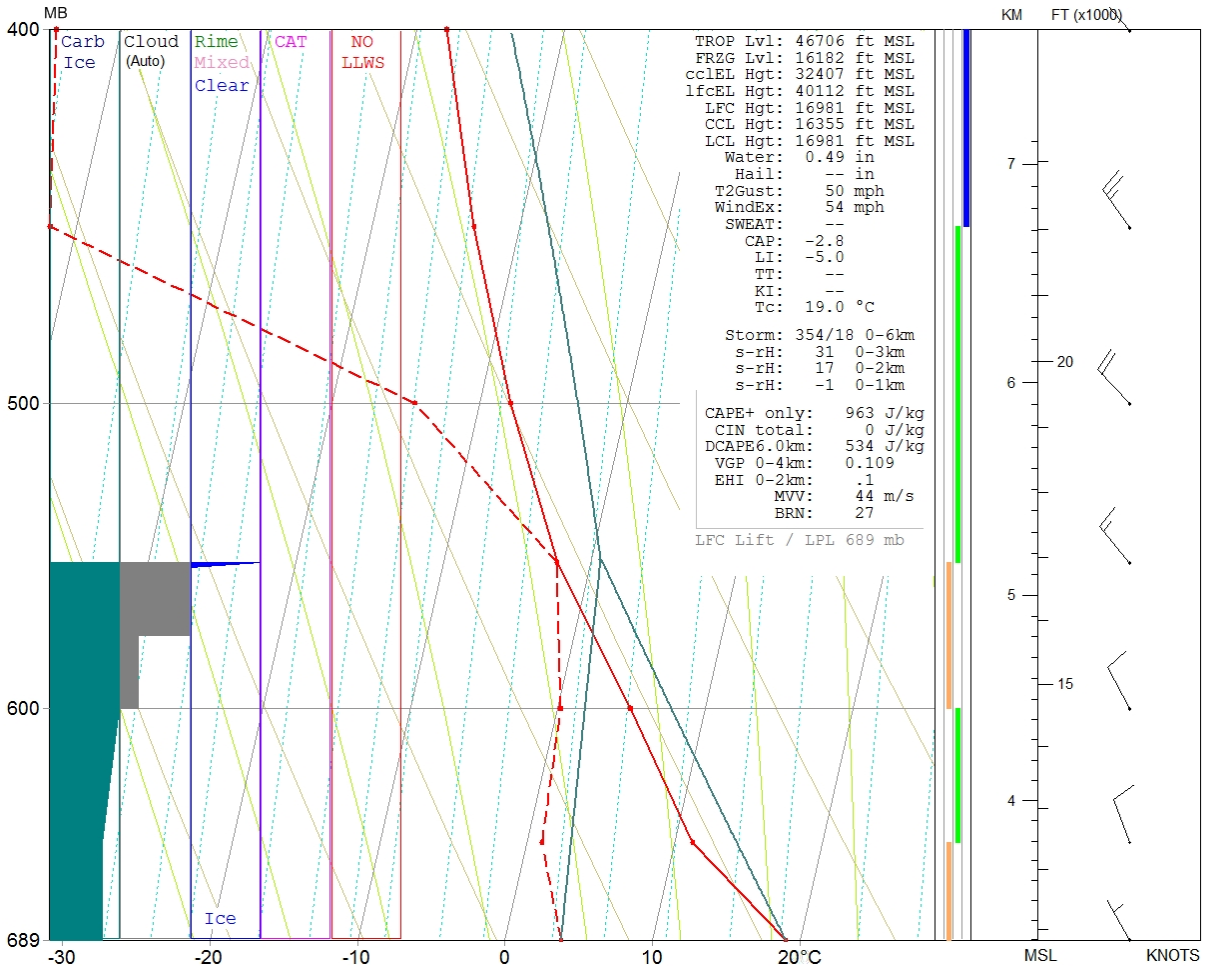


Figure 13 – 1200 MDT NAM sounding

The 1200 MDT NAM sounding indicated a relatively dry vertical environment from the surface through 15,000 feet msl with several layers of conditional instability through 22,000 feet msl. This environment would have been conducive of cloud formation as indicated by RAOB from 14,000 feet through 17,000 feet. No icing was indicated by RAOB. With cumulus clouds, rain showers, and thunderstorms possible given the environment and observations from around the accident time, the NAM sounding indicated the strongest wind speeds possible with a microburst, outflow boundary, or gust front would have likely been 50 mph as indicated by the T2Gust parameter or 54 mph as indicated by the WindEx parameter.

The sounding wind profile indicated there was a surface wind from 332° at 7 knots and the wind remained out of the northwest through 24,000 feet between 10 and 25 knots. Low-level wind shear (LLWS) was not indicated by RAOB. Clear-air turbulence was not indicated by RAOB from the surface through 24,000 feet.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) was obtained from the NCDC and processed with the NTSB's Man-computer Interactive Data Access System (McIDAS) workstation. Visible and infrared imagery (GOES-15 bands 1 and 4) at a wavelength of 0.65 microns (μm) and 10.7 μm retrieved brightness temperatures for the scene. Satellite imagery surrounding the time of the accident, from 1100 MDT through 1700 MDT at approximately 15-minute intervals, were reviewed and the closest images to the time of the accident are documented here.

Figures 14 and 15 present the GOES-15 visible imagery from 1330 and 1341 MDT at 3X magnification with the accident site marked by a red square. The visible imagery indicated abundant cumuliform cloud cover over and around the accident site at the accident time. Attachment 1 showed the visible imagery from 1300 through 1500 MDT with the cumuliform clouds moving across the mountainous terrain from northwest to southeast. One larger cumuliform cloud formed just south to southeast of the accident site between 1330 and 1345 MDT. Figure 16 presents the GOES-15 infrared imagery from 1341 MDT at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated higher cloud tops to the west and southwest of the accident site (yellow and green colors, higher cloud tops). Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1200 MDT NAM sounding, the approximate cloud-top heights over the accident site were 13,000 feet at 1341 MDT.

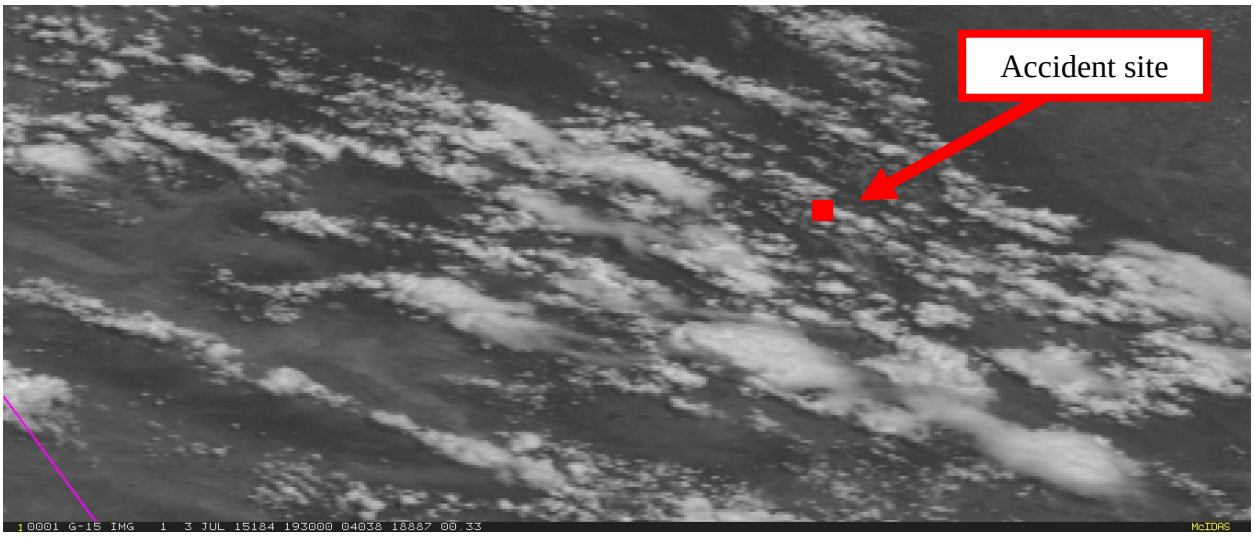


Figure 14 – GOES-15 visible image at 1330 MDT

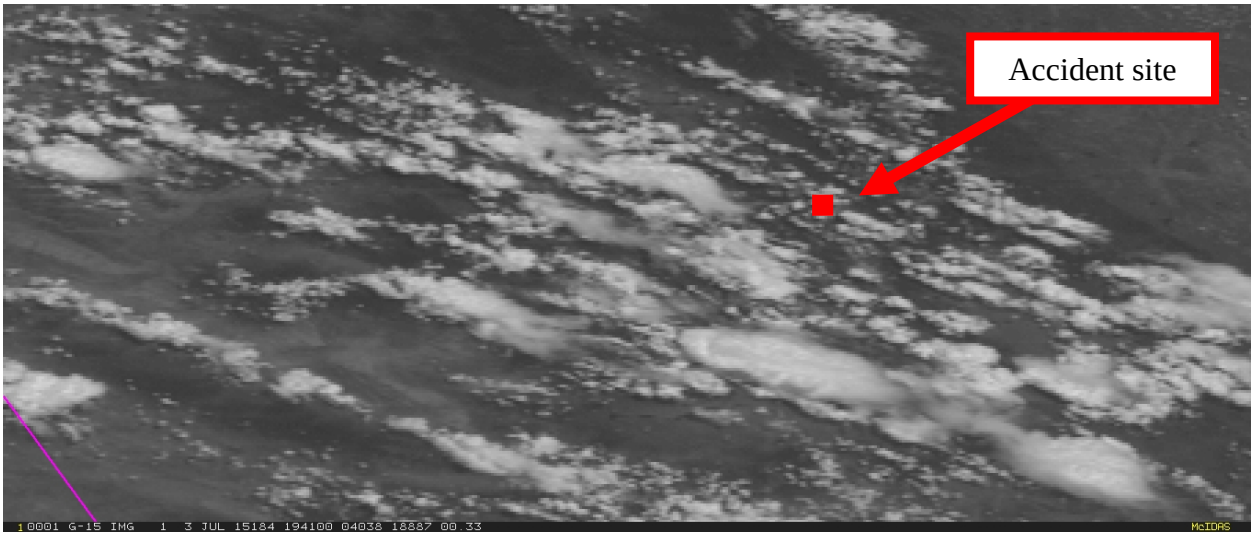


Figure 15 – GOES-15 visible image at 1341 MDT

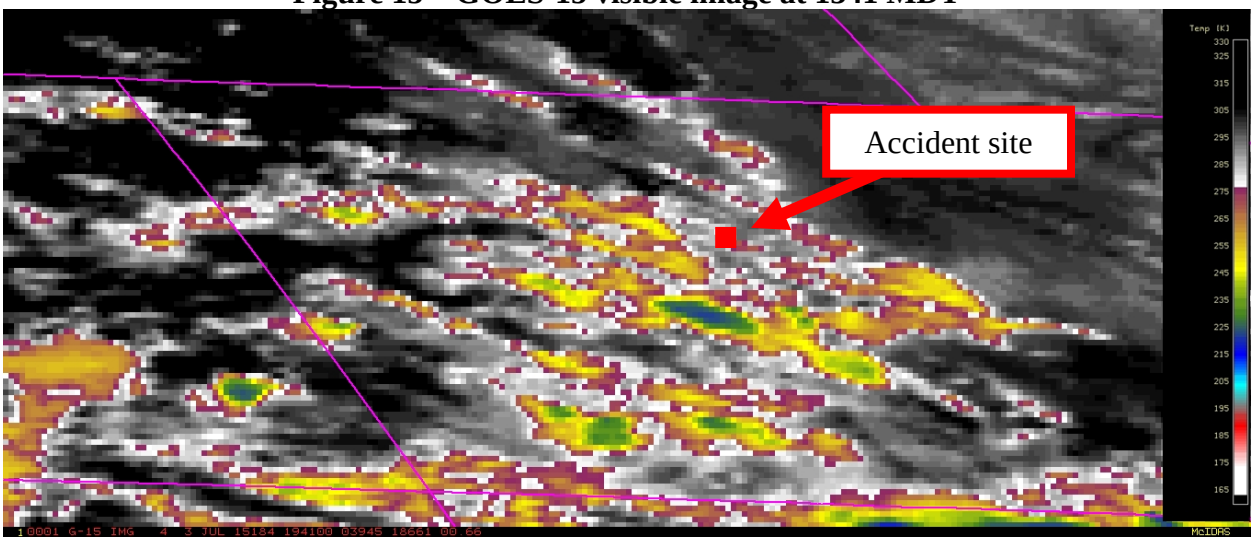


Figure 16 – GOES-15 infrared image at 1341 MDT

6.0 Radar Imagery Information

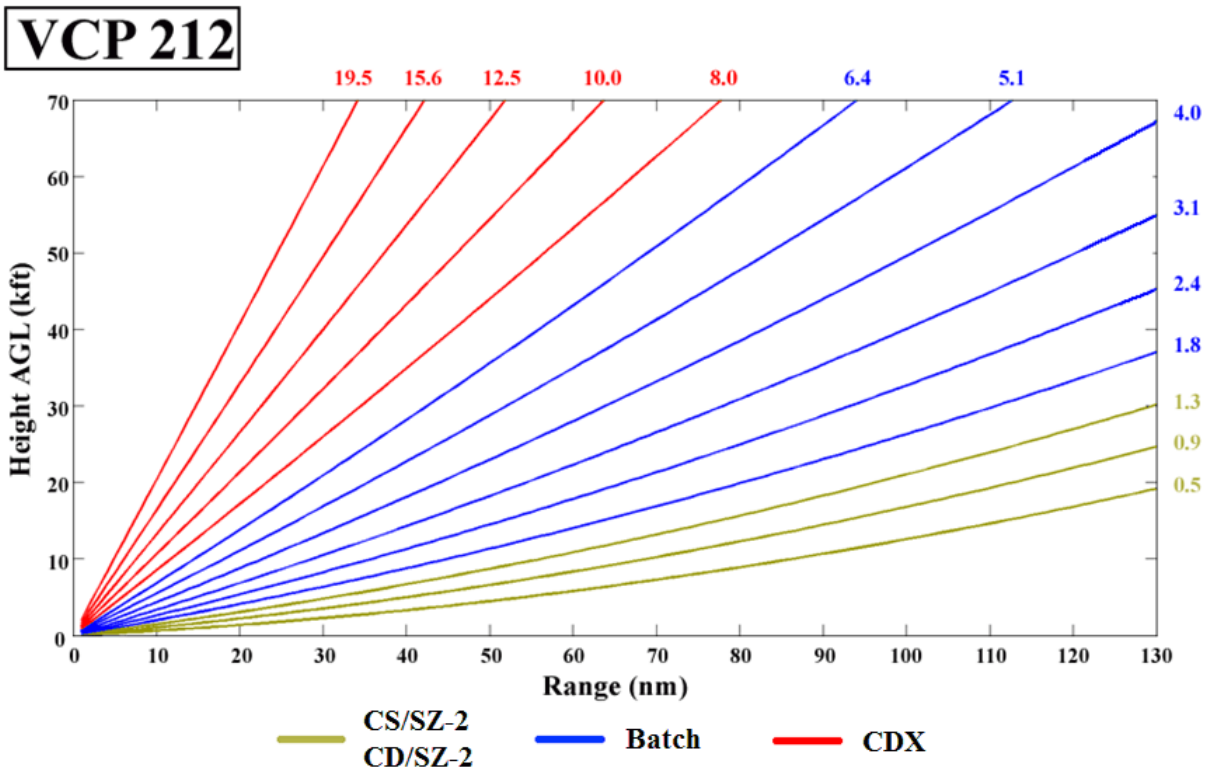
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[11] was KFTG, located in Denver, Colorado, 72 miles east-northeast of the accident site with an elevation of 5,497 feet. Level II and III archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

[11] 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 three common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 212 (VCP-212). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident, the KFTG WSR-88D radar was operating in the precipitation mode (Mode A, VCP-212). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.



VCP-212 Precipitation Mode Scan Strategy

6.2 Beam Height Calculation

Assuming standard refraction[12] of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width[13] information[14] 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
0.9°	16,120 feet	12,570 feet	19,670 feet	7,100 feet
1.3°	19,160 feet	15,610 feet	22,710 feet	7,100 feet

Based on the radar height calculations, the 0.9° elevation scan depicted the conditions between 12,570 feet and 19,670 feet msl over the accident site and these are the closest altitudes to the accident site. In addition, the 1.3° elevation scan depicted the conditions between 15,610 feet and 22,710 feet msl above the accident site at the accident time.

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.

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

[13] Beam width – A measure of the angular width of a radar beam.

[14] Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.

[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.

NWS VIP/DBZ CONVERSION TABLE

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

Federal Aviation Administration (FAA) Advisory Circular AC 00-24B, "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 and Lightning Data

Figures 17, 18, and 19 present the KFTG WSR-88D base reflectivity images for the 0.9° elevation scans initiated at 1333, 1337, and 1341 MDT with a resolution of 0.5° X 250 m. 5 to 15 dBZ base reflectivity values are located on the western side of Silverthorne and those 5 to 15 dBZ values decrease in areal coverage as they move southeastward toward the accident site (movement marked by the black dashed line, figures 17, 18, and 19). By 1341 MDT there are only 1 or 2 dots of 5 to 15 dBZ base reflectivity values right above the accident site at the accident time with those reflectivity values between roughly 12,500 and 19,500 feet msl. Figures 20, 21, and 22 present the KFTG WSR-88D base reflectivity images for the 1.3° elevation scans initiated at 1337, 1341, and 1345 MDT with a resolution of 0.5° X 250 m. Between 1337 and 1345 MDT there is an increase in areal coverage of 10 to 30 dBZ values south-southwest of the accident site right near KCCU. These reflectivity values near KCCU continue to move southeastward with time while growing in areal coverage (attachments 2 and 3). Attachments 2 and 3 provide weather radar information loops between 1320 and 1400 MDT for both the 0.9° and 1.3° elevation scans with the accident site marked by a white dot. There were no lightning strikes near the accident site at the accident time.

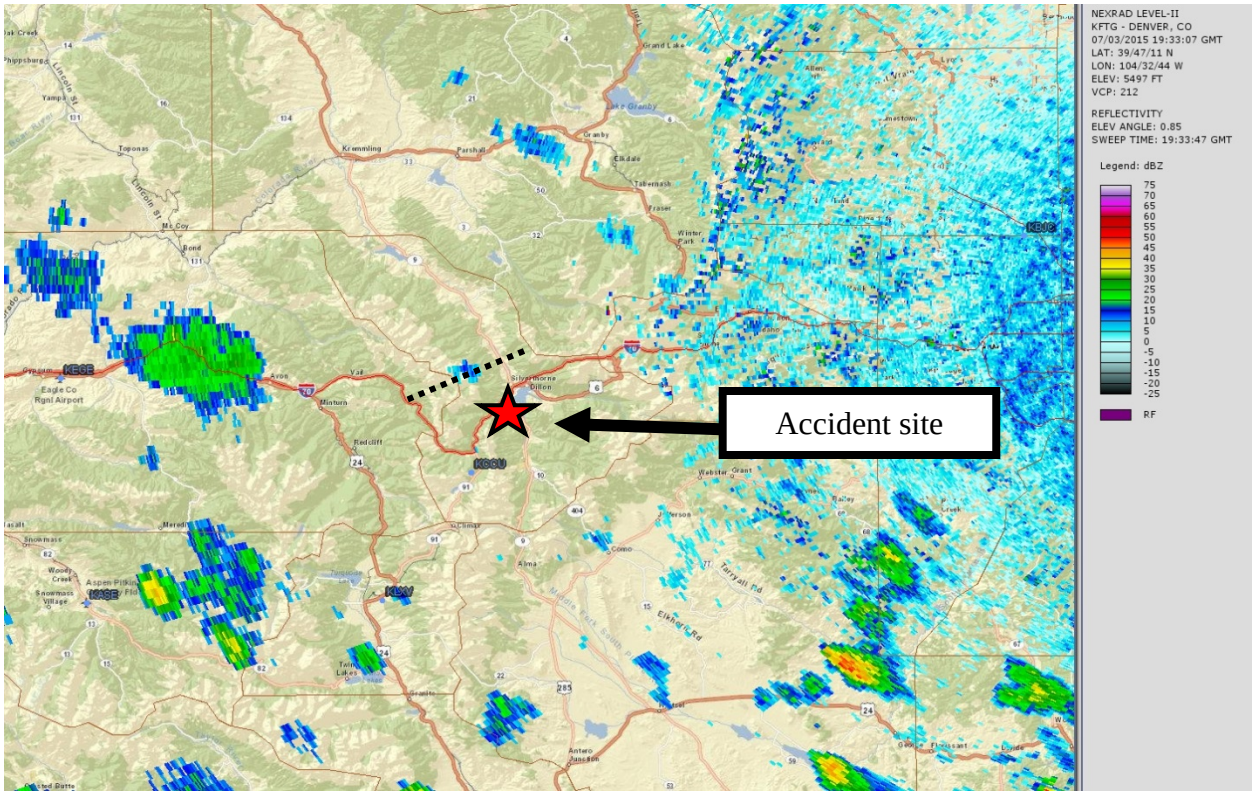


Figure 17 – KFTG WSR-88D reflectivity for the 0.9° elevation scan initiated at 1333 MDT

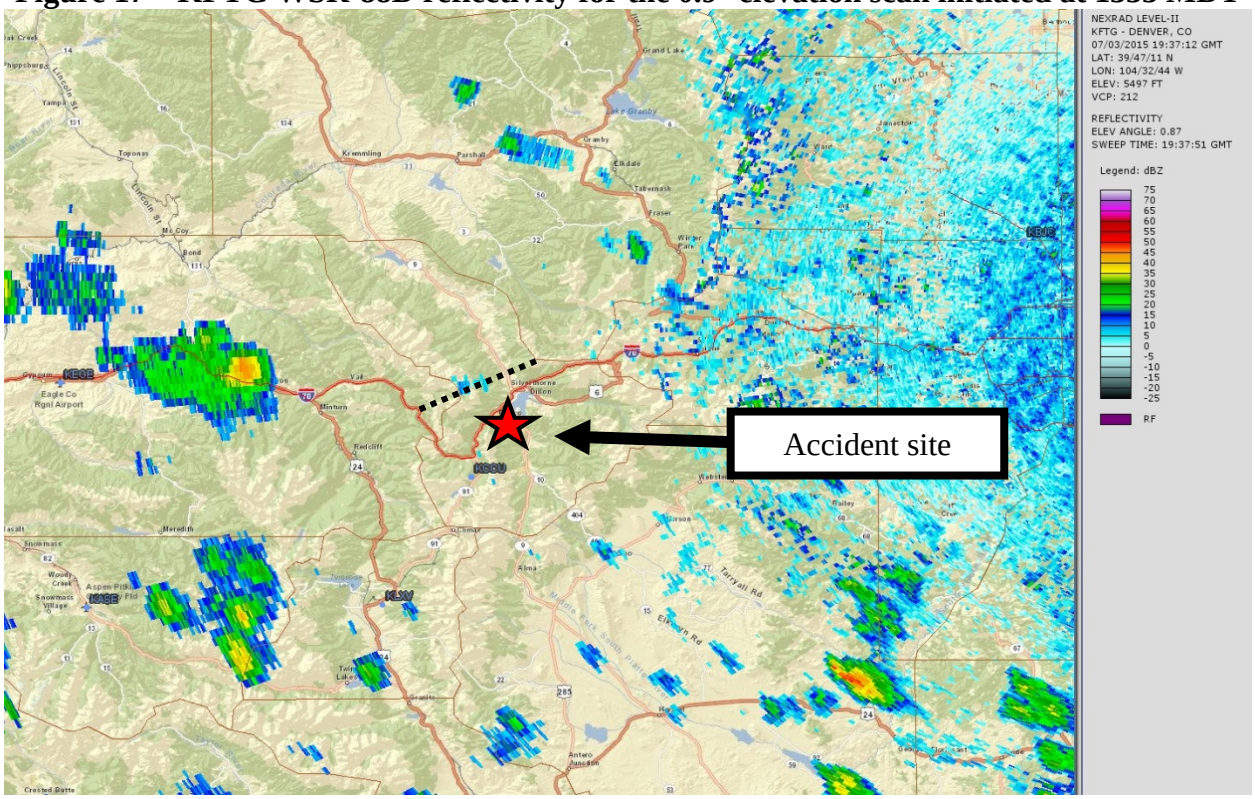


Figure 18 – KFTG WSR-88D reflectivity for the 0.9° elevation scan initiated at 1337 MDT

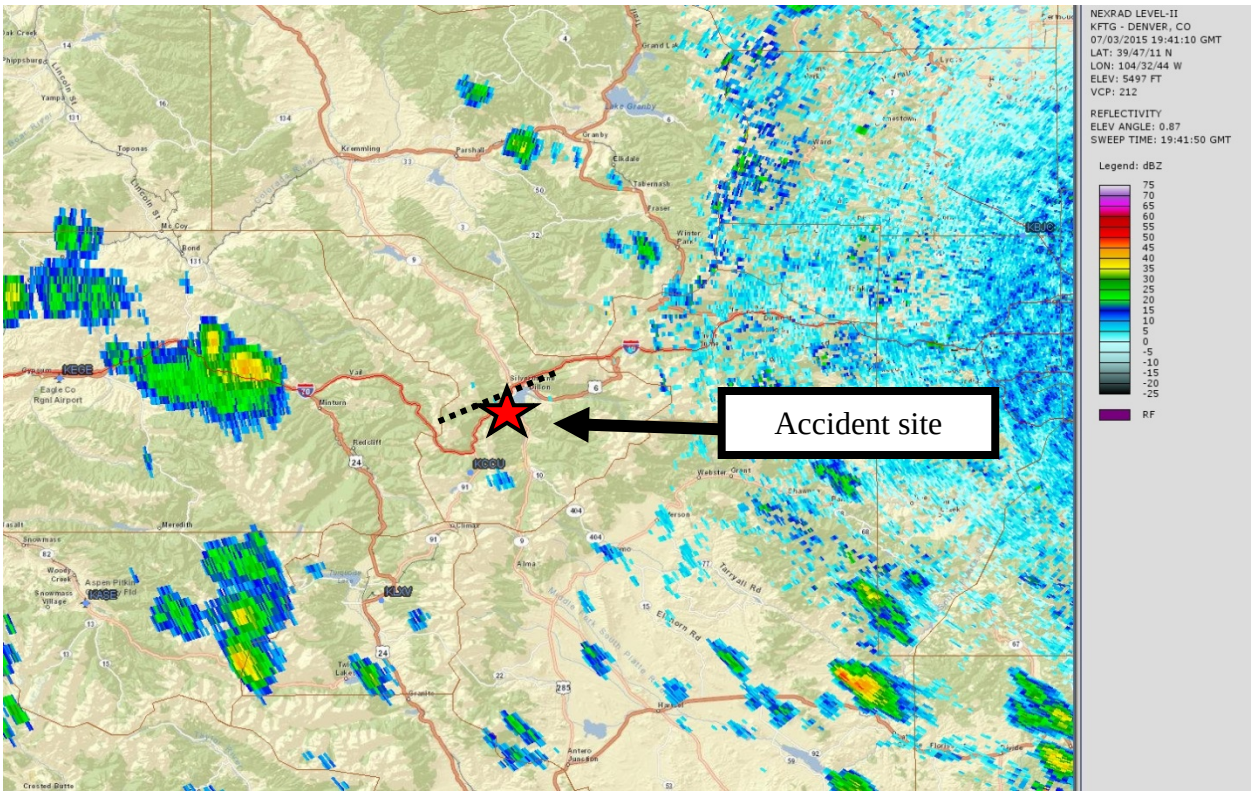


Figure 19 – KFTG WSR-88D reflectivity for the 0.9° elevation scan initiated at 1341 MDT

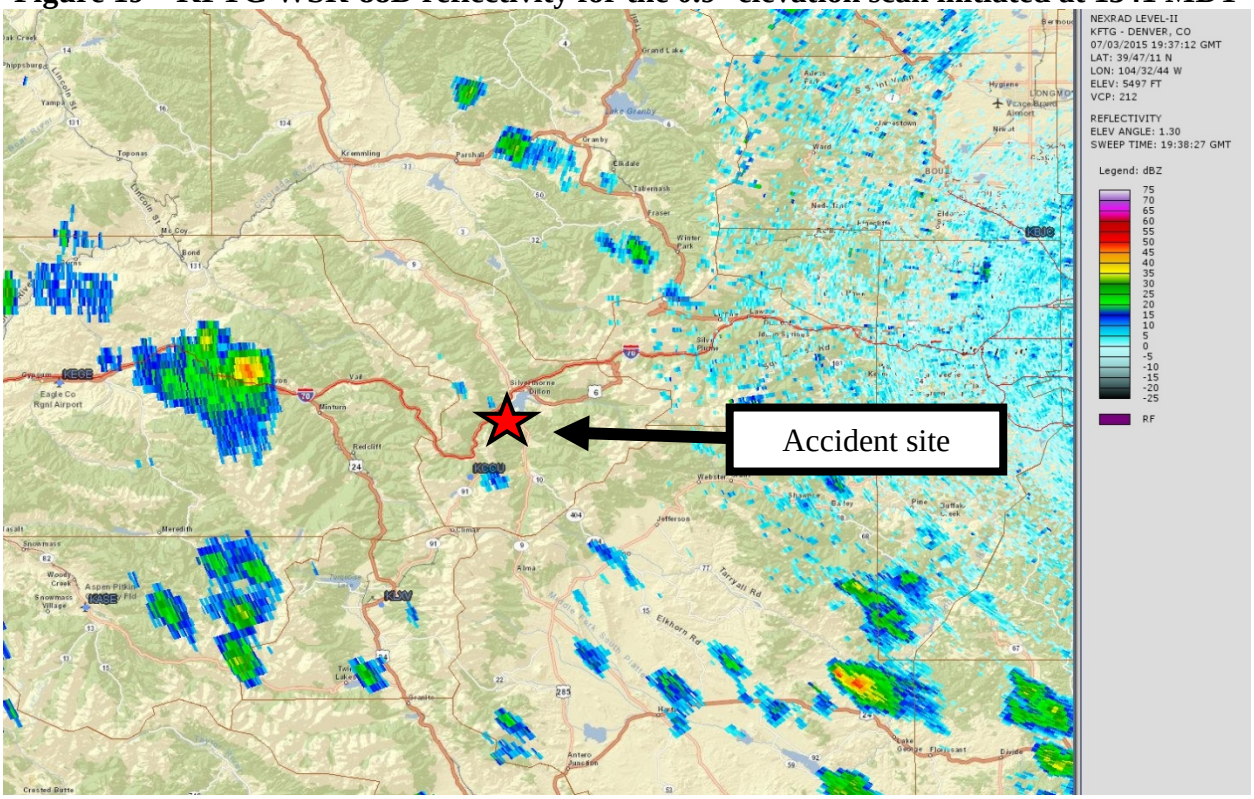


Figure 20 – KFTG WSR-88D reflectivity for the 1.3° elevation scan initiated at 1337 MDT

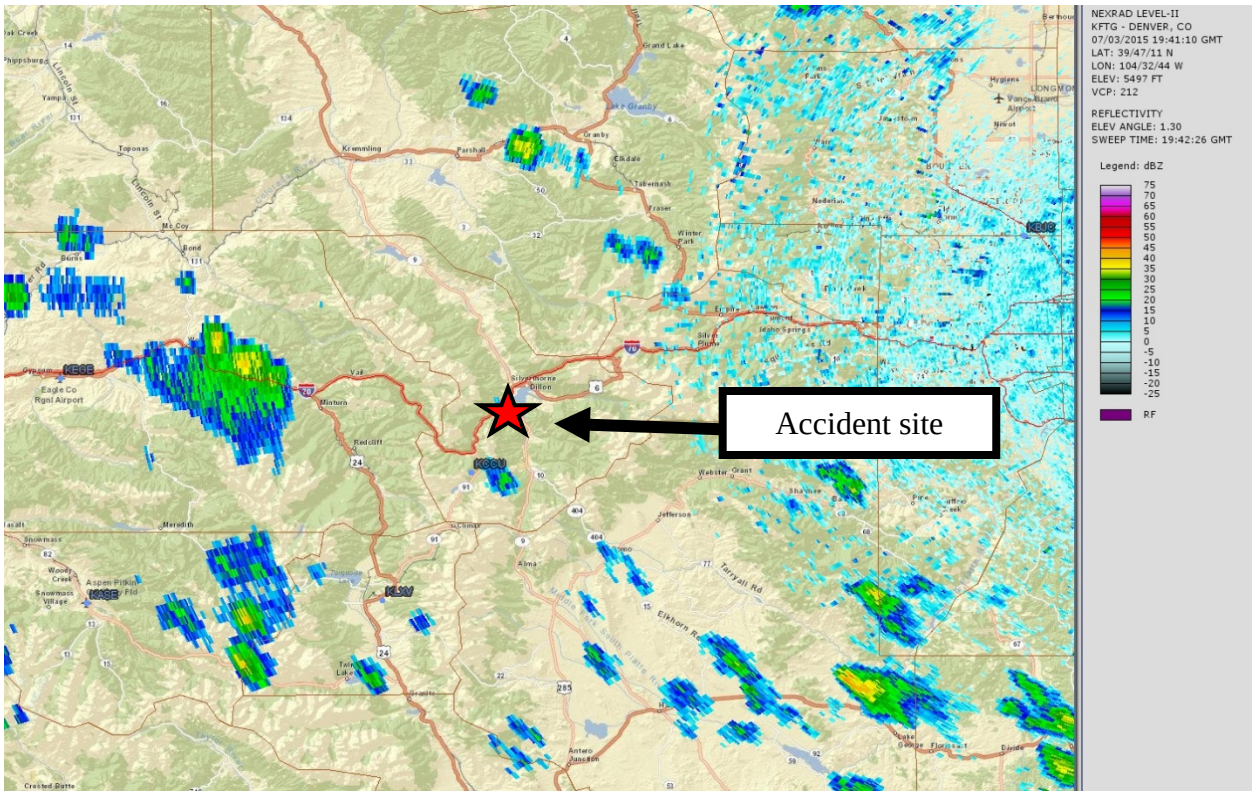


Figure 21 – KFTG WSR-88D reflectivity for the 1.3° elevation scan initiated at 1341 MDT

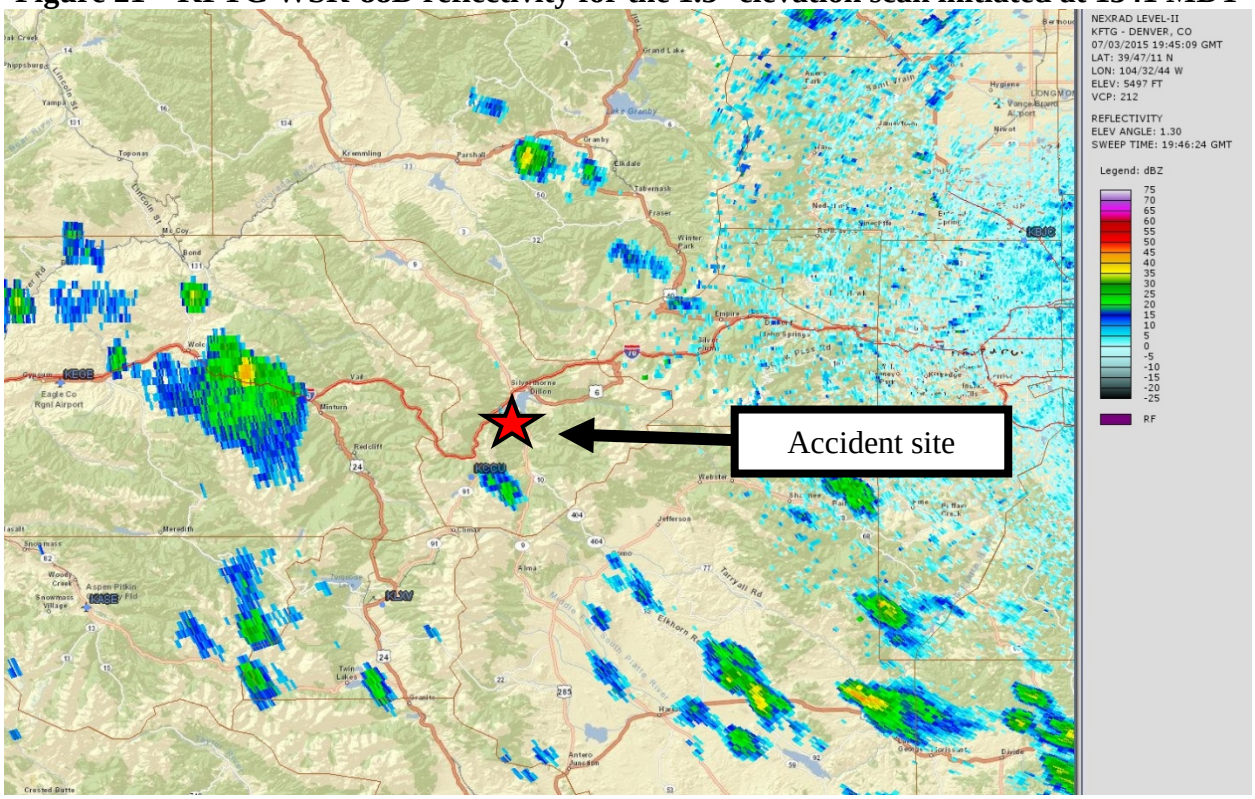


Figure 22 – KFTG WSR-88D reflectivity for the 1.3° elevation scan initiated at 1345 MDT

7.0 Pilot Reports

All pilot reports (PIREPs) near the accident site, from around three hours prior to the accident time to around two hours after the accident time, were reviewed and are displayed below:

FTG UA /OV DEN090008 /TM 1723 /FL065 /TP C172 /TB OCNL LGT CHOP=

ASE UA /OV DBL095010/TM 1848/FL190/TP GLF4/TA M09/TB MOD/IC LGT RIME/RM ZDV=

ASE UA /OV ASE315015 /TM 1934 /FL130 /TP H25B /TB MOD=

DEN UA /OV RLG030017/TM 2125/FL230/TP E55P/TB MOD/RM ZDV=

Routine pilot report (UA); 8 miles from Denver, Colorado, on the 090° radial; Time – 1123 MDT (1723Z); Altitude – 6,500 feet; Type aircraft – Cessna C172; Turbulence – Occasional light chop.

Routine pilot report (UA); 10 miles from Eagle, Colorado, on the 095° radial; Time – 1248 MDT (1848Z); Altitude – Flight level (FL)190[17]; Type aircraft – Gulfstream IV; Temperature – -9° C; Turbulence – Moderate; Icing – Light rime.

Routine pilot report (UA); 15 miles from Aspen, Colorado, on the 315° radial; Time – 1334 MDT (1934Z); Altitude – 13,000 feet; Type aircraft – Raytheon Hawker 800; Turbulence – Moderate.

Routine pilot report (UA); 17 miles from Kremmling, Colorado, on the 030° radial; Time – 1525 MDT (2125Z); Altitude – FL230; Type aircraft – Embraer Phenom 300; Turbulence – Moderate.

8.0 SIGMET and CWSU Advisories

No SIGMET was valid for the accident site at the accident time. SIGMETs and AIRMETs valid for the central United States for 1300 MDT are illustrated in figure 23. SIGMETs and AIRMETs valid for 1400 MDT are illustrated in figure 24. SIGMET 96C was issued for south and southwest of the accident site after the accident time at 1350 MDT, and valid from 1355 to 1555 MDT (figure 24).

No Center Weather Service Unit (CWSU) Advisory (CWA) was valid for the accident site at the accident time.

No Meteorological Impact Statement (MIS) was valid for the accident site at the accident time.

[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.

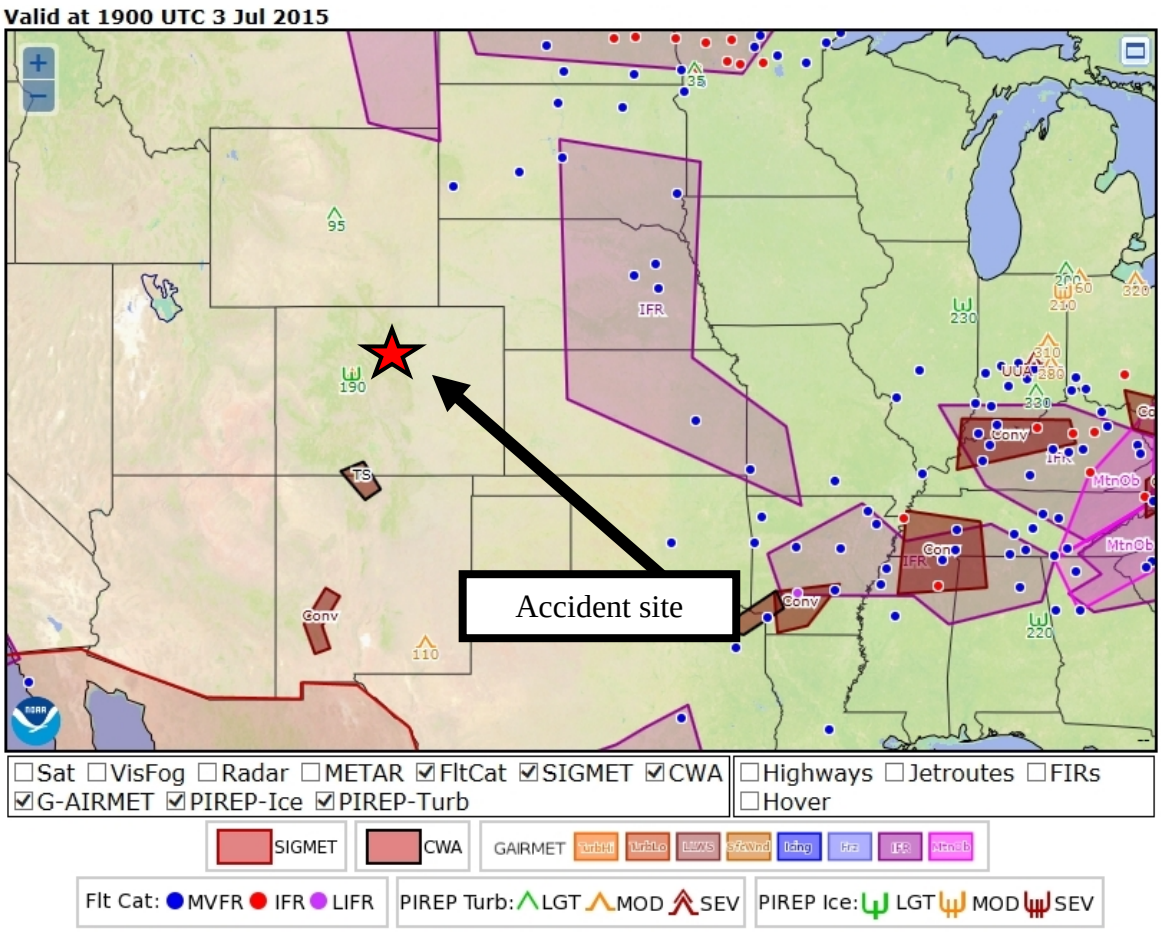


Figure 23 – SIGMETs and AIRMETs valid for the central United States at 1300 MDT

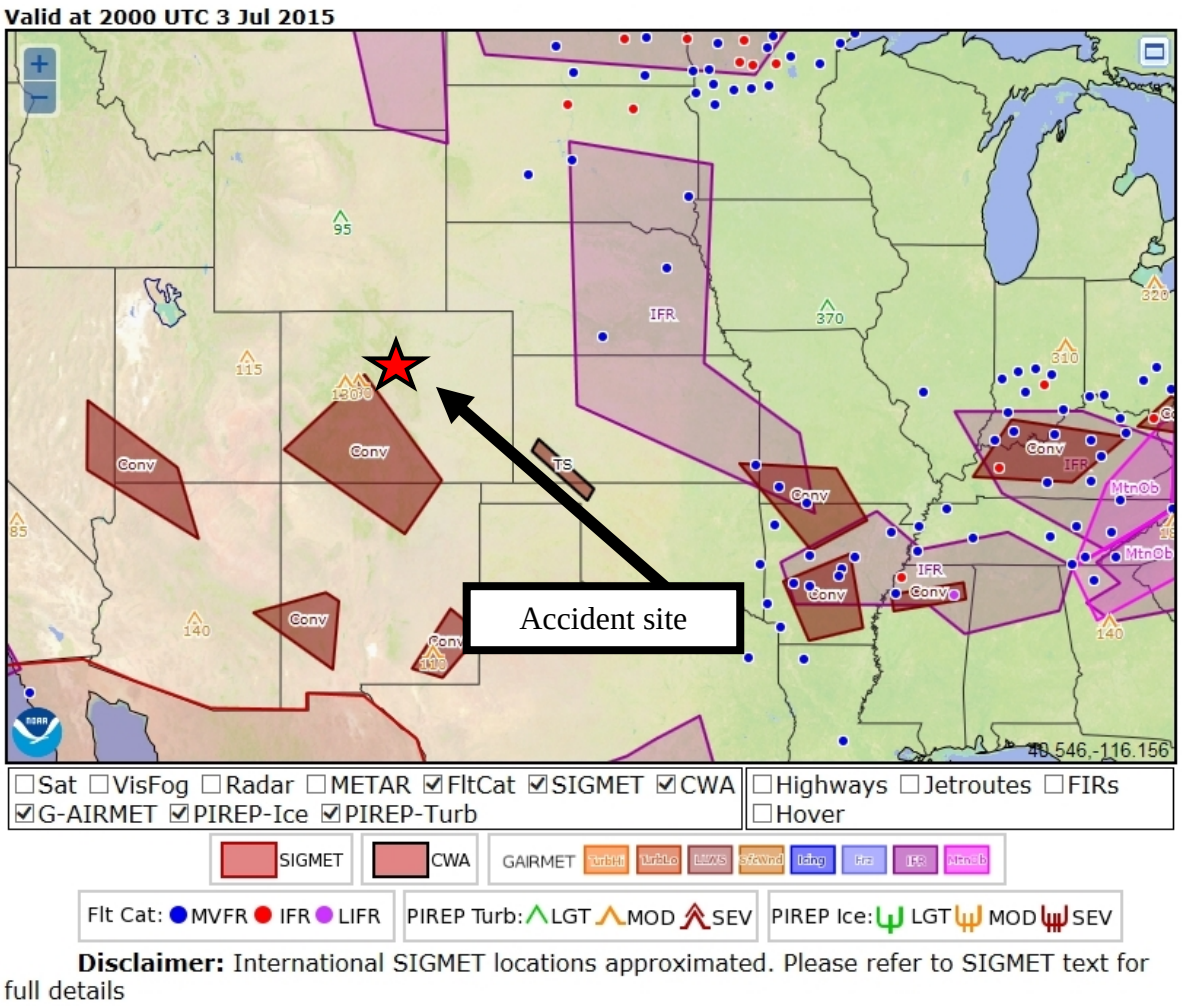


Figure 24 – SIGMETs and AIRMETs valid for the central United States at 1400 MDT

9.0 CCFP

The Collaborative Convective Forecast Product (CCFP) guidance is an automated forecasting tool available via the Aviation Weather Center website that forecast areas of convective (thunderstorm) activity for the United States. The CCFP issued at 0900 MDT valid for 1300 MDT (figure 25) and 1500 MDT (figure 26) forecasted a low confidence of sparse coverage of thunderstorm activity for the accident site. The CCFP forecast issued at 1100 MDT valid for 1300 MDT (figure 27) did not forecast thunderstorms for the accident site, while the CCFP issued at 1100 MDT valid for 1500 MDT (figure 28) forecasted a low confidence of sparse coverage of thunderstorm activity.

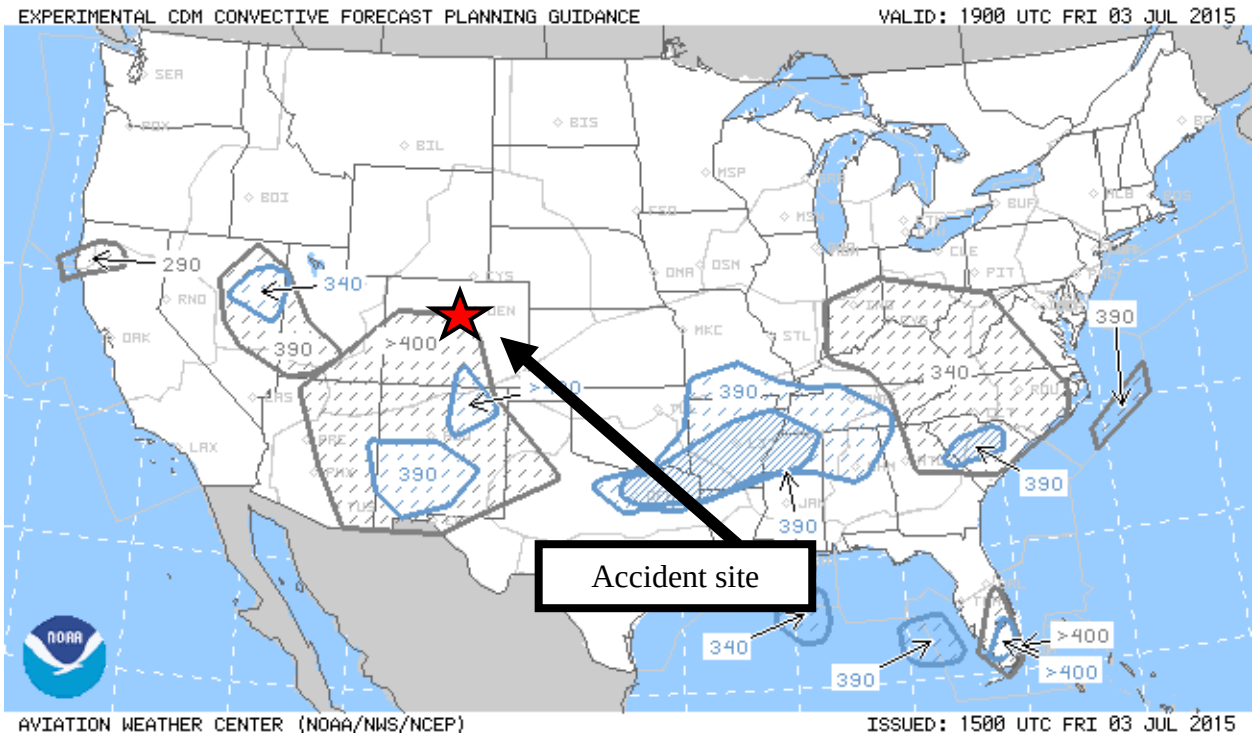


Figure 25 – CCFP issued at 0900 MDT valid at 1300 MDT

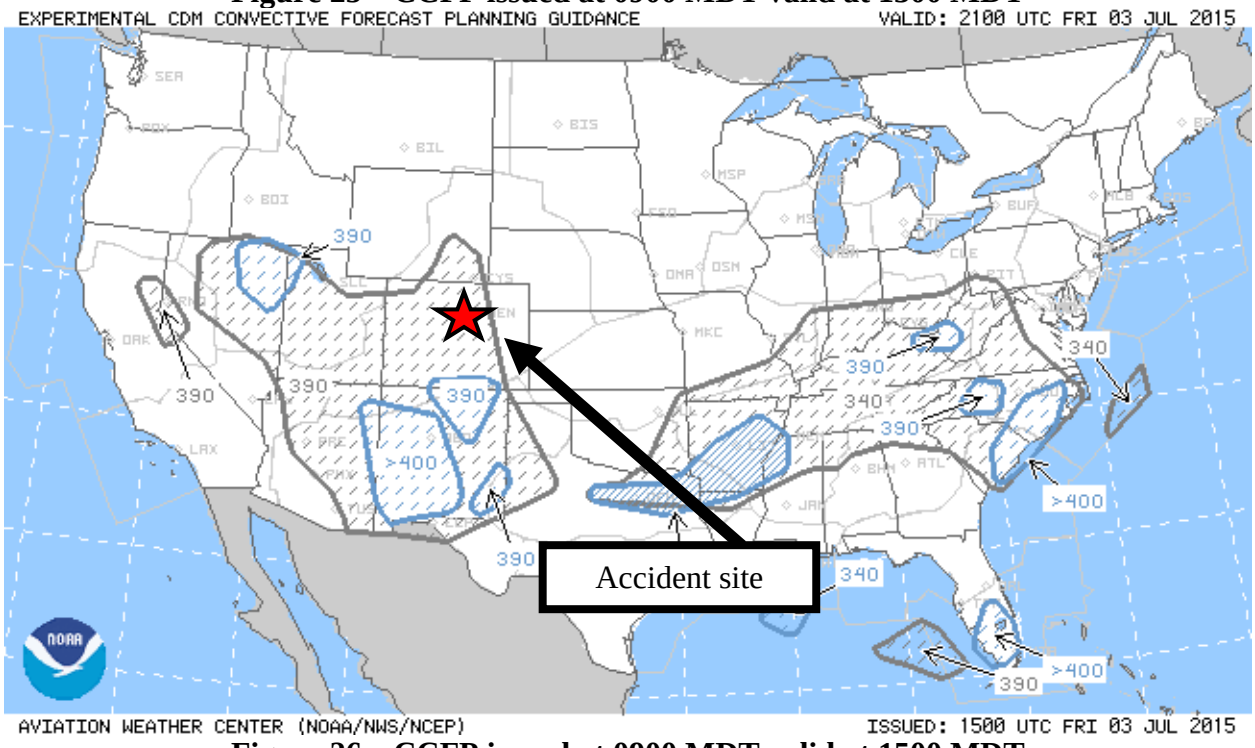


Figure 26 – CCFP issued at 0900 MDT valid at 1500 MDT

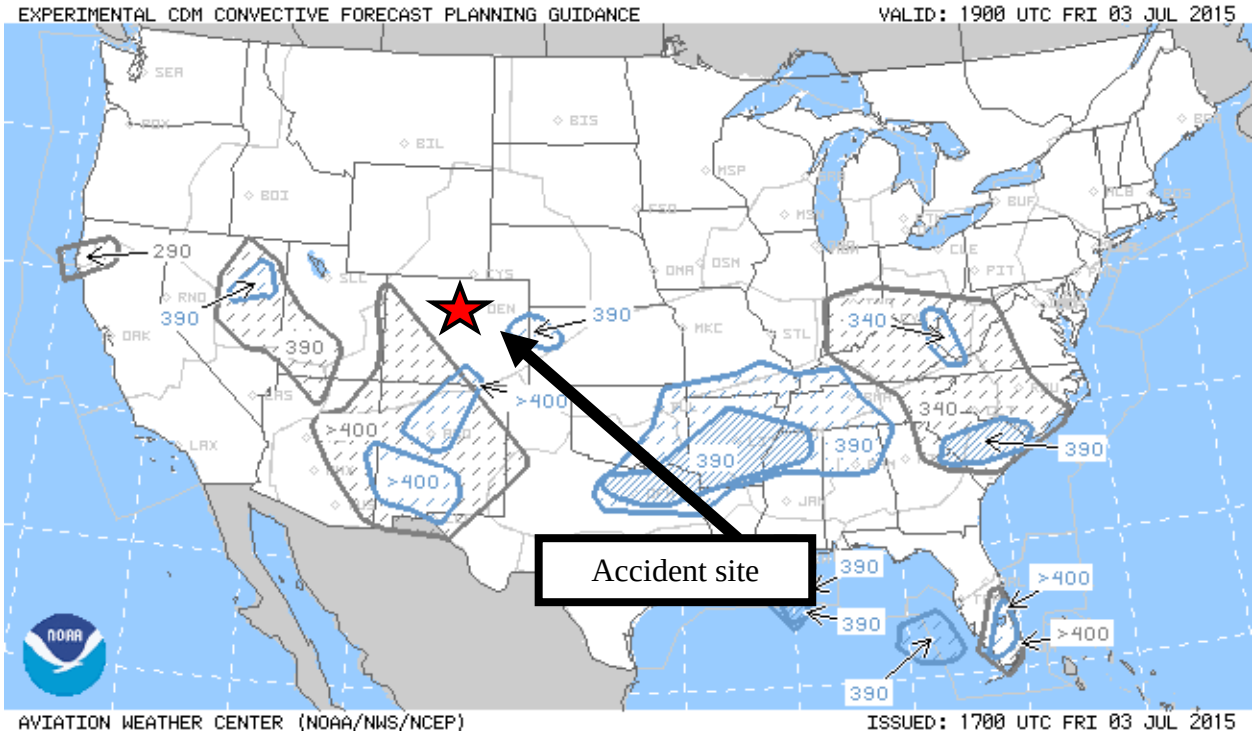


Figure 27 – CCFP issued at 1100 MDT valid at 1300 MDT

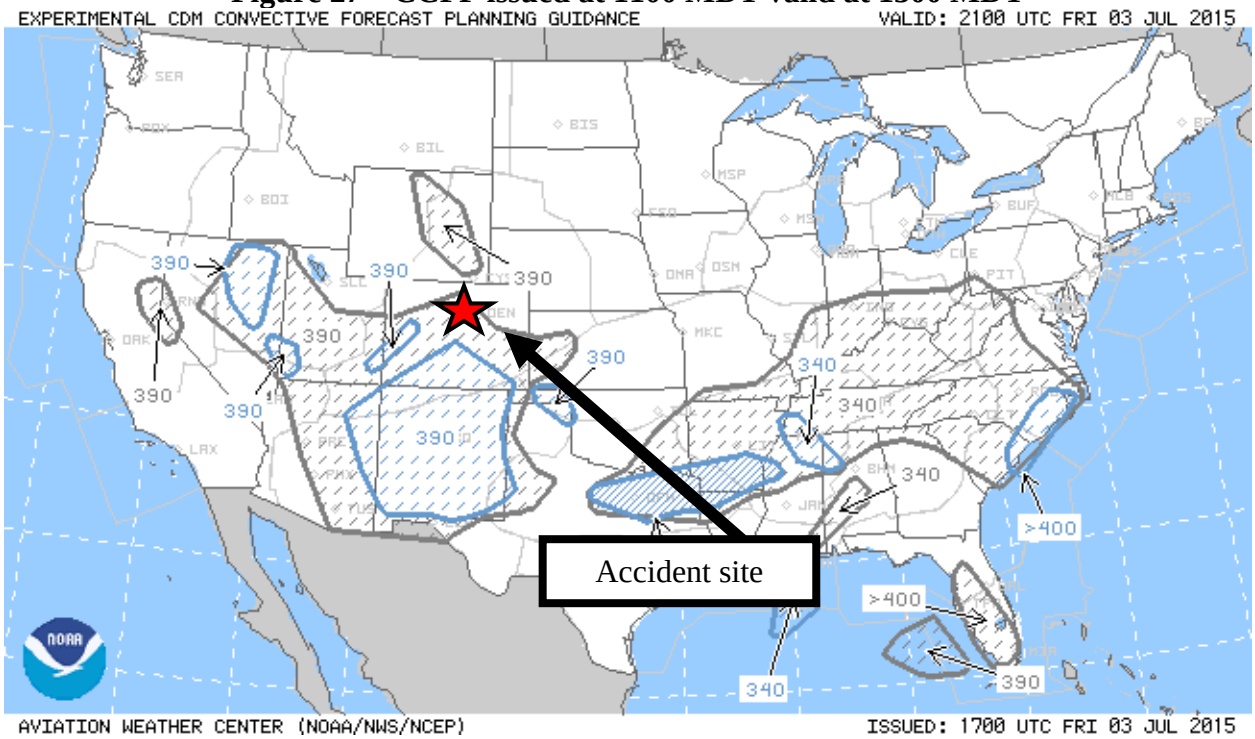


Figure 28 – CCFP issued at 1100 MDT valid at 1500 MDT

10.0 AIRMETs

No AIRMETs were valid for the accident site at the accident time (figures 23 and 24).

11.0 Area Forecast

The Area Forecast issued at 0445 MDT, valid at the accident time, forecasted a broken ceiling at 17,000 feet msl with tops at FL200. By 1400 MDT a broken ceiling at 14,000 feet msl was forecast with tops at FL200 with scattered light rain showers and thunderstorms. Cumulonimbus cloud tops were forecast to reach to FL420:

FAUS45 KKCI 031045
FA5W
_SLCC FA 031045
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 040500
CLDS/WX VALID UNTIL 032300...OTLK VALID 032300-040500
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..HI PRES RDG FM NRN CA TO NWRN AZ. SHRTWV SWRN MT
WL WKN AND MOV SE TO NWRN WY BY END OF PD. LTL CHG THRU PD.
SFC..QSTNRY FNT SERN CO. TROF ERN WA TO SWRN ID....LTL CHG THRU
PD. 05Z TROF CNTRL MT. CDFNT NRN WA TO EXTRM NWRN MT.
.
ID
NRN...SKC OCNL SCT CI AFT 19Z. OTLK...VFR.
CNTRL MTNS...SKC OCNL SCT CI. OTLK...VFR.
SRN...SKC OCNL SCT CI. 18Z SCT150 SCT CI. OTLK...VFR.
.
MT
CONTDVD WWD-SWRN MTNS...SKC. OTLK...VFR.
ERN SLOPES...SKC. 20Z SCT CI. OTLK...VFR.
N CNTRL...SKC OCNL SCT CI. OTLK...VFR.
S CNTRL...SCT150. OTLK...VFR.
ERN...SCT CI. OCNL VIS 3-5SM FU. OTLK...VFR.
.
WY
MTNS W CONTDVD...SKC OCNL SCT CI. 20Z SCT160. ISOL TSRA. CB TOP
FL380. OTLK...VFR TIL 03Z TSRA.
MTNS E CONTDVD...SCT140. BECMG 2022 BKN160 TOP FL260. WDLY SCT
-SHRA/TSRA. CB TOP FL380. OTLK...VFR TIL SHRA TSRA.
PLAINS...
N HLF...SCT100. 22Z SCT-BKN100 TOP 160. WDLY SCT -SHRA/TSRA. CB
TOP FL380. OTLK...VFR TIL 03Z SHRA TSRA.
S HLF...SCT100. TIL 14Z ISOL TSRA. CB TOP FL380. 22Z BKN160 TOP
FL200. OTLK...VFR TIL 03Z SHRA TSRA.
.
NV
NWRN...BKN150 TOP FL260. 20Z SCT -SHRA/TSRA. CB TOP FL440.
OTLK...VFR TIL 03Z SHRA TSRA.
NERN...SCT150 SCT CI. 20Z BKN150 TOP FL200. SCT -SHRA/TSRA. CB
TOP FL430. OTLK...VFR TIL 03Z SHRA TSRA.
SRN...SCT CI. 20Z BKN CI. OTLK...VFR.
.
UT

NRN HLF...SCT CI. OTLK...VFR.
SRN HLF...BKN150 TOP FL200. 20Z SCT -SHRA/TSRA. CB TOP FL400.
OTLK...VFR TIL 04Z SHRA TSRA.
.
CO
MTNS WWD...
N HLF...BKN170 TOP FL200. 20Z BKN140 TOP FL200. SCT -SHRA/TSRA.
CB TOP FL420. OTLK...VFR TIL 04Z SHRA TSRA.
S HLF...BKN CI. 20Z BKN150 TOP FL180. SCT -SHRA/TSRA. CB TOP
FL420. OTLK...VFR TIL 04Z SHRA TSRA.
PLAINS...BKN100 TOP 160. ISOL -TSRA. CB TOP FL440. 15Z SCT100 SCT
CI. OTLK...VFR 03Z SHRA TSRA.
.
AZ
NRN HLF...BKN150 TOP FL200. 20Z BKN-OVC150 TOP FL260. SCT
-SHRA/TSRA. CB TOP FL450. OTLK...VFR SHRA TSRA.
SWRN...BKN CI. OTLK...VFR.
SERN...BKN150 TOP FL260. TIL 15Z SCT -SHRA/TSRA. CB TOP FL450.
17Z BKN CI. 20Z BKN120 TOP FL180. SCT -SHRA/TSRA. OTLK...VFR SHRA
TSRA.
.
NM
MTNS WWD...BKN-OVC140 TOP FL260. WDLY SCT -SHRA/TSRA. CB TOP
FL450. 16Z ISOL -SHRA/TSRA. 22Z BKN-OVC160. SCT -SHRA/TSRA.
OTLK...VFR SHRA TSRA.
PLAINS...
N HLF...BKN-OVC160 TOP FL200. TIL 15Z SHRA/TSRA. CB TOP FL450.
21Z BKN100 TOP FL180. SCT -SHRA/TSRA. OTLK...VFR SHRA TSRA.
S HLF...BKN CI. 15Z BKN120 TOP FL260. SCT -SHRA/WDLY SCT TSRA. CB
TOP FL450. OTLK...VFR SHRA TSRA.
....

12.0 Terminal Aerodrome Forecast

Eagle, Colorado, (KEGE) was the closest site with a NWS TAF located 39 miles west of the accident site. The TAF valid at the time of the accident was issued at 1235 MDT and was valid for a 23-hour period beginning at 1300 MDT. The TAF forecast for KEGE was as follows:

TAF AMD KEGE 031835Z 0319/0418 **25007KT P6SM VCTS SCT100CB BKN200**
TEMPO 0319/0323 VRB20G30KT -TSRA SCT070 BKN090CB
FM040200 09005KT P6SM VCSH SCT080 BKN120
FM040600 00000KT P6SM SCT200=

The forecast expected a wind from 250° at 7 knots, greater than 6 miles visibility, vicinity[18] thunderstorms, scattered cumulonimbus clouds at 10,000 feet agl, and an overcast ceiling at 20,000 feet agl. Temporary conditions were forecast between 1300 and 1700 MDT of a variable wind at 20 knots with gusts to 30 knots, light rain and thunderstorms scattered clouds at 7,000 feet agl, and a broken ceiling at 9,000 feet agl.

[18] In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

13.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Denver/Boulder, Colorado, was the closest National Weather Service office to the accident site, but the National Weather Service Office in Grand Junction, Colorado, was the NWS Office responsible for the KEGE TAF. The Grand Junction NWS Office issued an Area Forecast Discussion (AFD) at 1144 MDT. The aviation section of the AFD mentioned isolated light rain showers and thunderstorms occurring along the higher terrain through the evening hours with only small chances of the individual thunderstorms or rain showers moving directly over one of the TAF sites. The thunderstorms were expected to end by the late evening hours:

FXUS65 KGJT 031744
AFDGJT
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE GRAND JUNCTION CO
1144 AM MDT FRI JUL 3 2015
.UPDATE...
ISSUED AT 927 AM MDT FRI JUL 3 2015
FORECAST TODAY GENERALLY ON TRACK. MADE A MORNING UPDATE TO
REFLECT CURRENT TRENDS OF SHOWERS AND THUNDERSTORMS MOVING SLOWLY
SOUTH OVER THE SAN JUAN MOUNTAINS...ASSOCIATED WITH WEAK SHORTWAVE
AND NARROW BAND OF 700-500 MB THETA-E ADVECTION IN THE NORTHWEST
FLOW ALOFT. ELSEWHERE...PLENTY OF SUNSHINE WILL GET SURFACE
HEATING AND ATTENDANT INSTABILITY GOING...LEADING TO ISOLATED TO
SCATTERED SHOWERS/STORMS. COVERAGE EXPECTED TO BE BETTER OVER THE
SAN JUAN MTN AREAS AND ADJACENT AREAS TO THE SOUTH.
&&
.SHORT TERM...(TODAY THROUGH SATURDAY)
ISSUED AT 308 AM MDT FRI JUL 3 2015
HIGH PRESSURE CENTERED OVER SOUTHERN UTAH WILL KEEP EASTERN UTAH
AND WESTERN COLORADO UNDER WEST NORTHWEST FLOW. MOISTURE POOLED
UNDERNEATH THE RIDGE COMBINED WITH HOT DAYTIME TEMPERATURES WILL
RESULT IN A CONTINUATION OF DAILY CONVECTION...FOCUSED OVER THE
HIGHER ELEVATIONS IN THE AFTERNOON...WITH STORMS THEN DRIFTING
OVER THE VALLEYS BY EARLY EVENING. BEST AND DEEPEST MOISTURE WILL
REMAIN OVER THE FOUR CORNERS AND ACROSS THE SOUTHWEST SAN
JUANS...WITH PRECIPITABLE WATER VALUES ARE HOLDING AROUND 1.2
INCHES PER MODEL SOUNDINGS. WOULD EXPECT HEAVY RAINFALL...HAIL AND
GUSTY WINDS TO NEAR 40 MPH WITH THIS ACTIVITY THIS AFTERNOON AND
EVENING AND AGAIN ON SATURDAY. ACROSS THE NORTH...STORMS WILL BE
MORE ISOLATED IN COVERAGE...BUT STILL CAPABLE OF PRODUCING LOCALLY
HEAVY RAIN. MOS TEMPS LOOK GOOD AND NO REASON TO STRAY FAR.
.LONG TERM...(SATURDAY NIGHT THROUGH THURSDAY)
ISSUED AT 308 AM MDT FRI JUL 3 2015
CONVECTION WILL CONTINUE SATURDAY EVENING WITH SOME SHOWERS AND A
FEW ISOLATED STORMS PERSISTING AFTER MIDNIGHT. AS THIS
OCCURS...MOISTURE WILL KEEP STREAMING UP FROM THE SOUTH CAUSING A
SIGNIFICANT INCREASE IN AVAILABLE MOISTURE. FORECAST PWAT VALUES
VARY FROM 1 INCH TO 1.3 INCHES FOR MUCH OF THE AREA BY SUNDAY
MORNING. THIS IS ABOUT 200% OF NORMAL FOR THIS TIME OF YEAR. ADD
THIS MOISTURE TO THE TRAILING EDGE OF AN UPPER LEVEL TROUGH AND
YOU HAVE INGREDIENTS IN PLACE FOR SOME DECENT CONVECTION. WITH
THIS MUCH MOISTURE...THE BIGGEST CONCERN BECOMES STORMS PRODUCING
HEAVY RAINS AND POSSIBLE FLASH FLOODING BENEATH THEM. AVAILABLE

MOISTURE DROPS TO ABOUT AN INCH BY MONDAY THOUGH THIS MIGHT BE A
BIT TOO QUICK. EVEN SO...STILL A LOT OF MOISTURE AVAILABLE FOR
STORMS THAT FORM.
A LOW WILL APPROACH THE CALIFORNIA COAST TUESDAY WHILE THE RIDGE
OF HIGH PRESSURE REMAINS OVER OUR AREA. WHILE THIS IS NOT A
CLASSIC MONSOON PER SE...THE STREAM OF MOISTURE FROM THE
SUBTROPICS AND LOCATION OF THIS PLUME CERTAINLY LOOKS MONSOON-
LIKE. REGARDLESS...AFTERNOON AND EVENING SHOWERS AND STORMS WILL BE
THE RULE TUESDAY THROUGH THURSDAY.
PLENTY OF CLOUDS ACROSS THE REGION WILL BRING TEMPS TO MORE NORMAL
VALUES SUNDAY AND BEYOND.
&&
.AVIATION...(FOR THE 18Z TAFS THROUGH 18Z SATURDAY AFTERNOON)
ISSUED AT 1144 AM MDT FRI JUL 3 2015
SW COLORADO...SCATTERED -SHRA/-TSRA IS EXPECTED WITH ISOLATED
+SHRA/+TSRA CIGS BELOW ILS BREAKPOINTS FOR KTEX AND KDRO.
THUNDERSTORMS ACROSS THIS AREA WILL BE SLOW TO DISSIPATE AFTER
SUNSET WITH ISOLATED -TSRA/-SHRA PERSISTING THROUGH 12Z SATURDAY
MORNING.
NW COLORADO AND ERN UTAH...MOSTLY DRY BUT ISOLATED -TSRA/-SHRA
WILL OCCUR ALONG THE HIGHER TERRAIN. THE CHANCE THAT ANY OF THESE
STORMS MOVE OVER A TAF SITE (SUCH AS KVEL AND KCNY) IS LOW.
ANY THUNDERSTORMS ACROSS THIS REGION SHOULD END BETWEEN 03Z-06Z THIS
EVENING.
&&
.GJT WATCHES/WARNINGS/ADVISORIES...
CO...NONE.
UT...NONE.
&&
$$

14.0 National Weather Service Hazardous Weather Outlook

The National Weather Service Office in Denver/Boulder, Colorado, was the closest National Weather Service office to the accident site and issued the Hazardous Weather Outlook below at 1101 MDT. It mentioned scattered strong thunderstorms were expected to develop especially across the mountainous terrain with possible large hail, damaging wind, and heavy rainfall:

FLUS45 KBOU 031701
HWOBOU
HAZARDOUS WEATHER OUTLOOK
NATIONAL WEATHER SERVICE DENVER/BOULDER CO
1101 AM MDT FRI JUL 3 2015
COZ030>051-041715-
JACKSON COUNTY BELOW 9000 FEET-
WEST JACKSON AND WEST GRAND COUNTIES ABOVE 9000 FEET-
GRAND AND SUMMIT COUNTIES BELOW 9000 FEET-
SOUTH AND EAST JACKSON/LARIMER/NORTH AND NORTHEAST GRAND/
NORTHWEST BOULDER COUNTIES ABOVE 9000 FEET-
SOUTH AND SOUTHEAST GRAND/WEST CENTRAL AND SOUTHWEST BOULDER/
GILPIN/CLEAR CREEK/SUMMIT/NORTH AND WEST PARK COUNTIES ABOVE
9000 FEET-LARIMER AND BOULDER COUNTIES BETWEEN 6000 AND 9000 FEET-
JEFFERSON AND WEST DOUGLAS COUNTIES ABOVE 6000 FEET/GILPIN/CLEAR
CREEK/NORTHEAST PARK COUNTIES BELOW 9000 FEET-
CENTRAL AND SOUTHEAST PARK COUNTY-

LARIMER COUNTY BELOW 6000 FEET/NORTHWEST WELD COUNTY-
BOULDER AND JEFFERSON COUNTIES BELOW 6000 FEET/WEST BROOMFIELD
COUNTY-
NORTH DOUGLAS COUNTY BELOW 6000 FEET/DENVER/WEST ADAMS AND
ARAPAHOE COUNTIES/EAST BROOMFIELD COUNTY-
ELBERT/CENTRAL AND EAST DOUGLAS COUNTIES ABOVE 6000 FEET-
NORTHEAST WELD COUNTY-CENTRAL AND SOUTH WELD COUNTY-MORGAN COUNTY-
CENTRAL AND EAST ADAMS AND ARAPAHOE COUNTIES-
NORTH AND NORTHEAST ELBERT COUNTY BELOW 6000 FEET/NORTH LINCOLN
COUNTY-
SOUTHEAST ELBERT COUNTY BELOW 6000 FEET/SOUTH LINCOLN COUNTY-
LOGAN COUNTY-WASHINGTON COUNTY-SEDGWICK COUNTY-PHILLIPS COUNTY-
1101 AM MDT FRI JUL 3 2015
THIS HAZARDOUS WEATHER OUTLOOK IS FOR NORTHEAST AND NORTH CENTRAL
COLORADO.
.DAY ONE...TODAY AND TONIGHT
SCATTERED AND STRONGER THUNDERSTORMS ARE EXPECTED TO DEVELOP THIS AFTERNOON AND EARLY EVENING AS THE AIRMASS DESTABILIZES. THE STORMS WILL BE MOST NUMEROUS OVER THE MOUNTAINS...HIGHER FOOTHILLS AND PALMER DIVIDE. SUFFICIENT WIND SHEAR IN THE ATMOSPHERE MAY ALLOW ONE OR TWO STORMS TO BECOME SEVERE WITH LARGE HAIL AND DAMAGING WINDS THE PRIMARY THREATS. LOCALLY HEAVY RAINFALL OF 1 INCH IN 30 MINUTES WILL ALSO BE POSSIBLE WITH THE STRONGER STORMS. MOST THUNDERSTORMS WILL COME TO AN END BY LATE EVENING...WITH THE EXCEPTION OF THE EASTERN PLAINS WHERE THUNDERSTORMS WITH BRIEF HEAVY RAIN AND SMALL HAIL MAY LINGER THROUGH THE NIGHT.
.DAYS TWO THROUGH SEVEN...SATURDAY THROUGH THURSDAY
IT WILL BE HOTTER AND DRIER SATURDAY WITH SCATTERED AFTERNOON
AND EVENING THUNDERSTORMS OVER THE MOUNTAINS...AND ISOLATED
THUNDERSTORMS ACROSS THE NORTHEAST PLAINS. HIGH TEMPERATURES
OVER THE HOLIDAY WEEKEND WILL CLIMB BACK TO AROUND 90 ACROSS THE
PLAINS AND I-25 CORRIDOR.
THE CHANCE OF SHOWERS AND THUNDERSTORMS WILL INCREASE LATE SUNDAY
THROUGH MONDAY AS A SYSTEM PUSHES ACROSS NORTHERN COLORADO...BRINGING
COOLER AND WETTER WEATHER FOR EARLY NEXT WEEK. DRIER AND WARMER
CONDITIONS WILL RETURN BY THE MIDDLE OF THE WEEK.
.SPOTTER INFORMATION STATEMENT...
SPOTTER ACTIVATION IS NOT ANTICIPATED TODAY. HOWEVER...ANY REPORTS
OF HEAVY RAIN...HAIL GREATER THAN ONE HALF INCH IN DIAMETER...OR
HIGH WINDS WOULD BE APPRECIATED.
$$

15.0 Pilot Weather Briefing

The accident pilot received a crew briefing where the accident pilot said the weather was "fine." None of the weather information reviewed by the pilot before the accident flight was available or archived. There is no knowledge of any additional weather briefing information the accident pilot received.

16.0 Weather Research and Forecasting Model Simulation

A Weather Research and Forecasting Model (WRF) simulation was run to simulate the weather conditions surrounding the accident site at the accident time. WRF ARW (Advanced Research WRF core) version 3.2.1.5 was run with 3 domains with horizontal grid spacing of 8 km, 1.6 km, and 320 m over the accident site. Other WRF simulation parameters included: 55 vertical levels, the Kain-Fritsch cumulus parameterization scheme used on the outer domain, a Lin et al. microphysics scheme, a Yonsei University boundary layer scheme, Noah land surface physics, and the Dudhia scheme used for the long and short wave radiation. The terrain (in feet) used in domain 3 is shown in figure 29 along with the location of the cross sections used figures 30 through 43 with the location of the accident site marked.

Figures 30, 31, and 32 depicted the potential temperature[19] (solid lines) and horizontal wind speed (color fill) at 1340, 1400, and 1420 MDT around the accident site. An increase in horizontal wind speed is visible near the accident site from 1340 to 1420 MDT with the wind speed increasing from between 8 and 10 knots to between 20 and 25 knots. These horizontal wind speeds do not include any higher gusts. A similar horizontal wind speed increasing is visible on the west to east cross section between 1340 and 1420 MDT (figures 33, 34, and 35). Attachments 4 and 5 give an overall context of the horizontal wind speed increase between 1300 and 1450 MDT at the accident site at the accident time with an increase between 15 and 25 knots at the surface between 1300 and 1450 MDT near the accident site.

Figures 36 through 38 depicted the potential temperature (solid lines) and vertical velocity (color fill) at 1340, 1400, and 1420 MDT along a north to south cross section with figures 39 through 41 depicting the same environmental fields on a west to east cross section through the accident site. The vertical velocity data indicated that directly above the accident site were updrafts with a velocity between 200 and 600 feet per minute (figures 36 and 41) at the accident time.

There was also a corresponding downdraft just west of the accident site on figures 40 and 41, associated with an increase in relative humidity (figures 42 and 43) at the surface, as well as the relative humidity increasing in height over the strong updraft and downdraft areas. Attachments 6 and 7 show the vertical velocity values between 1300 and 1450 MDT on the north to south and west to east cross sections, with attachment 8 showing the relative humidity values on the west to east cross section between 1300 and 1450 MDT. Attachments 4 through 8 showed environmental conditions very similar to the conditions described in sections 3.0 and 6.4 with rain showers in and around the accident site at the accident time with a corresponding wind speed increase.

[19] Potential temperature of a parcel of fluid at pressure P is the temperature that the parcel would acquire if adiabatically brought to a standard reference pressure P_0, usually 1000 hPa.

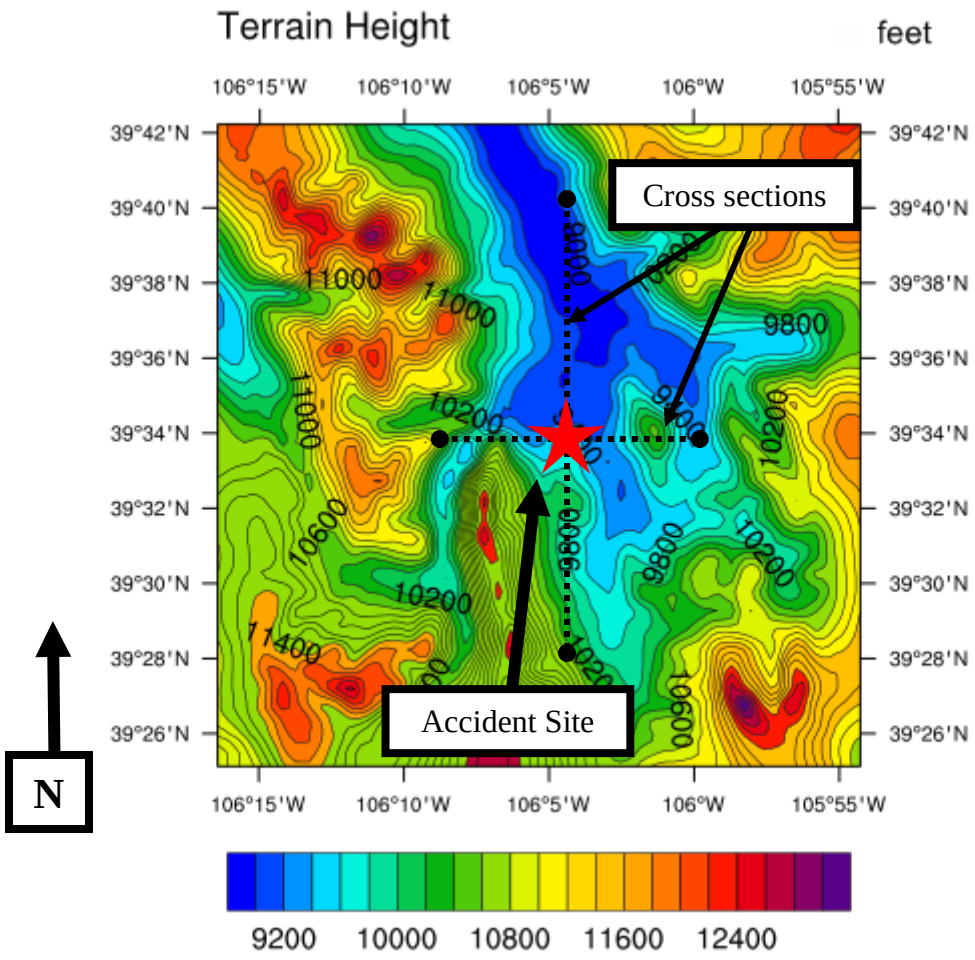


Figure 29 – WRF simulation terrain in feet with the accident site marked and the locations of the cross sections in the following figures

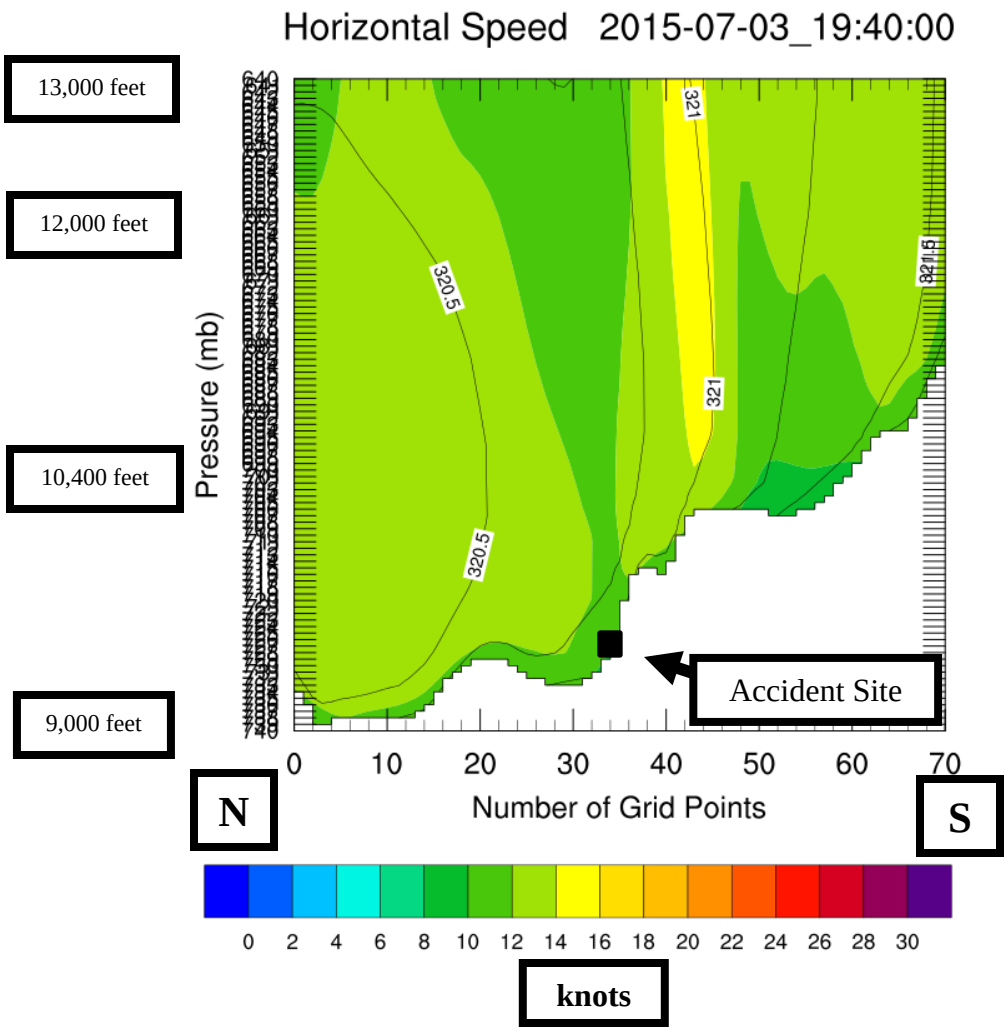


Figure 30 – WRF cross section from 1340 MDT of horizontal speed in knots and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

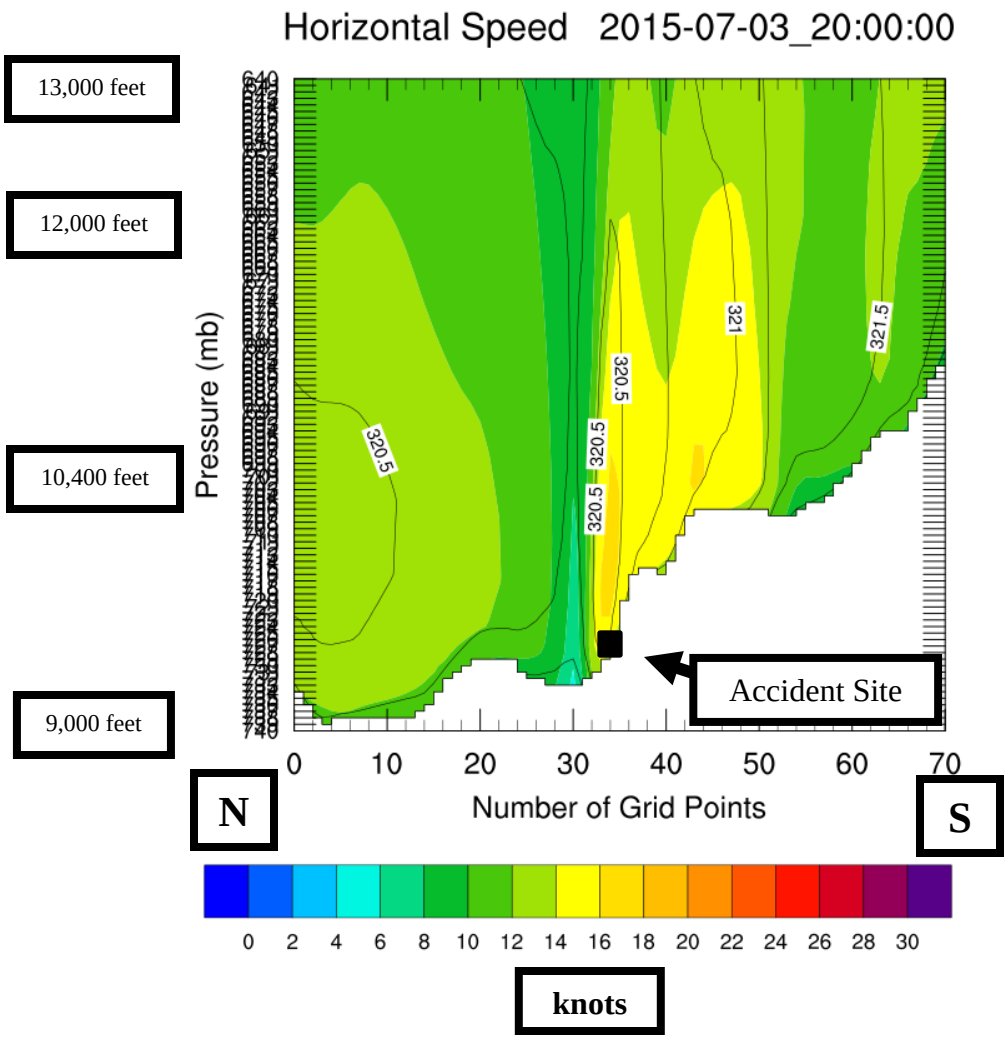


Figure 31 – WRF cross section from 1400 MDT of horizontal speed in knots and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

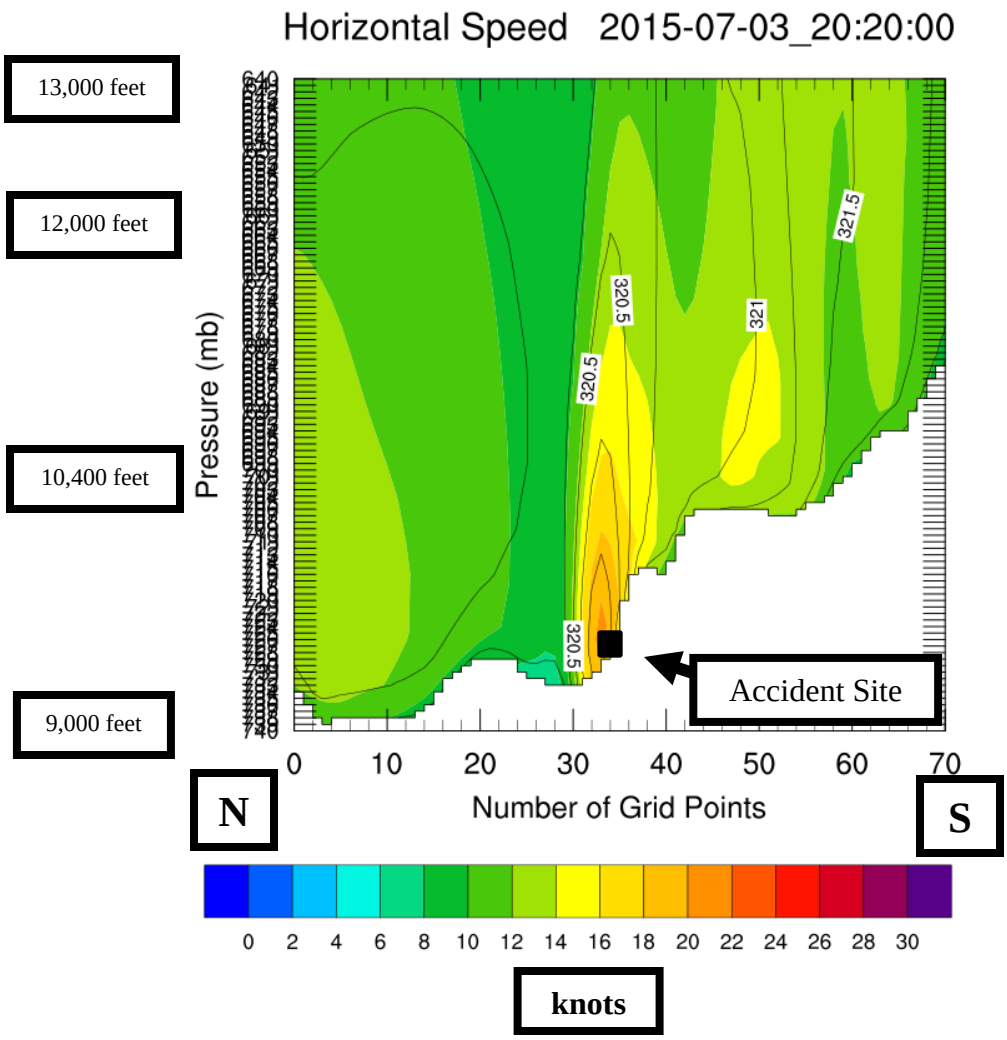


Figure 32 – WRF cross section from 1420 MDT of horizontal speed in knots and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

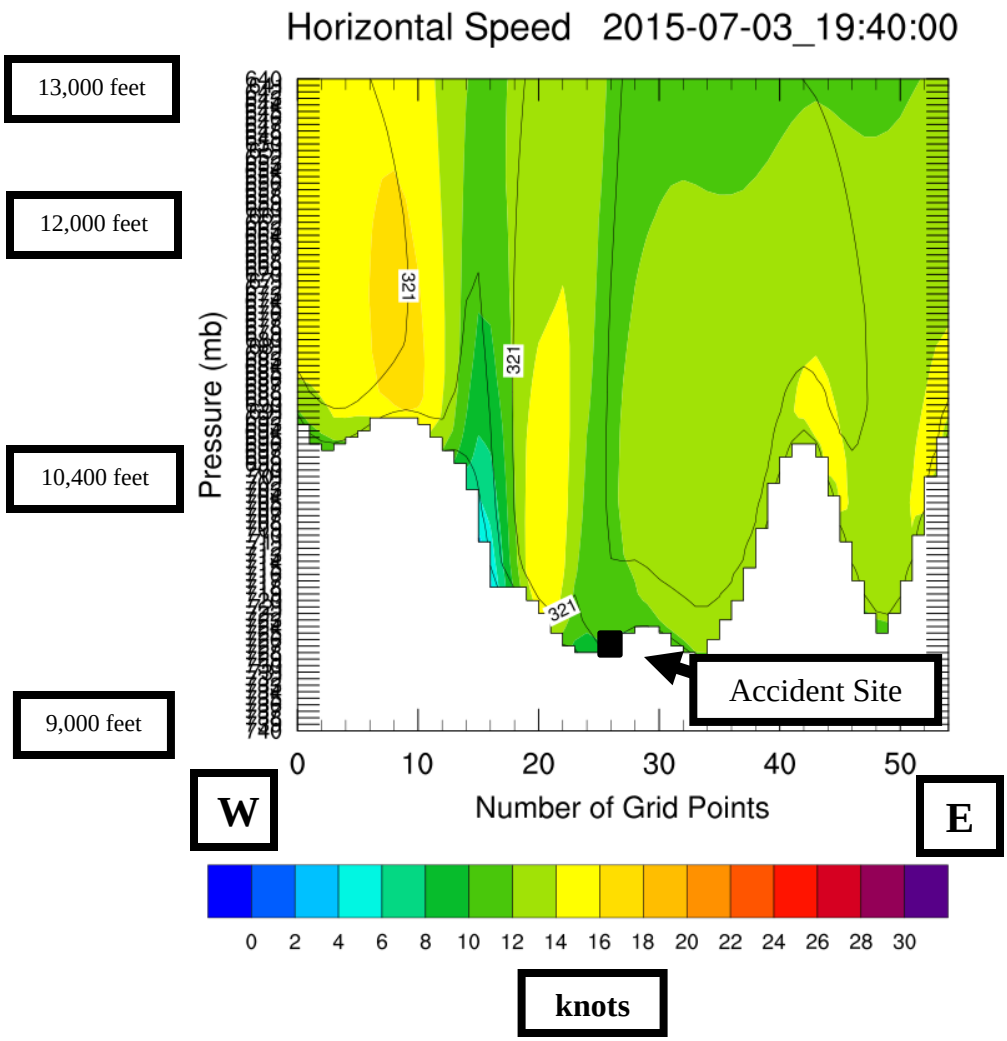


Figure 33 – WRF cross section from 1340 MDT of horizontal speed in knots and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

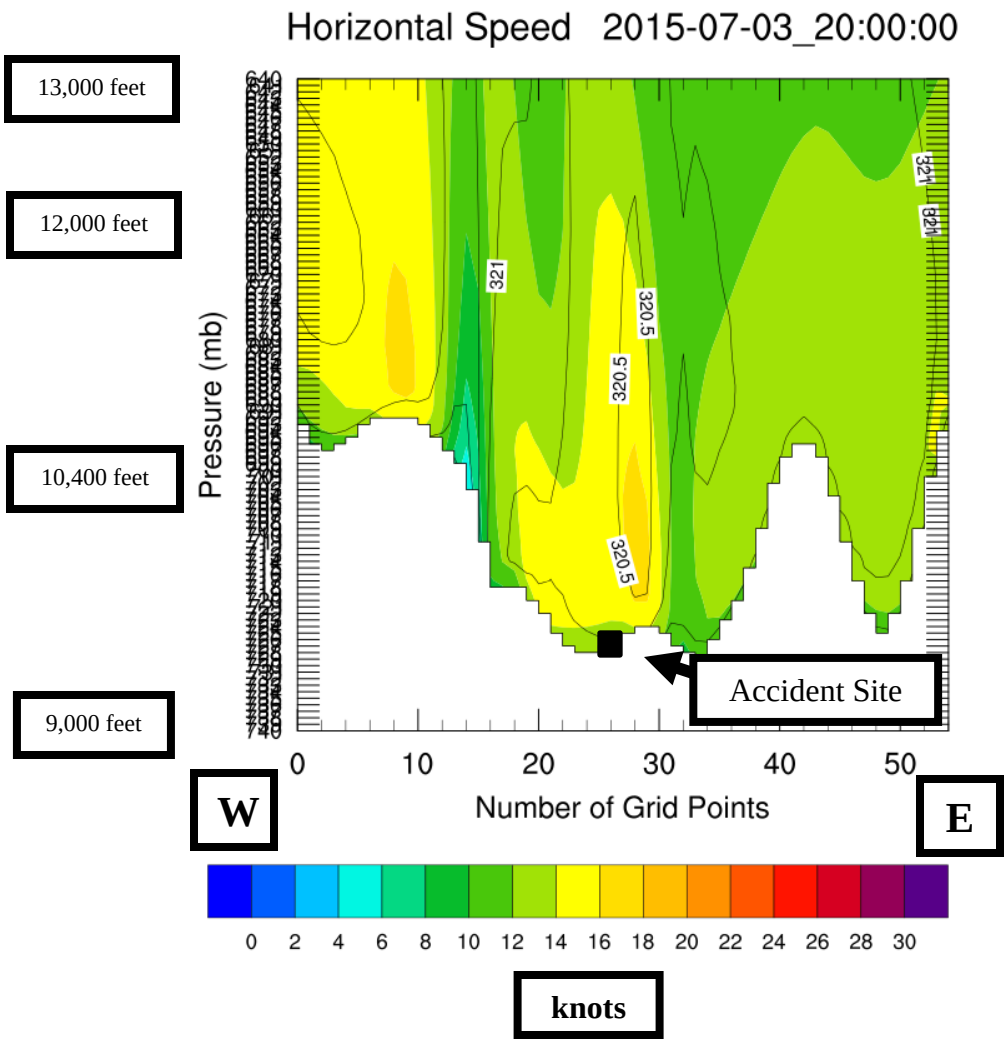


Figure 34 – WRF cross section from 1400 MDT of horizontal speed in knots and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

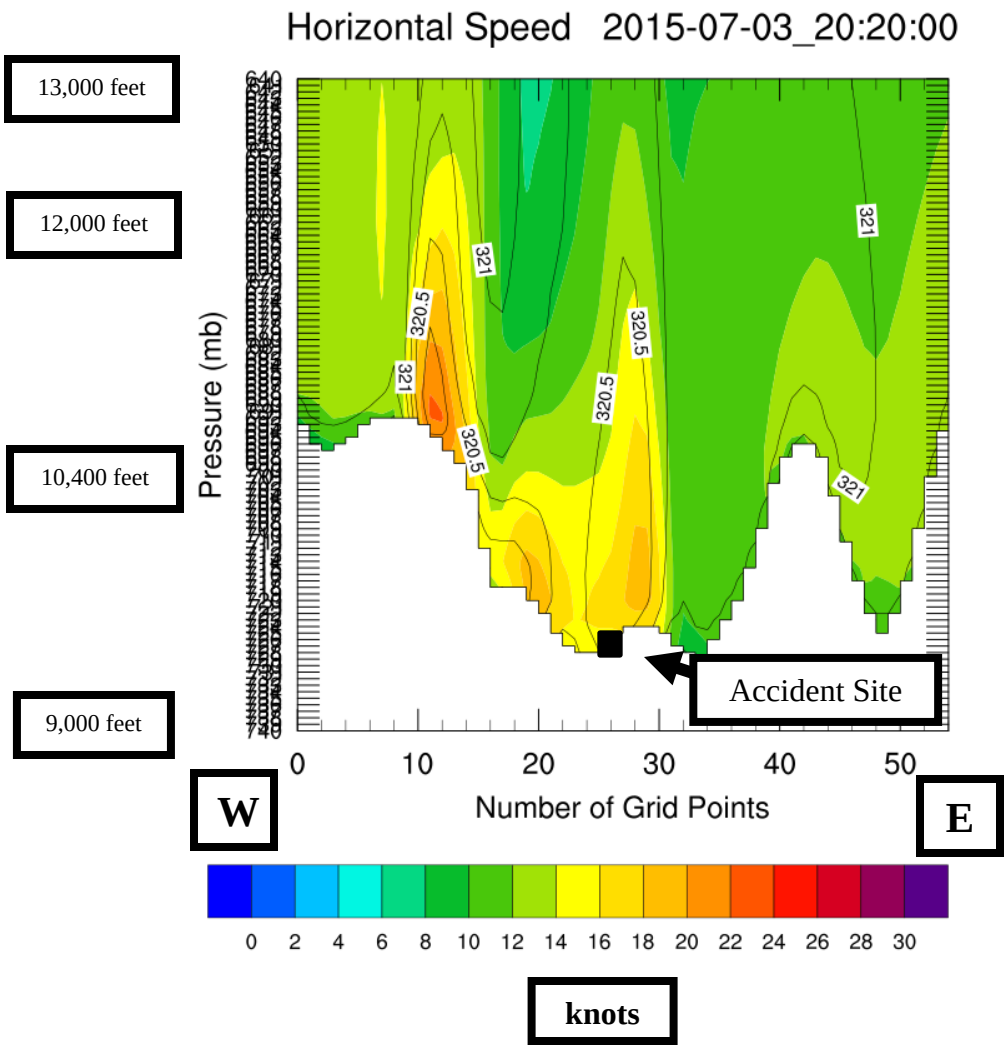


Figure 35 – WRF cross section from 1420 MDT of horizontal speed in knots and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

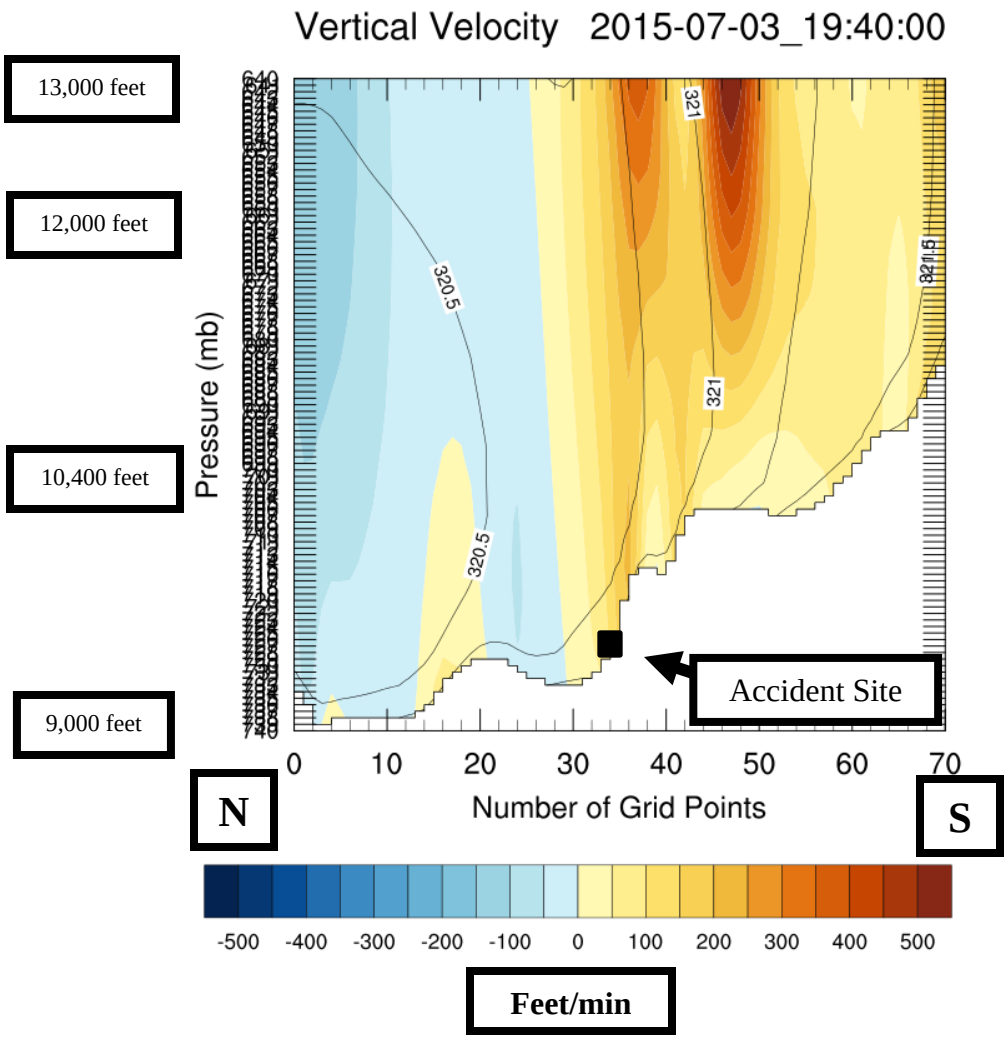


Figure 36 – WRF cross section from 1340 MDT of vertical speed in feet per minute and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

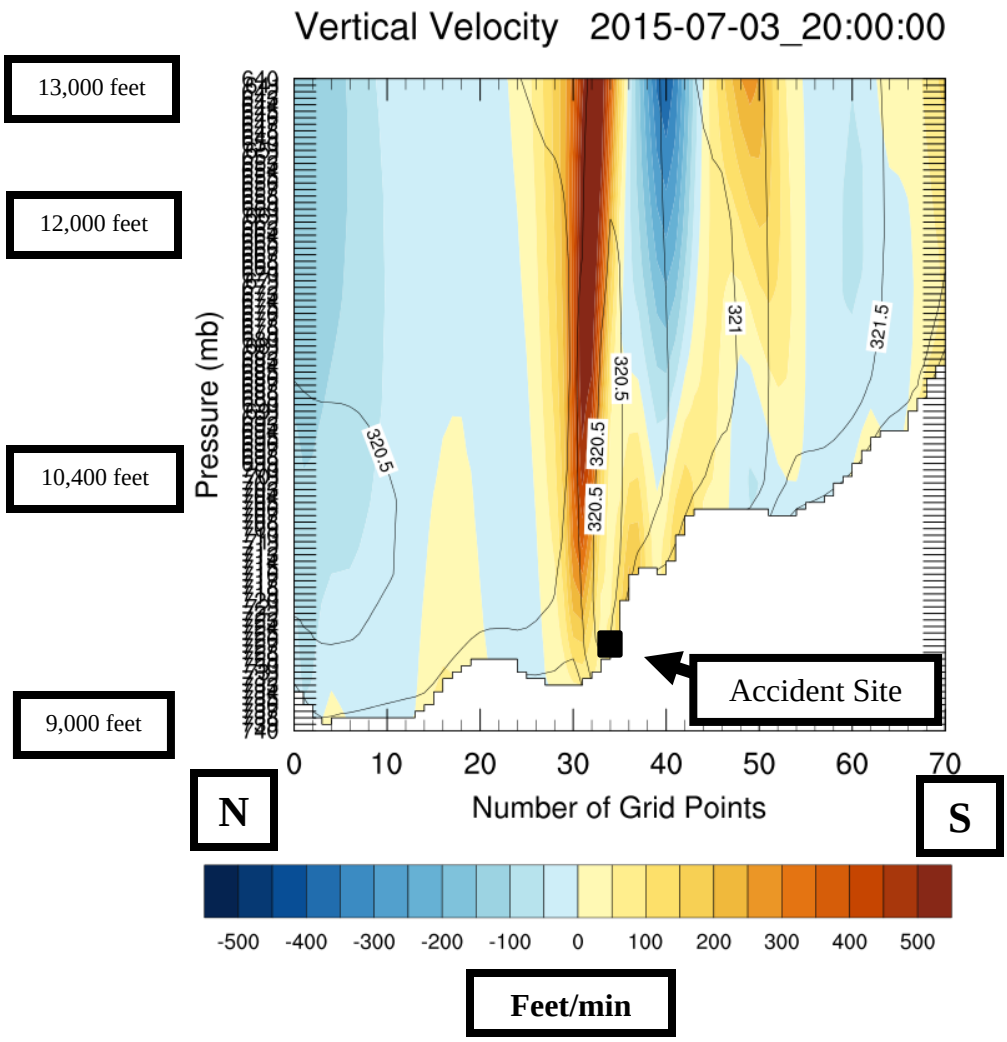


Figure 37 – WRF cross section from 1400 MDT of vertical speed in feet per minute and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

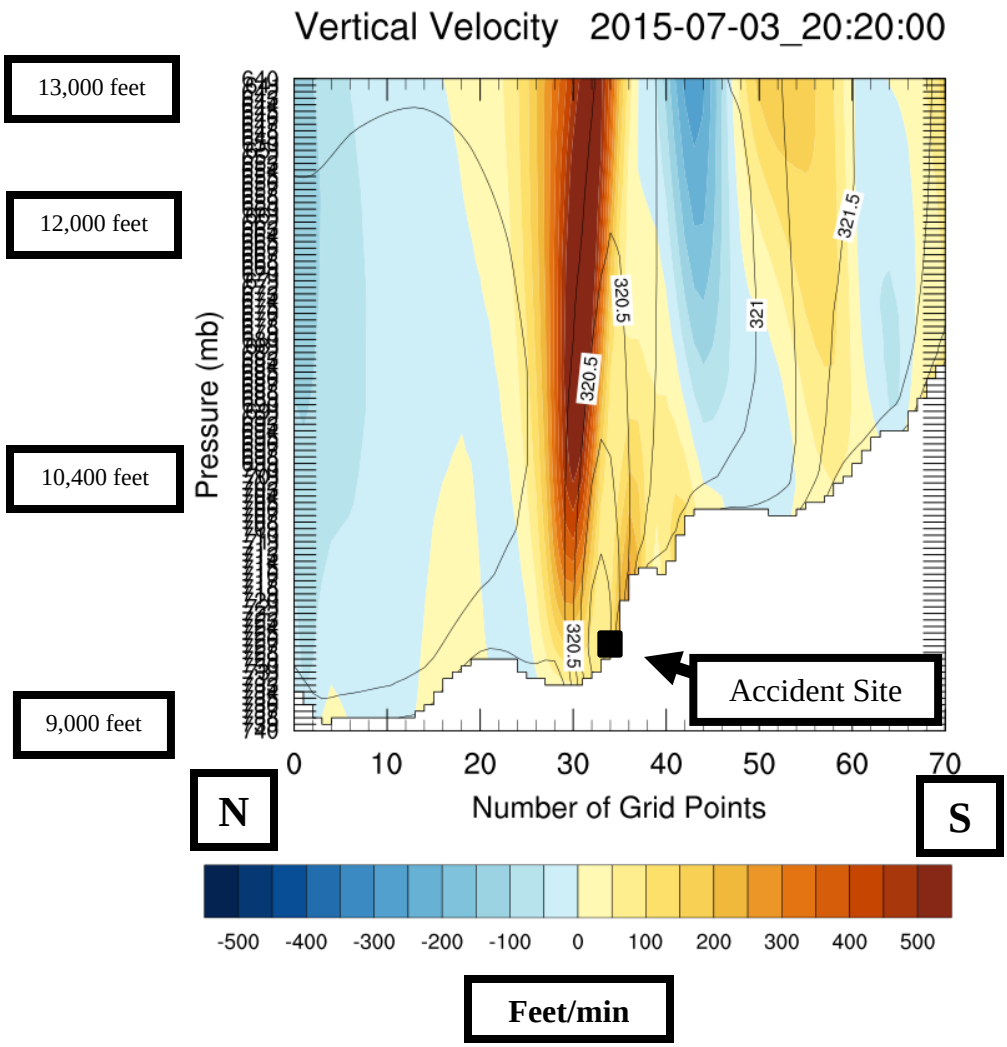


Figure 38 – WRF cross section from 1420 MDT of vertical speed in feet per minute and potential temperature in kelvin from north to south across the terrain with the approximate accident site marked

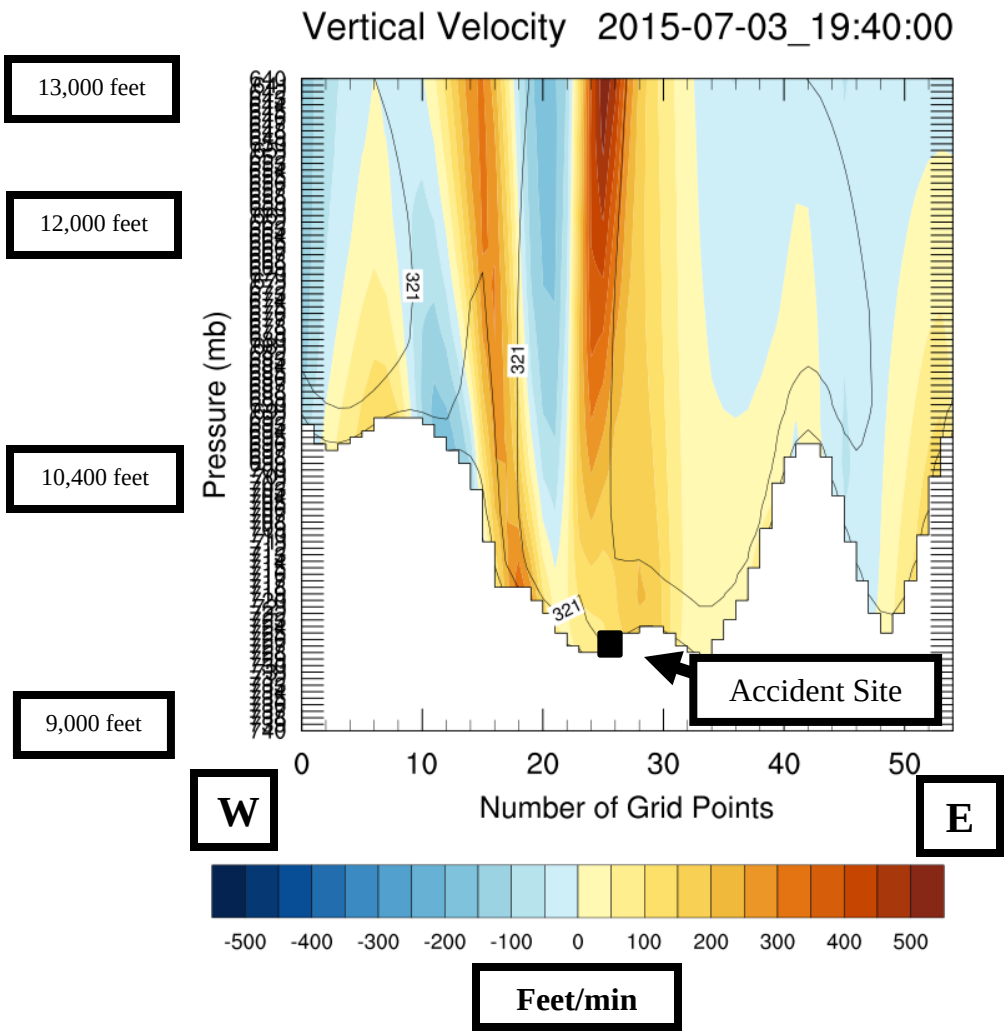


Figure 39 – WRF cross section from 1340 MDT of vertical speed in feet per minute and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

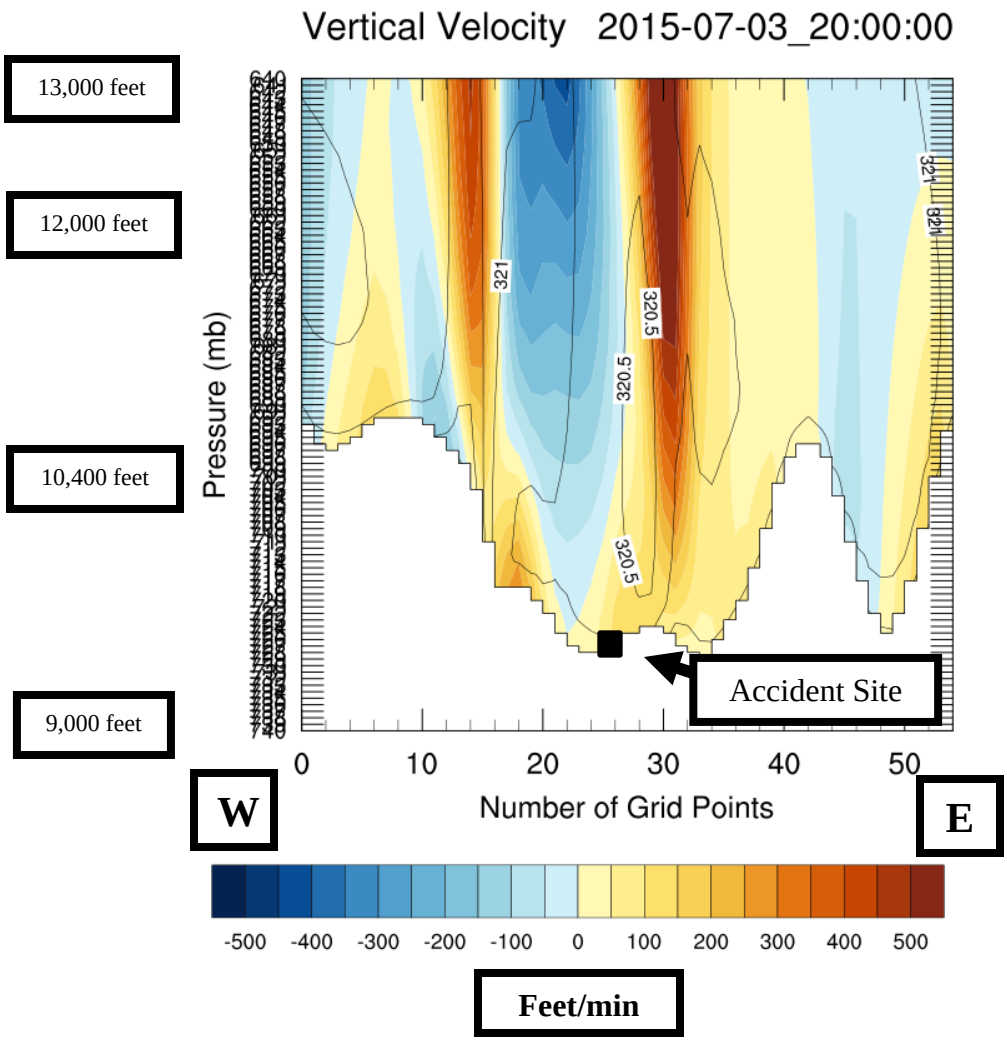


Figure 40 – WRF cross section from 1400 MDT of vertical speed in feet per minute and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

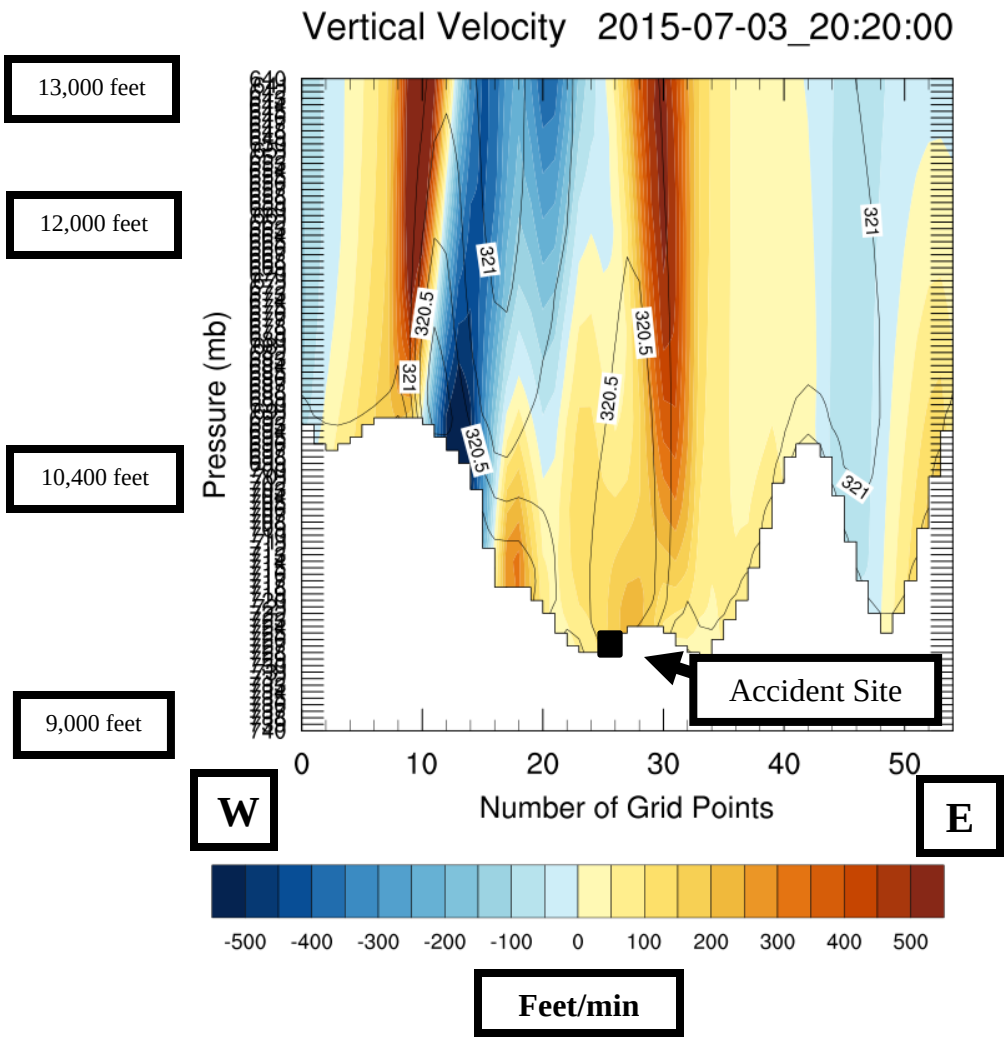


Figure 41 – WRF cross section from 1420 MDT of vertical speed in feet per minute and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

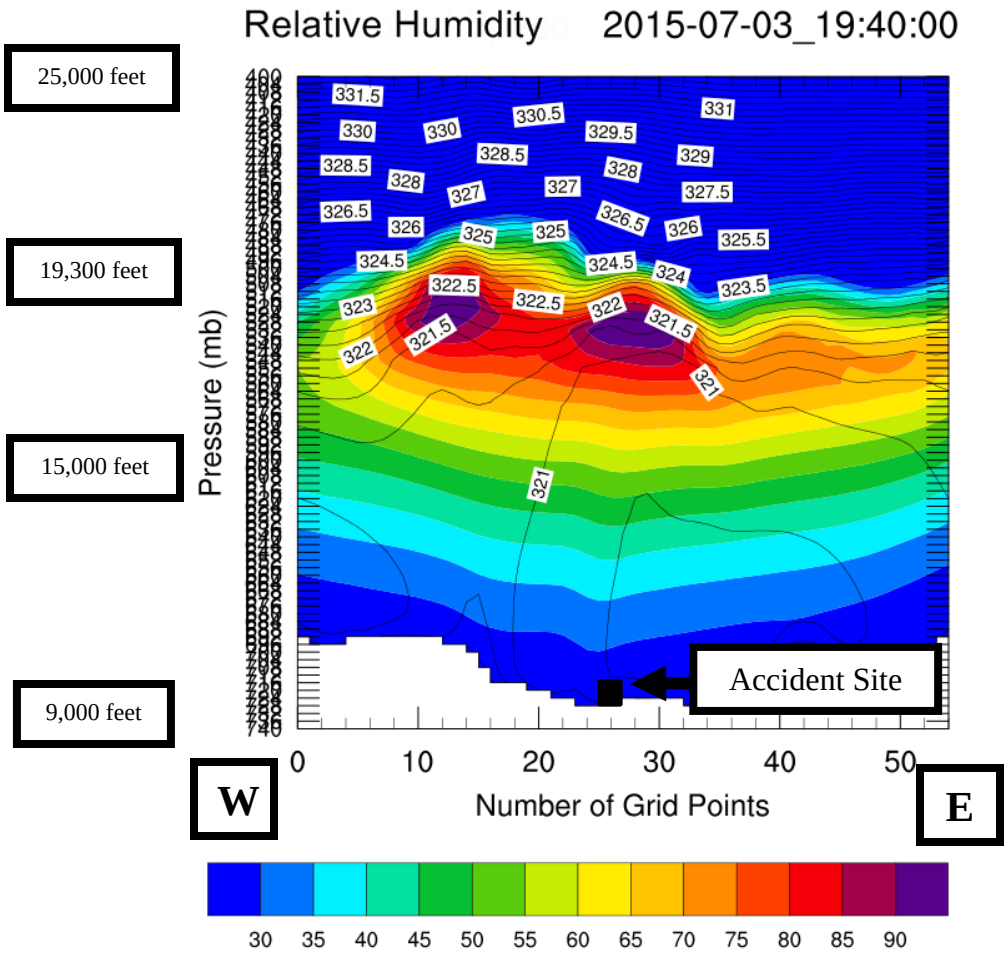


Figure 42 – WRF cross section from 1340 MDT of relatively humidity in percent and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

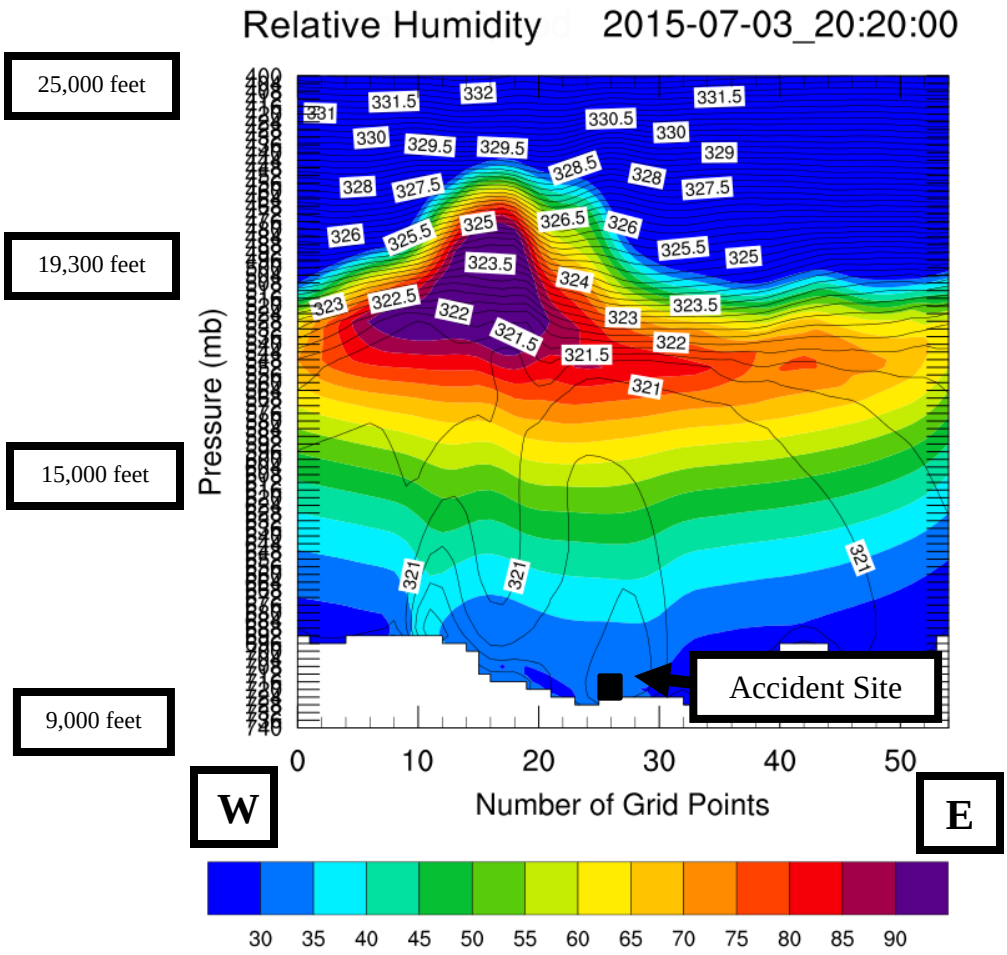


Figure 43 – WRF cross section from 1420 MDT of relatively humidity in percent and potential temperature in kelvin from west to east across the terrain with the approximate accident site marked

17.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on July 3, 2015, indicated the following:

SUN	
Begin civil twilight	0509 MDT
Sunrise	0542 MDT
Sun transit	1309 MDT
Sunset	2035 MDT
End civil twilight	2108 MDT

18.0 Witness and Video Information

A witness a quarter mile north-northwest of the accident site (located at the Frisco recycling center) took several pictures of the accident site after the accident time. Figure 44 is one of these images with the smoke plume blowing away from the accident site toward the southwest to west. The southwesterly to westerly oriented smoke plume was a different wind direction than observed from the wind sock at the helipad as the accident flight departed. The helipad wind sock was rated to 15 knots, with the wind sock fluctuating between below horizontal to above horizontal before, during, and after the accident time (figure 45).[20] The wind sock conditions were captured in security video taken from the ambulance bay and helipad areas. The wind sock wind speeds are similar to the conditions described in sections 3.0, 4.0, and 16.0.

Figure 44 – Witness image taken after the accident time a quarter mile north-northwest of the accident site

[20] For more information on the wind sock position and times relative to the accident please see the Performance Study report located in the docket for this accident.

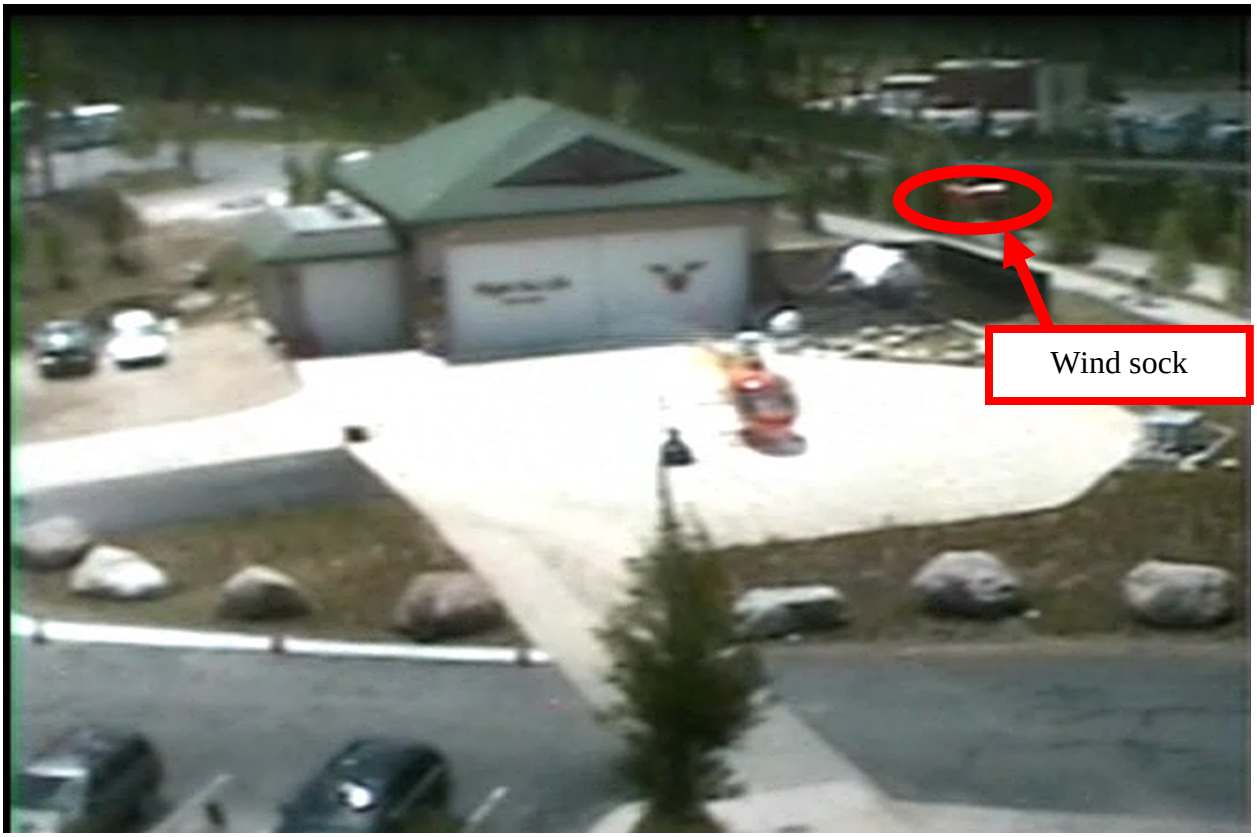


Figure 45 – Still image of the accident flight 3 seconds before takeoff with the wind sock highlighted

F. LIST OF ATTACHMENTS

Attachment 1 – Visible satellite imagery loop from 1300 MDT through 1500 MDT

Attachment 2 – Base reflectivity weather radar loop from KFTG between 1320 and 1400 MDT for the 0.9° elevation scan

Attachment 3 – Base reflectivity weather radar loop from KFTG between 1320 and 1400 MDT for the 1.3° elevation scan

Attachment 4 – WRF cross section animation from 1300 to 1450 MDT of horizontal speed in knots and potential temperature in kelvin from north to south across the terrain

Attachment 5 – WRF cross section animation from 1300 to 1450 MDT of horizontal speed in knots and potential temperature in kelvin from west to east across the terrain

Attachment 6 – WRF cross section animation from 1300 to 1450 MDT of vertical speed in feet per minute and potential temperature in kelvin from north to south across the terrain

Attachment 7 – WRF cross section animation from 1300 to 1450 MDT of vertical speed in feet per minute and potential temperature in kelvin from west to east across the terrain

Attachment 8 – WRF cross section animation from 1300 to 1450 MDT of relatively humidity in percent and potential temperature in kelvin from west to east across the terrain

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