NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 14, 2017

Weather Study

METEOROLOGY

WPR17FA045

Table Of Contents

A. ACCIDENT

Location: Near Payson, Arizona
Date: January 2, 2017
Time: 0937 mountain standard time
1637 Coordinated Universal Time (UTC)
Airplane: Cessna T210K, N272EF

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. 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 Centers for Environmental Information (NCEI). All times are mountain standard time (MST) on January 2, 2017, and are based upon the 24-hour clock, where local time is -7 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 34.43° N, longitude 111.28° W, at an approximate elevation of 6,670 feet.

D. WEATHER 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 and the Weather Prediction Center, 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 00-45H.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1100 MST is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart depicted a surface high pressure system located south of the accident site in south central Arizona with a pressure of 1019-hectopascals (hPa). A stationary frontal boundary was located in southern Utah with the frontal boundary stretching westward into western Nevada and eastward into central Colorado. The station models around the accident site depicted air temperatures in the low 30's to mid 40's degrees Fahrenheit (°F), dew point temperatures in the upper 20's to low 30's °F, a southwest wind between 10 and 20 knots, mostly cloudy skies with light snow north and west of the accident site, and mostly clear skies east of the accident site.

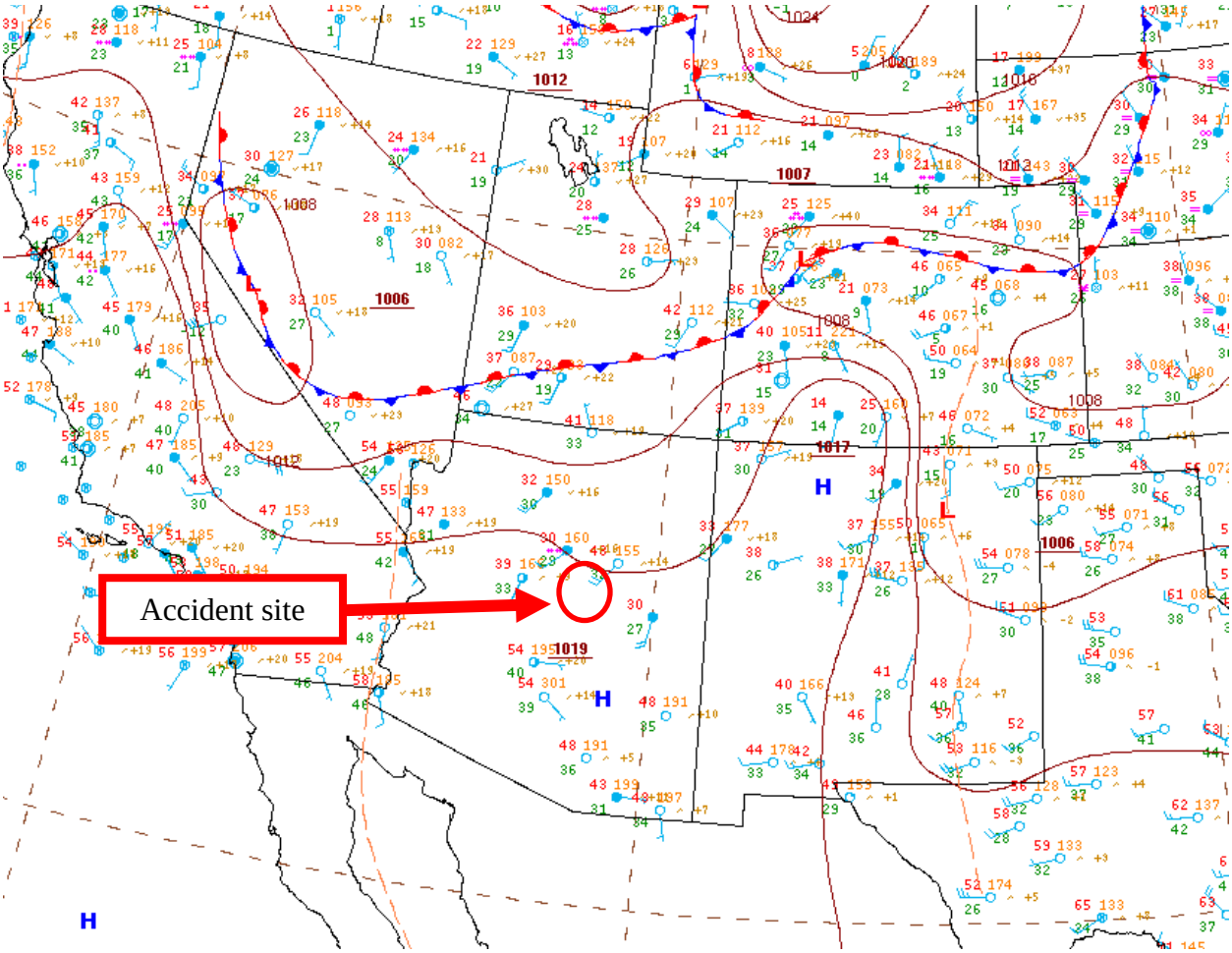

Figure 1 – NWS Surface Analysis Chart for 1100 MST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0500 MST at 700-, 500-, and 300-hPa are presented in figures 2 through 4. The accident site was located in between mid-level troughs[1] at 700- and 500-hPa (figures 2 and 3). Areas near troughs and mountainous terrain are favored locations for enhanced vertical motion, clouds, and precipitation. There was a west-southwest wind of 25 knots at 700-hPa (figure 2). The wind became westerly by 500-hPa and the wind speed increased to 60 knots (figure 3). By 300-hPa, the wind was from the west-northwest at 85 knots (figure 4).

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

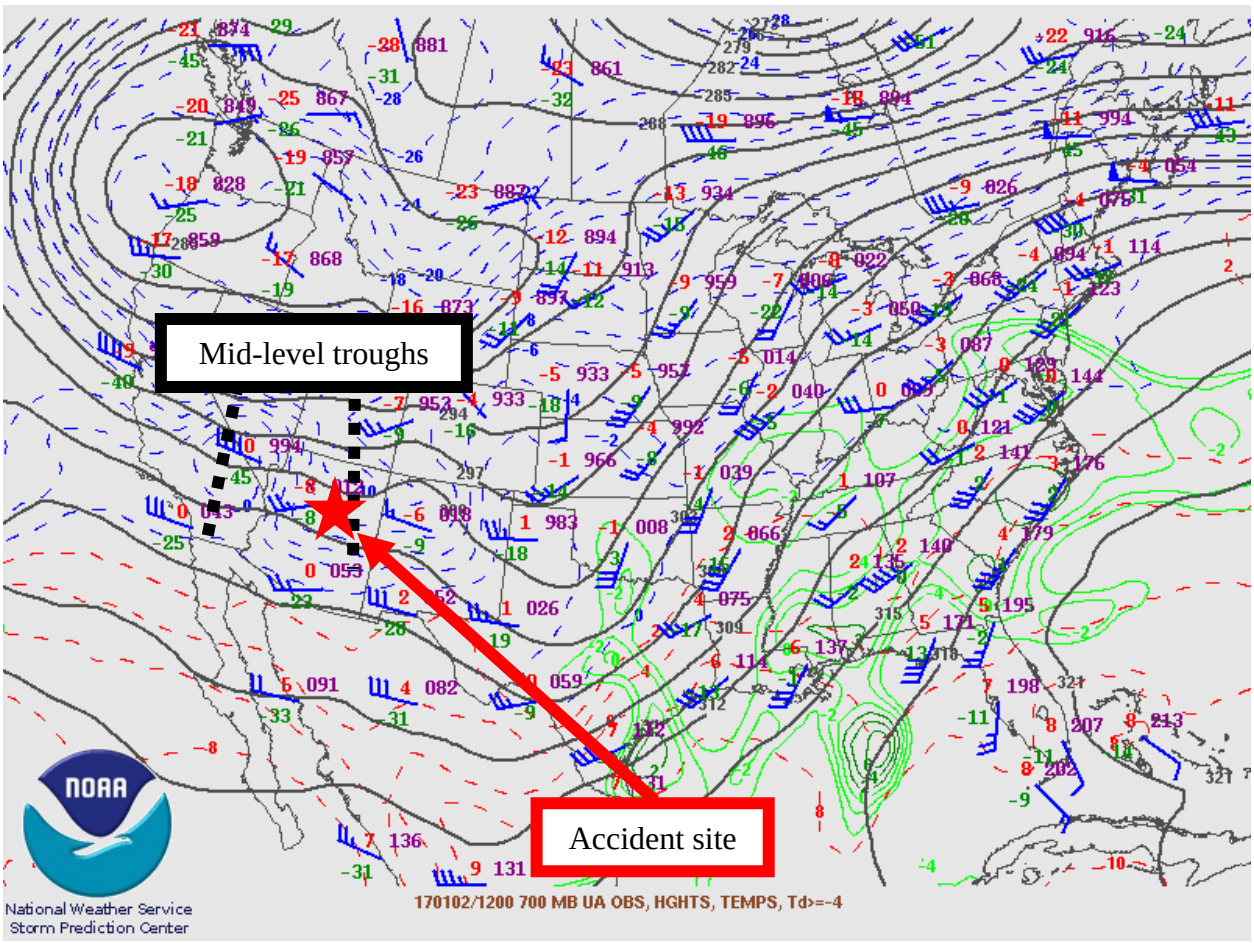

Figure 2 – 700-hPa Constant Pressure Chart for 0500 MST

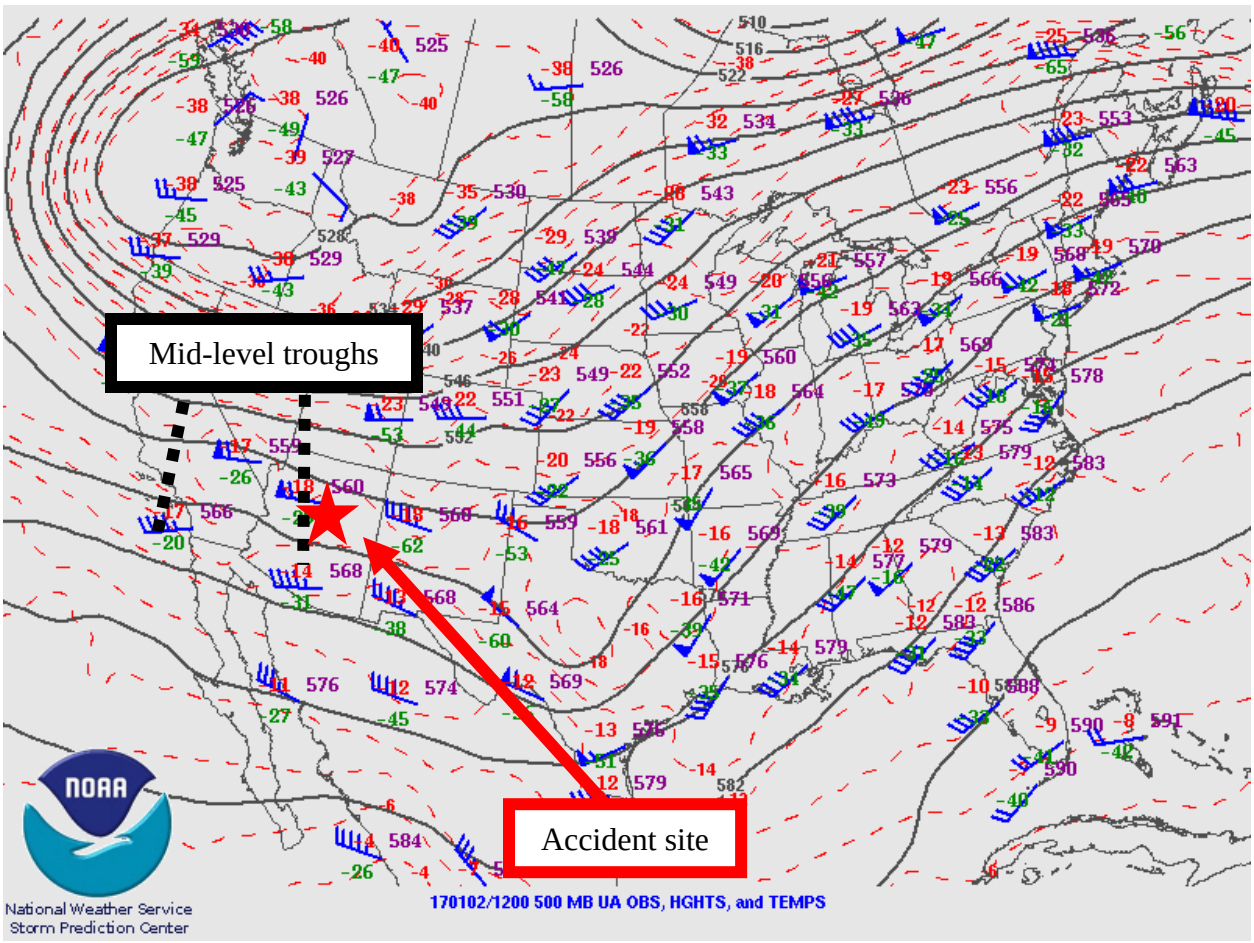

Figure 3 – 500-hPa Constant Pressure Chart for 0500 MST

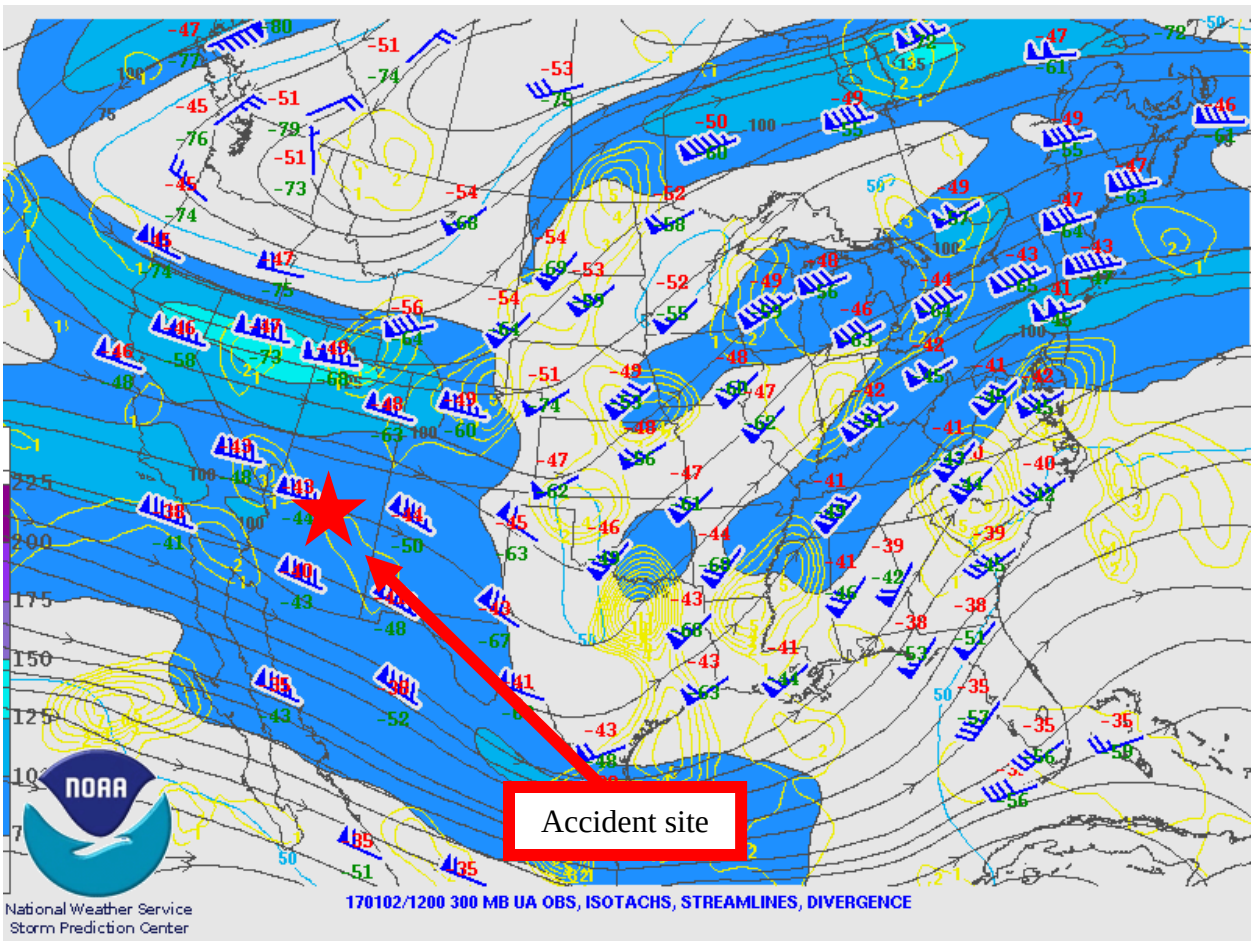

Figure 4 – 300-hPa Constant Pressure Chart for 0500 MST

2.0 SPC Products

There were no thunderstorms forecast for the accident site at the accident time.

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 with visibility reported in statute miles for this section. Figure 5 is a sectional chart with the accident site and the closest weather reporting location marked.

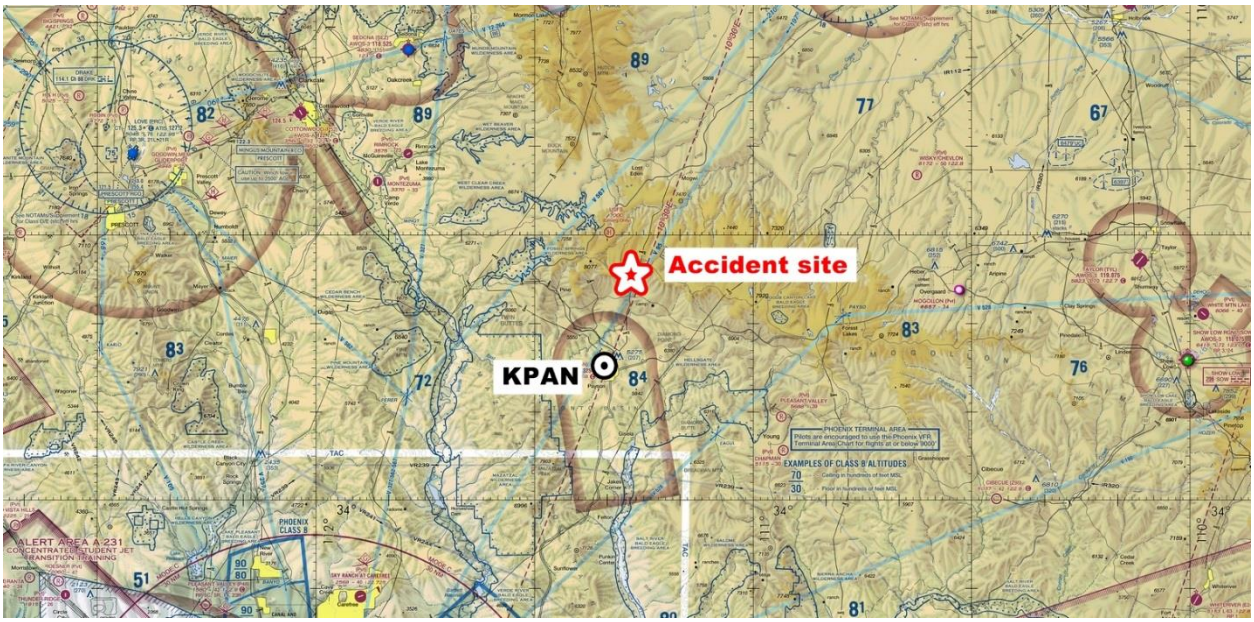

Figure 5 – Sectional chart of accident area with the location of the accident site and surface observation site

Payson Airport (KPAN) was the closest official weather station to the accident site, located 1 mile west of Payson, Arizona. KPAN had an Automated Weather Observing System (AWOS[2]) whose reports were not supplemented. KPAN was located 11 miles south-southwest of the accident site, at an elevation of 5,157 feet, and had a 12° easterly magnetic variation[3] (figure 5). The following observations were taken and disseminated during the times surrounding the accident: [4]

[0735 MST] METAR KPAN 021435Z AUTO 19004KT 10SM OVC003 02/01 A3007 RMK AO2=

[0755 MST] METAR KPAN 021455Z AUTO VRB04KT 6SM BR OVC003 02/01 A3008 RMK AO2=

[0815 MST] METAR KPAN 021515Z AUTO VRB05G10KT 3SM BR OVC003 02/01 A3008 RMK AO2=

[0835 MST] METAR KPAN 021535Z AUTO VRB03KT 10SM OVC003 02/01 A3009 RMK AO2=

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2 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.

3 Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2005, latest measurement taken from http://www.airnav.com/airport/KPAN

4 The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that affected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[0855 MST] METAR KPAN 021555Z AUTO VRB04KT 10SM OVC003 02/01 A3010 RMK AO2=

[0915 MST] METAR KPAN 021615Z AUTO 19005KT 10SM -UP OVC003 02/01 A3011 RMK AO2=

[0935 MST] METAR KPAN 021635Z AUTO VRB04G10KT 10SM OVC003 02/01 A3011 RMK AO2=

ACCIDENT TIME 0937 MST

[0955 MST] METAR KPAN 021655Z AUTO 17005KT 10SM OVC003 02/01 A3012 RMK AO2=

[1015 MST] METAR KPAN 021715Z AUTO VRB04KT 10SM OVC004 02/01 A3012 RMK AO2=

[1035 MST] METAR KPAN 021735Z AUTO 00000KT 10SM OVC004 02/02 A3012 RMK AO2=

[1055 MST] METAR KPAN 021755Z AUTO VRB05KT 10SM OVC005 02/02 A3012 RMK AO2=

KPAN weather at 0915 MST, automated, wind from 190° at 5 knots, 10 miles visibility or greater, light unknown precipitation, an overcast ceiling at 300 feet above ground level (agl), temperature of 2° Celsius (C), dew point temperature of 1° C, and an altimeter setting of 30.11 inches of mercury. Remarks, station with a precipitation discriminator.

KPAN weather at 0935 MST, automated, variable wind at 4 knots with gusts to 10 knots, 10 miles visibility or greater, an overcast ceiling at 300 feet agl, temperature of 2° C, dew point temperature of 1° C, and an altimeter setting of 30.11 inches of mercury. Remarks, station with a precipitation discriminator.

KPAN weather at 0955 MST, automated, wind from 170° at 5 knots, 10 miles visibility or greater, an overcast ceiling at 300 feet agl, temperature of 2° C, dew point temperature of 1° C, and an altimeter setting of 30.12 inches of mercury. Remarks, station with a precipitation discriminator.

KPAN weather at 1015 MST, automated, variable wind at 4 knots, 10 miles visibility or greater, an overcast ceiling at 400 feet agl, temperature of 2° C, dew point temperature of 1° C, and an altimeter setting of 30.12 inches of mercury. Remarks, station with a precipitation discriminator.

The observations from KPAN surrounding the accident time indicated IFR[5] ceiling conditions around the accident site. Precipitation was also reported at KPAN around the accident time with surface temperatures just above freezing. The movement and areal coverage of precipitation with the accident flight track is further discussed in section 6.4.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)[6] model sounding was created for the accident site for 1000 MST. The 1000 MST sounding was plotted on a standard Skew-T log P diagram[7] with the derived stability parameters included in figure 6 (with data from the surface to 600-hPa, or 14,000 feet msl.) This data was analyzed utilizing the RAOB[8] software package. The sounding depicted the lifted condensation level (LCL)[9] at 6,790 feet msl and a convective condensation level (CCL)[10] of 12,748 feet. The freezing level was at the surface. The precipitable water value was 0.30 inches.

5 Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 feet agl and/or less than 3 miles visibility.

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

7 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.

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

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

10 Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

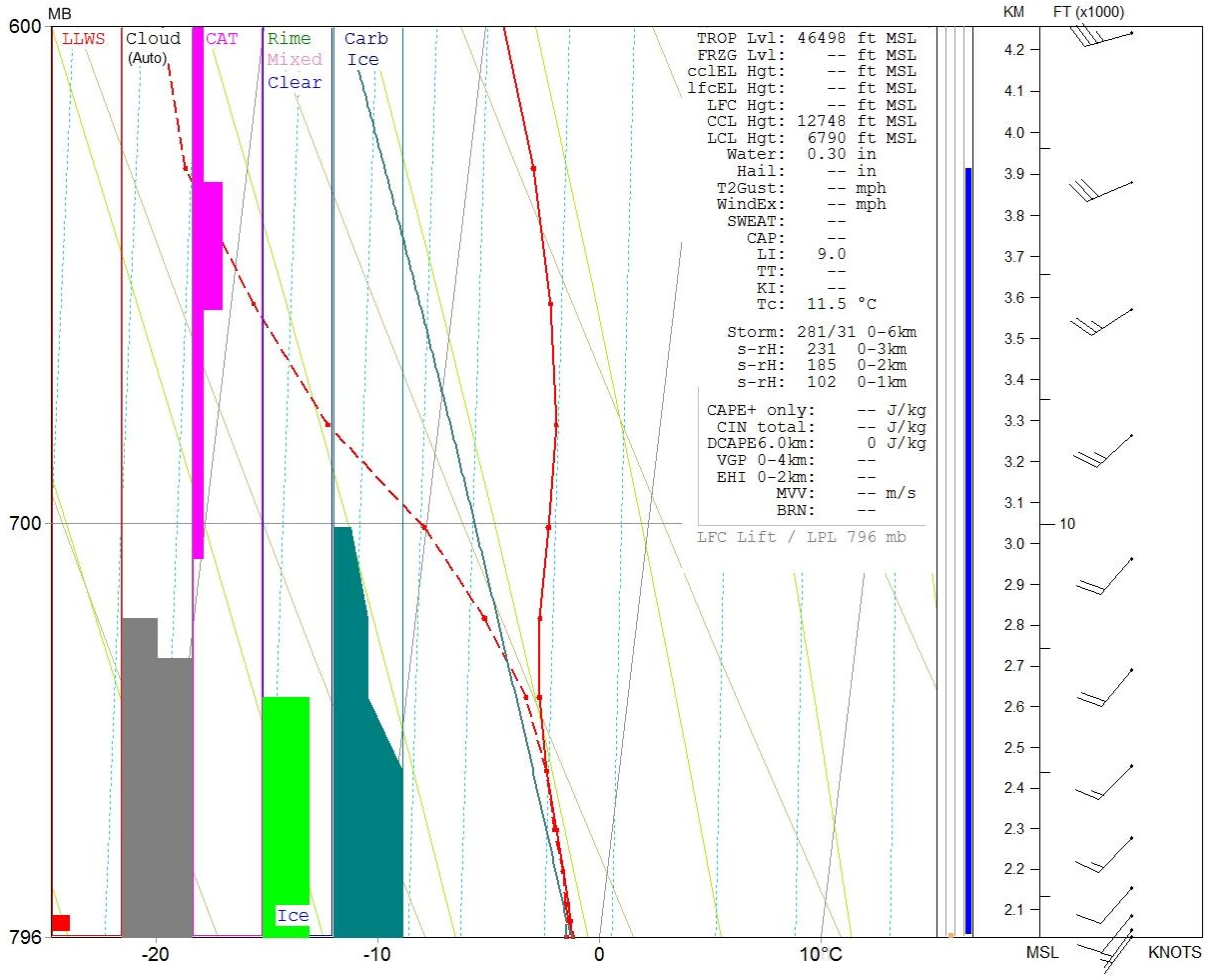


Figure 6 – 1000 MST HRRR sounding for the accident site

The 1000 MST HRRR sounding indicated a conditionally unstable layer between the surface and 13,000 feet. RAOB indicated that clouds were likely from the surface through 9,500 feet. Moderate rime icing conditions were indicated by RAOB between the surface and 9,000 feet. With a relatively dry layer above 10,000 feet and insufficient moisture in the favored dendritic growth zone between -10° C and -20° C, little to no precipitation would be expected at the surface. With insufficient moisture in the dendritic growth zone, the supercooled liquid water would have likely remained in the cloud cover between the surface and 9,500 feet.[11] Icing potential is further discussed in section 15.0.

[11] S.G. Cober, G. A. Isaac, and J. W. Strapp, Characterizations of Aircraft Icing Environments that Include Supercooled Large Drops (Journal of Applied Meteorology, 2001), pp. 1984-2002.
B.C Bernstein, C.A. Wolff, and F. McDonough, An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part I: Canada and the Continental United States (Journal of Applied Meteorology and Climatology, 2007), pp. 1857-1878.
Williams, E.R., D.J. Smalley, M.F. Donovan, R.G. Hallowell, K.T. Hood, B.J. Bennett, R. Evaristo, A. Stepanek, T. Bals-Elsholz, J. Cobb, J. Ritzman, A. Korolev, M. Wolde, Measurements of Differential Reflectivity in Snowstorms in Warm Season Stratiform Systems (Journal of Applied Meteorology and Climatology, in press).

The 1000 MST HRRR sounding wind profile indicated a surface wind from 214° at 6 knots with the wind remaining southwesterly through 14,000 feet. The wind increased in speed to 15 knots by 8,500 feet and increased again to 25 knots by 10,500 feet. At 14,000 feet the wind speed was 35 knots from the west-southwest. RAOB indicated the possibility of light low-level wind shear between the surface and 7,000 feet, with light clear-air turbulence possible above 10,000 feet.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 bands 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm, respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 0700 MST through 1200 MST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 7 and 8 present the GOES-15 visible imagery from 0930 and 0945 MST at 3X magnification with the accident site highlighted with a red square. The visible imagery indicated extensive cloud cover over the accident site with the clouds moving from west to east (attachment 1). In attachment 1, there are two distinct cloud layers visible with one lower cloud layer near the mountainous terrain moving slowly from the southwest to northeast, while the higher cloud layer is moving more rapidly from the west to the east. The lower cloud layer was likely the cloud layer encountered by the accident flight. The departure airport of Scottsdale Airport, Arizona, (KSDL) is marked in figures 7 through 11 for reference.

Figures 9 and 10 present the GOES-15 infrared imagery from 0945 and 1000 at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant clouds over the accident site at the accident time. The lower brightness temperatures (green and blue colors, higher cloud tops) were over and to the north of the accident site around the accident time. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1000 MST HRRR sounding, the approximate cloud-top heights over the accident site were estimated at 28,000 feet at 0945 MST (figure 9). It should be noted that figures in this section have not been corrected for any parallax error.

Based on the surface observations (section 3.0), the 1000 MST HRRR sounding data (section 4.0), and the infrared satellite imagery, a flight profile was created[12] and included as figure 11 to indicate the likely cloud cover encountered by the accident flight while travelling to its intended destination. The accident flight likely encountered instrument meteorological conditions (IMC) shortly after flying over the Mazatzal Mountains. IMC likely continued for the rest of the flight. Visual meteorological conditions (VMC) were likely above 9,500 feet.

[12] For more information, please see the air traffic control (ATC) data located in the docket for this accident.

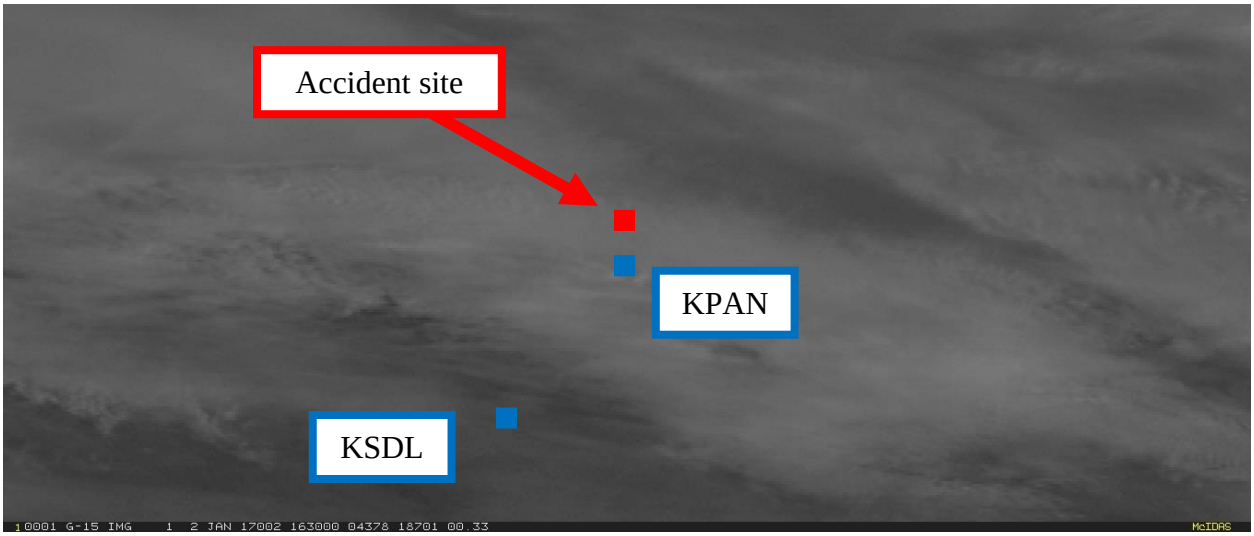


Figure 7 – GOES-15 visible image at 0930 MST

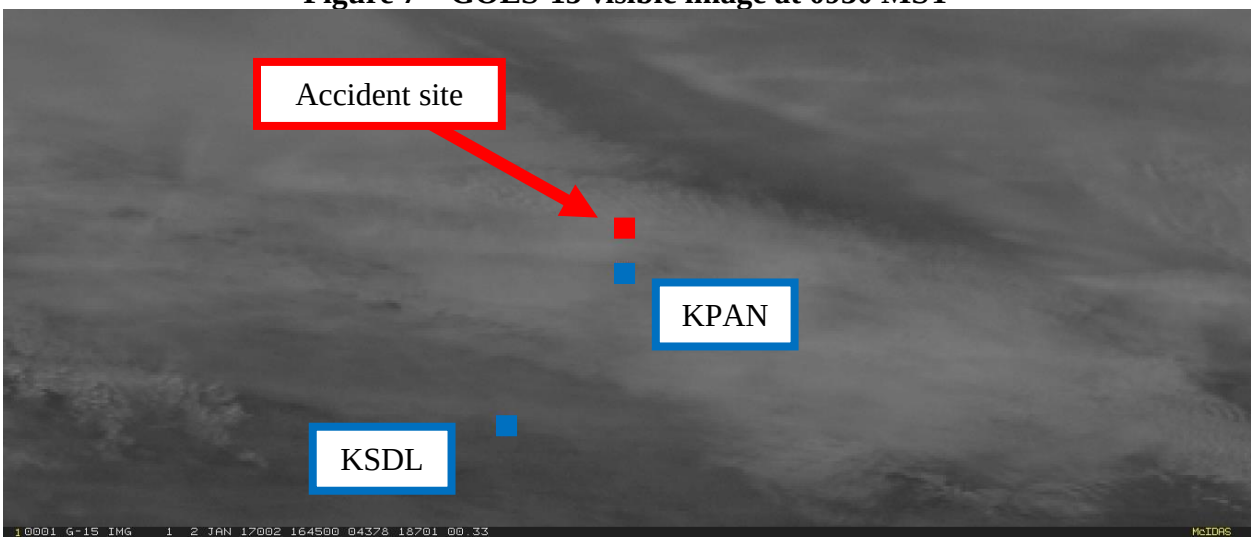


Figure 8 – GOES-15 visible image at 0945 MST

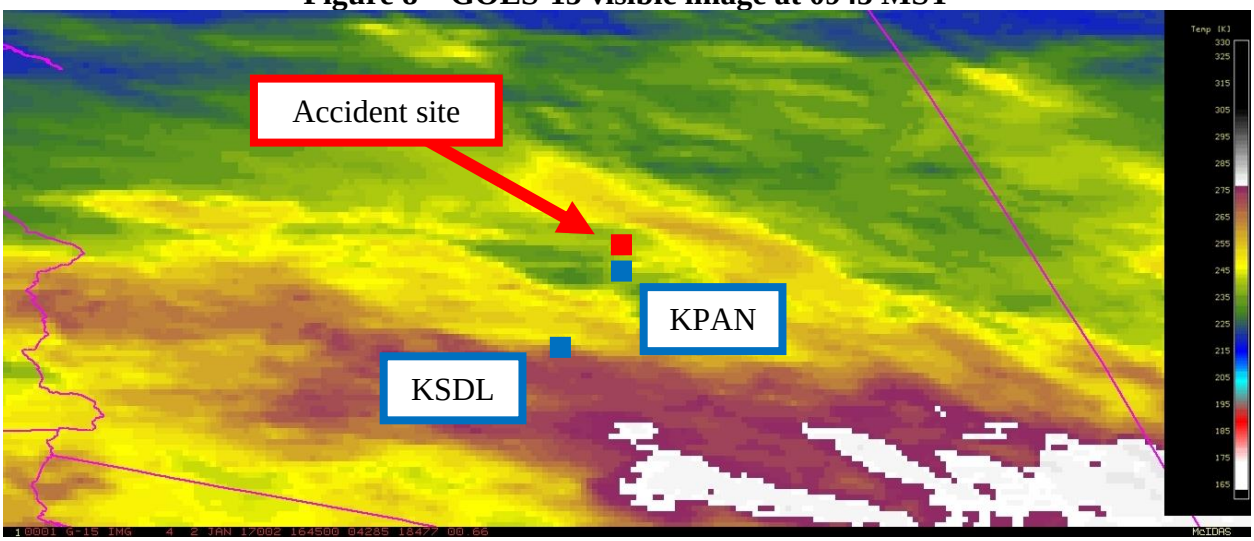


Figure 9 – GOES-15 infrared image at 0945 MST

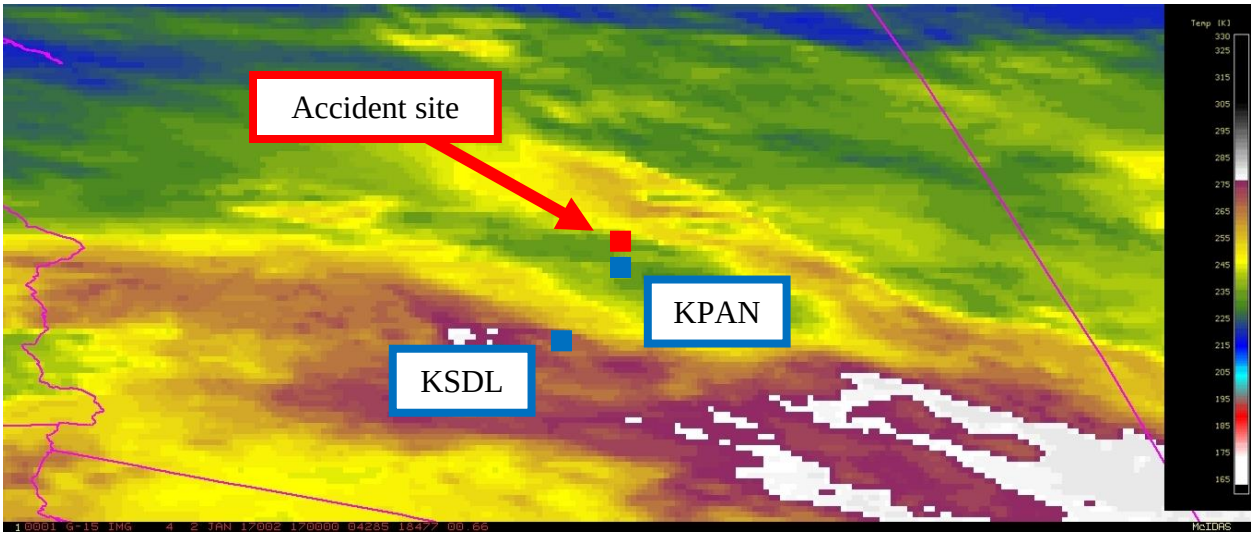


Figure 10 – GOES-15 infrared image at 1000 MST

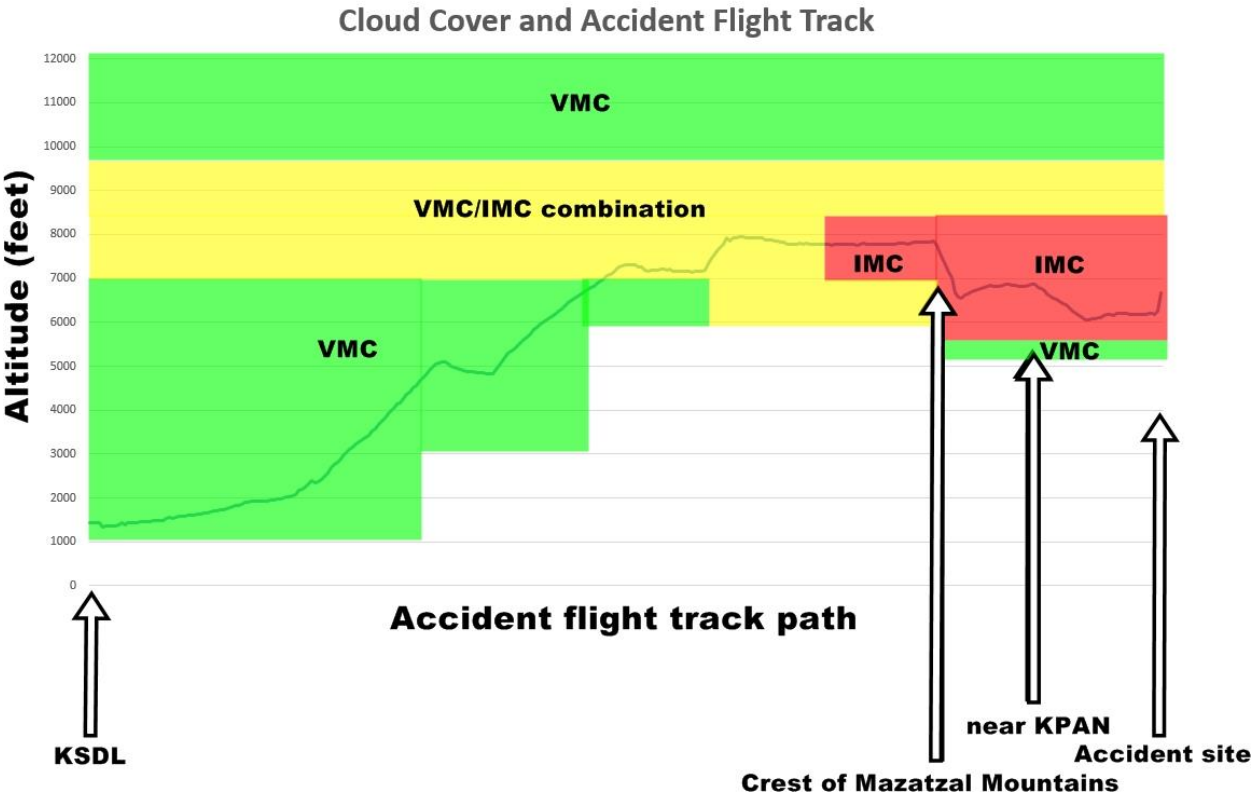


Figure 11 – Cloud cover with height (color fill) and accident flight track (line)

6.0 Radar Imagery Information

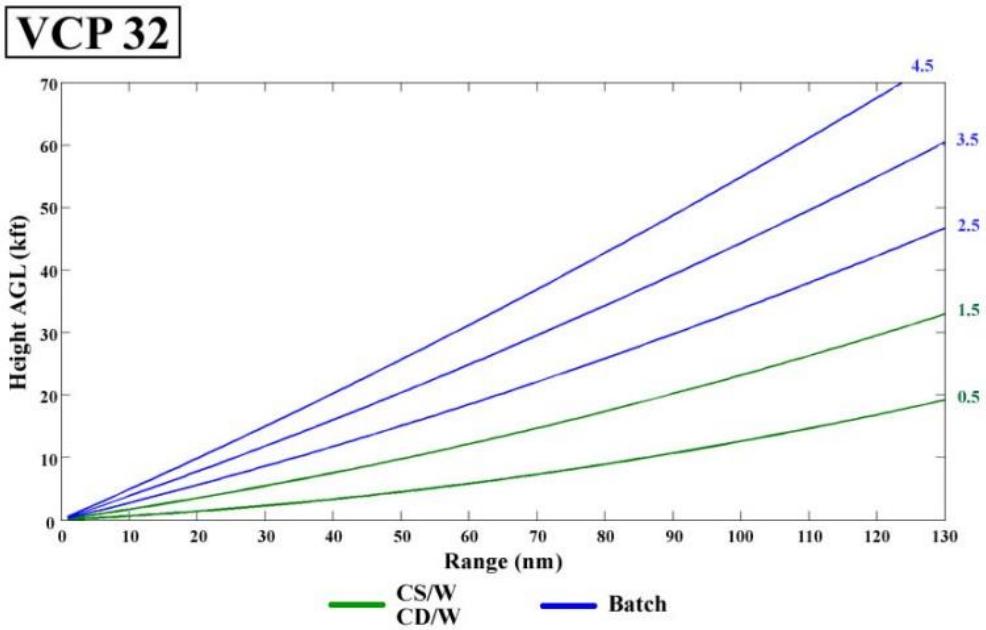
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[13] to the accident site was the Coconino/Flagstaff, Arizona, radar (KFSX), which was located 9 miles north-northeast of the accident site at an elevation of 7,417 feet. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

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 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). 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 KFSX WSR-88D radar was operating in the clear-air mode (Mode B, VCP-32). 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.

[13] 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.



VCP-32 Clear-Air Mode Scan Strategy[14]

6.2 Beam Height Calculation

Assuming standard refraction[15] of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width[16] information[17] of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	7,950 feet	7,510 feet	8,390 feet	880 feet

[14] Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured. Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values.
Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.
W – With range unfolding (W)
WO – Without range unfolding (WO)

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

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

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

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 7,510 feet and 8,390 feet msl over the accident site and these scans are the closest altitudes to the accident site before the accident occurred.[18]

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[19] 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[20]), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, "Thunderstorms," dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be "light." For dBZ values between 30 and 40, the terminology should be "moderate." "Heavy" terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as "extreme." From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

[18] For more information, please see the ATC data located in the docket for this accident.

[19] 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.

[20] 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.

6.4 Base Reflectivity and Lightning Data

Figures 12 and 13 present the KFSX WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 0935 and 0944 MST with a resolution of 0.5° X 250 m. Base reflectivity values between 0 to 10 dBZ were located above the accident site around the accident time. The precipitation bands were moving from southwest to northeast above the accident site around the accident time (attachment 2). With little precipitation reported at the surface (section 3.0) around the accident time, the majority of the precipitation particles likely remained in the cloud cover and with temperatures below freezing in the cloud cover (section 4.0), icing conditions were likely. Icing potential is further discussed in section 15.0. There were no lightning strikes around the accident site at the accident time.[21] A review of the dual-polarization level II and III data was done, but results were inconclusive.

[21] A review of Earth Networks Total Lightning network was done.

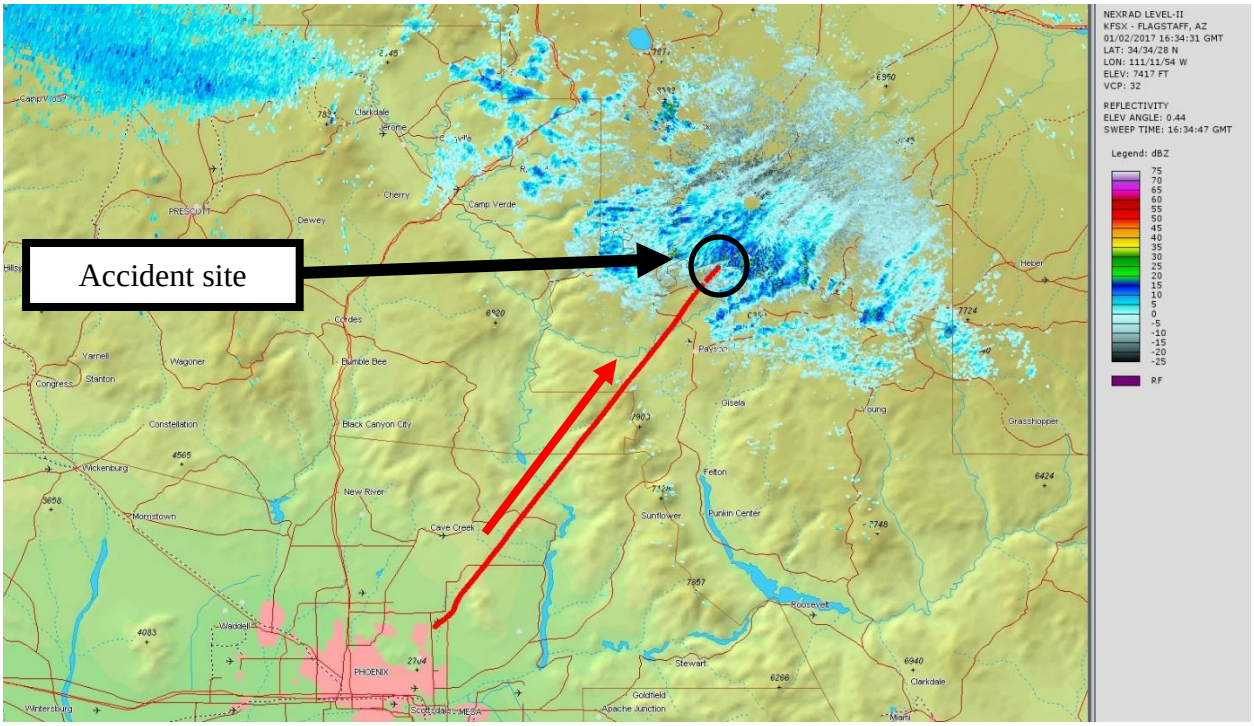


Figure 12 – KFSX WSR-88D reflectivity for the 0.5° elevation scan initiated at 0935 MST with the accident site marked with black circle and ATC track as red dots with arrow in direction of travel

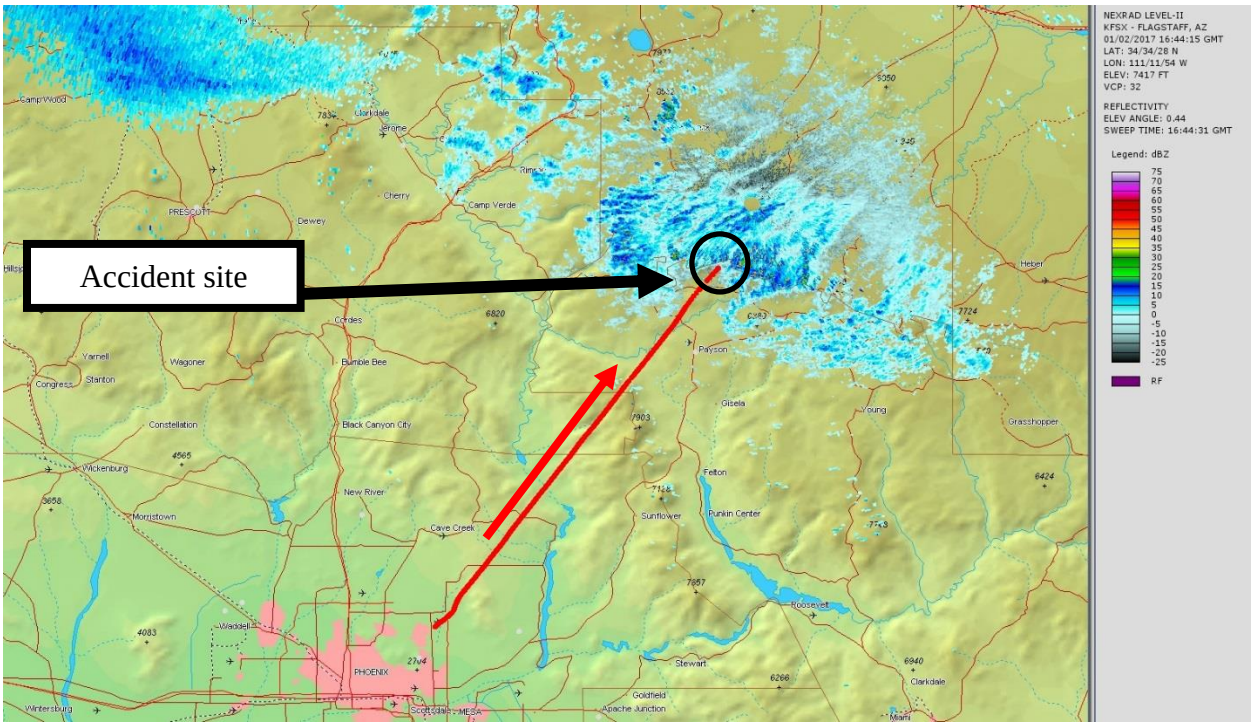


Figure 13 – KFSX WSR-88D reflectivity for the 0.5° elevation scan initiated at 0944 MST with the accident site marked with black circle and ATC track as red dots with arrow in direction of travel

7.0 Pilot Reports[22]

All pilot reports (PIREPs) close to the accident site from three hours prior to the accident time to three hours after the accident time were reviewed. Only PIREPs for below FL200[23] are provided below:

PRC UA /OV PRC360012/TM 1642/FL120/TP C172/SK BKN-TOP105

PRC UA /OV PRC135017/TM 1657/FL120/TP C172/SK OVC-TOP110

BXK UA /OV BXK220015/TM 1701/FL160/TP B737/TB LT TURB/RM LT TURB160-130 ZAB FDCS

PRC UA /OV PRC12003/TM 1741/FL080/TP C172/SK SCT059 BKN064/WX 10/TA M02/WV 18008/IC NEGATIVE/RM BASES BETWEEN 059 AND 064, TOPS 080

PHX UA /OV DRK050013/TM 1811/FL090/TP MAUL/TA M04/IC LGT RIME

PRC UA /OV PRC03015/TM 1812/FL090/TP ML4/TA M04/IC LIGHT RIME

PRC UA /OV PRC03003/TM 1818/FL060/TP ML4/SK BKN060/RM BASES 060

PAN UA /OV DRK090060/TM 1841/FL105/TP PA44/SK SCT-TOP094/SKC/WX FV99SM/TA M01

PRC UA /OV PRC/TM 1900/FLSFC/TP B190/SK T 9600 B 7300 OVC/TA M02/TB LGHT TURB/IC TRACE CLR/RM ON APCH RY21L

Routine pilot report (UA); 12 miles from Prescott, Arizona, on the 360° radial; Time – 0942 MST (1642Z); Altitude – 12,000 feet; Type aircraft – Cessna 172; Sky – Broken skies with tops at 10,500 feet.

Routine pilot report (UA); 17 miles from Prescott, Arizona, on the 135° radial; Time – 0957 MST (1657Z); Altitude – 12,000 feet; Type aircraft – Cessna 172; Sky – Overcast skies with tops at 11,000 feet.

Routine pilot report (UA); 15 miles from Buckeye, Arizona, on the 220° radial; Time – 1001 MST (1701Z); Altitude – 16,000 feet; Type aircraft – Boeing B737-700; Turbulence – Light turbulence; Remarks – Light turbulence between 16,000 and 13,000 feet.

Routine pilot report (UA); 3 miles from Prescott, Arizona, on the 120° radial; Time – 1041 MST (1741Z); Altitude – 8,000 feet; Type aircraft – Cessna 172; Sky – Scattered clouds at 5,900 feet and a broken ceiling at 6,400 feet; Weather – 10 miles visibility; Temperature – -2° C; Wind – From 180° at 8 knots; Icing – Negative; Remarks – Bases between 5,900 and 6,400 feet with tops at 8,000 feet.

[22] Only pilot reports with the WMO header UBAZ** identifier were considered.

[23] 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.

Routine pilot report (UA); 13 miles from Prescott, Arizona, on the 050° radial; Time – 1111 MST (1811Z); Altitude – 9,000 feet; Type aircraft – Maule; Temperature – -4° C; Icing – Light rime.

Routine pilot report (UA); 15 miles from Prescott, Arizona, on the 030° radial; Time – 1112 MST (1812Z); Altitude – 9,000 feet; Type aircraft – ML4; Temperature – -4° C; Icing – Light rime.

Routine pilot report (UA); 3 miles from Prescott, Arizona, on the 030° radial; Time – 1118 MST (1818Z); Altitude – 6,000 feet; Type aircraft – ML4; Sky – Broken skies at 6,000 feet; Remarks – Bases at 6,000 feet.

Routine pilot report (UA); 60 miles from Prescott, Arizona, on the 090° radial; Time – 1141 MST (1841Z); Altitude – 10,500 feet; Type aircraft – Piper PA-44 Seminole; Sky – Scattered clouds with tops at 9,400 feet, sky clear above; Weather – Unlimited visibility; Temperature – -1° C.

Routine pilot report (UA); Over Prescott, Arizona; Time – 1200 MST (1900Z); Altitude – Surface; Type aircraft – Beechcraft 1900; Sky – Tops at 9,600 feet with bases at 7,300 feet overcast; Temperature – -2° C; Turbulence – Light turbulence; Icing – Trace clear; Remarks – On approach into runway 21L.

8.0 SIGMET and CWSU Advisory

There were no Significant Meteorological Information advisories valid for the accident site at the accident time.

No Center Weather Service Unit (CWSU) Center Weather Advisories were valid for the accident site at the accident time. No CWSU Meteorological Impact Statements were valid for the accident site at the accident time.

9.0 AIRMETs

Airmen's Meteorological Information (AIRMET) advisories SIERRA and TANGO were issued at 0745 MST and valid at the accident time for the accident site (figure 14). The AIRMET SIERRAs forecasted IFR conditions, mountain obscuration conditions due to clouds, precipitation, and mist, and the AIRMET TANGO forecasted moderate turbulence below FL180:

WAUS45 KKCI 021445
WA5S
-SLCS WA 021445
AIRMET SIERRA UPDT 2 FOR IFR AND MTN OBSCN VALID UNTIL 022100
.
AIRMET IFR...UT AZ
FROM 50SSE BCE TO 60SSE INW TO 20ENE PHX TO 20NW PGS TO 50SSE BCE
CIG BLW 010/VIS BLW 3SM BR. CONDS ENDG 15-18Z.
.
AIRMET IFR...WY CO
FROM BFF TO GLD TO 30NNW LAA TO 20WSW LAR TO BFF

CIG BLW 010/VIS BLW 3SM BR/FG. CONDS ENDG 15-18Z.
.
AIRMET IFR...CO AZ NM
FROM 60SW DEN TO 30S ALS TO 30SW RSK TO 40ESE JNC TO 60SW DEN
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS ENDG 18-21Z.
.
AIRMET IFR...ID MT WY UT CO
FROM 30NNW HVR TO 50NNW ISN TO 70SW RAP TO BFF TO 40ENE DTA TO 30SSW MLD TO 50S BIL TO 70E LWT TO 30NNW HVR
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
.
AIRMET MTN OBSCN...ID MT WY NV UT CO WA OR CA
FROM 40SW YQL TO 30NNW HVR TO SHR TO 40NE LAR TO 40WNW DEN TO 40SW CHE TO 50W BCE TO 30SE BTY TO 40SSW FMG TO 40SE LKV TO 50SW LKV TO 60SE BTG TO 40ENE SEA TO 80SSE MLP TO 40SW YQL
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
.
AIRMET MTN OBSCN...UT CO AZ NM
FROM 40WNW DEN TO 40SE ALS TO 50W ABQ TO 20S DRK TO 50N PGS TO 50W BCE TO 40SW CHE TO 40WNW DEN
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.
....

WAUS45 KKCI 021445
WA5T
-SLCT WA 021445
AIRMET TANGO UPDT 2 FOR TURB AND LLWS VALID UNTIL 022100
.
AIRMET TURB...ID WY NV UT CO AZ NM OR CA
FROM 30NE CZI TO 70SW RAP TO BFF TO 30ESE TBE TO INK TO 60W INK TO PHX TO EED TO 50NE EHF TO 30NNE SAC TO 30S LKV TO 20WNW MLD TO 30NE CZI
MOD TURB BLW FL180. CONDS CONTG BYD 21Z THRU 03Z.
.
AIRMET TURB...ID MT WY NV UT CO AZ NM
FROM 100SE MLS TO 70SW RAP TO GLD TO 50W LBL TO 30ESE TBE TO INK TO ELP TO 50S TUS TO BZA TO EED TO 40SSW FMG TO 40SE LKV TO 50SE REO TO 30WNW DNJ TO LKT TO 30W SHR TO 100SE MLS
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 21Z THRU 03Z.
.
LLWS POTENTIAL...NV CA
BOUNDED BY FMG-20NNE BTY-70E EHF-30NNE SAC-FMG
LLWS EXP. CONDS ENDG 18-21Z.
....

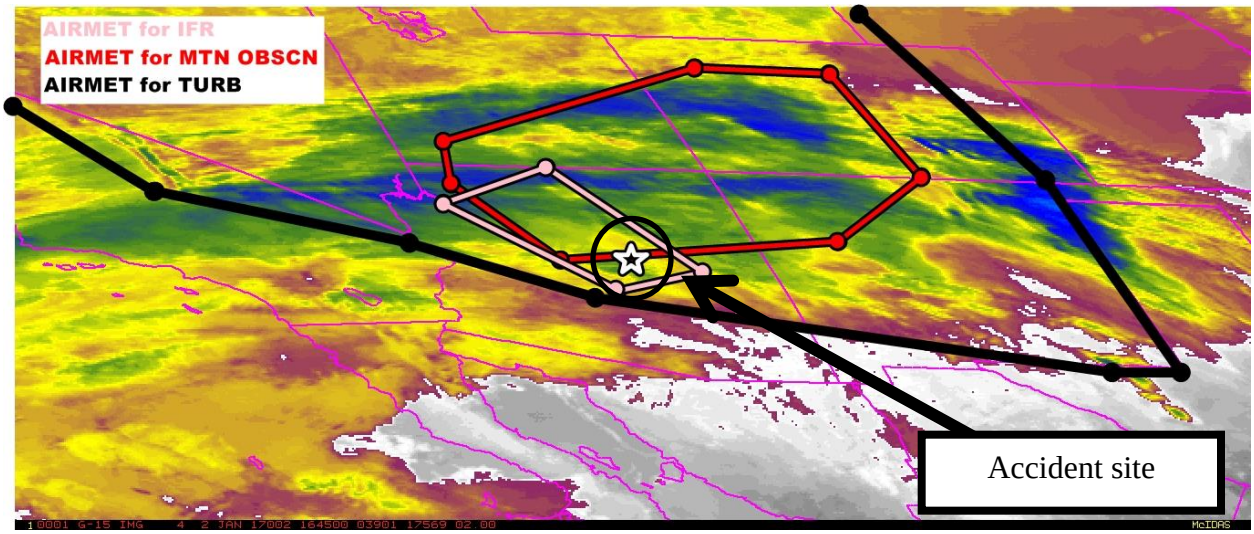


Figure 14 –AIRMETs valid for the accident area for the accident time

10.0 Area Forecast

The Area Forecast issued at 0445 MST, valid at the accident time, forecasted a broken to overcast ceiling at 9,000 feet with clouds tops at 10,000 feet and a south wind gusting to 25 knots:

614
FAUS45 KKCI 021145
FA5W
-SLCC FA 021145
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 030600
CLDS/WX VALID UNTIL 030000...OTLK VALID 030000-030600
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..WLY TO SWLY FLOW TO PREVAIL ACRS THE AREA THRU
THE PD. FLOW IS EXPD TO REMAIN STRONG ACRS THE SRN 2/3 OF THE
AREA AS SRN STREAM JET STRENGTHENS. SFC STNRY FNT IS EXPD TO
REMAIN DRAPED ACRS NRN UT AND CO THRU THE PD AS ARCTIC HIGH PRES
BEGINS TO BUILD IN ACRS NRN PTNS.
.
ID
NRN...BKN-OVC090 LYRD FL190. WND N G25KT. OTLK...VFR WND.
CNTRL MTNS...BKN-OVC070 LYRD FL190. 15Z ISOL -SHSN. 20Z ISOL
-SHRA. OTLK...MVFR CIG SHRA. 02Z VFR.
SWRN...BKN-OVC050 LYRD FL190. VIS 3-5SM SCT -SHSN. 17Z ISOL
-SHRA. OTLK...MVFR CIG BR. 02Z VFR.
SERN...BKN-OVC070 LYRD FL190. SRN PTNS BKN-OVC060. VIS 3-5SM BR.
15Z BKN-OVC070. ISOL -SHRA. 18Z ISOL -SHSN. OTLK...MVFR CIG SHRA.
.
MT
CONTDVD WWD...BKN-OVC120 LYRD FL220. 14Z SCT120. OTLK...VFR.

SWRN MTNS...BKN-OVC080 LYRD FL220. ISOL -SHSN. 15Z BKN080.
OTLK...MVFR CIG BR.
ERN SLOPES OF CONTDVD...SCT045 BKN065 LYRD FL220. VIS 3-5SM -SN
BLSN. 14Z SCT040 BKN070. OTLK...VFR.
CNTRL...BKN-OVC050 LYRD FL220. VIS 3-5SM ISOL -SHSN. 15Z
BKN-OVC050. ISOL -SHSN. NRN PTNS BKN060. 18Z BKN060. OTLK...MVFR
CIG BR.
ERN...BKN-OVC030 LYRD FL220. VIS 3-5SM SCT -SHSN. OTLK...MVFR CIG
SHSN. 02Z MVFR CIG SHRA.
.
WY
PLAINS...
N HLF...BKN-OVC050 TOP 160. VIS 3-5SM WDLY SCT -SHSN. 18Z
BKN060. OTLK...MVFR CIG BR.
S HLF...BKN CI. 15Z WND NW G25KT. OTLK...VFR.
MTNS E OF CONTDVD...
N HLF...BKN-OVC080 TOP FL180. VIS 3-5SM -SN. 18Z BKN-OVC090 TOP
150. OTLK...MVFR CIG BR.
S HLF...BKN-OVC080 TOP FL180. VIS 3-5SM -SN BLSN. WND SW
20G30KT. 18Z BKN-OVC090 TOP 150. OTLK...MVFR CIG BR.
MTNS W OF CONTDVD...
N HLF...BKN-OVC090 LYRD FL210. VIS 3-5SM -SN. 18Z BKN-OVC100.
ISOL -SHRA. OTLK...MVFR CIG SHRA.
S HLF...BKN-OVC080 LYRD FL210. VIS 3-5SM -SN. 18Z BKN-OVC100.
ISOL -SHRA. OTLK...MVFR CIG SHRA.
.
NV
NWRN...
N HLF...BKN-OVC060 TOP 160. VIS 3-5SM -SN. 18Z BKN-OVC070. ISOL
-SHSN. OTLK...MVFR CIG SHSN.
S HLF...SCT060. 16Z SCT-BKN110 TOP 120. OTLK...VFR.
NERN...SCT-BKN090 TOP 110. WRN PTNS BKN-OVC080 TOP 160. VIS 3-5SM
-SN. 18Z BKN090. WRN PTNS ISOL -SHSN. OTLK...MVFR CIG BR. WRN
PTNS MVFR CIG SHSN.
SRN...BKN CI. WND S G25KT. OTLK...VFR WND. 02Z VFR.
.
UT
NRN HLF...
UINTA BASIN...BKN-OVC090 TOP 160. ISOL -SHRA. 18Z TOP 120.
OTLK...MVFR CIG SHRA.
ELSW...BKN-OVC050 TOP 160. VIS 3-5SM -RASN. 12Z ISOL -SHRA. 15Z
SCT-BKN060. OTLK...MVFR CIG BR. 02Z MVFR CIG SHRA.
SRN HLF...BKN-OVC090 TOP 110. ISOL -SHRA. WND S 20G30KT. 15Z WND
S G25KT. OTLK...MVFR CIG BR WND. 01Z VFR.
.
CO
PLAINS...SCT CI. OCNL BKN CI. OTLK...VFR.
MTNS E OF CONTDVD...
N HLF...SCT-BKN CI. OTLK...VFR.
S HLF...BKN-OVC090 TOP 110. VIS 3-5SM BR. 15Z SCT-BKN100.
OTLK...VFR.
MTNS W OF CONTDVD...
N HLF...BKN-OVC110 TOP 130. ISOL -SHRA. OTLK...MVFR CIG SHRA.
S HLF...BKN-OVC100 TOP 120. VIS 3-5SM ISOL -SHSN. 15Z BKN110.
ISOL -SHRA. WND S G25KT. OTLK...MVFR CIG SHRA WND.
.

AZ
NRN HLF...BKN-OVC090 TOP 100. WND S G25KT. NWRN PTNS BKN-OVC050 TOP 070. VIS 3-5SM ISOL -SHSN. WND SW G25KT. 15Z SCT-BKN080 LYRD FL220. WND SW 20G30KT. OTLK...VFR.
SWRN...SCT-BKN CI. OTLK...VFR.
SERN...SCT-BKN070 TOP 080. 15Z SCT080 BKN CI. OTLK...VFR.
.
NM
PLAINS...SKC. OCNL SCT CI. 17Z NRN PTNS WND W G25KT. OTLK...VFR.
MTNS E OF CONTDVD...SCT-BKN120 TOP 130. 17Z WND W 20G30KT.
OTLK...VFR.
MTNS W OF CONTDVD...BKN-OVC090 TOP 110. 16Z BKN120 LYRD FL220.
OTLK...VFR.
....

11.0 Terminal Aerodrome Forecast

Sedona Airport (KSEZ), located 35 miles west-northwest of the accident site at an elevation of 4,830 feet, was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 0433 MST and was valid for a 24-hour period beginning at 0500 MST. The TAF for KSEZ was as follows:

TAF KSEZ 021133Z 0212/0312 17010G19KT P6SM BKN004 OVC010
FM021500 18011G20KT P6SM -SHRA SCT002 BKN004 OVC012
FM021700 18012KT P6SM SCT012 OVC018
TEMPO 0300/0302 4SM -SHRA BKN012
FM030230 19008KT 4SM BR SCT005 OVC010=

The forecast expected a wind from 180° at 11 knots with gusts to 20 knots, greater than 6 miles visibility, light rain showers, scattered clouds at 200 feet agl, a broken ceiling at 400 feet agl, and overcast skies at 1,200 feet agl.

12.0 NWS Area Forecast Discussion

The NWS Office in Flagstaff, Arizona, issued the following Area Forecast Discussion (AFD) at 0343 MST (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed IFR conditions likely along the higher terrain, especially south and west facing terrain. Mogollon Rim and Kaibab Plateau were areas specifically mentioned to likely have scattered light snow/rain shower conditions:

118
FXUS65 KFGZ 021043
AFDFGZ

Area Forecast Discussion
National Weather Service Flagstaff AZ
343 AM MST Mon Jan 2 2017

.SYNOPSIS... Scattered to numerous showers will persist through today over mountainous areas with additional light snow accumulations. Expect gusty winds to develop late this morning and last through the daytime. Drier weather looks to return by

Tuesday. Drier weather looks to return Tuesday, but there is still potential for additional precipitation later in the week.

&&

.DISCUSSION...Northern Arizona remains under a strengthening west to southwest flow aloft in response to cold low pressure moving through the Pacific Northwest. Rather shallow moisture and the strengthening upslope flow has continued shower development through last evening and into early this morning with elevations above 6000-6500 feet receiving additional light snow. The saturated upslope flow will continue through the day, and in fact, moisture profiles will deepen further as a very moist Pacific air mass moves into the state. This will lead to an increase in shower activity this afternoon and evening and have correspondingly increased precipitation chances favoring areas along the Mogollon Rim and Kaibab Plateau. These are the most likely areas to receive additional snow accumulation today. In addition to the precipitation, winds will increase this morning and remain gusty through the afternoon. A wind advisory remains in effect for much of northern Arizona through the day.

Rain and snow chances decrease Tuesday and Wednesday while temperatures have a chance to warm closer to normal values. There still remains potential for additional rain and snow sometime in the late Wednesday night through Friday time period as the Pacific Northwest low weakens and passes through the Great Basin. There is still a considerable amount of spread among model outcomes at this time so confidence remains low.

&&

.AVIATION...For the 12Z Forecast...Expect wdsprd MVFR/IFR conditions along south and west facing higher terrain through at least 02z-04z Tuesday. Areas northeast of higher terrain will be predominately VFR. Sct -shsn/-shra will persist along and just south of the Mogollon Rim and over the Kaibab Plateau. Areas of rain and snow will increase from KFLG northward from roughly 22z-03z today as jet streak moves across the area. Conditions will improve from west to east tonight, although areas of IFR cigs will persist from KFLG northward, along west facing higher terrain. Expect gusty sfc winds sw15-25g35kts over higher terrain today, 10-20g30kts in the lower elevations. Aviation discussion not updated for TAF amendments.

&&

.FGZ WATCHES/WARNINGS/ADVISORIES...Wind Advisory from 8 AM this morning to 11 PM MST this evening FOR AZZ004-006-007-009-011>017-039-040.

&&

$$

13.0 Winds and Temperature Aloft Forecast

The NWS 0658 MST Winds and Temperature Aloft forecast valid for the accident flight are included below:

```
FBUS31 KWNO 021358
FD1US1
-DATA BASED ON 021200Z
VALID 021800Z   FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT  3000    6000    9000   12000   18000   24000  30000  34000  39000
PRC              2523-01 2731-06 2562-19 2683-25 761540 773350 784660
```

The accident site was closest to the Prescott, Arizona, (PRC) forecast point. The 0658 MST PRC forecast indicated a wind at 9,000 feet from 250° at 23 knots with a temperature of -1° C and a wind at 12,000 feet from 270° at 31 knots with a temperature of -6° C.

14.0 Pilot Weather Briefing

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS) and Direct User Access Terminal Service (DUATS) was done and the accident pilot did not receive an official weather briefing from those sources. A search of ForeFlight weather information revealed that the accident pilot did not request a weather briefing using ForeFlight Mobile prior to his flight (attachment 3). However, while the accident pilot did not file a flight plan with ForeFlight Mobile, the accident pilot did enter route information at 08:26:07 MST with the route from KSDL to Telluride Regional Airport (KTEX) entered (attachment 3). The accident pilot did not look at any weather imagery (e.g., Prog Charts, G-AIRMETs, Icing information, etc…) before or during the accident flight using ForeFlight, LMFS, or DUATS, however, the accident pilot could have reviewed weather graphics from additional internet sources. The accident pilot could have accessed other "live" text weather information such as METARs/TAFs, etc… (attachment 3) on ForeFlight, but because that information is not logged by ForeFlight it is not known if the pilot accessed other "live" text weather information. The accident pilot's airplane ownership partner mentioned that the accident pilot asked for weather assistance about three days prior to the flight (attachment 3). The accident pilot's airplane partner said that the forecast was bad and that he told the accident pilot that he should drive to their destination (attachment 3). It is unknown if the accident pilot checked or received any more weather information before or during the accident flight.

15.0 Icing Potential[24]

Current Icing Potential (CIP) and Forecast Icing Potential (FIP) are produced by the NWS' Aviation Weather Center (AWC) and are intended to be supplemental to other icing advisories (e.g. AIRMETs and SIGMETs). Figures 15 through 17 were the FIP icing probabilities, icing severity, and Supercooled Large Droplet (SLD) potential 2-hour forecast valid at 0900 MST at 7,000, 7,500, 8,000 feet msl (similar values in the FIP are seen in the 1-hour forecast valid at both 0900 and 1000 MST, attachment 4). The FIP indicated a 40 to 70 percent probability of icing at 7,000, 7,500, and 8,000 feet at 0900 MST at the accident site. The FIP also indicated that the icing near the accident site would likely be light to moderate (figures 15, 16, and 17). The FIP did not indicate any SLD potential near the accident site around the accident time. This FIP information would have been available on the NWS AWC website well before the accident flight departed KSDL.[25]

The CIP indicated a 50 to 70 percent probability of icing at 7,000, 7,500, and 8,000 feet at 0900 MST at the accident site. The CIP also indicated that the icing near the accident site would likely be trace to light (figures 18, 19, and 20). The CIP did indicate a 50 to 70 percent chance of SLD near the accident site around the accident time. Given the FIP and CIP information (figures 15 through 20 and attachment 4) the accident flight likely encountered icing conditions while in IMC. In addition, the accident flight likely encountered icing conditions containing SLD while near and north of KPAN. For more FIP and CIP information and altitudes please see attachment 4.

[24] B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cunning, Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations (Journal of Applied Meteorology, 2005), pp. 969-986.
C.A. Wolff, F. McDonough, M. K. Politovich, B.C. Bernstein, and G. Cunning, FIP Severity Technical Document (Prepared for the Aviation Weather Technology Transfer Technical Review Board), pp. 1-44.

[25] https://www.aviationweather.gov/icing/fip

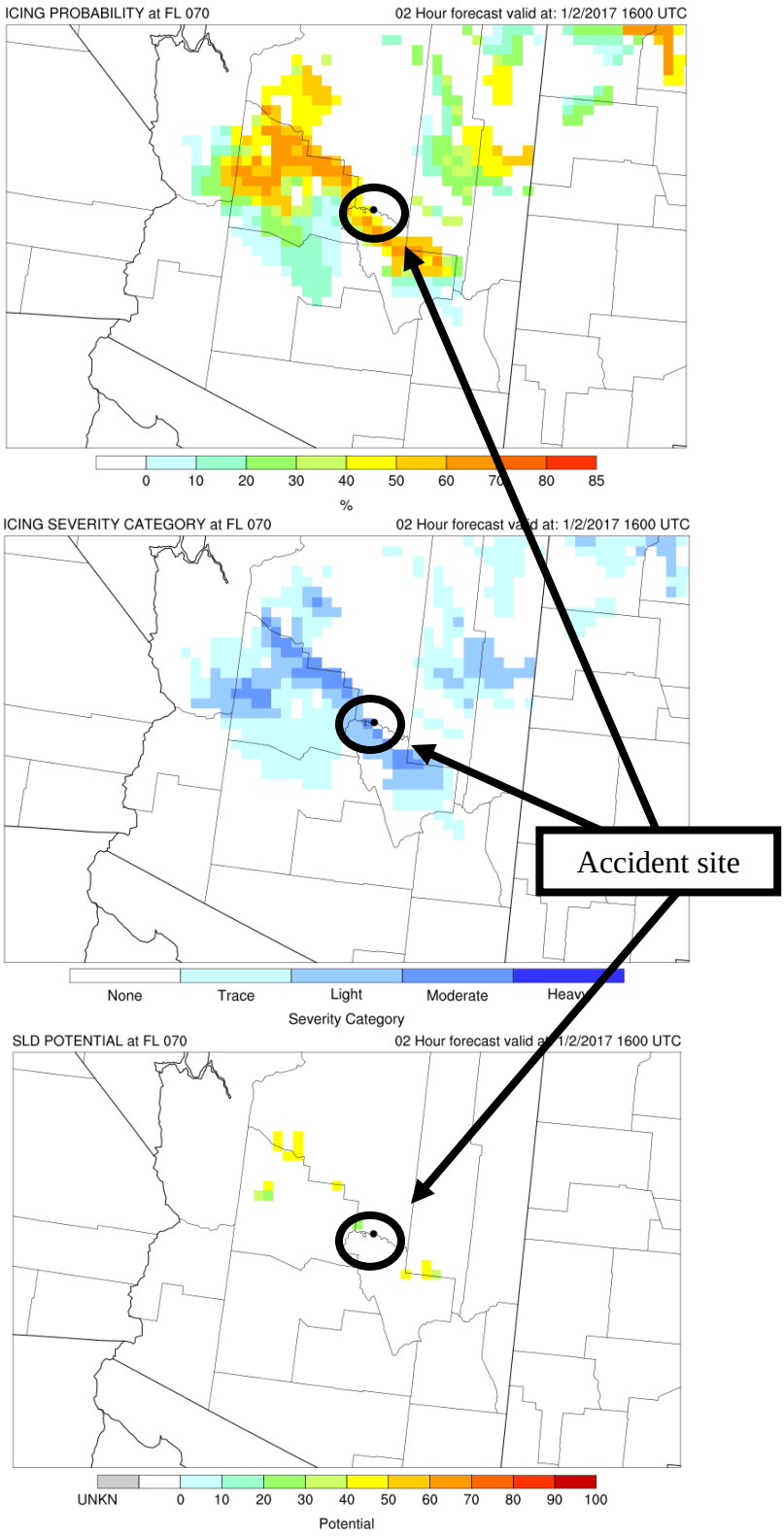


Figure 15 – (top) FIP probability of icing at 7,000 feet msl, (middle) FIP severity of icing at 7,000 feet msl, and (bottom) FIP SLD potential at 7,000 feet msl 2-hour forecast valid for 0900 MST

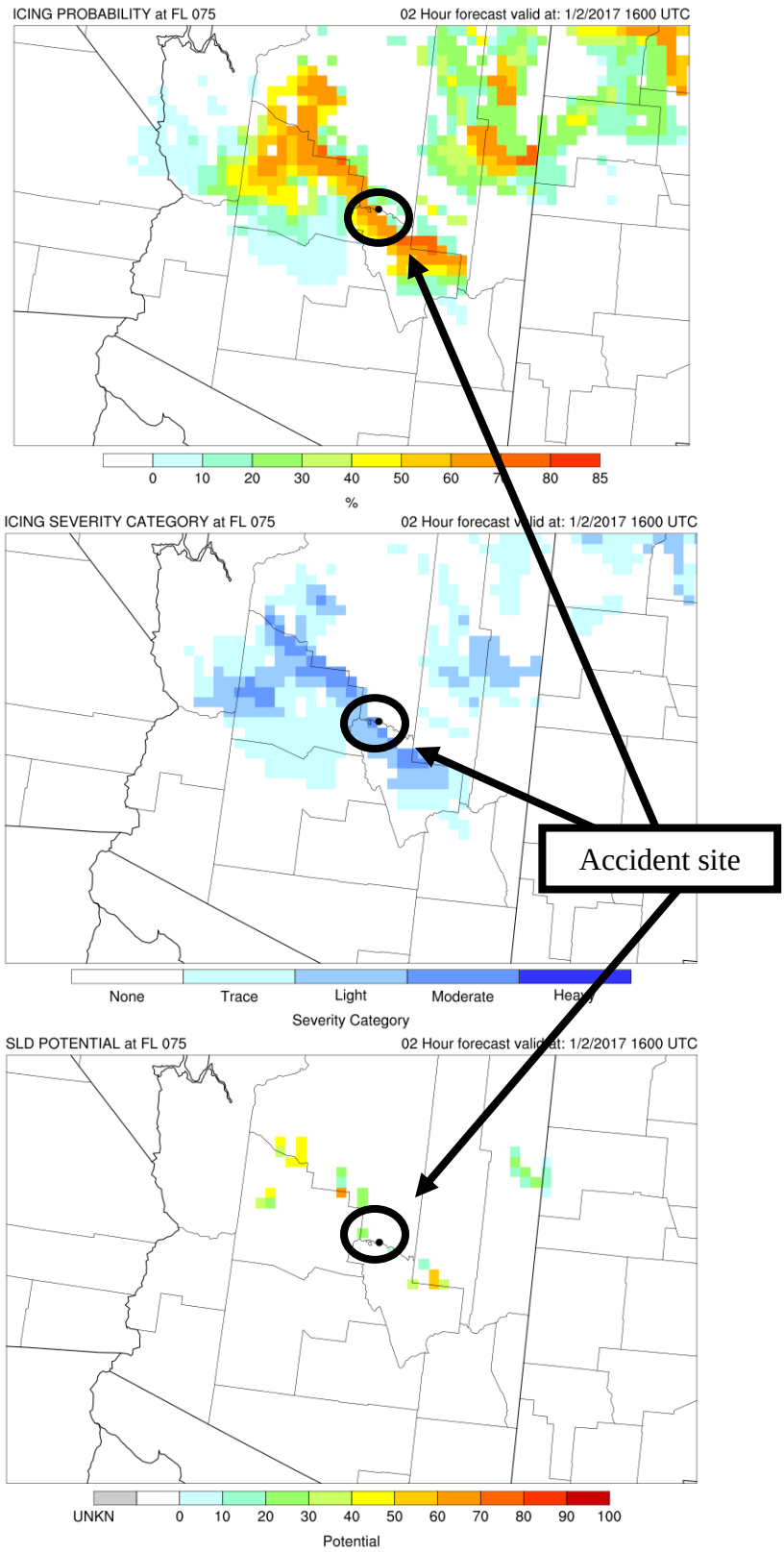


Figure 16 – (top) FIP probability of icing at 7,500 feet msl, (middle) FIP severity of icing at 7,500 feet msl, and (bottom) FIP SLD potential at 7,500 feet msl 2-hour forecast valid for 0900 MST

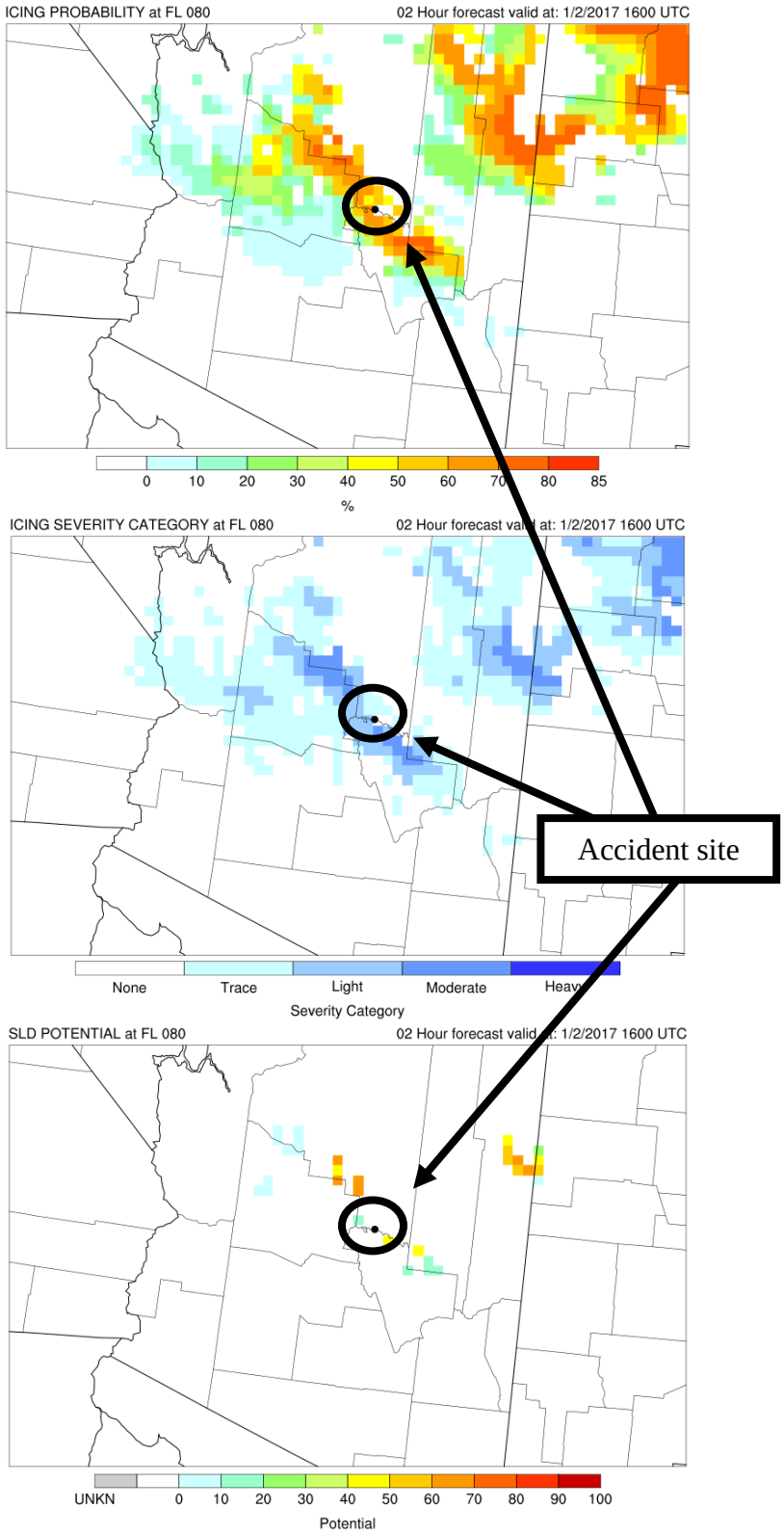


Figure 17 – (top) FIP probability of icing at 8,000 feet msl, (middle) FIP severity of icing at 8,000 feet msl, and (bottom) FIP SLD potential at 8,000 feet msl 2-hour forecast valid for 0900 MST

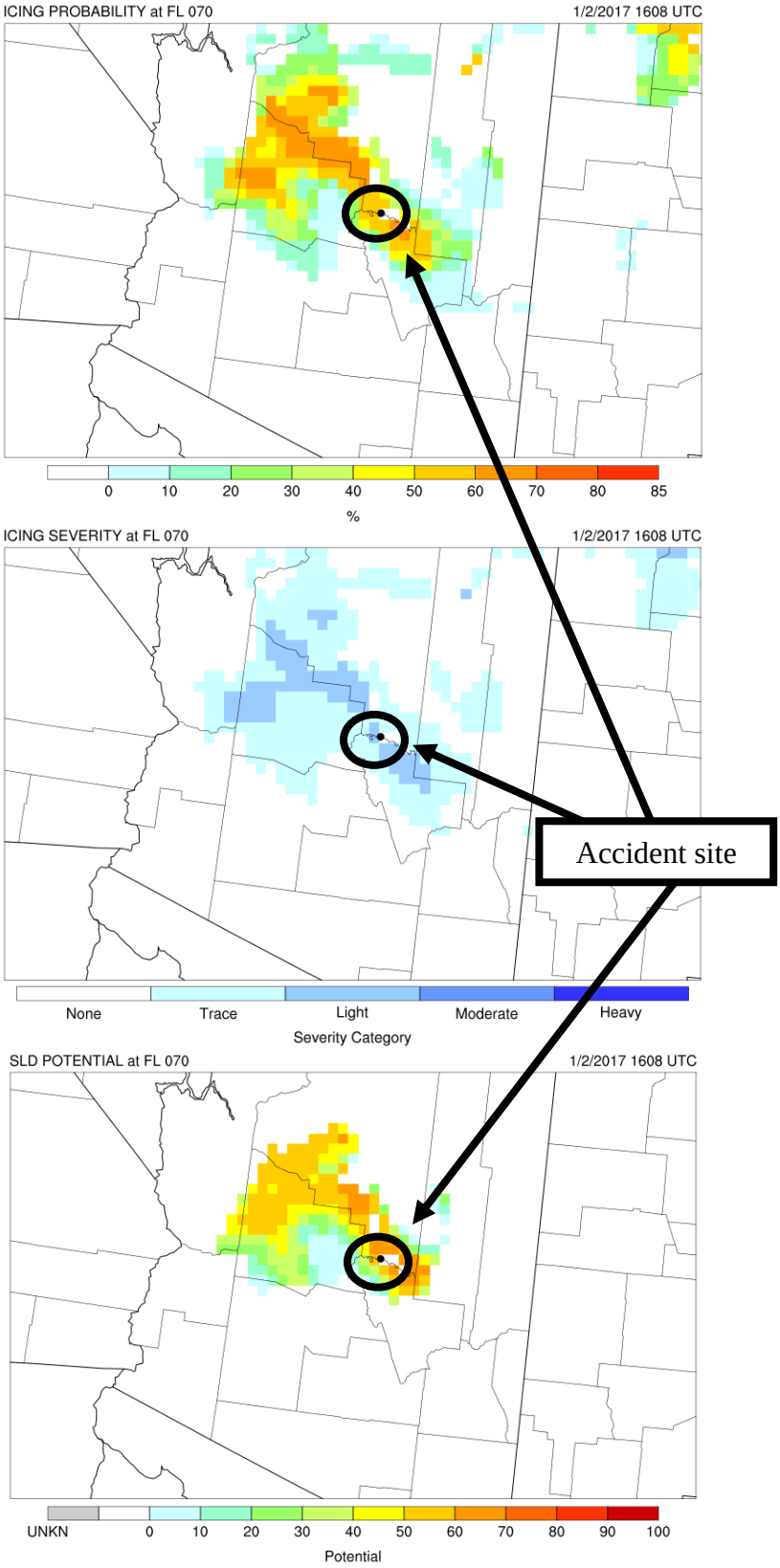


Figure 18 – (top) CIP probability of icing at 7,000 feet msl, (middle) CIP severity of icing at 7,000 feet msl, and (bottom) CIP SLD potential at 7,000 feet msl valid for 0900 MST

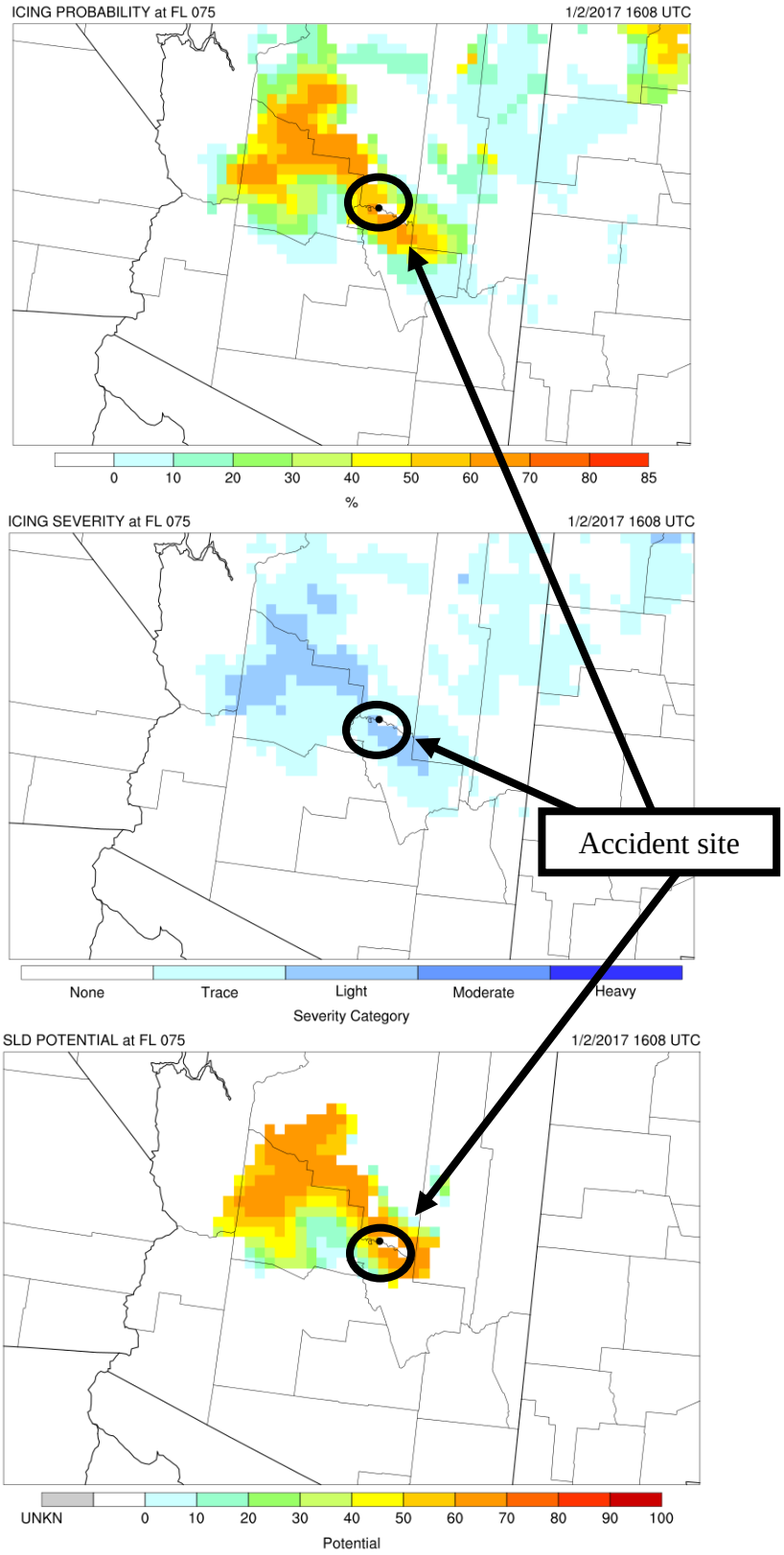


Figure 19 – (top) CIP probability of icing at 7,500 feet msl, (middle) CIP severity of icing at 7,500 feet msl, and (bottom) CIP SLD potential at 7,500 feet msl valid for 0900 MST

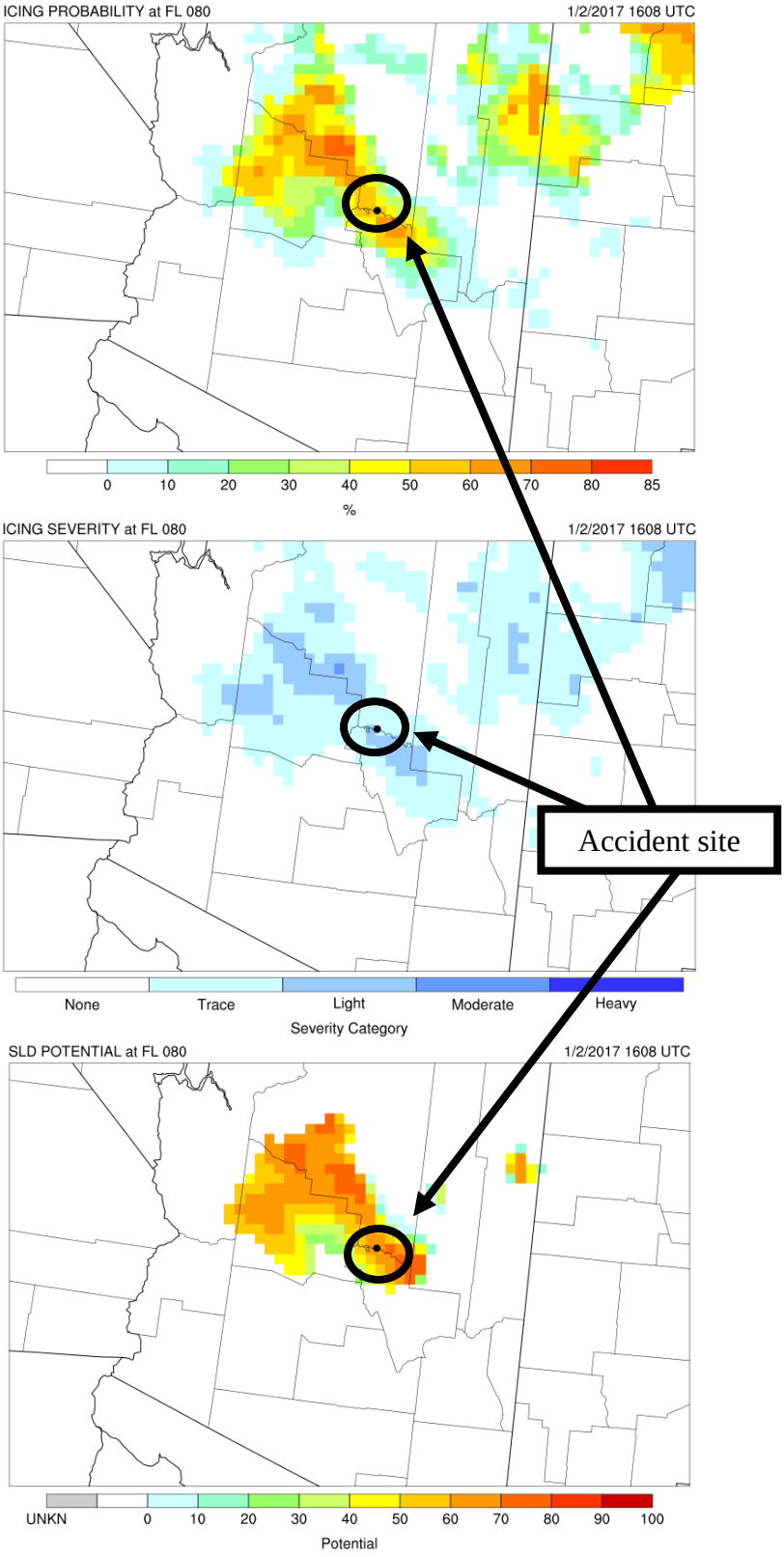


Figure 20 – (top) CIP probability of icing at 8,000 feet msl, (middle) CIP severity of icing at 8,000 feet msl, and (bottom) CIP SLD potential at 8,000 feet msl valid for 0900 MST

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on January 2, 2017, indicated the following:

SUN	
Begin civil twilight	0704 MST
Sunrise	0732 MST
Sun transit	1229 MST
Sunset	1727 MST
End civil twilight	1755 MST

E. LIST OF ATTACHMENTS

Attachment 1 – Animation of GOES-15 visible satellite imagery from 0845 to 1045 MST

Attachment 2 – Animation of KFSX WSR-88D base reflectivity images for the 0.5° elevation scans initiated from 0905 to 1003 MST

Attachment 3 – Weather briefing information

Attachment 4 – CIP/FIP data for 0900 and 1000 MST around the accident site

Submitted by:

_____

Paul Suffern
Senior Meteorologist

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