NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

July 2, 2012

Group Chairman's Factual Report

METEOROLOGY

DCA12FA062

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A. ACCIDENT

Location:	About 15 nm ESE of Buena Vista, Colorado
Date:	April 14, 2012
Time:	About 2340 mountain daylight time (0540 UTC[1] on April 15, 2012)
Airplane:	US Airways Airbus A-319 flight 496; registration N808AW

B. METEOROLOGY SPECIALIST

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C. SUMMARY

On 14 April 2012, at approximately 2340 mountain daylight time, an Airbus Industries A319-132, US registration N808AW, operated by US Airways as flight 496 from PHX to DEN, encountered severe mountain wave turbulence at flight level 320 in the vicinity of Buena Vista, CO. Two flight attendants were injured during the encounter. No turbulence had been reported previously. The flight continued to DEN, and landed normally. There was no damage to the aircraft.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are reported in mountain daylight time (MDT) based upon the 24 hour clock, local time is +6 hours to UTC, and UTC=Z. 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 38.8833° N and longitude 105.8144° W at approximately 32,000 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) located in Camp Springs, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 0000 MDT (0600Z) on April 15, 2012 is included as figure 1 with the approximate accident site marked. The chart depicted a low pressure system over the Kansas and Nebraska border at 991-hectopascals (hPa) with a defined cold front extending southward and a stationary that extended northeastward from the low and became defined as a warm front extending eastward across Iowa. A squall line or line of thunderstorms was depicted extending ahead of the front from Kansas southward Oklahoma into Texas that was to be associated with a major severe thunderstorm outbreak. A trough of low pressure extended from the low westward across Kansas into central and southern Colorado. A relatively steep 24-hPa pressure gradient existed across southwestern Colorado and New Mexico with sustained southwesterly winds of 15 to 20 knot. Multiple stations over western and central Colorado reported light to moderate snow showers with temperatures in the 20's degrees Fahrenheit (F). The station model for Denver located north of the trough depicted a northerly wind of 15 knots, broken clouds, with a temperature of 39° F and dewpoint of 36° F, with a sea level pressure of 994.3-hPa.

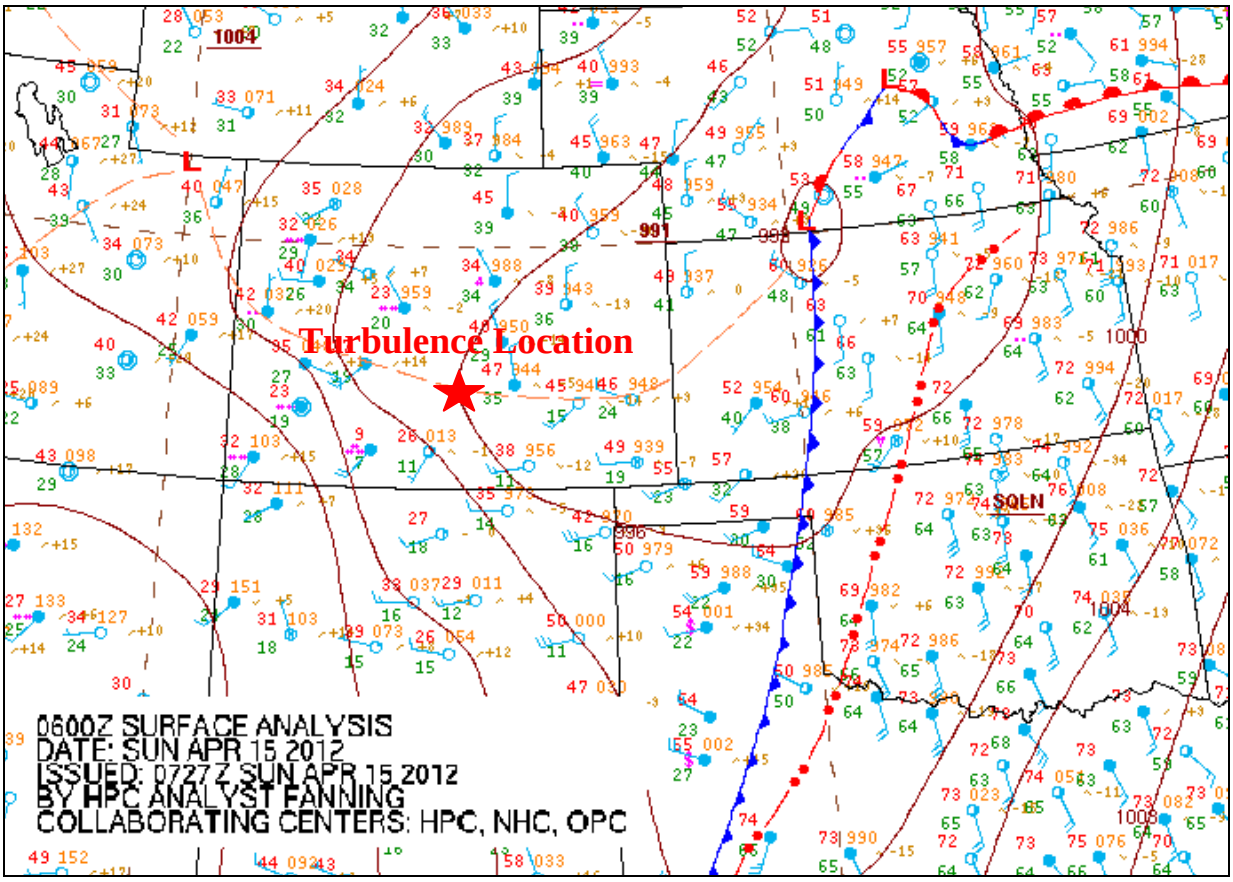

Figure 1 - NWS Surface Analysis Chart for 2400 MDT

1.2 Constant Pressure Charts

The NWS Constant Pressure Charts for 1800 MDT (0000Z on April 15, 2012) for 500-, 300-, and 250-hPa are included as figure 2 through 4. The 500-hPa chart (figure 2) represented flight conditions at approximately 18,000 feet or conditions of the mean atmosphere. The chart depicted an upper level low pressure system centered over the four corners area of Utah, Arizona, New Mexico, and Colorado with a long wave trough extending southward. A strong band of 50 knots and greater winds were depicted New Mexico northeastward into the Texas Panhandle, Oklahoma, Kansas, Nebraska, into Iowa. The upper air model for Denver depicted a southwest wind of 20 knots, a temperature of -20° Celsius (C), and a temperature-dew point depression of 5° C, a height of the 500-hPa surface at 5,510 meters (18,077 feet), with a 50 meter (160 feet) height fall during the last 12-hours. The approximate accident site is included by the red circle and was located ahead of the upper low in an area of upper level divergence.

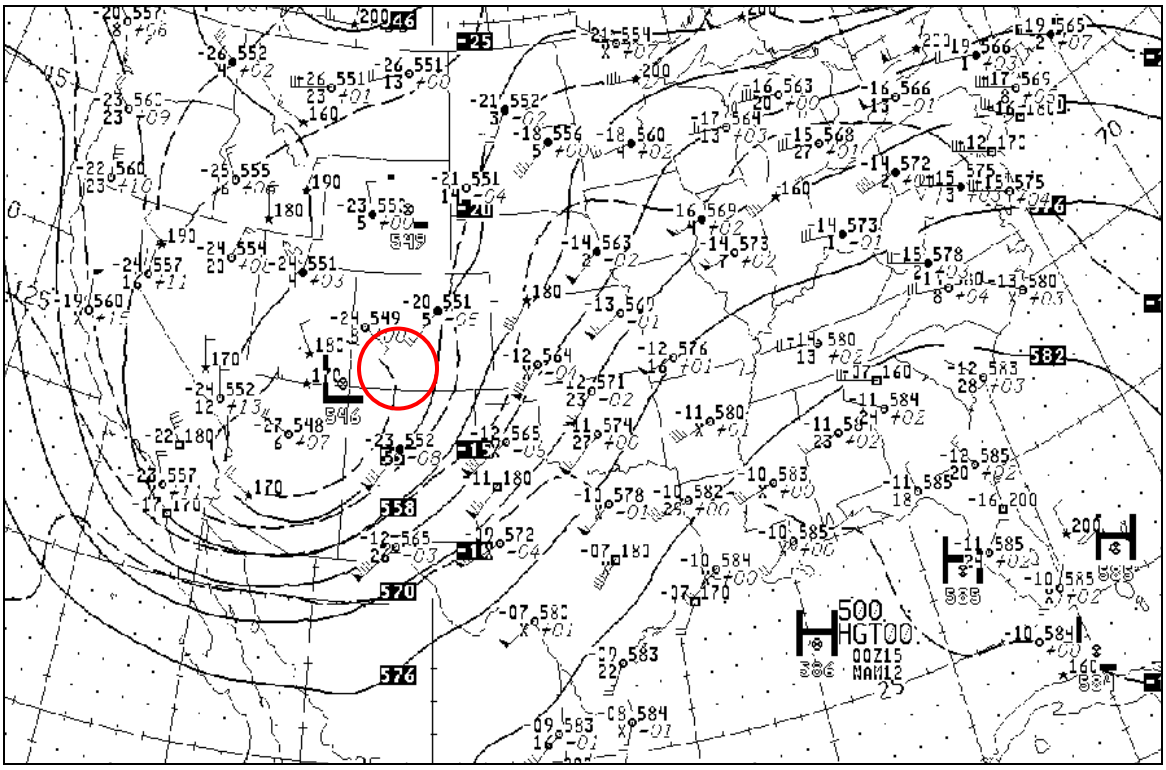

Figure 2 - 500-hPa Constant Pressure Chart for 1800 MDT

The 300-hPa chart (figure 3) depicted the conditions at approximately 30,000 feet. The chart continued to depict the upper level low pressure system over the four corner area with a strong jet stream depicted by the isotachs or lines of equal wind speed every 20 knots moving northeastward across New Mexico into the southeast section of Colorado and the Texas Panhandle into Kansas with maximum winds of 130 knots. The Denver station model depicted a wind from the south at 20 knots, a temperature -51 C, a temperature-dew point depression of 8 C, a height of 9,070 meters (29,757 feet), and a height fall of 70 meters (229 feet) in the last 12-hours.

The 250-hPa chart (figure 4) depicted the conditions at approximately 34,000 feet. The upper level low continued to be depicted over southern Utah to the southwest of the accident site. The Denver upper air site depicted a wind from the southwest at 65 knots, a temperature of -48° C, a temperature-dew point depression of 21° C, a height of 10,250 meters (33,628 feet), and a 12-hour height fall of 80 meters (260 feet).

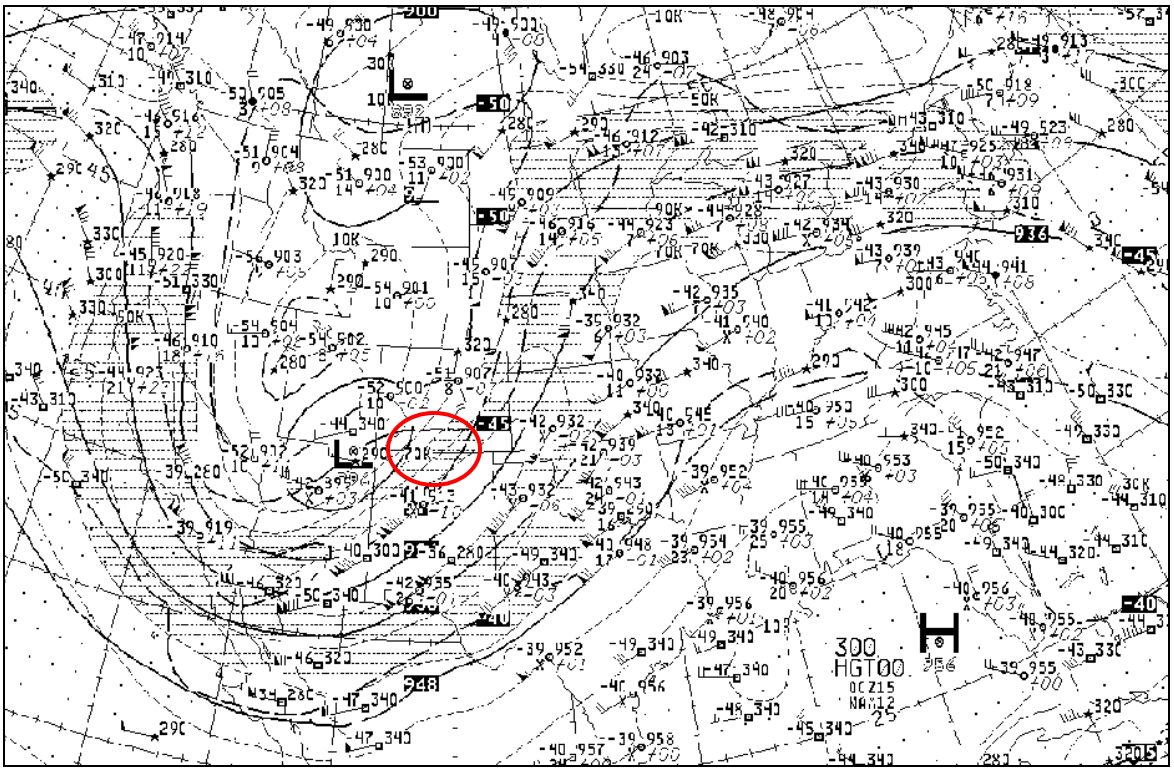

Figure 3 - 300-hPa Constant Pressure Chart for 1800 MDT

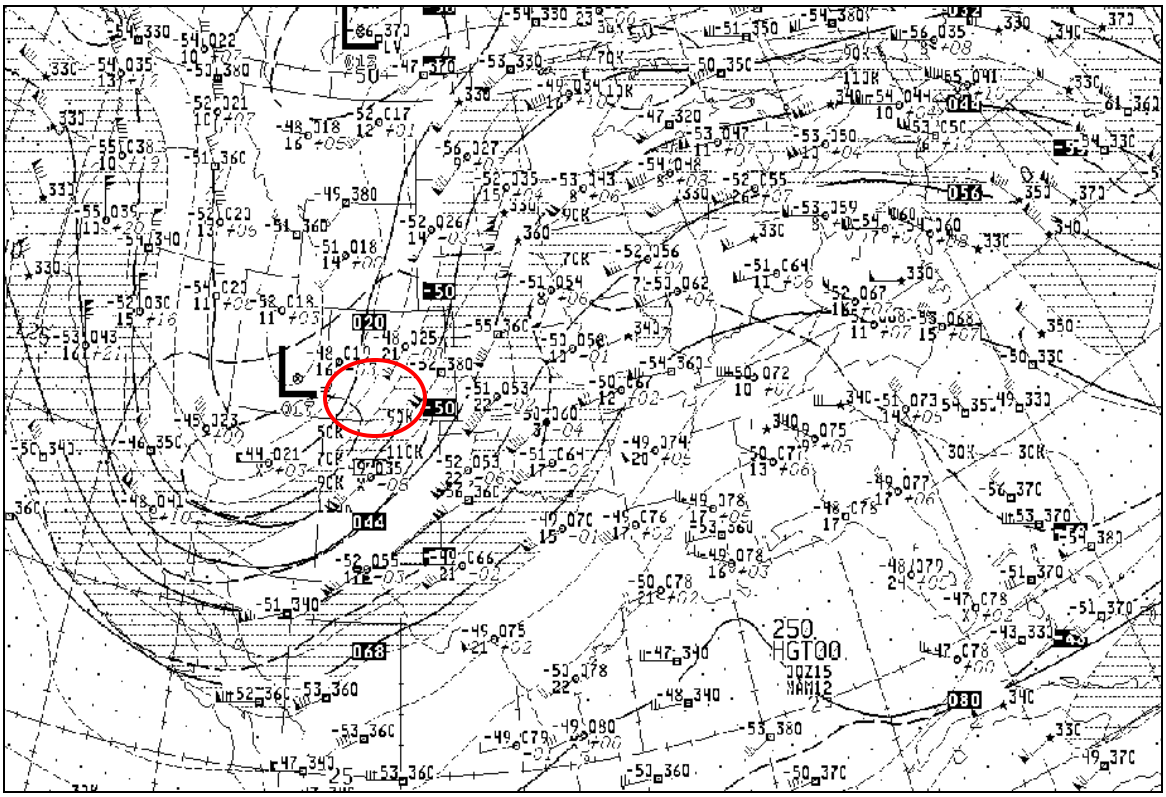

Figure 4 - 250-hPa Constant Pressure Chart for 1800 MDT

1.3 High Level Significant Weather Prognostic Chart

The High Level Significant Weather Prognostic Chart for 0000 MDT (0600Z) on April 15, 2012 is included as figure 2. The chart depicted the main polar jet stream at FL320 with a maximum wind speed of 130 knots moving northeastward immediately east of the Denver area, with an upper level low depicted to the west over Utah/New Mexico with the tropopause lowering to FL290 in the low.

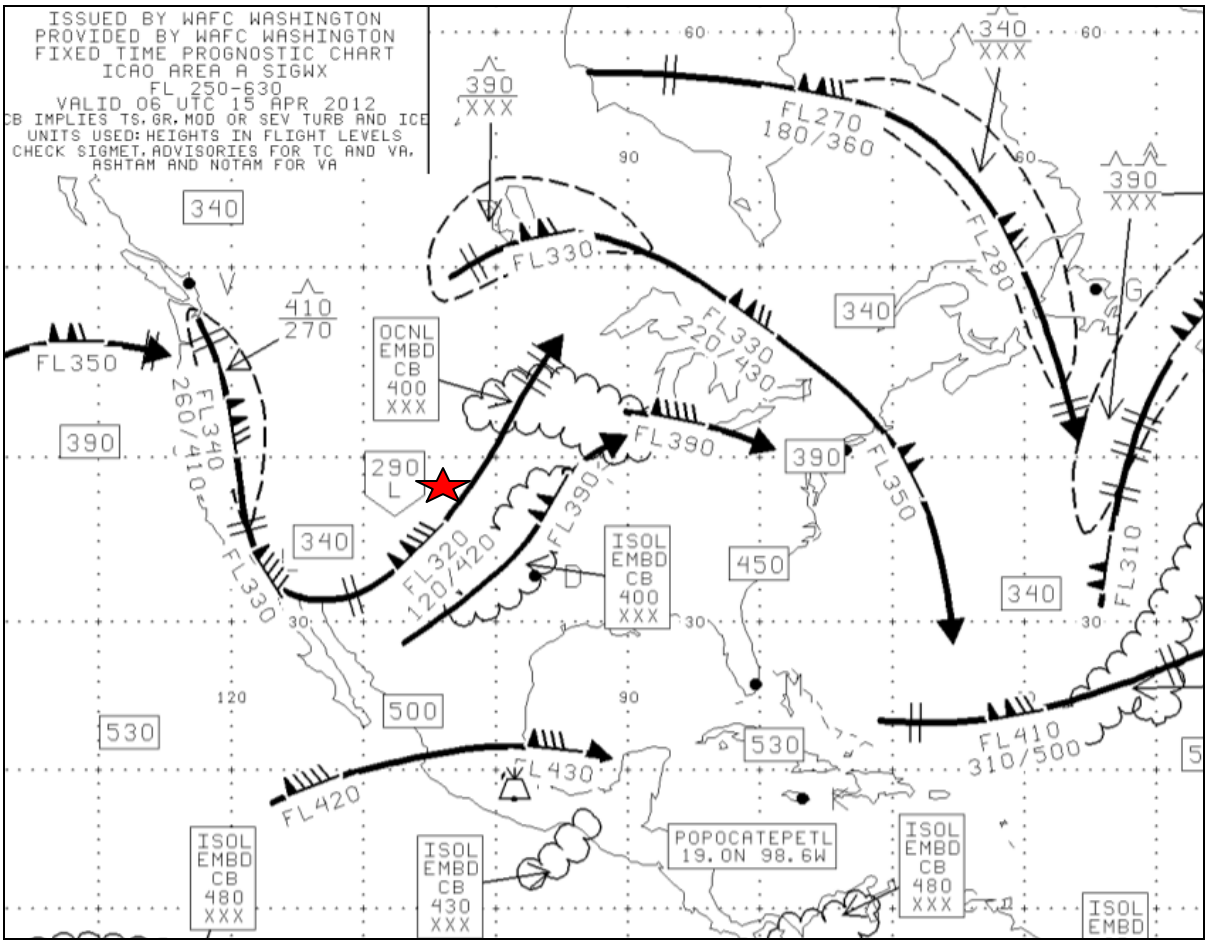

Figure 5 - High level Significant Weather prognostic Chart

2.0 Upper Air Data

The Denver 1800 MDT (0000Z on April 15, 2012) sounding plotted on a standard Skew-T log P diagram[2] utilizing RAOB[3] software with the observed and derived stability parameters is

[2] 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.

[3] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.

included as figure 6 from the surface to 250-hPa or 34,000 feet. The red arrow on the top left side of the diagram indicates the turbulence level.

The sounding depicted the lifted condensation level (LCL)[4] and level of free convection (LFC)[5] at 4,073 feet agl, and the convective condensation level (CCL)[6] at 5,104 feet agl. The sounding had a relative humidity of 75 percent or more from the LCL to approximately 15,000 feet and supported low nimbostratus type cloud formation. The precipitable water content of the sounding was 0.45 inches. The freezing level was noted at 8,721 feet msl and remained below freezing through the depth of the sounding. An upper level frontal inversion was identified at 286-hPa or 30,827 feet with a defined increase of temperature with height and was located in the immediate vicinity of the tropopause, which was identified at 31,275 feet.

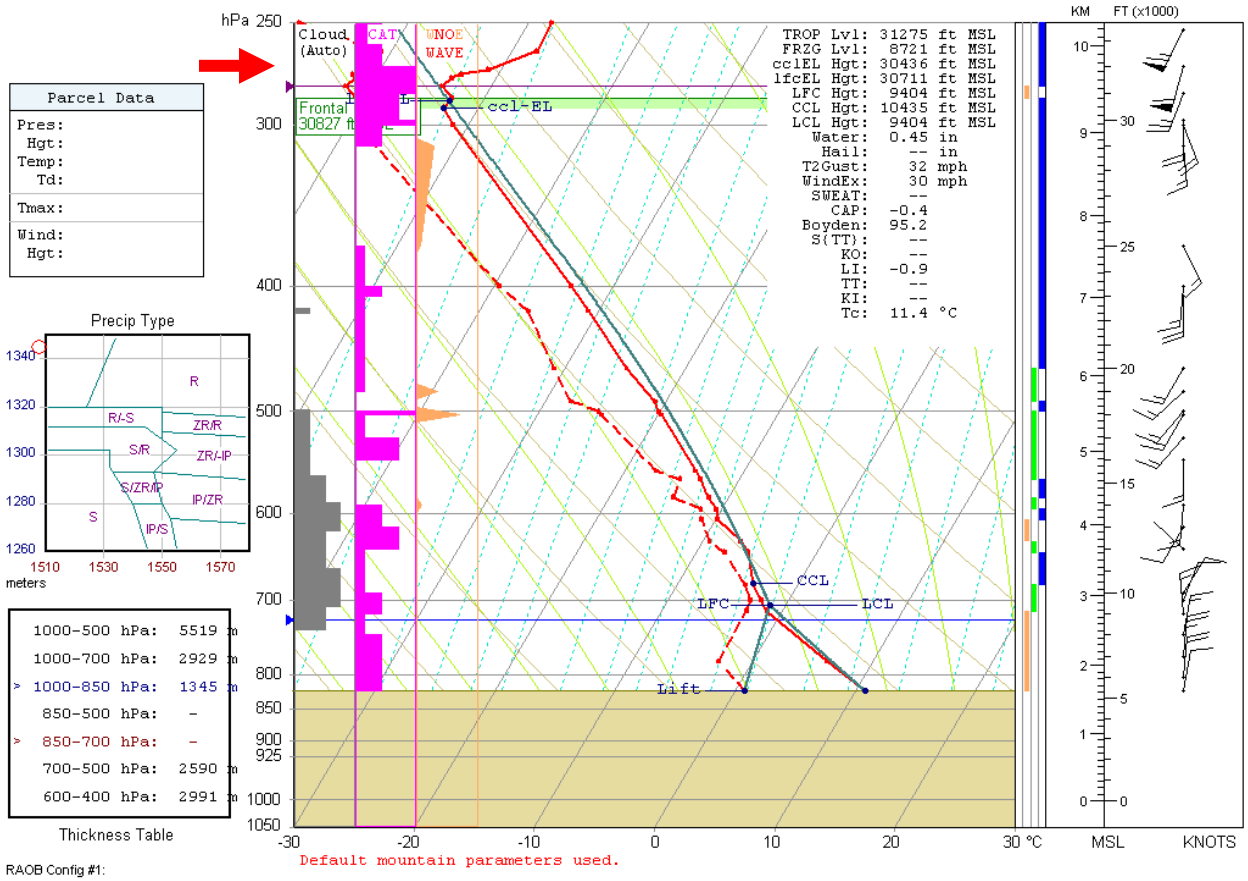

Figure 6- Denver 1800 MDT sounding

[4] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

[5] 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.

[6] Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

The sounding wind profile indicated a surface wind from 010° at 12 knots with little directional variation with height within the lowest 5,000 feet from the surface. The wind shifted abruptly to the south to south-southwest above this level at approximately 10,000 feet msl with wind speeds in excess of 50 knots above 31,000 feet. The level of maximum wind was located above the tropopause at 37,000 feet at 67 knots. At 32,000 feet the sounding indicated a wind from 195° at 58 knots, and a temperature of -50.6° C.

The turbulence algorithm of the RAOB program (showed on the left side of the sounding axis in pink) depicted a high probability of clear air turbulence (CAT) between 28,000 and 32,000 feet due to strong vertical wind shears in the stable atmosphere. A chart of the observed sounding elements of height, pressure, temperature, dew point, relative humidity, wind, and derived turbulence, icing, and mountain wave potential is included below.

Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (S-F clouds)	Wave/X---W---Turb nm fpm max
13832	595	-10.5	-11.8	90		MDT		TRC Rime	
14000	591				185 / 16				2.21 139 LIGHT
14346	583	-11.7	-14.6	79				TRC Clear	
15177	564	-13.3	-15.0	87				TRC Rime	
15534	556	-14.1	-17.4	76				TRC Clear	
16000	546				180 / 16	SVR			
17000	524				220 / 16	LGT			
18000	503				210 / 17				6.36 1809 MD-SV
18003	503	-19.7	-24.7	64		XTR		TRC Clear	
18149	500	-20.1	-25.1	64	220 / 15			TRC Clear	
18590	491	-20.9	-27.9	53					
19000	483				225 / 14	LGT			2.06 494 LT-MD
20000	463				210 / 15				
20003	463	-24.9	-30.9	57					
22414	418	-30.9	-35.9	61		LGT		TRC Rime	
23000	408				180 / 19	MDT			
23433	400	-33.5	-39.5	55	185 / 15	LGT			
25000	373				155 / 15				2.89 95 LIGHT
29000	311				175 / 15	MDT			6.79 699 LT-MD
29813	300	-51.3	-59.3	38	160 / 18	XTR			
30000	297				180 / 20				
30460	291	-52.9	-60.9	37					
30827	286	-52.7	-60.7	37		SVR			
31000	284				200 / 27				
31275	280	-54.1	-62.1	37					
31578	276	-53.7	-61.7	37					
31732	274	-53.1	-62.1	33					
31888	272	-51.1	-60.1	33		XTR			
32000	271				195 / 58				
32611	263	-47.9	-60.9	21		MDT			
33708	250	-48.1	-69.1	7	205 / 64				3.30 973 MD-SV
34144	245	-48.7	-71.7	5					
35045	235	-47.7	-81.7	1					
35955	225	-48.3	m			MDT			10.39 2157 MD-SV
36000	225				215 / 53	SVR			

Figure 7- Sounding parameters from 13,000 to 36,000 feet

3.0 Model Data

A review of the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (ARL) archive data for the North American Mesoscale Model (NAM) at 12 kilometer resolution 3 hour data provided the following wind model over the approximate accident site for the time periods of 0000 (0600Z), 0300 (0900Z), and 0600 MDT (1200Z) on April 15, 2012 is included as figure 8. The model data indicated westerly winds from the surface through 700-hPa or 10,000 feet with wind speeds of 25 knots or more at the level of highest peaks in the area. The wind direction shifted to the north through 400-hPa before backing to the southwest and increasing in speed at 300-hPa or approximately 30,000 feet. At 32,000 feet the wind was from the southwest at 60 knots.

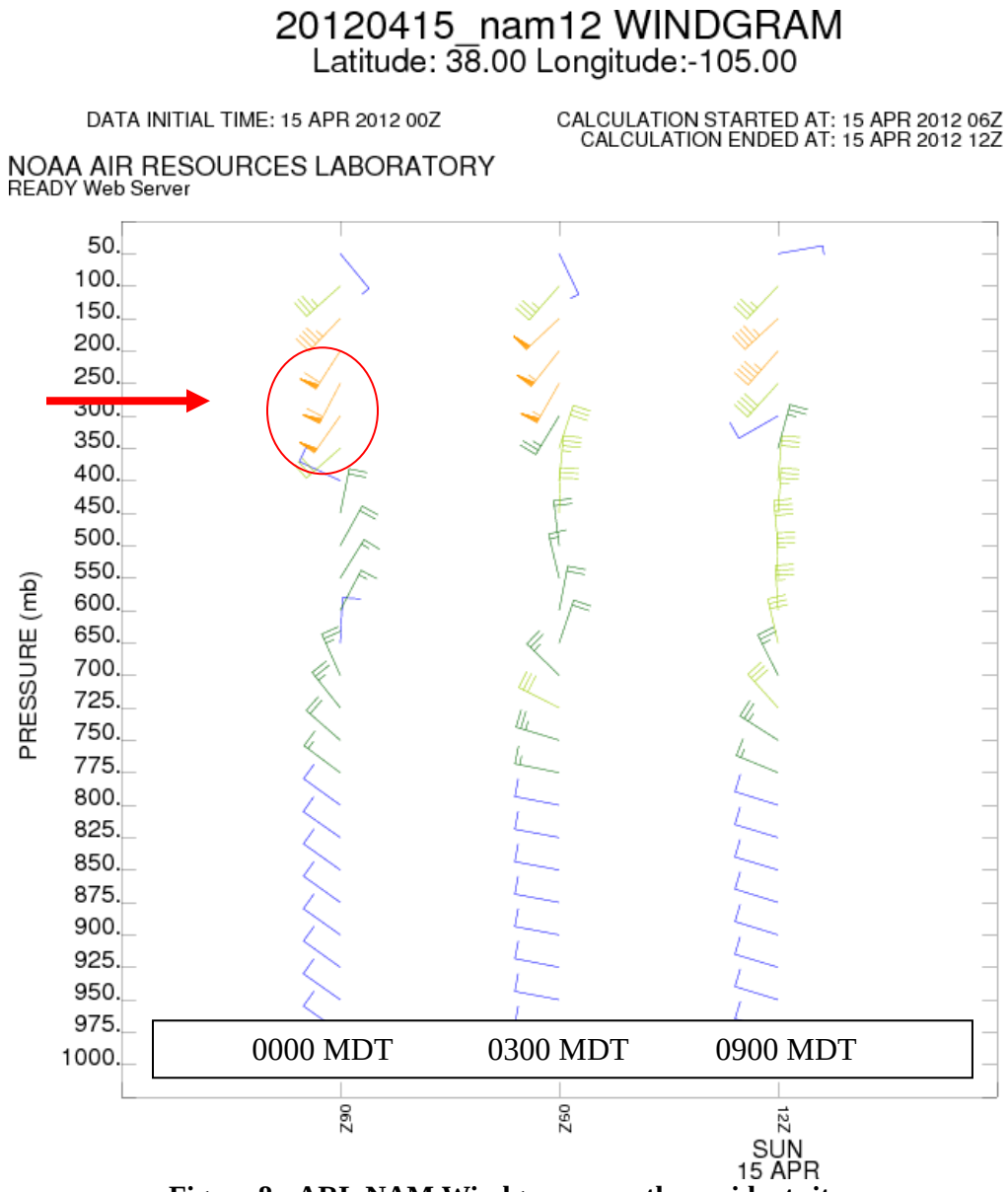

Figure 8 - ARL NAM Windgram over the accident site

4.0 Surface Observations

The closest NWS surface observation reporting location to the turbulence event was from Harriet Alexander Field Airport (KANK), located in Salida, Colorado, approximately 8 miles east from the accident site at an elevation of 7,523 feet. The airport had an Automated Weather Observation System (AWOS) and reported the following conditions at the approximate time of the accident.

Salida weather at 2355 MDT (0555Z), automated observation, wind from 210° at 16 knots gusting to 26 knots, visibility 10 miles, scattered clouds at 6,500 feet agl, ceiling broken at 7,000 feet, overcast at 11,000 feet, temperature 2° C, dew point -9° C, altimeter 29.66 inches of mercury (Hg). Remarks: automated observation system without a precipitation discriminator, temperature 1.5° C, dew point -9.0° C.

The raw observations were as follows:

METAR KANK 150535Z AUTO 22014G22KT 10SM SCT120 01/M09 A2966 RMK AO1 T00111095=

METAR KANK 150555Z AUTO 21016G26KT 10SM SCT065 BKN070 OVC110 02/M09 A2966 RMK AO1 T00151090 10090 20011 401430010=

METAR KANK 150615Z AUTO 24013G23KT 10SM SCT043 OVC055 02/M10 A2968 RMK AO1 T00151096=

The NWS also had a remote observation site on Salida Mountain in Monarch Pass (KMYP) located approximately 5 miles west of the accident site at an elevation of 12,031 feet. The site reported the following condition at the approximate time of the accident:

Monarch Pass weather (KMYP) at 2359 MDT (0559Z), automated observation site, wind from 260° at 30 knots gusting to 40 knots, thunderstorms in the vicinity, ceiling overcast at 100 feet agl, temperature -10° C, dew point -12° C, altimeter 29.71 inches of Hg. Remarks: automated observation system, lightning distant northeast and east.

A review of lightning data did not indicate any cloud-to-ground lightning strikes between 2330 through 2400 MDT in the vicinity of the accident site. The maximum wind recorded at the Monarch Pass was 55 knots at 0239 MST on April 15, 2012, with the wind sensor dropping off line shortly thereafter for unknown reasons. The raw observations were as follows:

METAR KMYP 150519Z AUTO 25023G31KT OVC001 M10/M11 A2973 RMK AO2 LTG DSNT NE AND E PWINO=

METAR KMYP 150539Z AUTO 25025G34KT OVC001 M10/M12 A2972 RMK AO2 PWINO=

METAR KMYP 150559Z AUTO 26030G40KT VCTS OVC001 M10/M12 A2971 RMK AO2 LTG DSNT NE AND E=

METAR KMYP 150619Z AUTO 26032G38KT OVC001 M11/M12 A2971 RMK AO2 PWINO=

METAR KMYP 150639Z AUTO 27038G47KT OVC001 M11/M12 A2970 RMK AO2 PWINO=

METAR KMYP 150659Z AUTO 27039G45KT M11/M12 A2969 RMK AO2 SKY OBSCURED LTG DSNT E PWINO=

METAR KMYP 150719Z AUTO 27038G49KT M11/M12 A2969 RMK AO2 SKY OBSCURED LTG DSNT E PWINO=

METAR KMYP 150739Z AUTO 27039G50KT M11/M13 A2969 RMK AO2SKY OBSCURED PWINO=

METAR KMYP 150759Z AUTO 27045G52KT OVC001 M11/M13 A2969 RMK AO2 PWINO=

METAR KMYP 150819Z AUTO 27044G52KT OVC001 M11/M13 A2968 RMK AO2 PWINO=

METAR KMYP 150839Z AUTO 27043G55KT OVC001 M11/M13 A2969 RMK AO2 PWINO=

Figure 9 is a topographical map of the area with the NWS weather reporting locations and the accident site with a plot of wind speed and direction and the peak gust within the hour reported in miles per hour (mph) highlight in a box next to the stations. The plot also shows the NWS site at Beers Creek approximately 8 miles south-southeast of Harriet Alexander Field at 9,000 feet reported a southwest wind at 14 mph gusting to 39 mph at the time. Strong gusting winds were also noted in the Colorado Springs, Pueblo, and Limon areas to the east of the turbulence location with wind gusts to 35 mph.

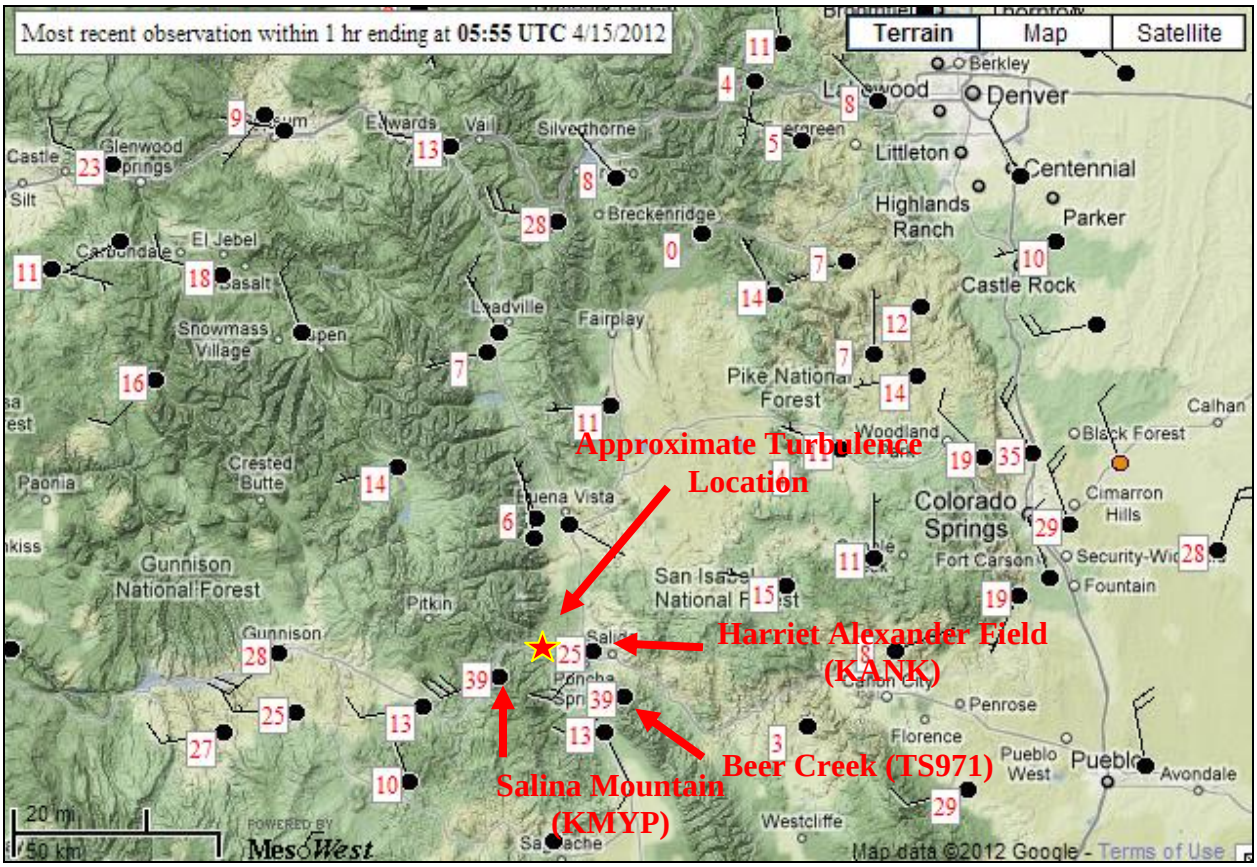

Figure 9 - Topographical map with NWS reporting location wind gusts at 2355 MDT

5.0 Satellite Data

The Geostationary Operations Environmental Satellite number 15 (GOES-15) data was obtained from the University of Wisconsin's Space Science and Engineering Center (SSEC) archive data and displayed on the National Transportation Safety Board's Man-computer Interactive Data Access System (McIDAS) workstation. The infrared or band 4 imagery at a wavelength of 10.7 microns (μm) provided a 4-kilometer (km) resolution with radiative cloud top temperatures at 15-minute intervals.

Figure 10 is the GOES-15 infrared band 4 image at 2345 MDT (0545Z) at 2X magnification with a standard EMB temperature enhance curve applied to highlight the higher and colder cloud tops. The flight track of US Airways flight 496 every 2-minutes from 2248 to 2358 MDT on April 14, 2012 was overlaid with the approximate turbulence location at 2340 MDT noted as the flight was descending through 32,000 feet. The image depicted a large area of enhanced clouds over most of Colorado and Nebraska, with several northwest to southeast bands perpendicular to the mean wind embedded in the enhanced cloud layer. The embedded band of clouds did not show any significant motion with time and were characteristic of those associated with cirrocumulus standing lenticular (CCSL) clouds associated with mountain wave activity. A larger area of enhanced clouds associated with the surface frontal system and low pressure system is noted further northeast and east over eastern Nebraska, South Dakota, into Minnesota, and Iowa. The radiative cloud top temperature over the accident site was 237° kelvin or -36.16° C, which corresponded to cloud tops near 27,000 feet and confirms the flight was in night visual meteorological conditions (VMC) at the time of the accident.

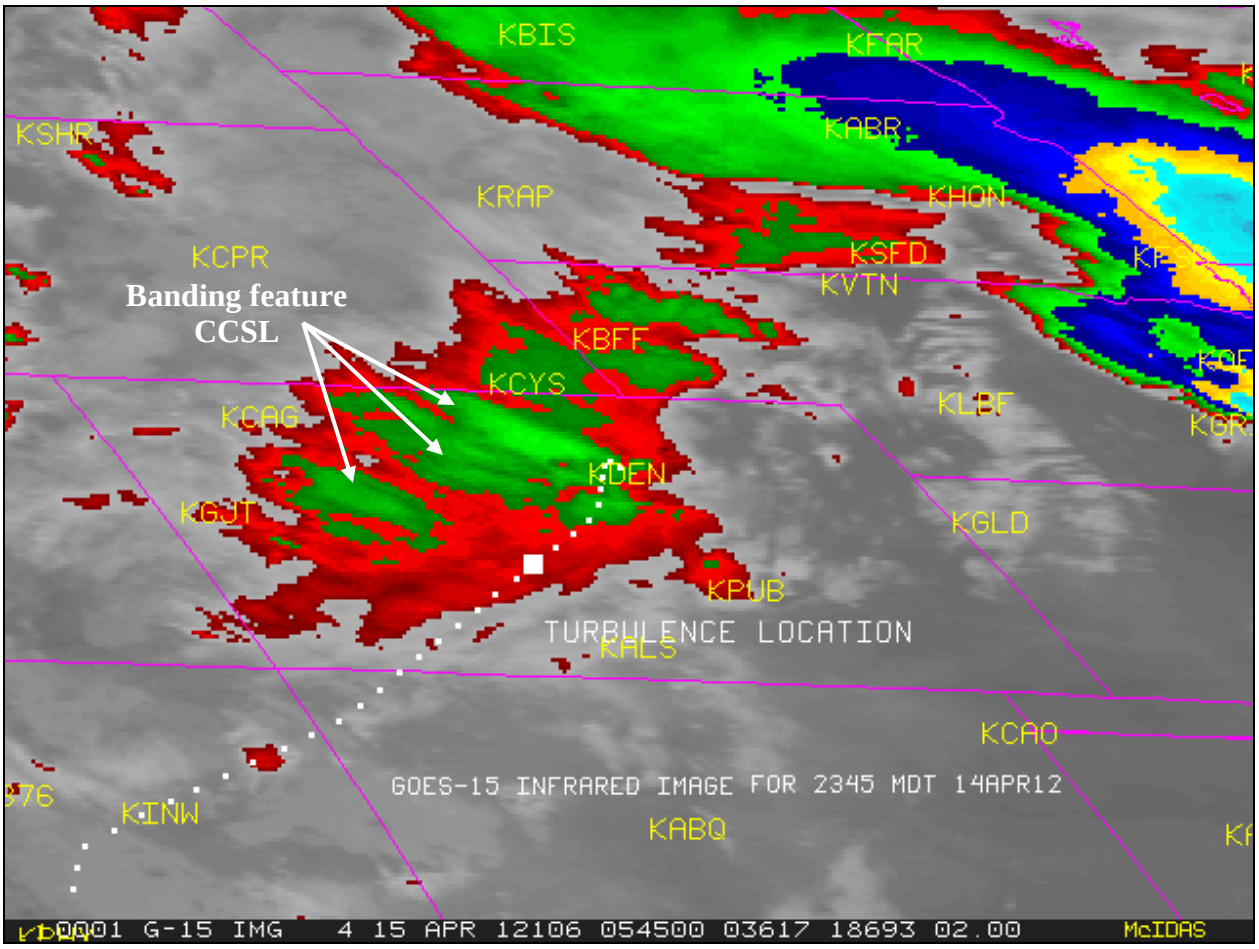

Figure 10- GOES-15 infrared satellite image at 2345 MDT

Figure 11 is the GOES-15 water vapor image for 2345 MDT at 2X magnification with the accident site marked (in yellow). The water vapor image depicted clouds below the accident airplanes flight level and highlighted some of the banding features to the west through north of the accident site. An area of moisture channel darkening was depicted south of the Pueblo (KPUB) area associated with subsiding motion associated with potential mountain wave activity and potential turbulence; however, no significant darkening was noted in the vicinity of the accident site.

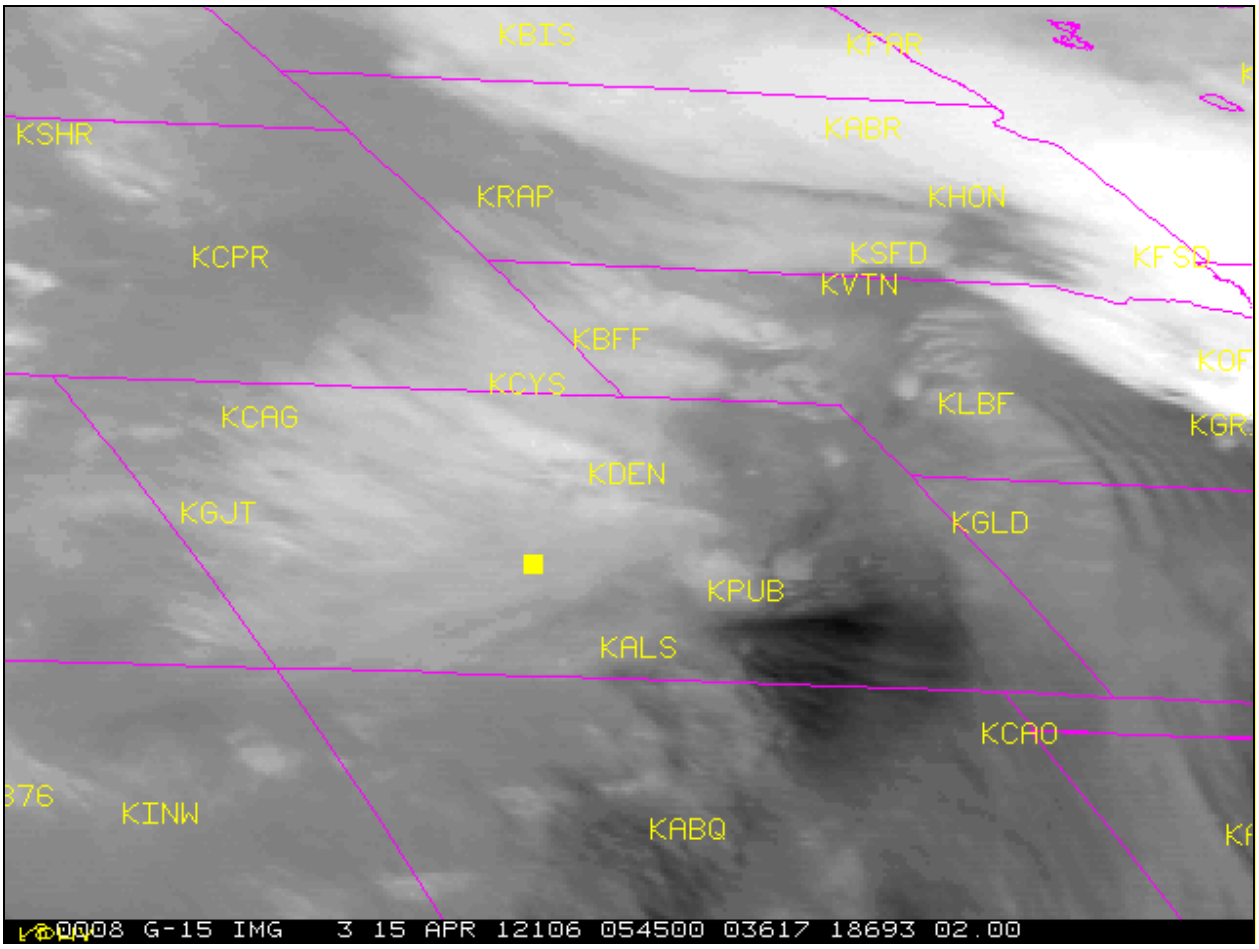

Figure 11 - GOES-15 moisture channel image for 2345 MDT

6.0 Pilot Reports

The following pilot reports were recorded surrounding the period over Colorado. Urgent pilot reports or those reporting severe turbulence are added in bold text. The reports were as follows:

DEN UA /OV DEN220070/TM 1945/FLDURD/TP SVRL/TB CONS MOD/RM DURD FL240-210 FROM ZDV=

DEN UA /OV DEN310070/TM 2135/FL240/TP B737/TB MOD/RM ZDV=

PUB UA /OV PUB160030/TM 2137/FL225/TP MD80/TA M13/TB MOD/IC LGT RIME/RM FROM ZDV=

EGE UA /OV RLG080015/TM 2200/FL240 /TP CRJ2/TA M20/TB OCNL MOD/IC LGT RIME=

PUB UUA /OV PUB/TM 2231/FLDURD/TP C560/TB MDT-SVR/RM FL270-210 DURD FROM ZDV=

DEN UA /OV DEN/TM 2250/FL220/TP B737/TB CONT MOD/RM CONT LT OCL MOD SFC-FL320. CONT MOD FL220-320. AWC-WEB:SWA=

LIC UUA /OV HGO090045/TM 2242/FLUNKN/TP BE58/TB SEV/RM SEV DOWN DFT FL100-110 FROM ZDV=

DEN UA /OV DEN310003 /TM 2247 /FL072 /TP A319 /TB MOD=

APA UA /OV DEN225025 /TM 0009 /FL140 /TP B737 /TB MOD=

DEN UA /OV FQF220090/TM 0030/FL310/TP B737/TB MOD/RM DURGD 310-230 FM ZDV=

LAA UA /OV LAA355015/TM 0058/FL340/TP A319/TB OCNL MOD CHOP/RM ALSO RPRTD AT FL320 FROM ZDV=

PUB UA /OV PUB260012/TM 0122/FLDURD/TP CRJ7/TB MOD CHOP/RM FL150-140 FROM ZDV=

COS UUA /OV COS /TM 0130 /FL003 /TP CRJ2 /RM LLWS +25KT 003 FAP RY35R=

LAA UA /OV HGO125040 /TM 0131 /FL270 /TP A319 /TB MOD=

ALS UA /OV ALS010030/TM 0220/FLUNKN/TP BE9L/TB MOD CHOP/RM FL210-230 FROM ZDV=

COS UA /OV BRK110025/TM 0300/FL220/TP LJ55/TA M05/TB LGT-MDT/ICLGT RIME/RM FROM ZDV=

Accident 0553Z

LAA UUA /OV LAA 040045/TM 1145/FL210/TP BE9L/TB SEV/RM SPEED FLUCTUATIONS FROM 120-180 KIAS. ZDV=

The reported showed numerous reports of moderate turbulence from the surface to 34,000 feet. There were also 3 reports of severe turbulence with 2 of those reports hours earlier between 1630 and 1642 MDT, and the other hours after the event at 0545 MDT on April 15, 2012 with numerous more moderate to severe turbulence reports continued into April 15th.

7.0 In-Flight Weather Advisories

The NWS issues in-flight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). In-flight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions, which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot and/or flight dispatcher to evaluate on the basis of experience and the operational limits of the aircraft. The following advisories were issued surrounding the period.

7.1 SIGMETs

The NWS did not have any Convective SIGMET[7]s (WST) or Severe Weather Forecast Alerts (AWW's) for any thunderstorms over Colorado or the route of flight surrounding the period. A

[7] Significant Meteorological Information (SIGMET) - is a weather advisory that contains meteorological information concerning the safety of all aircraft.

previous non-convective SIGMET was issued at 1915 MDT over New Mexico and the Texas Panhandle for a widespread area of visibility below 3 miles in blowing dust below 15,000 feet. The advisory was cancelled at 2048 MDT prior to the accident. The advisory was as follows:

WSUS05 KKCI 150115 2012106 0114
WS5W
-SLCW WS 150115
SIGMET WHISKEY 3 VALID UNTIL 150515
NM TX
FROM 30E TCC TO INK TO 40W MRF TO ELP TO 30E TCC
OCNL VIS BLW 3SM IN WDSPR DS BLW 150. CONDS ENDG 0515Z.
.

WSUS05 KKCI 150248 2012106 0248
WS5W
-SLCW WS 150248
CANCEL SIGMET WHISKEY 3.

7.2 AIRMETs

The NWS issued the following AIRMET[8]s for turbulence and icing conditions of concern to all operators over the region:

WAUS45 KKCI 150245 2012106 0245
WA5T
-SLCT WA 150245
AIRMET TANGO FOR TURB AND STG SFC WNDS VALID UNTIL 150900
.
AIRMET TURB...UT CO AZ NM
FROM 40E SNY TO 50W LBL TO 30ESE TBE TO INK TO ELP TO 50S TUS TO
BZA TO EED TO 60WSW BCE TO 20ESE CYS TO 40E SNY
MOD TURB BLW FL180. CONDS CONTG BYD 09Z THRU 15Z.
.
AIRMET TURB...ID WY NV UT CO AZ NM CA AND CSTL WTRS
FROM 70SW RAP TO 40ESE CYS TO 40ESE SNY TO 50W LBL TO 30ESE TBE
TO INK TO ELP TO 50S TUS TO BZA TO 20S MZB TO 50W RZS TO 50SW
LKV TO 60WSW TWF TO 70SW RAP
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 09Z THRU 15Z.
.
OTLK VALID 0900-1500Z
AREA 1...TURB WY CO AZ NM
BOUNDED BY 20ENE SHR-70NW RAP-50SSW BFF-40E SNY-50W LBL-30ESE
TBE-INK-ELP-50SSW SSO-30SSE OCS-20ENE SHR
MOD TURB BLW FL180. CONDS CONTG THRU 15Z.
.
AREA 2...STG SFC WNDS WY CO

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[8] Airmen's Meteorological Information (AIRMET) – is a concise description of the occurrence or expected occurrence of specified en route weather phenomena which may affect the safety of aircraft operations, but at intensities lower than those which require the issuance of a SIGMET. AIRMETs are intended for dissemination to all pilots in flight to enhance safety and are of particular concern to operators and pilots of aircraft sensitive to the phenomena described and to pilots without instrument ratings.

BOUNDED BY 70SW RAP-50SSW BFF-40E SNY-30NNW GLD-40SE DEN-30NNE LAR-70SW RAP
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 12-15Z.
CONDS CONTG THRU 15Z.

.
WAUS45 KKCI 150245 2012106 0236
WA5Z
-SLCZ WA 150245
AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 150900
.
AIRMET ICE...ID MT
FROM 70WSW YXC TO 50SE YQL TO 40NNW GTF TO 60SSE MLP TO 30ESE GEG
TO 70WSW YXC
MOD ICE BTN FRZLVL AND 150. FRZLVL SFC-060. CONDS DVLPG 06-09Z.
CONDS CONTG BYD 09Z THRU 15Z.
.
AIRMET ICE...WY NV UT AZ NM
FROM 20E BPI TO 40W RSK TO 60SE SJN TO 60ENE PHX TO 50S PGS TO
20S LAS TO 20W OAL TO 40WSW BAM TO 50S BVL TO 20E BPI
MOD ICE BTN FRZLVL AND 160. FRZLVL SFC-060. CONDS CONTG BYD 09Z ENDG 12-15Z.
.
AIRMET ICE...MT WY CO
FROM 50SW ISN TO 50SSW BFF TO 50E SNY TO 40NNW GLD TO 30SW TBE TO
50S DVC TO 20E BPI TO 60W BIL TO 50SW ISN
MOD ICE BTN FRZLVL AND FL200. FRZLVL 060-080. CONDS CONTG BYD 09Z THRU 15Z.
.
OTLK VALID 0900-1500Z...ICE ID MT
BOUNDED BY 40NE HVR-40SE LWT-20NE LKT-30SE GEG-60SW YXC-40NE HVR
MOD ICE BLW 150. CONDS CONTG THRU 15Z.
.
FRZLVL...RANGING FROM SFC-090 ACRS AREA
SFC ALG 40SW YXC-40E FCA-40WNW GTF-30NW HVR-50SSE YXH
SFC ALG 50ESE LKV-20WSW OAL-40ESE ILC-20ENE SSO-50E TCS-30WNW
TBE-70SSW LWT
SFC BOUNDED BY 20S TWF-40WSW MLD-30S MLD-50SSE MLD-30E SLC-
30W MTU-50SW MTU-50NNW HVE-50SE DTA-50S DTA-40W DTA-50ENE
ELY-50S BVL-30WSW BVL-50NW BVL-30S TWF-20S TWF
040 ALG 70E FCA-30SW HVR-70S YYN
080 ALG 70W INK-50WNW INK-40SSW TXO
080 ALG 50W LBL-60SE LAA-30WSW GLD-40E AKO

The NWS had issued AIRMET Tango at 2045 MDT which was valid until 0300 MDT on April 15, 2012 for moderate turbulence between 18,000 to 41,000 feet which extended over the southwest United States and included the entire route of flight and the accident site. Other AIRMETs were current for turbulence below 18,000 feet and for low-level icing conditions. AIRMETs require weather phenomena to extend over 3,000 square miles.

7.3 Center Weather Advisories

The Denver (KZDV) Center Weather Service Unit (CWSU) was closed at the time of the turbulence event and no Center Weather Advisories (CWA's) were in effect for any hazardous weather for the Denver area during the period. A Meteorological Impact Statement (MIS) for

general weather and air traffic control planning was issued prior to their closure for the evening and was as follows:

FAUS20 KZDV 142338 2012105 2338
ZDV MIS 03 VALID 150000-150400
...FOR ATC PLANNING PURPOSES ONLY...
D01 FL180 WINDS: S-SE 15-35 KT.
D01 VISUALS/ILS OPS: ILS APCHS.
D01 TS WRN HLF: WDLY SCT MOVG N-NNW 15-20KT.
D01 TS ERN HLF: SCT MOVG NNE-N 20KT.
REMARKS: SMALL HAIL POSSIBLE.

There was no mention of turbulence or mountain wave conditions over the area by the Denver CWSU.

8.0 Weather Document

The flight crew received their primary preflight weather briefing information through the US Airways computer system and from their adverse weather phenomena and reporting system in the form of a weather document, which includes a review of major map features, company issued in-flight advisories or SIGMECs[9] through their Enhanced Weather Information System (EWINS), and NWS Convective SIGMETs. US Airways EWINS is an FAA approved proprietary system for tracking, evaluating, reporting, and forecasting the presence, or absence of adverse weather phenomena. EWINS is authorized to produce flight movement forecasts, adverse weather phenomena forecasts, and other meteorological advisories.

The flight plan and weather document was issued at 2230 MDT on April 14, 2012 for US Airways flight 496 from Phoenix to Denver with Albuquerque listed as the alternate airport. The weather document included a section for major map features, significant clear air turbulence, significant mountain wave activity, and thunderstorms, as well as the current and forecast conditions and notices to airmen for the route. The significant clear air turbulence potential section indicated that occasional moderate turbulence was expected over the upper Mississippi Valley and the eastern portions of the northern plains from FL300[10] to FL380, with another area of moderate turbulence was possible over the central plains and the southern Rocky Mountains from FL250 to FL350. The weather document also included a section for significant mountain wave activity and stated that occasional moderate turbulence was expected over northeast New Mexico between FL250 to FL350. The significant storms section noted a developing storm system over the plain states with strong thunderstorms, and with snow showers over the northern and central Rockies. No company SIGMEC advisories were current at the time of issuance.

The weather document also included the current weather conditions at the departure, destination, and alternate airport were included as well as several terminal forecasts from the

[9] SIGMEC – the airlines FAA approved Enhanced Weather Information System (EWINS) issued adverse weather advisory similar to the NWS SIGMETs and AIRMETs.

[10] Flight Level (FL) – altitude in hundreds of feet.

companies EWINS provider and the NWS, notices to airmen (NOTAMs), and the current Convective SIGMETs for the central region (which were not applicable for the route in this case).

The flight data history from the flight indicated that the flight contacted flight dispatch through ACARS at 2350 MDT (0550Z) notifying them that the flight had encountered severe mountain turbulence at 32,000 feet and had possible injuries. At 0004 MDT an ACARS message indicated that the flight was declaring a medical emergency. Dispatch advised that paramedics had been notified.

9.0 Graphical Turbulence Guidance (GTG)

The NWS Graphical Turbulence Guidance product, version 2 (GTG2), is an automatically-generated turbulence forecast product that provides a forecast of mid- and upper-level clear air turbulence (CAT) potential from 10,000 to 45,000 feet. The current model however, does not include an analysis of mountain wave activity. The GTG2 is a supplementary weather product that may be used for enhanced situational awareness and supplements AIRMETs and SIGMETs by identifying areas of turbulence. If utilized, a supplementary weather product must only be used in conjunction with one or more primary weather product (as reference to Aeronautical Information Manual section 7-1-3). It is authorized for operational use by meteorologists and dispatchers.

Figures 12 and 13 are the GTG2 analysis for 31,000 and 33,000 feet respectively at 2100 MDT (0300Z) or prior to flight 496's departure from Phoenix, Arizona. The GTG2 analysis at 31,000 feet depicted light turbulence over most of Colorado including the accident site with moderate or greater turbulence over the northeast section of Colorado into southwest Wyoming, Nebraska, South Dakota, and portions of Kansas. The forecast for 33,000 feet depicted light turbulence potential over Colorado and relatively smooth conditions for the majority of the route of flight.

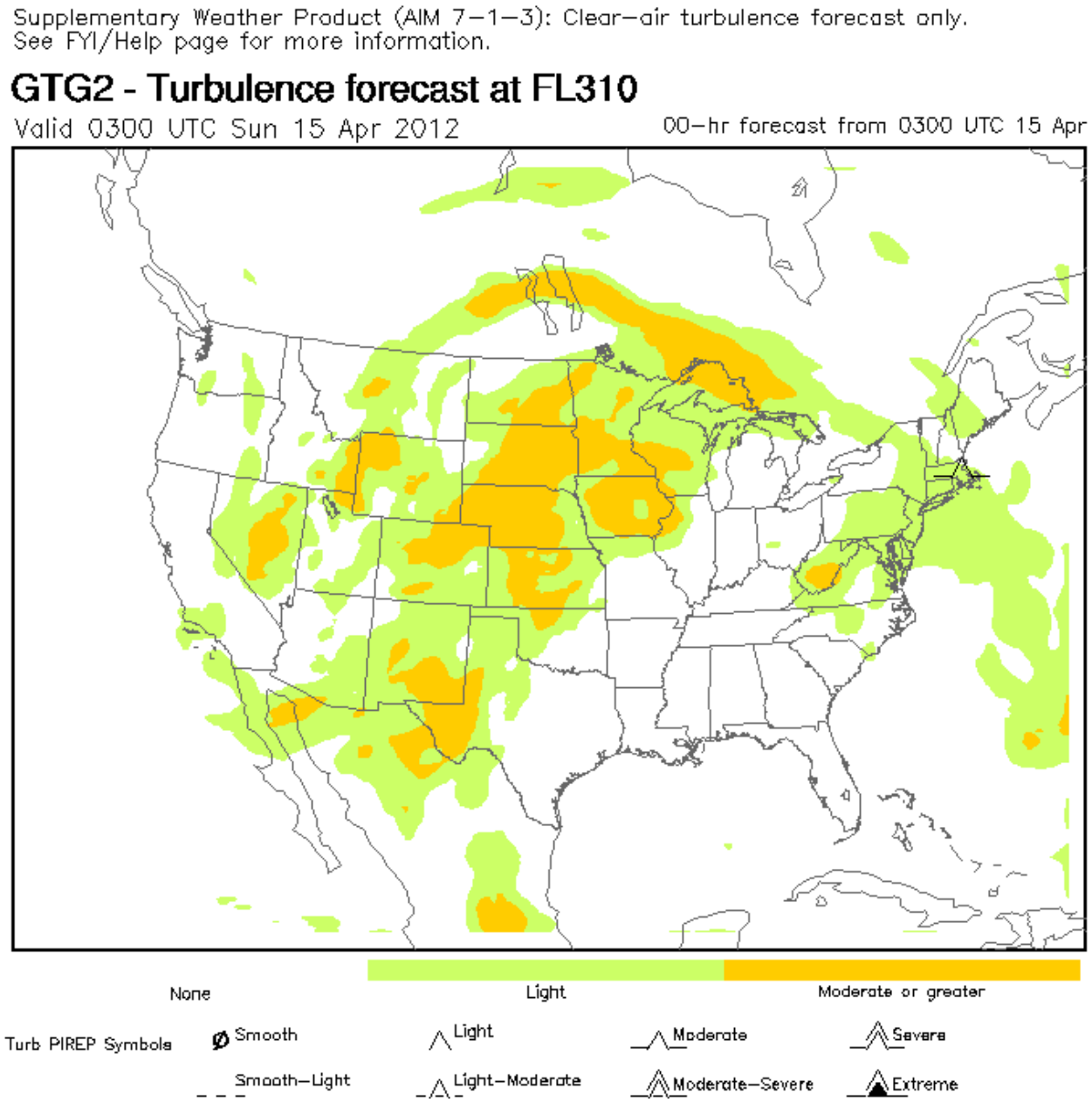

Figure 12 - GTG2 analysis for 31,000 feet at 2100 MDT

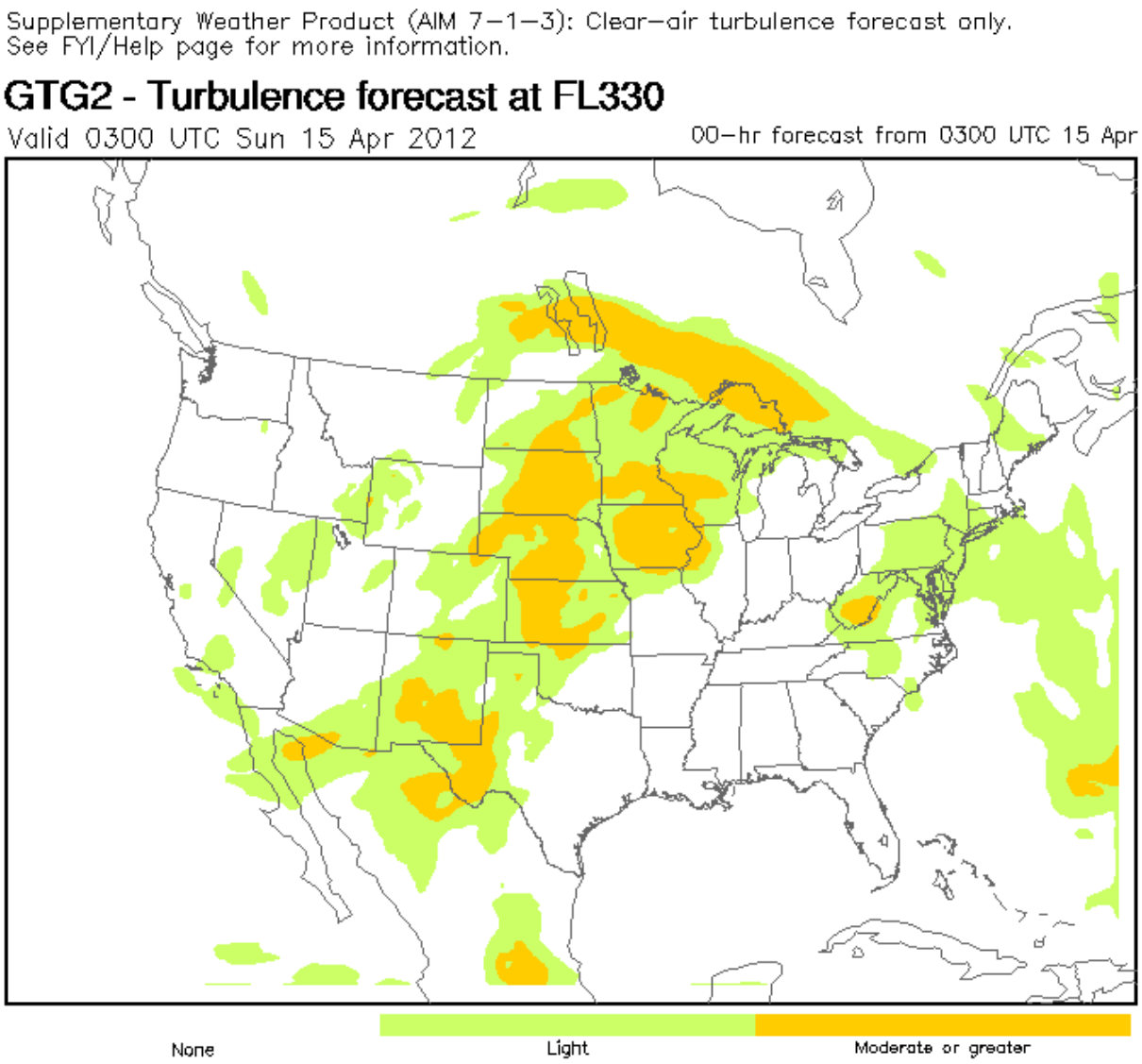

Figure 13 - GTG2 analysis for 33,000 feet at 2100 MDT

10.0 Flight Data Recorder (FDR)

According to US Airways the maximum vertical acceleration on the Flight Data Recorder (FDR) was +2.6 g's and the minimum was -0.55 g during the turbulence encounter. The ICAO standard quantitative measurement of turbulence intensity chart listed below indicates that the turbulence encountered by flight 496 would be classified as extreme.

Turbulence Intensity	Airspeed Fluctuation (KTS)	Vertical Acceration (G)	Derived Gust (FPM)
Light	5-14.9	0.20 – 0.49	300 – 1,199
Moderate	15 – 24.9	0.50 – 0.99	1,200 – 2,099
Severe	$\geq$ 25	1.0 – 1.99	2,100 – 2,999
Extreme		$\geq$ 2.0	$\geq$ 3,000

11.0 Reference Material

The FAA Advisory Circular AC-6A "Aviation Weather" describes basic structure of the atmosphere, jet streams, and the formation of mountain wave activity. In the advisory circular it is stated that mountain wave turbulence is most common within a 5,000 feet layer near the tropopause. Additional references on turbulence mitigation are found in AC 00-30B "Atmospheric Turbulence Avoidance" dated September 9, 1997, which provides common avoidance rules for turbulence. Several of the rules from the advisory circular are as follows:

- Jet streams stronger than 110 knots have potential for generating significant turbulence near the sloping tropopause above the core, in the jet stream front below the core, and on the low-pressure side of the core.

- Windshear and its accompanying CAT in jet streams is more intense above and to the lee of mountain wave ranges. CAT should be anticipated whenever the flight path traverses a strong jet stream in the vicinity of mountainous terrain.

- Both vertical and horizontal windshear are greatly intensified in mountain wave conditions.

- On charts for standard isobaric surfaces, such as 300-hPa, if 20-knot isotachs are spaced closer together than 150 nautical miles (2 1/2° latitude), there is sufficient horizontal shear for CAT. This area is normally on the poleward or northern side (low-pressure) of the jet stream axis.

- Turbulence is also related to vertical shear. Vertical shears of greater than 5 knots per 1,000 feet are likely to produce turbulence.

Mountain wave activity basically requires three requirements for a standing wave to develop:

1. Wind flow that is within 30º of perpendicular to the ridge, with velocities of 20 knots or more at mountain top levels.

2. A wind profile which shows an increase in wind velocity with altitude and a strong steady flow at higher levels up to the tropopause.

3. An inversion or stable layer somewhere below 15,000 feet.

Intensities of any given wave are determined by mountain height, degree of slope and the strength of the wind flow.

12.0 Astronomical Data

The United States Naval Observatory website provided the following astronomical data for April 14, 2012 for the Denver, Colorado area:

Sun	
Beginning of civil twilight	0555 MDT
Sunrise	0623 MDT
Sunset	1938 MDT
End of civil twilight	2006 MDT

Moon	
Moonrise	0247 MDT
Moonset	1335 MDT
Moonrise	0320 MDT April 15, 2012
Phase of Moon	Waning crescent

At the time of the accident both the Sun and the Moon were more than 15° below the horizon and provided no illumination.

F. LIST OF ATTACHMENTS

Attachment 1: Flight plan and weather document

Submitted by:

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July 2, 2012