



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

December 19, 2017

Group Chairman's Factual Report

METEOROLOGY

WPR17FA213

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A. ACCIDENT

Location: Perkinsville, Arizona
Date: September 22, 2017
Time: about 1634 mountain standard time
or 2334 coordinated universal time (UTC)
Airplane: Cessna 172L; registration: N7070Q

B. METEOROLOGIST

Don Eick
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On September 22, 2017, about 1634 mountain standard time, a Cessna 172L, N7070Q, collided with mountainous terrain near Perkinsville, Arizona. The private pilot and passenger sustained fatal injuries and the airplane was destroyed by post impact fire. The airplane was registered to Peach Flyers LLC., and operated by the pilot under the provisions of 14 *Code of Federal Regulations* Part 91 as a personal flight. The local flight departed Ernest A. Love Field Airport, Prescott, Arizona, at 1621. Visual meteorological conditions prevailed and no flight plan had been filed.

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 Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are mountain standard time (MST) based upon the 24 hour clock, local time is +7 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 airplane was found inverted, with the accident site located on the north face of Verde Canyon at latitude 34.8830° N and longitude 112.1563° W at an elevation of about 4,290 feet (ft), or about 200 ft below the canyon top.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

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

1.1 Surface Analysis Chart

The southwest section of the NWS WPC Surface Analysis Chart for 1700 MST (0000Z on September 23, 2017) is included as figure 1 with the approximate accident site marked by a red star. The chart depicted a low pressure system at 998-hectopascals (hPa)¹ over Utah along a stationary front, which extended southward across Utah into eastern Arizona and northern Mexico. A second thermal low² pressure at 1003-hPa was located over the California, Nevada and Arizona borders. The accident site was located between the thermal low to the west and the stationary front to the east.

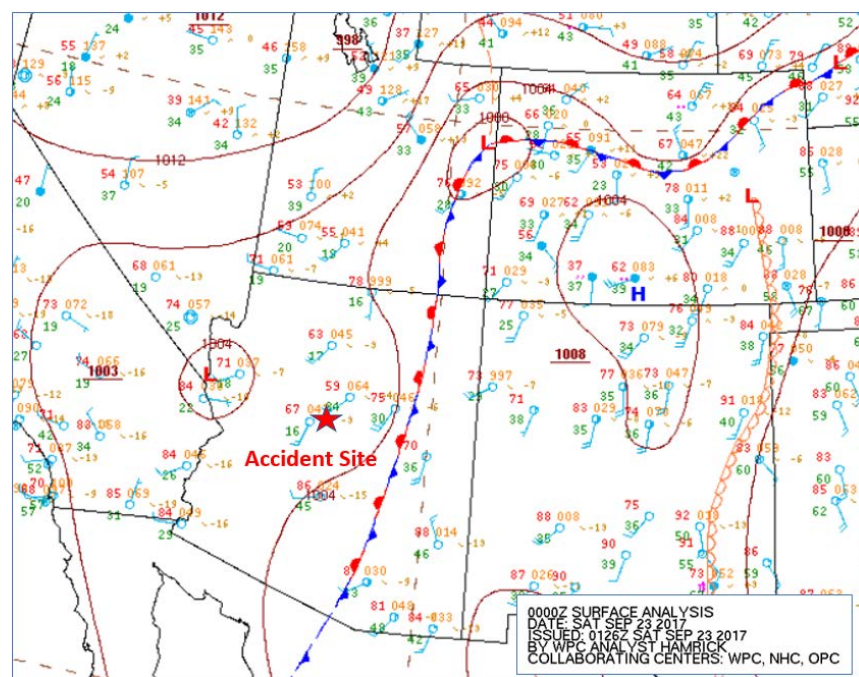


Figure 1 - Southwest section of the Surface Analysis Chart for 1700 MST

¹ Hectopascals (hPa) is the new standard term for reporting sea level pressure and is interchangeable with the old term millibars (mb) with the same units. Standard sea level pressure is 1013.25-hPa at 15° Celsius (C).

² Thermal lows are non-frontal low pressure areas that occur over the continental subtropics during the warm season, due to intense heating. They are typically slow moving or near stationary, and have a weak circulation center and are strongest near the surface.

The station models surrounding the site depicted southerly winds of 15 to 20 knots, clear skies, with no significant weather reported. The station model for Prescott, located about 20 miles southwest of the accident site indicated a wind from the south-southwest at 15 knots, clear skies below 12,000 ft above ground level (agl), a temperature of 67° Fahrenheit (F), a dew point temperature of 16° F, and a sea level pressure of 1004.7-hPa.

A review of the National Composite Weather Radar imagery from the NCEI surrounding the period was reviewed and depicted no significant meteorological echoes over the region and therefore was not reproduced for this report.

2.0 Surface Observations

The surrounding area was documented utilizing the official NWS Meteorological Aerodrome Reports (METARs) and special reports (SPECI). Cloud heights are reported agl in the following section. The magnetic variation across the region was estimated at 13° E based on the latest sectional chart.

2.1 Prescott, Arizona

The accident airplane departed from Ernest A. Love Field (KPRC), Prescott, AZ, which was located 19 miles southwest of the accident site at an elevation of 5,045 ft msl. The airport had an Automated Surface Observation System (ASOS) and was augmented by Air Traffic Control Tower Controllers during normal hours from 0600 through 2200 MST. The following conditions were observed at approximately the time of the accident:

Prescott weather observation at 1653 MST (2353Z), wind from 200° at 15 knots gusting to 22 knots, visibility 10 miles, sky clear below 12,000 ft, temperature 19° C, dew point -9° C, altimeter 29.86 inches of mercury (Hg). Remarks: automated observation system with a precipitation discriminator, sea level pressure 1004.7-hPa, temperature 19.4° C, dew point -8.9° C, 6-hour maximum temperature 21.1° C, 6-hour minimum temperature 18.9° C, 3-hour pressure tendency fallen 0.3-hPa.

The raw observations in standard code from 1152 through 1853 MST were as follows:

METAR KPRC 221853Z 18016G23KT 10SM CLR 20/02 A2990 RMK AO2 PK WND 16026/1837 SLP057
T02000022=
METAR KPRC 221953Z 19012G22KT 10SM CLR 21/M01 A2989 RMK AO2 SLP053 T02061011=
METAR KPRC 222053Z 18014G26KT 10SM CLR 21/M04 A2987 RMK AO2 PK WND 19027/2034 SLP048
T02061039 58009=
METAR KPRC 222153Z 20017G27KT 10SM CLR 21/M07 A2987 RMK AO2 PK WND 19027/2150 SLP046
T02111067=
METAR KPRC 222253Z 20013G21KT 10SM CLR 21/M08 A2986 RMK AO2 SLP045 T02061078=
Accident 2334Z
METAR KPRC 222353Z 20015G22KT 10SM CLR 19/M09 A2986 RMK AO2 SLP047 T01941089 10211
20189 56003=
METAR KPRC 230053Z 21013KT 10SM CLR 18/M11 A2986 RMK AO2 SLP052 T01781111=
METAR KPRC 230153Z 20007KT 10SM CLR 16/M09 A2986 RMK AO2 SLP053 T01611089=

At the time the accident airplane departed KPRC the temperature was reported at 21° C, dew point temperature -9° C, with an altimeter setting of 29.86 inches of Hg, which indicated a density altitude of 7,008 ft.

2.2 Sedona, Arizona

Sedona Airport (KSEZ), Sedona, AZ, was located approximately 18 miles east of the accident site at an elevation of 4,830 ft msl. The airport had an un-augmented Automated Weather Observation System (AWOS) and issued an observation every 20-minutes. The Chart Supplement for the airport warns pilots that turbulence may be experienced in the vicinity of the airport. The following conditions were reported about the time of the accident:

Sedona Airport weather observation at 1635 MST (2335Z), automated observation system, wind from 210° at 16 knots gusting to 24 knots, visibility 10 miles or more, skies clear below 12,000 ft, temperature 21° C, dew point 3° C, altimeter 29.84 inches of Hg. Remarks: automated observation system with a precipitation discriminator.

The raw observations surrounding the period were as follows:

METAR KSEZ 221955Z AUTO 20013G25KT 10SM BKN050 BKN060 BKN075 22/06 A2988 RMK AO2=
METAR KSEZ 222015Z AUTO 18016G27KT 10SM SCT050 BKN065 22/05 A2987 RMK AO2=
METAR KSEZ 222035Z AUTO 21014G28KT 10SM SCT060 SCT070 22/05 A2987 RMK AO2=
METAR KSEZ 222055Z AUTO 21014G28KT 160V230 10SM SCT060 SCT080 22/03 A2987 RMK AO2=
METAR KSEZ 222115Z AUTO 19014G25KT 160V220 10SM SCT060 SCT080 22/03 A2986 RMK AO2=
METAR KSEZ 222135Z AUTO 22015G23KT 180V260 10SM SCT060 23/03 A2985 RMK AO2=
METAR KSEZ 222155Z AUTO 20015G25KT 10SM CLR 22/03 A2985 RMK AO2=
METAR KSEZ 222215Z AUTO 20017G26KT 10SM CLR 22/02 A2985 RMK AO2=
METAR KSEZ 222235Z AUTO 19015G29KT 160V220 10SM CLR 22/02 A2985 RMK AO2=
METAR KSEZ 222255Z AUTO 20013G23KT 10SM CLR 22/03 A2985 RMK AO2=
METAR KSEZ 222315Z AUTO 21014G24KT 10SM CLR 22/02 A2984 RMK AO2=
Accident 2334Z
METAR KSEZ 222335Z AUTO 21016G24KT 10SM CLR 21/03 A2984 RMK AO2=
METAR KSEZ 222355Z AUTO 20010G21KT 10SM CLR 21/03 A2985 RMK AO2=
METAR KSEZ 230015Z AUTO 22012G21KT 10SM CLR 21/02 A2985 RMK AO2=
METAR KSEZ 230035Z AUTO 21014G21KT 10SM CLR 20/01 A2985 RMK AO2=
METAR KSEZ 230055Z AUTO 20013G20KT 10SM CLR 20/01 A2985 RMK AO2=
METAR KSEZ 230115Z AUTO 21010G18KT 10SM CLR 19/01 A2985 RMK AO2=
METAR KSEZ 230135Z AUTO 20009G17KT 10SM CLR 18/01 A2985 RMK AO2=

2.3 Williams, Arizona

H.A. Clark Memorial Airport (KCMR), in Williams, AZ, was the next closest field located 24 miles north of the accident site at an elevation of 6,691 ft msl. The airport had an AWOS and reported every 20-minutes. The following conditions surrounding the period:

Clark Memorial Airport weather observation at 1635 MST (2335Z), automated observation, wind from 190° at 19 knots gusting to 28 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 17° C, dew point -9° C, altimeter 29.90 inches of Hg. Remarks: automated observation system with a precipitation discriminator.

The raw observations reported surrounding the period were as follows:

KCMR 221955Z AUTO 20018G31KT 10SM CLR 18/M01 A2993 RMK AO2
KCMR 222015Z AUTO 21018G29KT 10SM CLR 18/M01 A2992 RMK AO2
KCMR 222035Z AUTO 19016G31KT 10SM CLR 18/M01 A2991 RMK AO2
KCMR 222055Z AUTO 21018G28KT 10SM CLR 18/M03 A2991 RMK AO2
KCMR 222115Z AUTO 20015G31KT 10SM CLR 18/M05 A2991 RMK AO2
KCMR 222135Z AUTO 19021G28KT 10SM CLR 18/M05 A2990 RMK AO2
KCMR 222155Z AUTO 19017G27KT 10SM CLR 18/M06 A2990 RMK AO2
KCMR 222215Z AUTO 20017G29KT 10SM CLR 18/M08 A2990 RMK AO2
KCMR 222235Z AUTO 20020G28KT 10SM CLR 18/M11 A2990 RMK AO2
KCMR 222255Z AUTO 21016G26KT 10SM CLR 18/M09 A2990 RMK AO2
KCMR 222315Z AUTO 20020G26KT 10SM CLR 17/M09 A2990 RMK AO2
Accident 2334Z
KCMR 222335Z AUTO 19019G28KT 10SM CLR 17/M09 A2990 RMK AO2
KCMR 222355Z AUTO 20017G24KT 10SM CLR 17/M09 A2991 RMK AO2
KCMR 230015Z AUTO 18018G25KT 10SM CLR 16/M10 A2991 RMK AO2
KCMR 230035Z AUTO 20016G24KT 10SM CLR 15/M10 A2991 RMK AO2

2.4 Flagstaff, Arizona

Flagstaff Pullman Airport (KFLG), Flagstaff, AZ, was located 28 miles northeast of the accident site at an elevation of 7,014 ft msl. The airport had an AWOS which was augmented by Air Traffic Controllers from 0600 through 2100 MST. The following conditions were reported at the about the time of the accident:

Flagstaff Pullman Airport weather observation at 1657 MST (2357Z), wind from 230° at 16 knots gusting to 29 knots, visibility 10 miles or more, sky clear below 12,000 ft, temperature 15° C, dew point 1° C, altimeter 29.94 inches of Hg. Remarks: automated observation system with a precipitation discriminator, peak wind from 220° at 33 knots occurred at 1612 MST, sea level pressure 1006.4-hPa, 6-hour precipitation 0.02 inches, temperature 15.0° C, dew point 1.1° C, 6-hour maximum temperature 16.7° C, 6-hour minimum temperature 10.6° C, 3-hour pressure tendency fallen 0.04-hPa.

The Chart Supplementary for the airport warns pilots that wind shear and turbulence can be expected at both ends of runway 03/21 with surface winds in excess of 10 knots. The raw observations surrounding the period were as follows:

KFLG 221757Z 21020G29KT 10SM SCT030 SCT045 BKN050 13/06 A2998 RMK AO2 PK WND 21033/1702 \ SLP067 T01330056 10144 20067 51006
KFLG 221857Z 20018G26KT 10SM FEW025 SCT032 BKN055 13/08 A2997 RMK AO2 PK WND 20029/1817 RAB23E40 SLP070 P0002 T01280083
KFLG 221957Z 23016G28KT 10SM SCT039 15/05 A2996 RMK AO2 PK WND 19030/1929 SLP063 T01500050
KFLG 222057Z 23023G31KT 10SM FEW055 16/02 A2995 RMK AO2 PK WND 22037/2029 SLP059 60002 T01610022 58006
KFLG 222157Z 20018G27KT 10SM SCT055 16/01 A2994 RMK AO2 PK WND 22035/2102 SLP055 T01610006
KFLG 222257Z 22020G28KT 10SM SCT055 16/M01 A2994 RMK AO2 PK WND 20031/2221 SLP057 T01611011
Accident 2334Z
KFLG 222357Z 23016G29KT 10SM CLR 15/01 A2994 RMK AO2 PK WND 22033/2312 SLP064 60002

T01500011 10167 20106 56004
 KFLG 230057Z 22014KT 10SM CLR 13/02 A2994 RMK AO2 PK WND 23026/0028 SLP071 T01280017
 KFLG 230157Z 22012KT 10SM CLR 11/01 A2994 RMK AO2 SLP068 T01110006

2.5 METAR display

A display of the METAR observations at 1630 MST was obtained from the NWS Aviation Weather Center's (AWC) website and is included as figure 2. The display depicted the METAR observations as a station plot similar to the surface analysis chart, and with all the ASOS/AWOS reporting sites in the area.

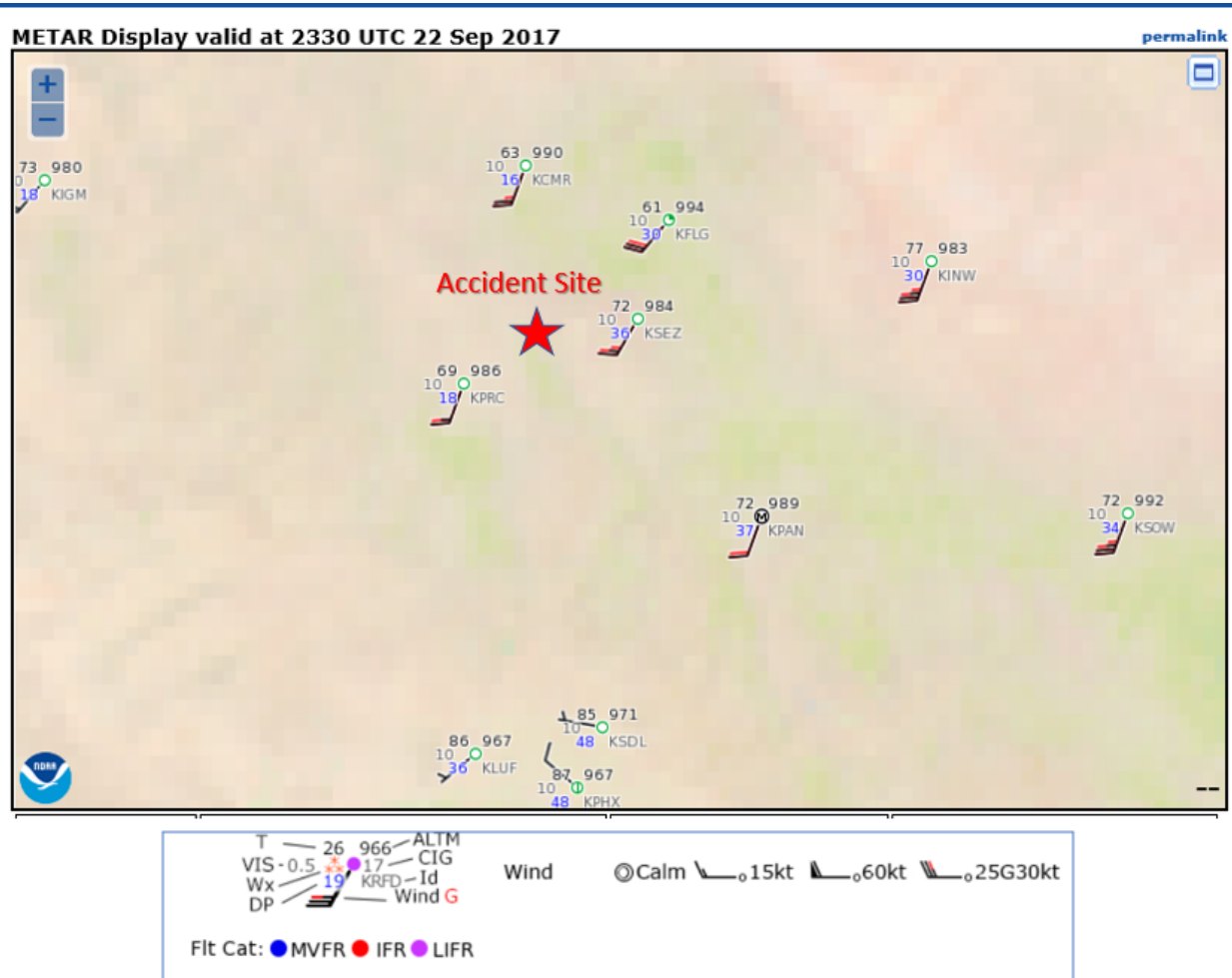


Figure 2 - METAR display at 1630 MST

The METAR display depicted southerly winds from 15 to 25 knots across the region, visibility 10 miles or more, with clear to scattered clouds over the region.

3.0 Sounding

A High Resolution Rapid Refresh (HRRR) numerical model was obtained from archive data from the NOAA Air Resource Laboratory database for the approximate location of the accident at

1700 MST (0000Z on September 23, 2017) and is included as figure 3. The model sounding was plotted on a standard Skew-T log P diagram³ from the surface to 500-hPa or about 18,000 ft msl utilizing RAOB software⁴.

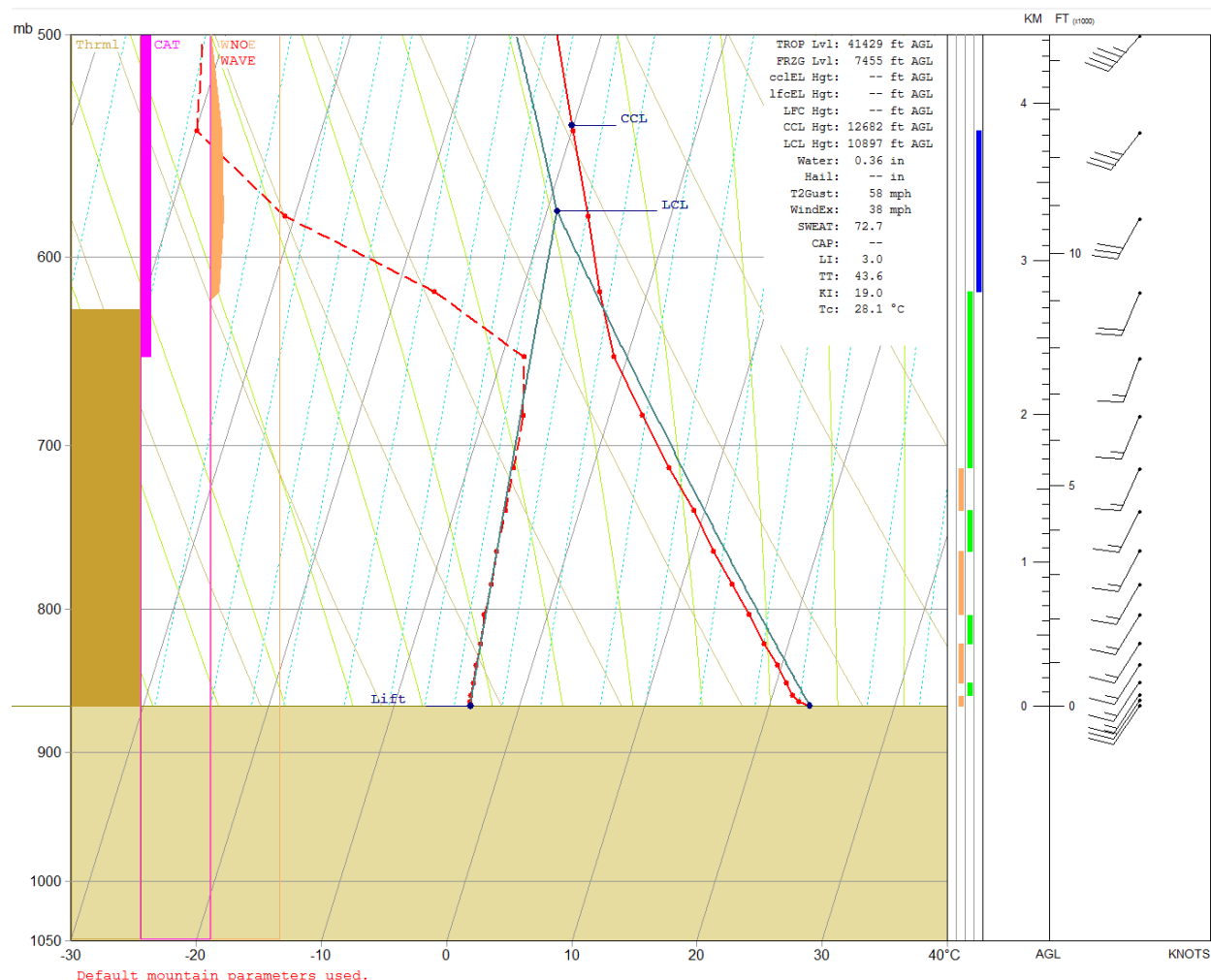


Figure 3 - HRRR model sounding over the accident site at 1700 MST

The HRRR numerical model depicted a surface temperature of 23.2° C (73.8° F), a dew point of -3.9° C (25° F), with a relative humidity of 16%, a density altitude of 6,255 ft, and a surface wind from 210° at 11 knots. The sounding supported strong thermals from the surface to 9,000 ft. The freezing level was at 11,600 ft. The lifted condensation level and convective condensation level were found at about 12,700 ft agl (16,700 ft msl) and indicated the base of any clouds if sufficient moisture was present.

³ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

⁴ RAOB software – The complete Rawinsonde Observation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

The wind profile indicated south-southwesterly winds from 10 to 20 knots through 10,000 ft, with the mean wind from 215° at 35 knots, and the maximum wind identified at 34,000 ft from 220° at 112 knots. At the accident airplanes last observed altitude at 4,550 ft, the conditions indicated a wind from 210° at 14 knots with a temperature of 21° C, and a density altitude near 6,343 ft. No strong vertical wind shears were noted in the model sounding to support any significant turbulence below 10,000 ft, and except for a shallow layer between 18,000 to 23,000 ft of potential moderate turbulence, only light turbulence was indicated at higher altitudes. The sounding data and potential winds and turbulence are included in figure 4 of the derived sounding parameters and include height (ft msl), pressure, temperature, dew point, relative humidity, wind, and derived clear air turbulence (CAT), low-level wind shear (LLWS), icing, and mountain wave potential through 18,000 ft.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x---W---Turb nm fpm max
4183	866	23.2	-3.9	16	212 / 11		LIGHT		
4282	863	22.2	-4.0	17	212 / 13				
4414	859	21.6	-4.1	17	212 / 14				
4713	850	20.8	-4.2	18	212 / 14				
5115	838	19.6	-4.4	19	211 / 14				
5623	823	18.0	-4.6	21	211 / 14				
6276	804	16.1	-5.0	23	210 / 15				
6975	784	14.0	-5.2	26	209 / 15				
7723	763	11.7	-5.6	29	207 / 15				
8633	738	9.1	-5.9	34	206 / 15				
9565	713	6.1	-6.3	41	203 / 15				
10714	683	2.7	-6.8	50	202 / 15				
11980	651	-1.0	-8.2	58	200 / 16	LGT			
13378	617	-3.8	-17.0	35	202 / 22	LGT			3.49 243 LIGHT
14971	580	-6.6	-30.8	13	208 / 28	LGT			4.21 411 LIGHT
16743	541	-9.9	-39.9	7	216 / 34	LGT			5.54 396 LIGHT
18773	499	-13.6	-41.8	7	220 / 45	MDT			7.33 549 LIGHT

Figure 4 - HRRR sounding parameters through 18,000 ft

The NWS Flagstaff 1700 MST sounding (0000Z) which was launched 28 miles northeast of the accident was also reviewed and is included in figure 5. The sounding showed similar temperature and moisture structures, but with a temperature inversion at 6,240 ft agl with strong thermals from the surface to this level. The wind profile showed some significant differences with wind at the surface from 190° at 10 knots gusting to 26 knots, with wind speeds increasing rapidly immediately above the surface to 24 knots within the first 1,000 ft. The observed sounding indicated a moderate potential for LLWS and a moderate and greater potential for turbulence below 1,000 ft agl due to the 14 knots/1,000 ft vertical wind shear. The winds were also stronger with little change in direction with height. The level of maximum wind was at 36,000 ft from 220° at 114 knots similar to the model soundings wind maximum; however, the mean wind was from 220° at 54 knots.

The wind profile also supported the development of mountain wave conditions across the region downwind from higher terrain, with a predominant wave near 5,000 ft capable of producing light to moderate turbulence with updrafts/downdrafts of 927 feet per minute (fpm)

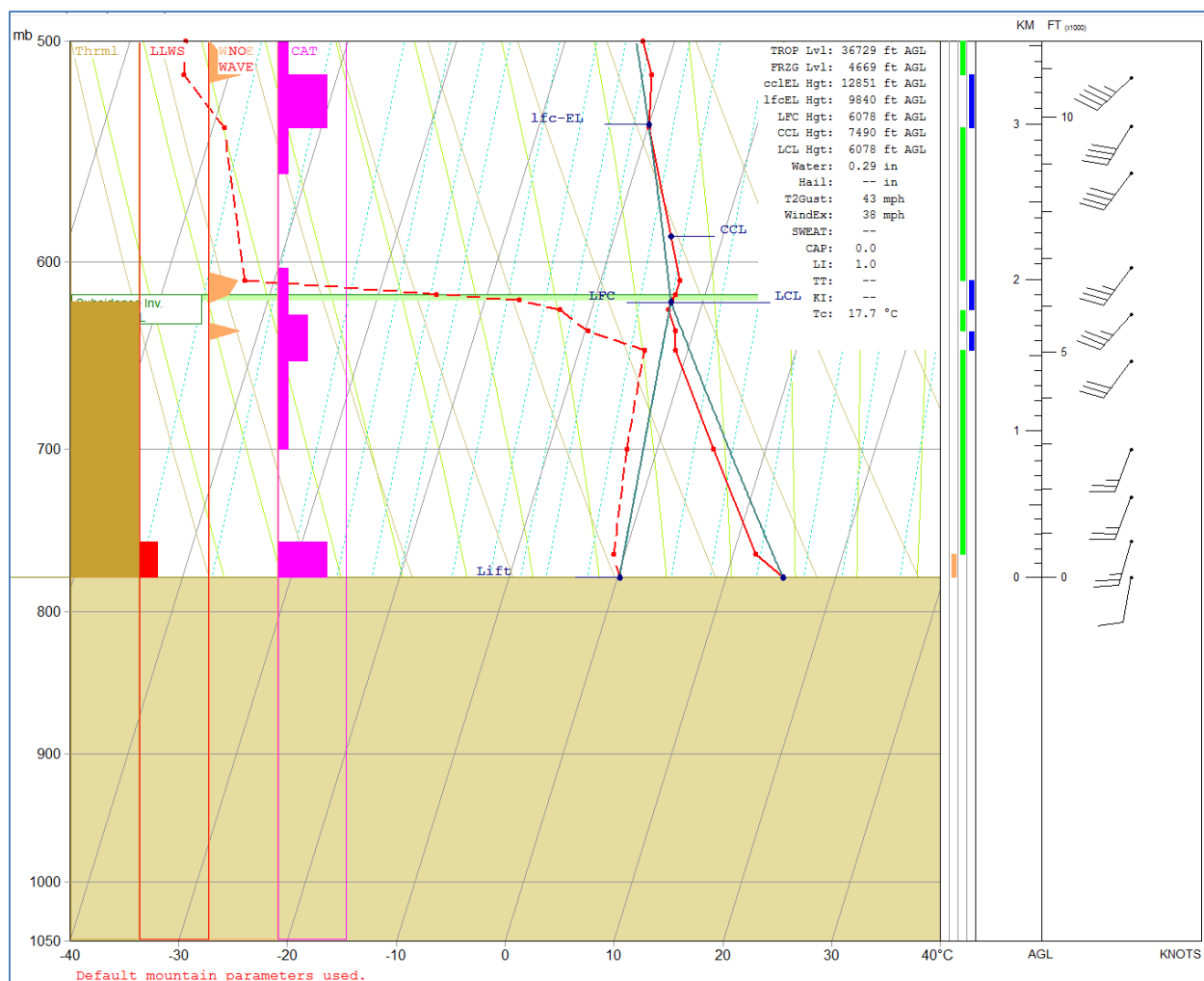


Figure 6 is a table of the KFLG observed sounding parameters of height, pressure, temperature, dew point, relative humidity, wind, and derived CAT, LLWS, icing, and mountain wave potential through 18,000 ft.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x---W---Turb nm fpm max
7192	778	15.2	0.2	36	190 / 10				
7730	763	12.0	-1.0	41		SVR	LIGHT		
8000	755				195 / 24				
9000	728				200 / 24				
10070	700	5.2	-2.8	56	200 / 25	LGT			
12000	651				215 / 28				
12240	645	-1.1	-4.0	81					
12649	635	-1.7	-9.7	54		MDT			5.64 927 LT-MD
13000	627				220 / 34				
13105	624	-2.9	-12.9	46					
13314	619	-2.9	-16.9	33					
13440	616	-2.7	-24.7	17					2.96 525 LT-MD
13737	609	-2.7	-42.7	3		LGT			3.98 779 LT-MD
14000	603				215 / 37				
16000	558				215 / 41	LGT			
16964	537	-9.9	-48.9	2	210 / 41	SVR			
18069	514	-11.1	-54.1	1	225 / 43	LGT			6.12 975 LT-MD

Figure 6 - KFLG observed and derived sounding parameters

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible band imagery were obtained surrounding the time of the accident and reviewed. The infrared long wave imagery (band 4) at a wavelength of 10.7 microns (μm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km. The visible imagery (band 1) at a wavelength of 0.65 μm provided a resolution of 1 km.

The GOES-15 west visible imagery at 2X magnification centered over the area for 1630 MST is included in figure 7 and depicted a line of fair weather cumulus to altocumulus clouds⁵ oriented in streets or bands parallel to the upper level winds. The accident site was located at the southern end of one of the cloud streets, under clear skies. An animation of the visible satellite imagery showed that the clouds moved slowly northward with the environmental winds and slowly dissipated with time; however, the bands remained for several hours from 1445 through 1700 MST with some of the clouds forming, moved northeastward, with additional clouds reforming in the same approximate location about 5 miles northeast of the accident site. Attachment 1 is an animation of the GOES-15 visible imagery from 1445 through 1700 MST with the accident marked.

The GOES-15 infrared image for the same period at 1630 MST (not included) depicted clear skies over the accident site with a temperature of 300° Kelvin or 27° C, which represented the surface or ground temperature over the location, with the cloud top temperature about 5 miles northeast at 288° K or 15° C, which corresponded to cloud tops near 6,600 ft.

⁵ Altocumulus (AC) clouds are a mid-level cloud between 6,500 to 20,000 ft agl and are characterized by globular masses or rolls in layers or patches.

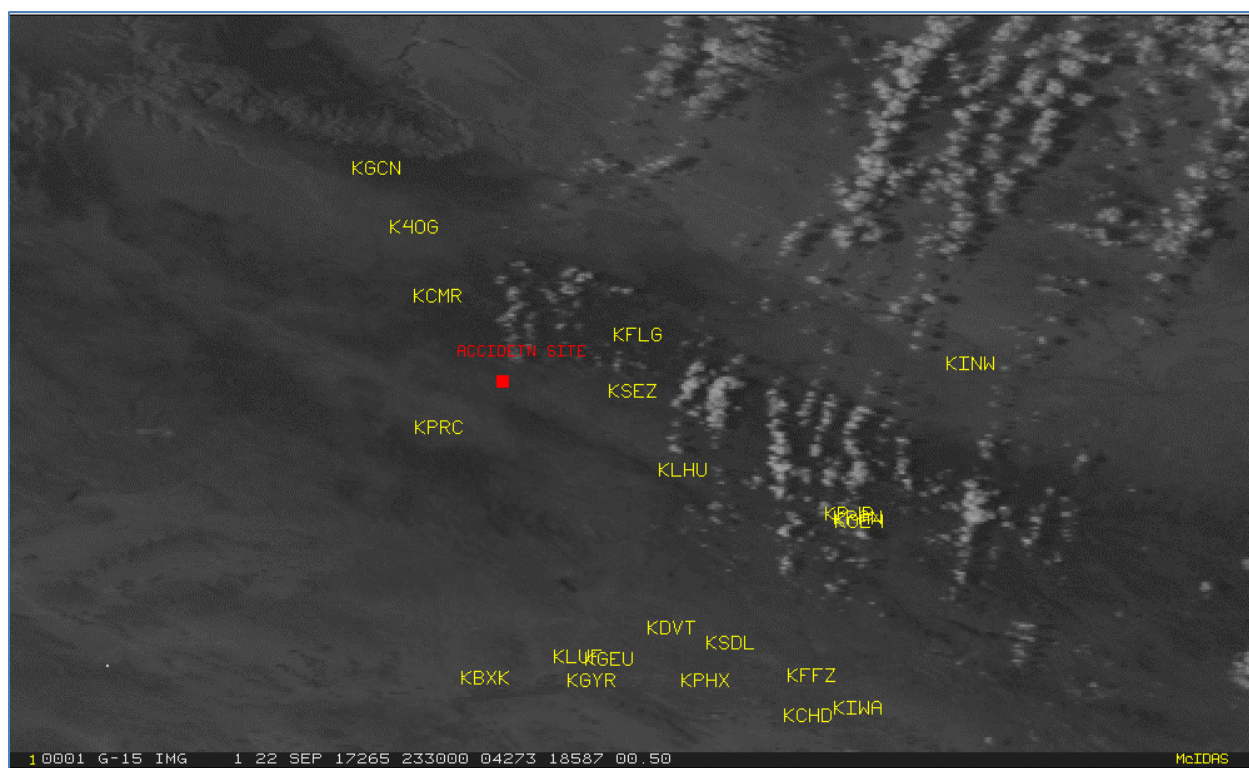


Figure 7 - GOES-15 visible image at 1630 MST

5.0 Pilot Reports

The following pilot reports (PIREPs) were recorded over Arizona between 0830 through 1700 MST on September 22, 2017. The reports are transcribed from standard code and abbreviation, and provided in plain language with time converted from UTC to local time. The reports were as follows:

Prescott routine pilot report (UA); over – 360° azimuth and 15 miles from Drake VORTAC⁶ (DRK); Time – 0836 MST; Altitude – 8,200 ft; Type aircraft – Cessna 182 Skylane single engine airplane; Sky cover – bases of clouds at 8,200 ft.

Phoenix (PHX) routine pilot report (UA); Over – 056° azimuth and 82 miles from Phoenix VORTAC (PXR); Time – 0952 MST; Altitude – 10,000 ft; Type aircraft – Beechcraft Bonanza high performance single engine airplane; Turbulence – moderate chop; Remarks – entered from Albuquerque Air Route Traffic Control Center (ZAB).

Winslow (INW) urgent pilot report (UUA); Over – 115° azimuth and 15 miles from Winslow VORTAC; Time – 1025 MST; Altitude – 14,000 ft; Type aircraft – Cessna 182 Skylane single engine airplane; Turbulence – moderate to severe turbulence between 14,500 and 10,000 ft.

⁶ VORTAC – is a very high frequency (VHF) omnidirectional range (VOR) beacon collocated with a tactical air navigation beacon (TACAN) or distance measuring equipment (DME) that provides azimuth and distance information from the station to for navigational purposes to pilots. Unless otherwise noted, the navigation aid is collocated with the city in the report.

Flagstaff (FLG) routine pilot report (UA); Over – 233° azimuth and 5 miles from FLG VORTAC; Time – 1155 MST; Altitude – 16,000 ft; Type aircraft – Bombardier Challenger 300 business jet; Sky cover – tops 16,000 ft; Temperature – minus 10° C; Icing – light rime icing; Remarks – entered by ZAB.

Prescott (PRC) routine pilot report (UA); Over – DRK VORTAC; Time – 1441 MST; Flight level⁷ – 290 or 29,000 ft; Type aircraft – Being 757 air carrier jet; Turbulence – light to moderate chop; Remarks – entered by ZAB.

Flagstaff (FLG) routine pilot report (UA); Over – 160° azimuth and 30 miles from FLG VORTAC; Time – 1512 MST; Flight level – 34,000 ft; Type aircraft – Boeing 767 heavy air carrier jet; Turbulence – light chop; Remarks – entered by ZAB.

Flagstaff (FLG) routine pilot report (UA); Over – 030° azimuth and 35 miles from FLG VORTAC; Time – 1538 MST; Flight level – 20,000 ft; Type aircraft – Cessna Citation business jet; Turbulence – moderate chop between 20,000 and 18,000 ft; Remarks – entered by ZAB.

Phoenix (PHX) routine pilot report (UA); Over – 030° azimuth and 60 miles from PXR VORTAC; Time – 1601 MST; Flight level – 36,000 ft; Type aircraft – Boeing 737 air carrier jet; Turbulence – none; Remarks – entered by ZAB.

Prescott (PRC) routine pilot report (UA); Over – 063° azimuth and 20 miles from DRK VORTAC; Time – 1601 MST; Flight level – 36,000 ft; Type aircraft – Being 737 air carrier jet; Turbulence – none; Remarks – entered by ZAB.

Flagstaff routine pilot report (UA); Over – FLG VORTAC; Time – 1602 MST; Flight level – 37,000 ft; Type aircraft – Boeing 737 air carrier jet; Turbulence – none; Remarks – entered by ZAB.

Accident 1634 MST, no reports noted after the accident.

Figure 8 is a plot of the pilot reports between 0830 and 1645 MST with the accident site marked by the red star. The report of severe turbulence near Winslow was about 85 miles east of the accident site. Another urgent pilot report was noted near Gallup, New Mexico, and that observation is included below:

Gallup (GUP), New Mexico, urgent pilot report (UUA); Over – 220° azimuth and 8 miles from GUP VORTAC; Time – 0944 MST; Altitude – 10,500 ft, Type aircraft – Cessna 182 Skylane single engine airplane; Turbulence – moderate to severe; Remarks – entered by ZAB.

⁷ Above 18,000 ft altitudes are typically referred to flight levels and given in 1,000 ft as aircraft are flying constant pressure surfaces with their altimeters set to 29.92 inches of Hg or standard sea level pressure.

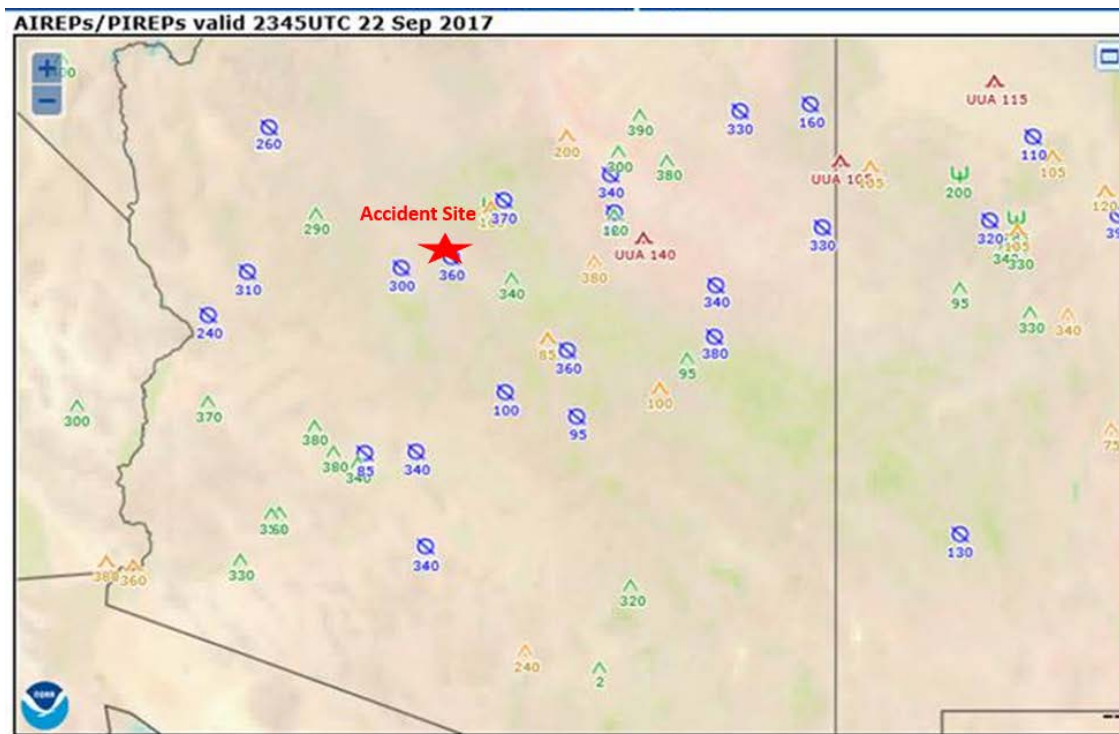


Figure 8 - NWS AWC plot of pilot reports ending at 1645 MST

6.0 Pilot Statement

Another pilot operating in the immediate vicinity west of the accident site surrounding the period was solicited in providing a statement of the flight conditions and weather during the period. The pilot's statement is included as attachment 2. A summary of his statement is included below.

The pilot operated from KPRC and was on an instruction flight during the period between 1530 and 1800 MST. He indicated the weather during the period was windy with south-southwesterly winds with gusts in the range of 25 knots, but nothing out of the ordinary for the area or the weather conditions he encountered. He indicated they had encountered continuous light turbulence from the surface to 9,000 ft.

7.0 NWS Forecasts and Advisories

The following forecasts were issued by the NWS for the nearby airports in the form of a Terminal Aerodrome Forecast (TAF), which were valid for a 5 mile radius of the airport center point, and the Area Forecast which was valid for the area outside of the terminal area, as amended by AIRMETs.

7.1 Terminal Aerodrome Forecast

The NWS Flagstaff Weather Forecast Office (WFO) was responsible for the issuance of the following Terminal Aerodrome Forecast (TAF) for Prescott (KPRC) and Sedona (KSEZ) during the period:

TAF KPRC 221720Z 2218/2318 21017G24KT P6SM FEW050
FM230200 21005KT P6SM SKC=

TAF KPRC 222338Z 2300/2324 21013G21KT P6SM SKC
FM230200 21005KT P6SM SKC
FM231800 22010G20KT P6SM SCT060=

The initial forecast for KPRC was issued at 1020 MST and expected a south-southwesterly wind at 17 knots gusting to 24 knots, visibility unrestricted at 6 miles or more, with a few clouds at 5,000 ft agl. The wind was forecasted to subside after 1900 MST. The next scheduled forecast was issued at 1638 MST, which modified the wind speed to 13 knots gusting to 21 knots with sky clear below 12,000 ft. The forecasts did not include any forecast for low-level wind shear⁸.

TAF KSEZ 221720Z 2218/2318 17017G24KT P6SM SCT050
FM230300 VRB06KT P6SM SKC=

AMD TAF KSEZ 222214Z 2222/2318 20015G25KT P6SM SCT050
FM230300 VRB06KT P6SM SKC=

The forecast for KSEZ also expected southerly winds at 17 knots gusting to 24 knots, visibility at 6 miles or more, with scattered clouds at 5,000 ft agl, with wind subsiding after 2000 MST to 6 knots. An amended forecast was issued at 1514 MST immediately prior to the accident, modifying the wind direction and speed. Other than the gusty winds, no hazards were identified or expected in the forecast and no wind shear was forecast.

7.2 Area Forecast Discussion

The NWS Flagstaff Area Forecast Discussion (AFD) provided a detailed description of the meteorological conditions influencing the area and the forecaster's reasoning in preparing the forecast that went into the general forecast and TAFs. The discussion issued at about 0930 MST was as follows:

FXUS65 KFGZ 221627
AFDFGZ
Area Forecast Discussion
National Weather Service Flagstaff AZ
927 AM MST Fri Sep 22 2017

.SYNOPSIS...Expect cooler temperatures and continued breezy conditions today, as a cold front moves through the area. Cool conditions will persist over the weekend as strong low pressure moves into the southern Great Basin. Expect possible freezing temperatures for much of the high country by Saturday, Sunday and Monday mornings.

.UPDATE...Low pressure remains entrenched across the Great Basin today with a cold front gradually moving east through northern Arizona. The current forecast handles the cool and breezy day well with only a few isolated light showers or a thunderstorm possible this afternoon. Moisture and instability are limited so any precipitation will remain light. Only minor updates were made to the cloud cover forecast to accommodate for the upslope stratus development along the Mogollon Rim and White Mountains.

⁸ Wind Shear (WS) is typically included in the TAF if the wind speeds in the lowest 2,000 ft agl of the atmosphere are 30 knots or greater, or if multiple PIREPs are received of wind shear within 2,000 feet of the surface, causing an indicated air speed loss or gain of 20 knots or more. NWS Instruction 10-813.

.PREV DISCUSSION /420 AM MST/...A cold front currently moving through western Coconino county will drop temperatures from west to east today. Southwest winds will continue to gust as high as 30-35 mph along and ahead of the front, but most areas should stay below criteria as cold air filters into the region.

Some low and middle clouds have developed ahead of the front, but vertical development is limited and only a slight chance of light showers is expected.

The trough driving this front through Arizona today will continue to drop south through the Great Basin over the weekend. This will bring even colder air into the region, with continued southwest breezes. The airmass will mainly be dry, but a slight chance will persist along the New Mexico border Saturday as the front slows down in that area. A few light instability showers will also be possible through the weekend, mainly near the Utah border.

The cold air will bring some chilly mornings to the region by Saturday, Sunday and Monday. Many areas above 6500 feet may see freezing temperatures. Winds may hamper the cooling tonight, but should decrease enough to allow strong radiational cooling by Saturday night and Sunday night.

Heights recover heading into next week, we expect moderating daytime temperatures and cool nights as a result. A secondary low may drop into the long wave trough position later in the week, so we have introduced low POPs by Thursday and Friday.

.AVIATION...For the 18z package...Expect mostly VFR conditions for the next 24 hours. Southwest winds 15-25 kts with gusts from 25-35 kts. Wind speeds will decrease after 03Z. Aviation discussion not updated for TAF amendments.

.FIRE WEATHER...For today, a mainly dry, cold front will move across northern Arizona causing breezy conditions and a slight chance of thunderstorms. For Saturday, Look for lighter winds and below normal temperatures with just a slight chance of thunderstorms.

Sunday through Tuesday...Expect light winds and well below normal temperatures all three days. Generally dry, but a bit of additional moisture will sneak over eastern portions of the area on Tuesday for a slight chance of showers and thunderstorms.

.FGZ WATCHES/WARNINGS/ADVISORIES...NONE.

PUBLIC...MCT/Peterson

AVIATION...McCollum

FIRE WEATHER...RR

The updated forecast for the afternoon for aviation was as follows with no significant changes to the forecast discussion:

.AVIATION...For the 00z package...Expect VFR conditions for the next 24 hours. Southwest winds 15-25 kts with gusts from 25-35 kts will diminish after 02Z. On Saturday, afternoon winds at 10-20 kts with gust to 25 kts are anticipated for most locations. Aviation discussion not updated for TAF amendments.

7.3 Area Forecast

The Area Forecast (FA) is a forecast of visual flight rules clouds and weather conditions over an area as large as the size of several states. It must be used in conjunction with the AIRMET Sierra (IFR) bulletin for the same area in order to get a complete picture of the weather. The area

forecast together with the AIRMET Sierra bulletin are used to determine forecast enroute weather and to interpolate conditions at airports which do not have a TAF issued. The NWS AWC located in Kansas City, Missouri, issues the FA at regular intervals and issues specials reports as necessary usually in the form of an AIRMET. The forecasts current at the time of the accident was issued at 1245 MST and was valid through 0700 MST on September 23, 2017, and was as follows:

*FAUS45 KPCI 221945
FA5W
-SLCC FA 221945
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 231400
CLDS/WX VALID UNTIL 230800...OTLK VALID 230800-231400
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..LRG UPR LOW OVR FCST AREA CENTERED OVR SW ID.
TROF AXIS FROM WRN MT-N CNTRL TO SW ID-NW NV. MOD-STG SW FLOW E
OF TROF AXIS. LIGHT NELY FLOW W OF TROF AXIS. LTL CHG EXPD.
SFC..STNR FNT FROM NRN CA-SE UT-WRN AZ. TROF NW CO-SE WY-SE TO W
CNTRL ID. 14Z CDFNT SE CO-NRN NM-CNTRL AZ.
.
AZ
W HLF...SKC. OTLK...VFR.
NERN...SCT130. WND SW 20G30KT. 01Z SKC. OTLK...VFR.
SERN...SCT100. WND SW 20G30KT. 01Z SKC. OTLK...VFR.*

7.4 Inflight Weather Advisories

No significant meteorological advisories (SIGMETs) or Convective SIGMETs or were issued over Arizona during the period. The Albuquerque Center Weather Service Unit (CWSU) issued a Center Weather Advisories (CWA) number 103 at 1157 MST (1857Z) for occasional light to moderate mountain wave activity between 12,000 and 23,000 ft for a large region of eastern Arizona and New Mexico, which did not extend over the accident site, as depicted in figure 9.

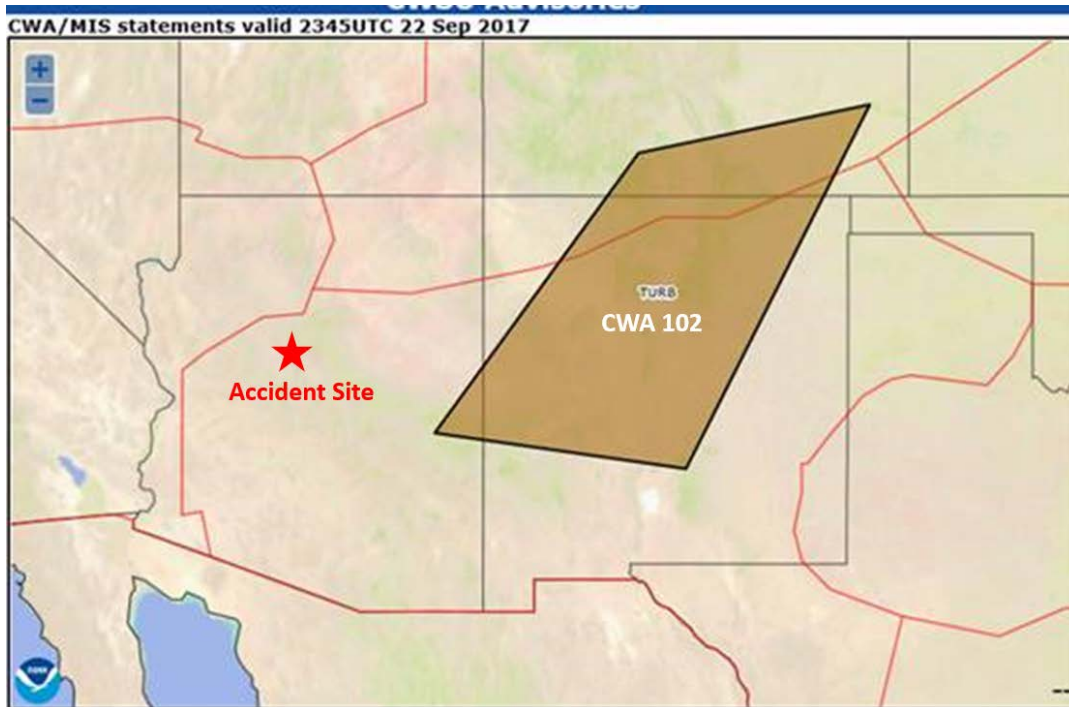


Figure 9 - Plot of CWA 103 issued at 1157 MST

FAUS21 KZAB 221857
 ZAB1 CWA 221900
 ZAB CWA 103 VALID UNTIL 222100
 FROM LAA-55W CME-50SW SJN-35WNW ALS-LAA
 AREA OCNL LGT-MOD MTN WAVE. 120-FL230.SPEED CHANGES OF +/-40 TO 50KTS
 AND ALT CHANGES OF +/-1500FT RPRTD BY SM ACFT.

The NWS airmen's meteorological advisory (AIRMET) included an advisory for the potential for moderate turbulence over the region from the surface to 18,000 ft, and between 18,000 to 39,000 ft, and is depicted by the Graphic-AIRMET in figure 10.

TANGO 2017-09-23 00:00:00



Figure 10 - G-AIRMET Tango valid for 1700 MST

WAUS45 KPCI 222045

SLCT WA 222045

AIRMET TANGO UPDT 3 FOR TURB VALID UNTIL 230300

AIRMET TURBC...ID MT WY NV UT CO AZ NM

FROM 50WSW YXC TO 50NNW ISN TO 70SW RAP TO BFF TO GLD TO 50W LBL TO 30ESE TBE TO 70SSE TBE TO 30S FTI TO 30WSW SJN TO 90SSW PHX

TO BZA TO EED TO 40SSW FMG TO 40SE LKV TO 50SE REO TO 50WSW YXC

MOD TURB BTN FL180 AND FL390. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET TURB...WY UT CO AZ NM

FROM 50SW DDY TO CYS TO 30SSW AKO TO 30S LAA TO 40SSE TBE TO 40E TCS TO 50NW DMN TO 40SW DRK TO 30E PGS TO 20ENE HVE TO 30W OCS TO 50SW DDY

MOD TURB BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.

7.5 Winds and Temperatures Aloft Forecast

The forecast winds and temperature aloft forecast current at the time of the accident was as follows:

WINDS ALOFT FORECASTS

DATA BASED ON 221800Z

VALID 230000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
PRC			2016+07	2022+00	2344-13	2282-22	720336	720545	239653
PHX	2506	2407+15	2124+08	2135+02	2264-09	2376-19	228236	238544	228054

The first forecast level for Prescott was for 9,000 ft and indicated a wind from 200° at 16 knots with a temperature of 7° C. The wind direction showed little directional variation with height with wind direction from 200° to 230° and wind speeds increasing with height to 105 knots at 34,000 ft.

8.0 Flight Track Map

The flight track of N7070Q was obtained from the NTSB Air Traffic Control Specialist and is plotted in figure 11 over a general topography map and with the final accident site noted. The flight track starts at KPRC at 1615 MST at an altitude of 4,875 ft msl⁹ and departs northeastward and the flight climbs to its maximum altitude during the flight of approximately 7,175 ft at 1624:43 MST. As the flight proceeds northeastward it begins to descend and at 1632:47 has turned to a heading of 069° and descended to 4,550 ft, which is the last radar hit recorded and located 1.64 miles east-southeast or 297° from the final accident site.

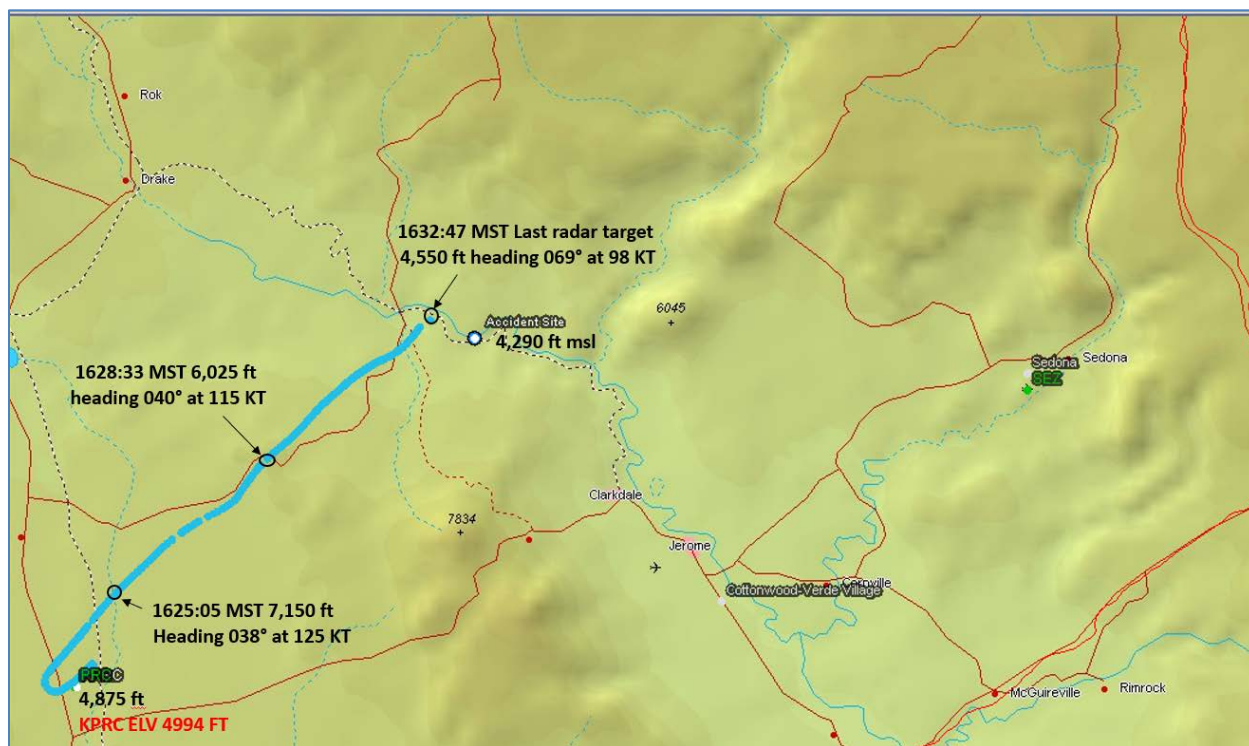


Figure 11 - Flight track and accident site

Figure 12 is a Google Earth image of the last radar hit at 1632 MST and the accident site, showing some of the terrain in the local area.

⁹ The initial altitude is 4,875 ft, which is -119 ft below the station elevation. The error is from the Ops View software data and rounding of the reported altitude.

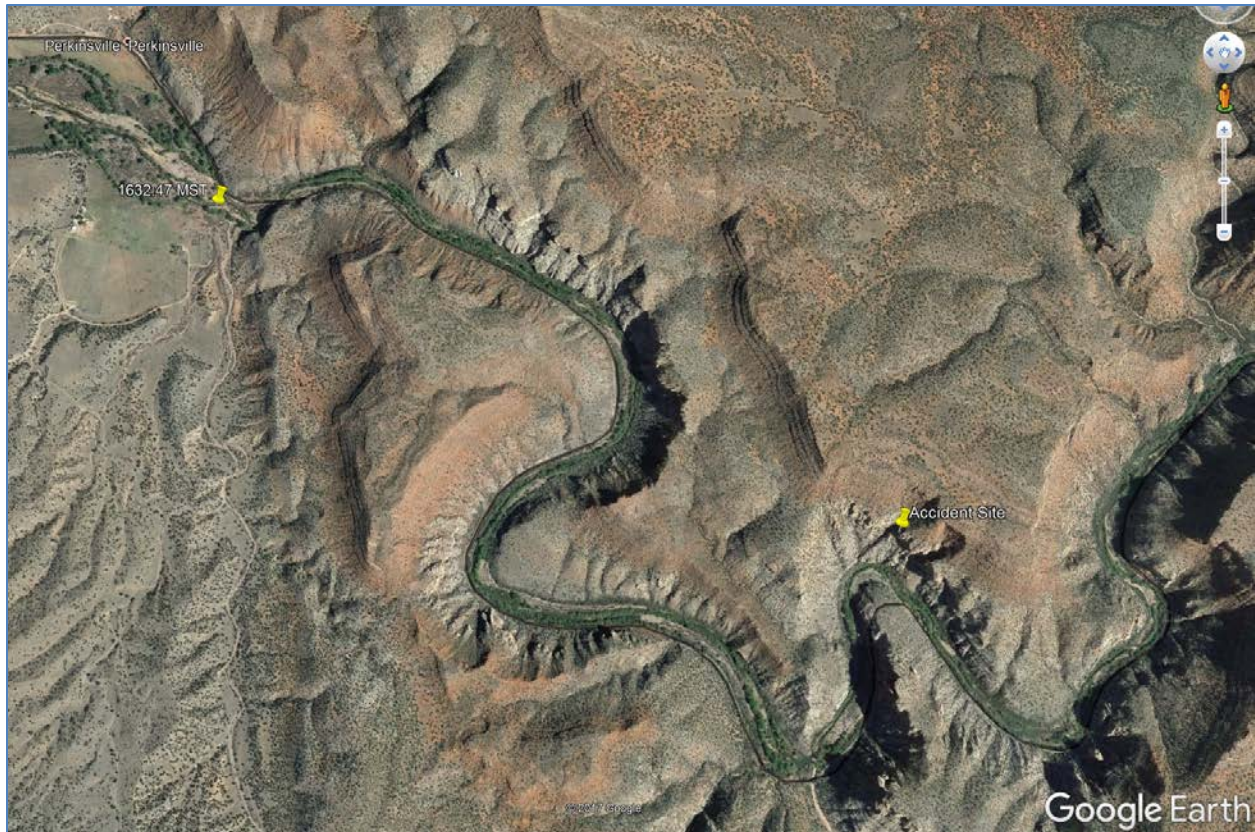


Figure 12 - Google Earth plot of the last radar target and the accident site

9.0 Turbulence References

The following turbulence reporting criteria table is from the FAA Airmen's Information manual, table 7-1-10, and Advisory Circular AC 120-88A – "Preventing Injuries Caused by Turbulence".

Intensity	Aircraft Reaction	Inside Aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as Light Turbulence ; or Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as Light Chop .	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variation in indicated airspeed. Report as Moderate Turbulence ; or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Reports as Moderate Chop .	Occupants feel definite strain against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.

Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as Severe Turbulence .	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Reports as Extreme Turbulence .	
	High level turbulence above 15,000 feet not associated with cumuliform clouds, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity.	Reporting Term – Definition Occasional – less than 1/3 of the time. Intermittent – 1/3 to 2/3. Continuous – More than 2/3.

The International Civil Aviation Organization (ICAO)¹⁰ also uses the following objective measurements for defining turbulence intensity.

Intensity	Airspeed Fluctuation (KT)	Vertical Acceleration (g)	Derived Gust (fpm)	EDR
Smooth	< 5			< 0.1
Light	5–14.9	0.20-0.49	300-1,199	0.1-0.3
Moderate	15-24.9	0.50-0.99	1,200-2,099	0.4-0.70
Severe	≥25	1.0 to 1.99	2,100-2,999	>0.70
Extreme	-	≥2.00	≥3,000	

10.0 Graphic Turbulence Guidance

The NWS AWC Graphic Turbulence Guidance (GTG) provides computer-generated four-dimensional forecasts of information related to the expected intensity of atmospheric turbulence associated with clear air turbulence (CAT), mountain wave turbulence (MWT), and low-level terrain and thermally-induced turbulence sources. It is not intended to predict turbulence associated with convection and thunderstorm clouds, but may provide some guidance in areas of properly predicted thunderstorms when the convection is widespread. The following snapshots are the GTG guidance products issued during the period.

The GTG images are the turbulence intensity based on the forecast Eddy Dissipation Rate (EDR), which is an atmospheric turbulence intensity metric and individual aircraft response to this depends on the type of aircraft, its weight, airspeed, altitude, and configuration. The accident airplane weight was in the light category¹¹, and the color coded legion on the bottom of the image provides the turbulence intensity for this aircraft weight class based on the estimated EDR values with the appropriate intensity of turbulence as light, moderate, severe, or extreme for the selected altitudes immediately above the surface for 5,000 ft and 7,000 ft, the maximum altitude the accident airplane had climbed.

¹⁰ International Civil Aviation Organization, 2016: Annex 3 - Meteorological Service for International Air Navigation.

¹¹ Light category is defined by ICAO definition of less than 15,500 pounds maximum takeoff weight.

Figures 13 through 16 are the GTG initial model run for 1600 MST (2300Z) for 5,000 ft and 7,000 ft¹² for the light category aircraft for CAT, mountain wave related turbulence, combined turbulence events, and combined with the EDR values. The images represent what the NWS AWC was displaying at the time of the accident for potential turbulence. Figure 17 through 20 includes the GTG model run images for 1700 MST (0000Z), immediately after the accident.

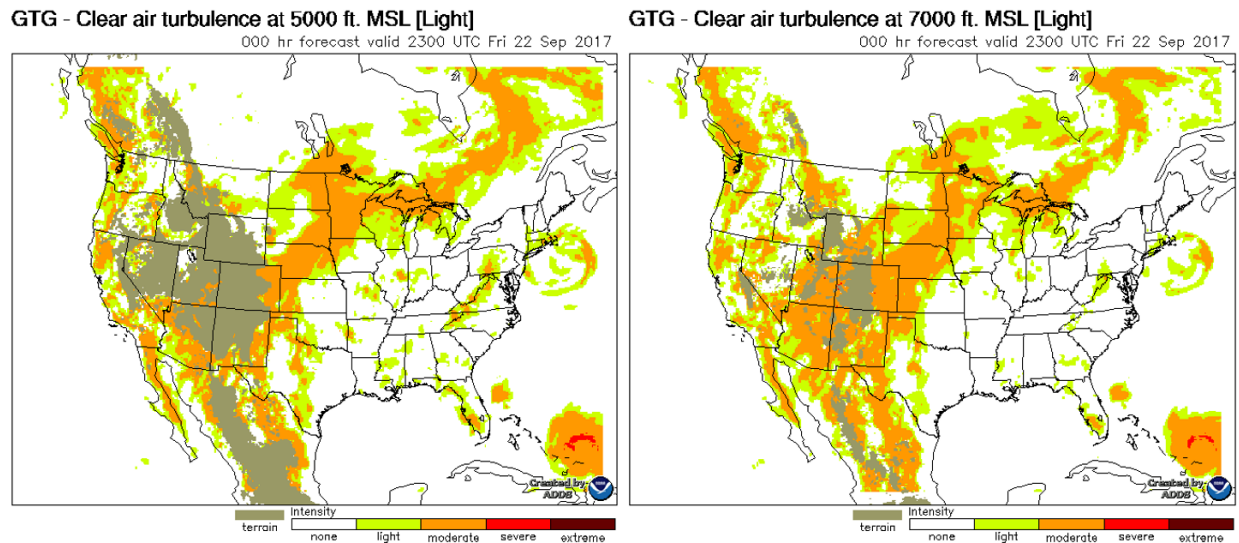


Figure 13 - GTG 1600 MST model run of CAT at 5,000 ft and 7,000 ft for light aircraft

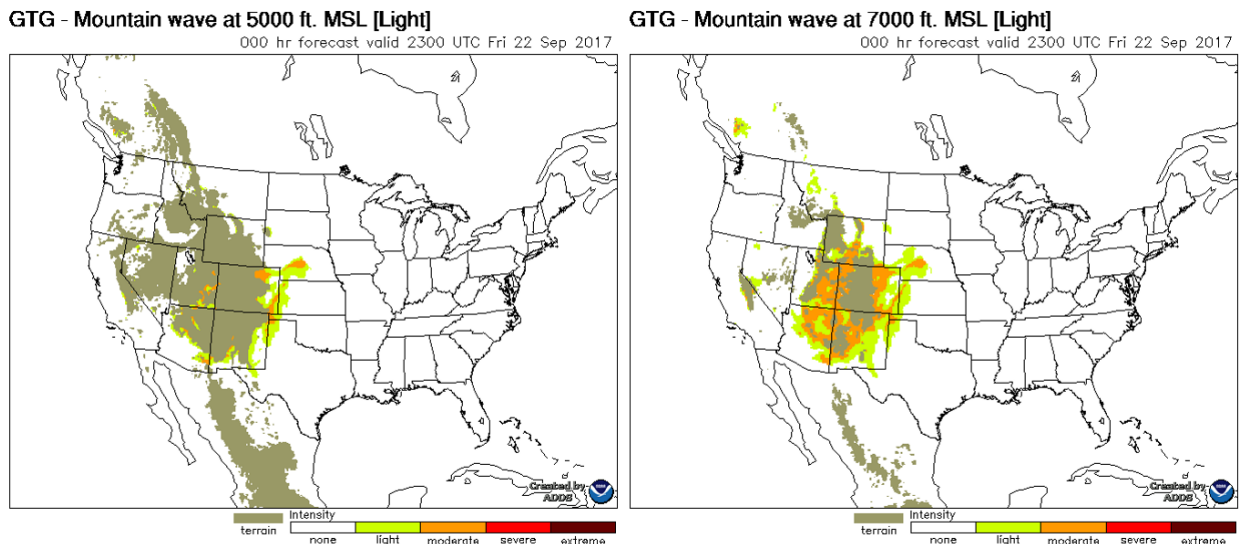
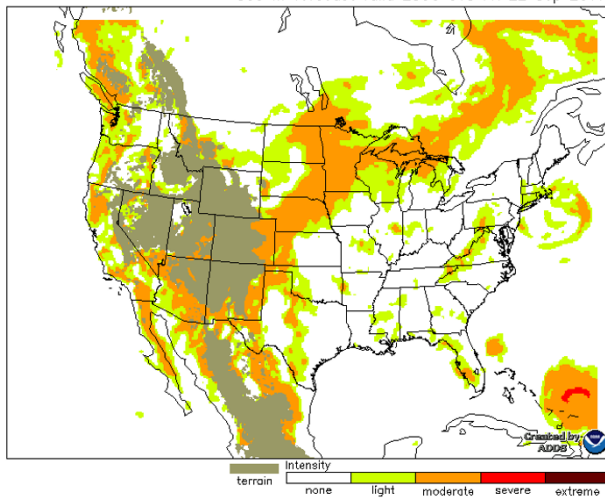


Figure 14 - GTG 1600 MST mountain wave turbulence at 5,000 ft and 7,000 ft for light aircraft

¹² Only the altitudes from the surface to 7,000 ft were examined for this case.

GTG - Combined CAT+MTW at 5000 ft. MSL [Light]

000 hr forecast valid 2300 UTC Fri 22 Sep 2017



GTG - Combined CAT+MTW at 7000 ft. MSL [Light]

000 hr forecast valid 2300 UTC Fri 22 Sep 2017

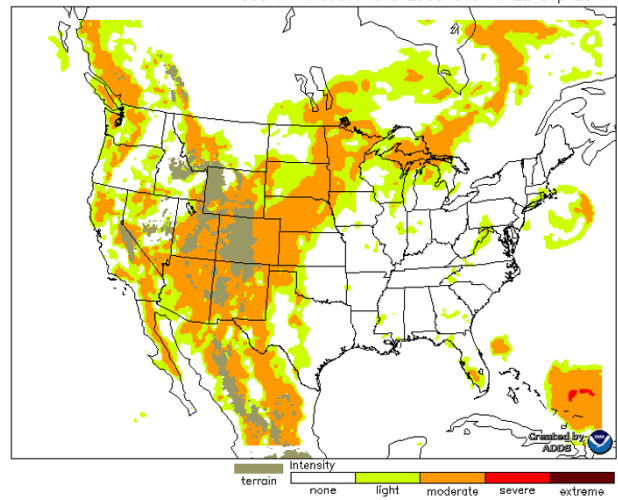
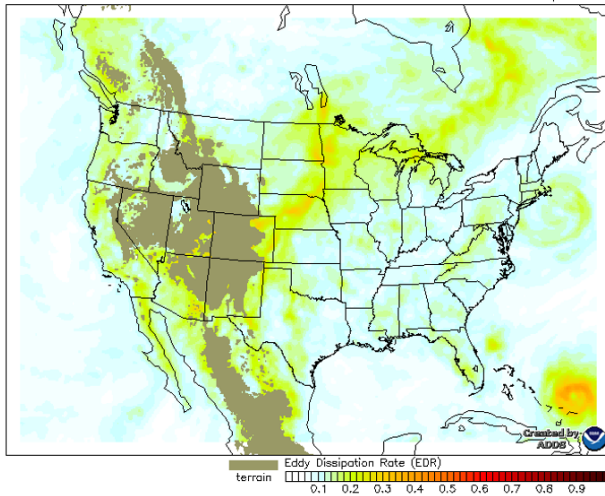


Figure 15 - GTG 1600 MST combined CAT and mountain wave for 5,000 ft and 7,000 ft for light aircraft

GTG - Combined CAT+MTW at 5000 ft. MSL

000 hr forecast valid 2300 UTC Fri 22 Sep 2017



GTG - Combined CAT+MTW at 7000 ft. MSL

000 hr forecast valid 2300 UTC Fri 22 Sep 2017

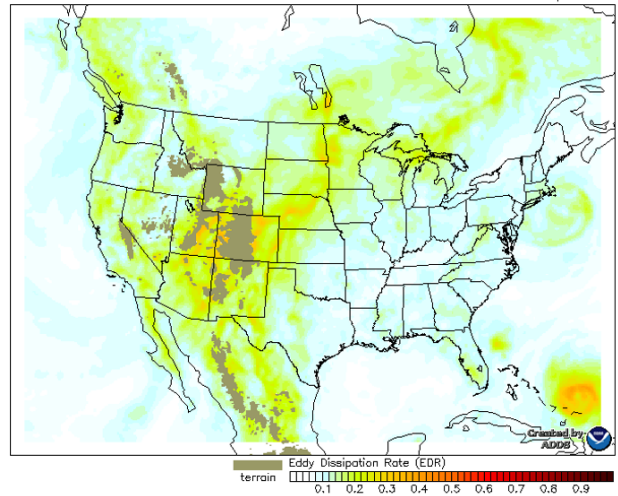
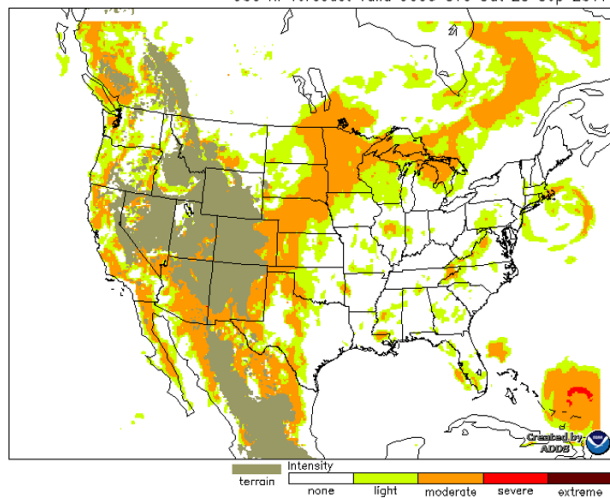


Figure 16 - GTG 1600 MST combined EDR values for CAT and mountain wave at 5,000 ft and 7,000 ft

GTG - Clear air turbulence at 5000 ft. MSL [Light]
000 hr forecast valid 0000 UTC Sat 23 Sep 2017



GTG - Clear air turbulence at 7000 ft. MSL [Light]
000 hr forecast valid 0000 UTC Sat 23 Sep 2017

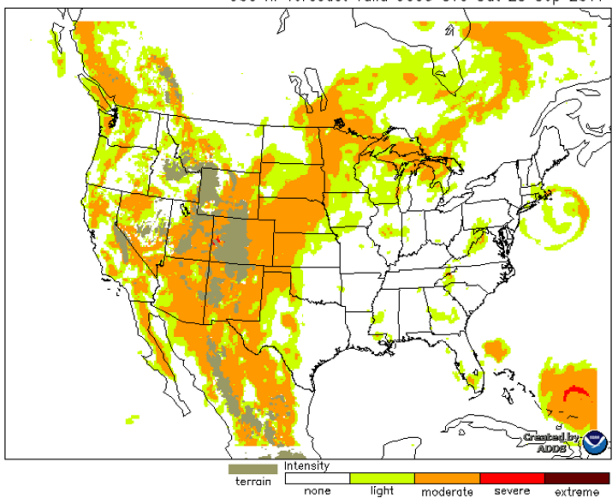
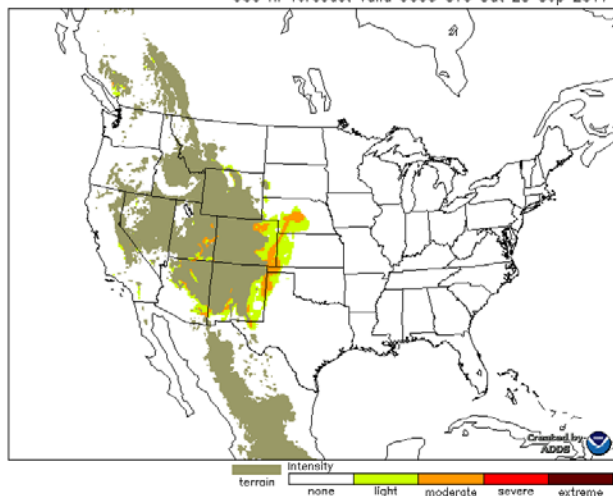


Figure 17 – GTG 1700 MST model run of CAT at 5,000 ft and 7,000 ft for light aircraft

GTG - Mountain wave at 5000 ft. MSL [Light]
000 hr forecast valid 0000 UTC Sat 23 Sep 2017



GTG - Mountain wave at 7000 ft. MSL [Light]
000 hr forecast valid 0000 UTC Sat 23 Sep 2017

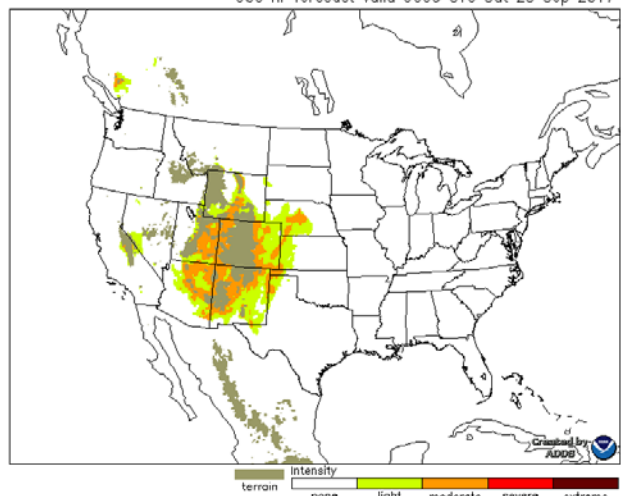
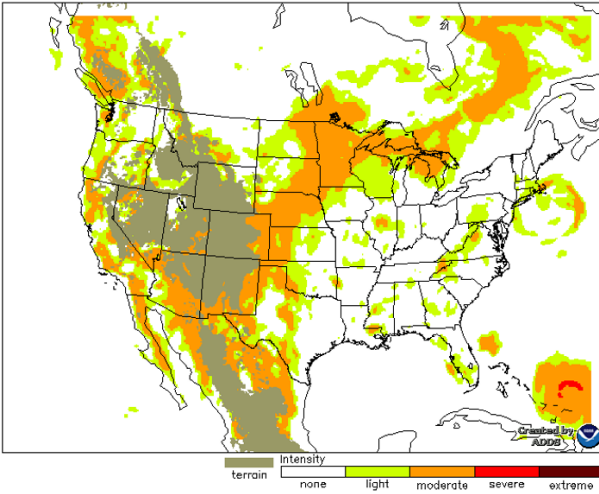


Figure 18 - GTG 1700 MST mountain wave turbulence at 5,000 ft and 7,000 ft for light aircraft

GTG - Combined CAT+MTW at 5000 ft. MSL [Light]

000 hr forecast valid 0000 UTC Sat 23 Sep 2017



GTG - Combined CAT+MTW at 7000 ft. MSL [Light]

000 hr forecast valid 0000 UTC Sat 23 Sep 2017

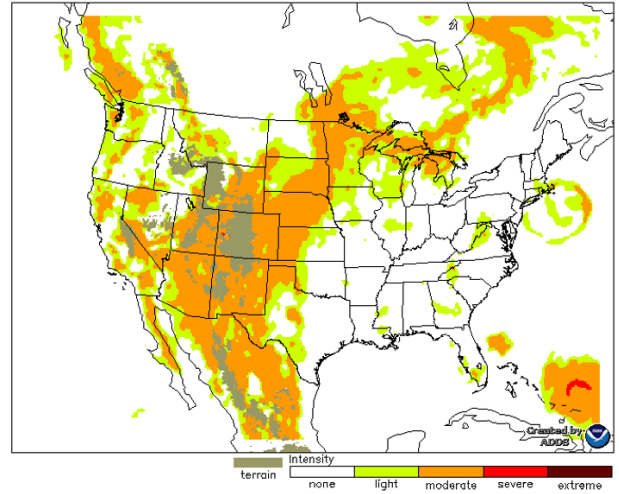
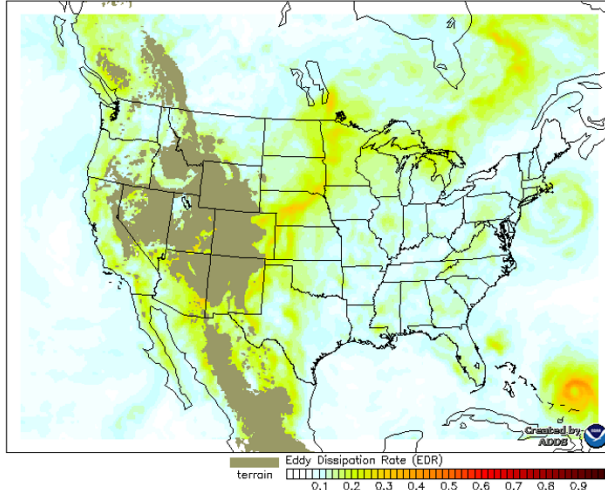


Figure 19 – GTG 1700 MST combined CAT and mountain wave for 5,000 and 7,000 ft for light aircraft

GTG - Combined CAT+MTW at 5000 ft. MSL

000 hr forecast valid 0000 UTC Sat 23 Sep 2017



GTG - Combined CAT+MTW at 7000 ft. MSL

000 hr forecast valid 0000 UTC Sat 23 Sep 2017

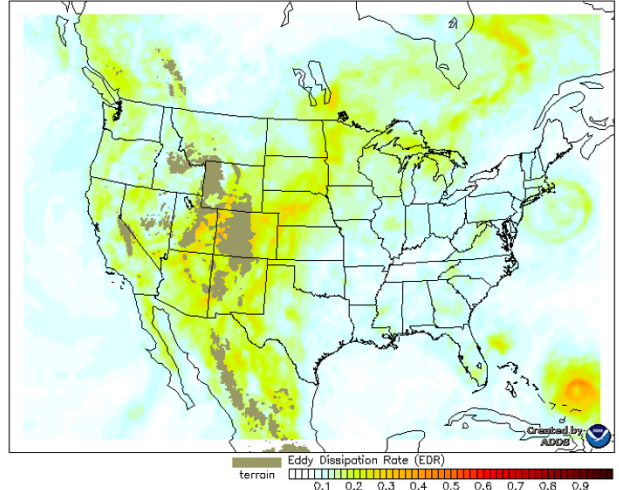


Figure 20 - GTG 1700 MST combined EDR values for CAT and mountain wave at 5,000 ft and 7000 ft

11.0 Weather Research and Forecasting Model Simulation

A Weather Research and Forecasting (WRF) numerical model was run to simulate the weather conditions during the period with regards to wind, vertical motion, and the Richardson number (Ri) for turbulence determination surrounding the time of the accident. The WRF Advanced Research WRF core (ARW) version 3.2.1.5 was run with horizontal grid spacing from 84 kilometers (km) down to 320 meters.

Figure 21 is the WRF simulation terrain in feet, with figure 22 the WRF cross section of horizontal wind speed in knots and potential temperature in degrees Kelvin (black lines) from west to east, with the accident site position indicated by the red triangle. Figure 23 and 24 are the north

to south, and then west to east cross section across the region at 1630 MST of the Richardson Number (Ri). The Richardson Numbers less than 1.0 are areas favorable for turbulence, with values less than 0.25 where turbulence is likely. Figure 25 and 26 are the cross section of vertical velocity (in feet per minute (fpm)) over the region with updrafts in yellow and downdrafts in blue, with the approximate accident site marked by a red triangle.

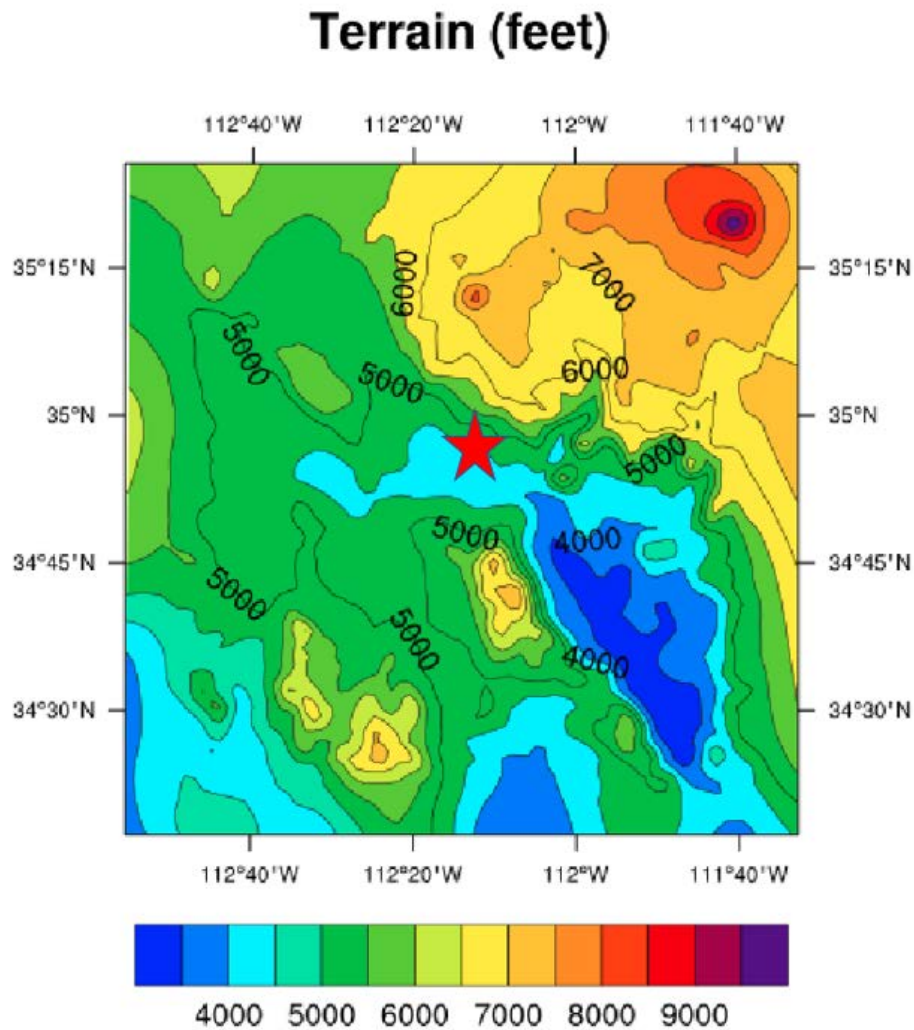


Figure 21 - WRF model terrain over the area

Horizontal Speed 2017-09-22_23:30:00 Z

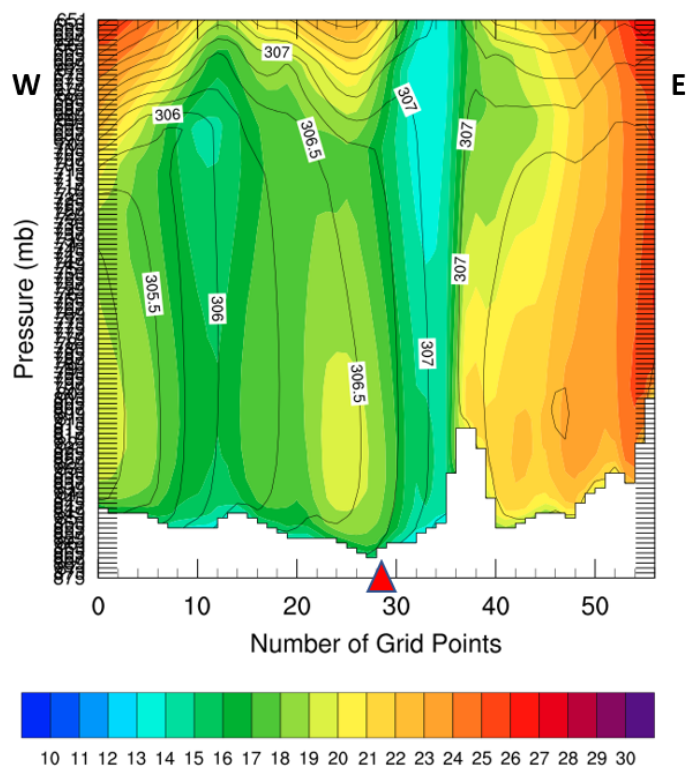


Figure 22 - West to East Cross Section of wind at 1630 MST
WRF: 2017-09-22_23:30:00Z

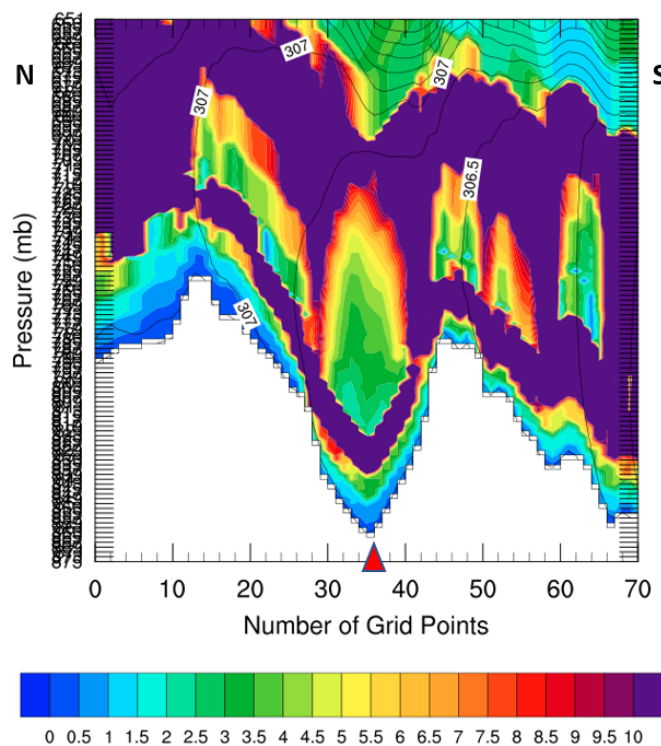


Figure 23 - North to South Cross Section of Ri values at 1630 MST

WRF: 2017-09-22_23:30:00 Z

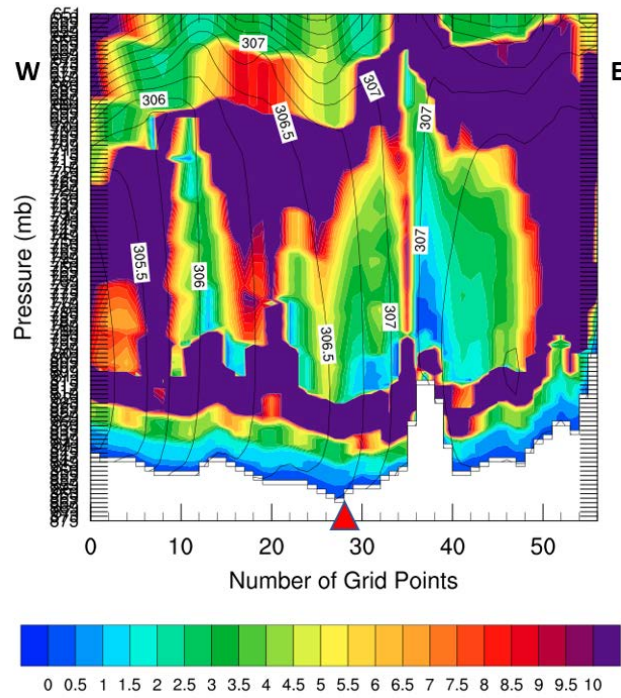


Figure 24 - West to East Cross Section of Ri values at 1630 MST

Vertical Velocity 2017-09-22_23:30:00 Z

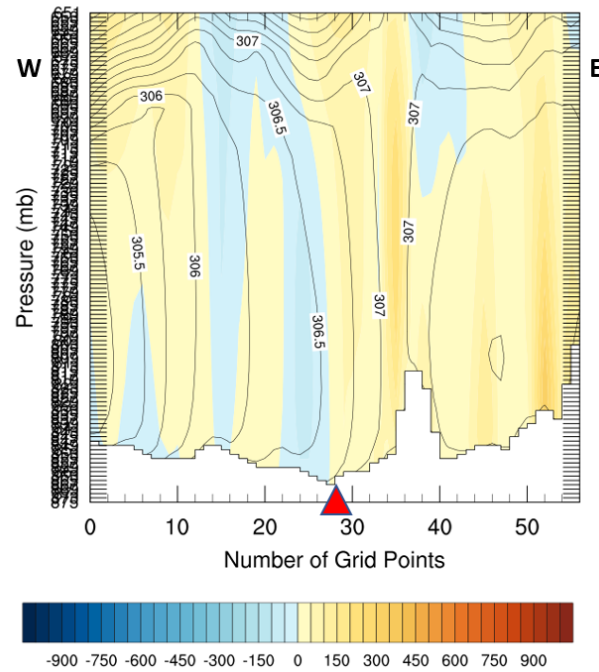


Figure 25 - North to South cross section of vertical velocity at 1630 MST

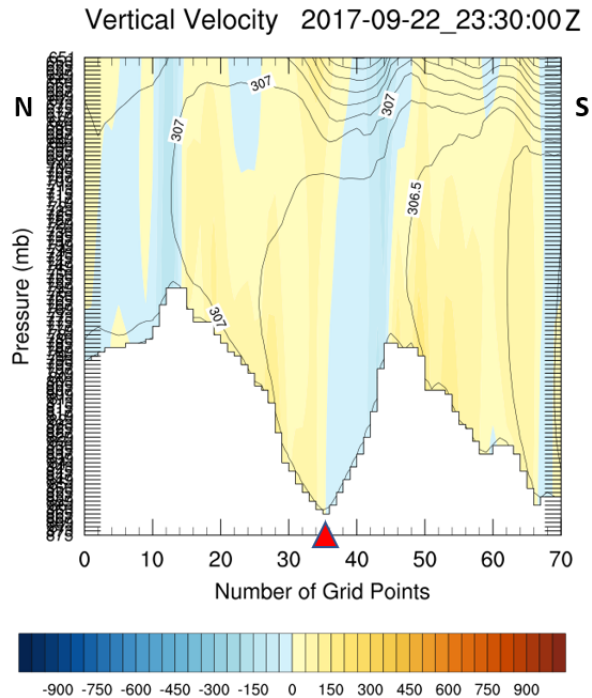


Figure 26 - West to East cross section of vertical velocity at 1630 MST

12.0 Astronomical Conditions

The United States Naval Observatory website (<http://www.usno.navy.mil/USNO/>) provided the following astronomical conditions for Prescott, Yavapai County, AZ, on September 22, 2017.

SUN

Beginning civil twilight 0553 MST

Sunrise 0618 MST

Sun transit 1222 MST

Accident 1634 MST

Sunset 1826 MST

End civil twilight 1851 MST

F. LIST OF ATTACHMENTS

Attachment 1 – GOES-15 visible satellite animation from 1445 through 1700 MST

Attachment 2 – Flight instructors operating in the area statement

Submitted by:

Don Eick
Senior Meteorologist