



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

September 21, 2018

Factual Report

METEOROLOGY

CEN18LA077

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A. ACCIDENT

Location: Near Santa Fe, New Mexico
Date: January 15, 2018
Time: 1935 mountain standard time
0235 Coordinated Universal Time (UTC) on January 16, 2018
Aircraft: Velocity XL-RG, Registration: N787SB

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 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 15, 2018, 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 approximate location of the accident site was at latitude 35.5431° N, longitude 105.9831° W, with an approximate elevation of 6,530 feet (ft).

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 southern section of the NWS Surface Analysis Chart for 2000 MST is provided as figure 1 with the approximate location of the accident site marked with the red circle. The chart indicated a frontal boundary extending from central Colorado southward over Santa Fe, New Mexico, southwestward into southern New Mexico, then southeastward into western Texas. The accident site was located east of the frontal boundary in the colder airmass.

The station models around the accident site depicted air temperatures in the upper teens to low 30's degrees Fahrenheit (°F), dew point temperatures in the mid-teens to low 20's °F with temperature-dew point spreads of 5° F or less, a southeast wind of 10 to 15 knots, and overcast sky cover.

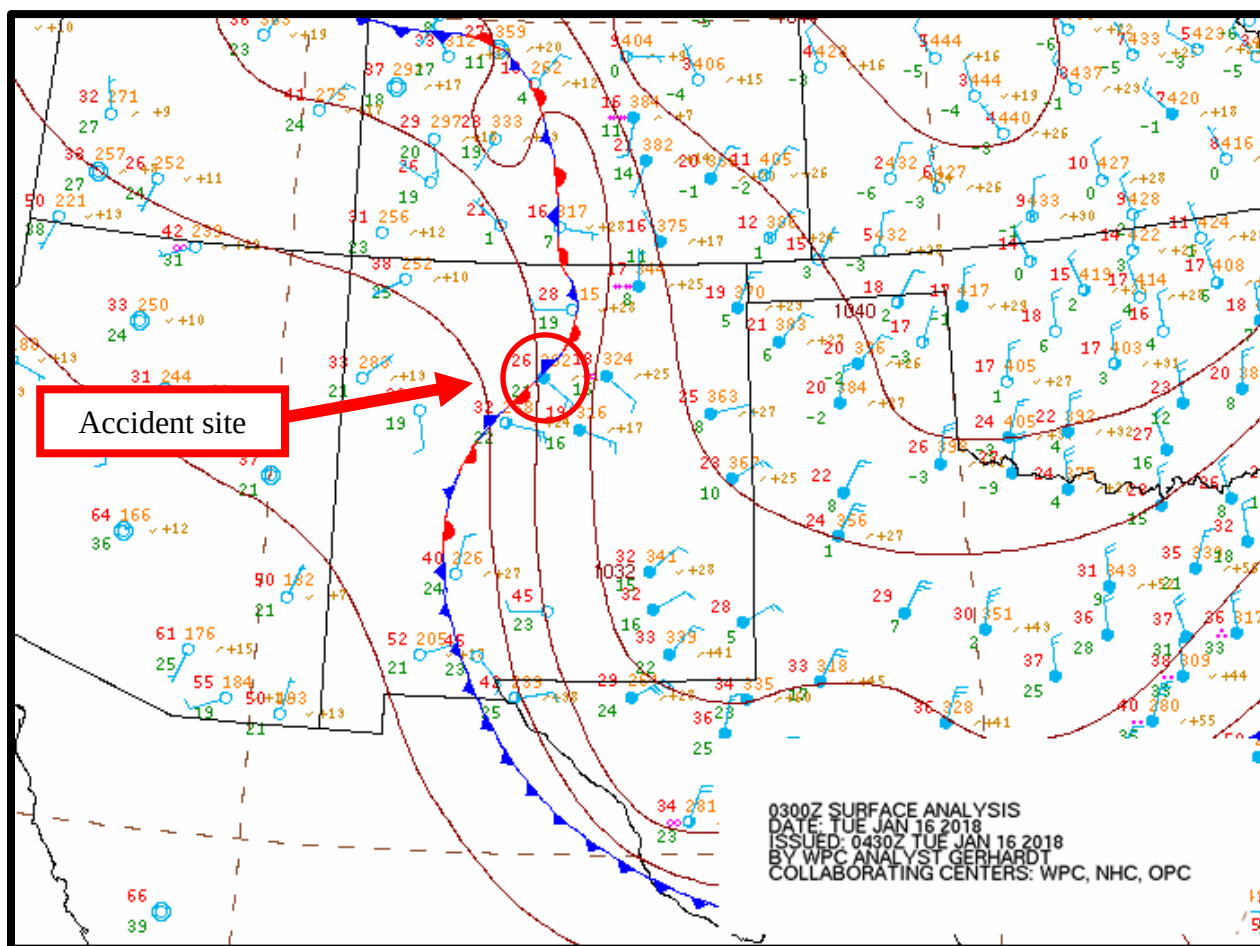


Figure 1 – NWS Surface Analysis Chart for 2000 MST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1700 MST at 700-, 500-, and 300-hectopascals (hPa) are presented in figures 2 through 4. There were mid-level troughs¹ located on either side of the accident site (figure 2) at 700-hPa. Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. There was a west-northwest wind of 15 knots at 700-hPa with the wind increasing in speed to 40 knots by 500-hPa. By 300-hPa, the wind was still from the west-northwest at 40 knots (figure 4).

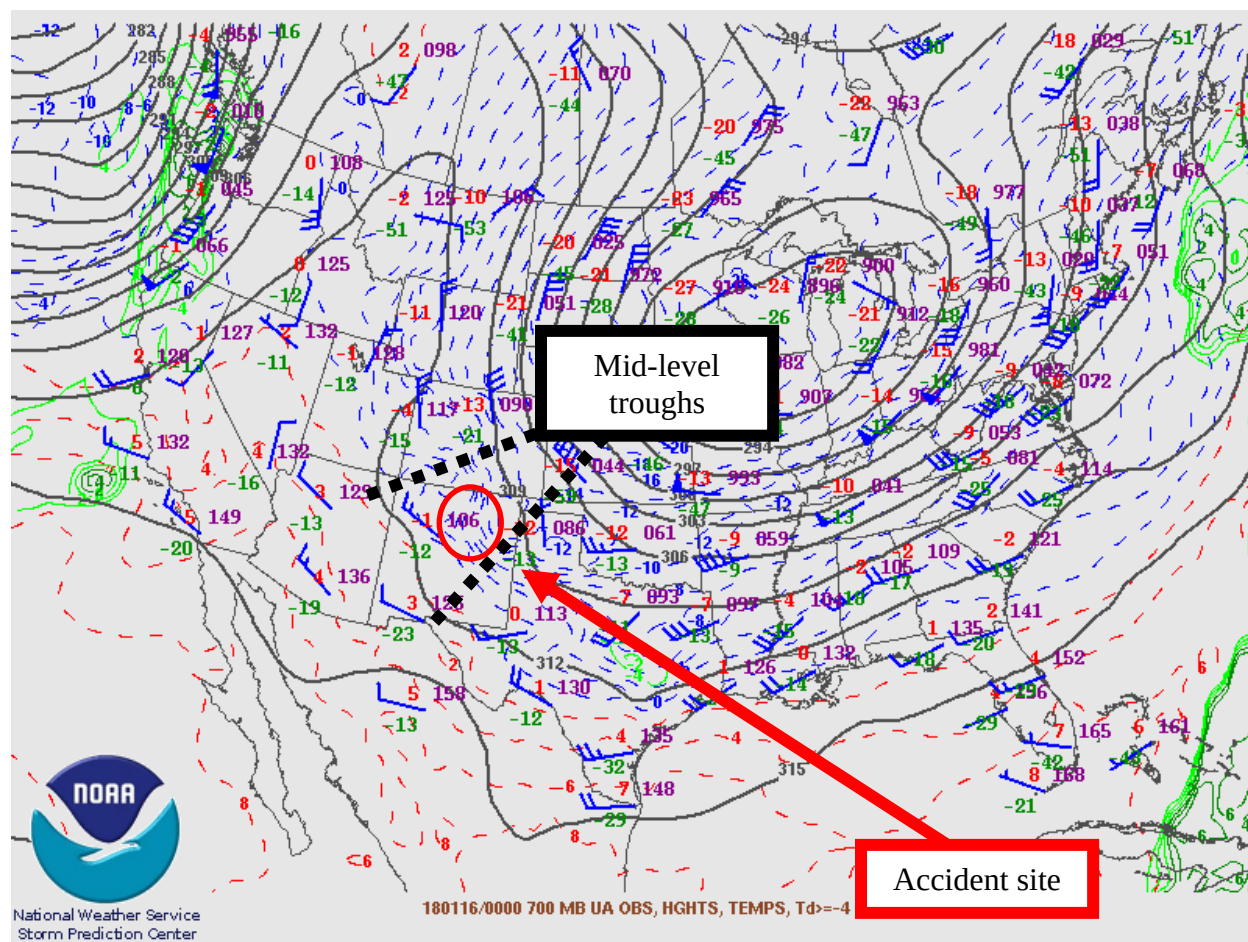


Figure 2 – 700-hPa Constant Pressure Chart for 1700 MST

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

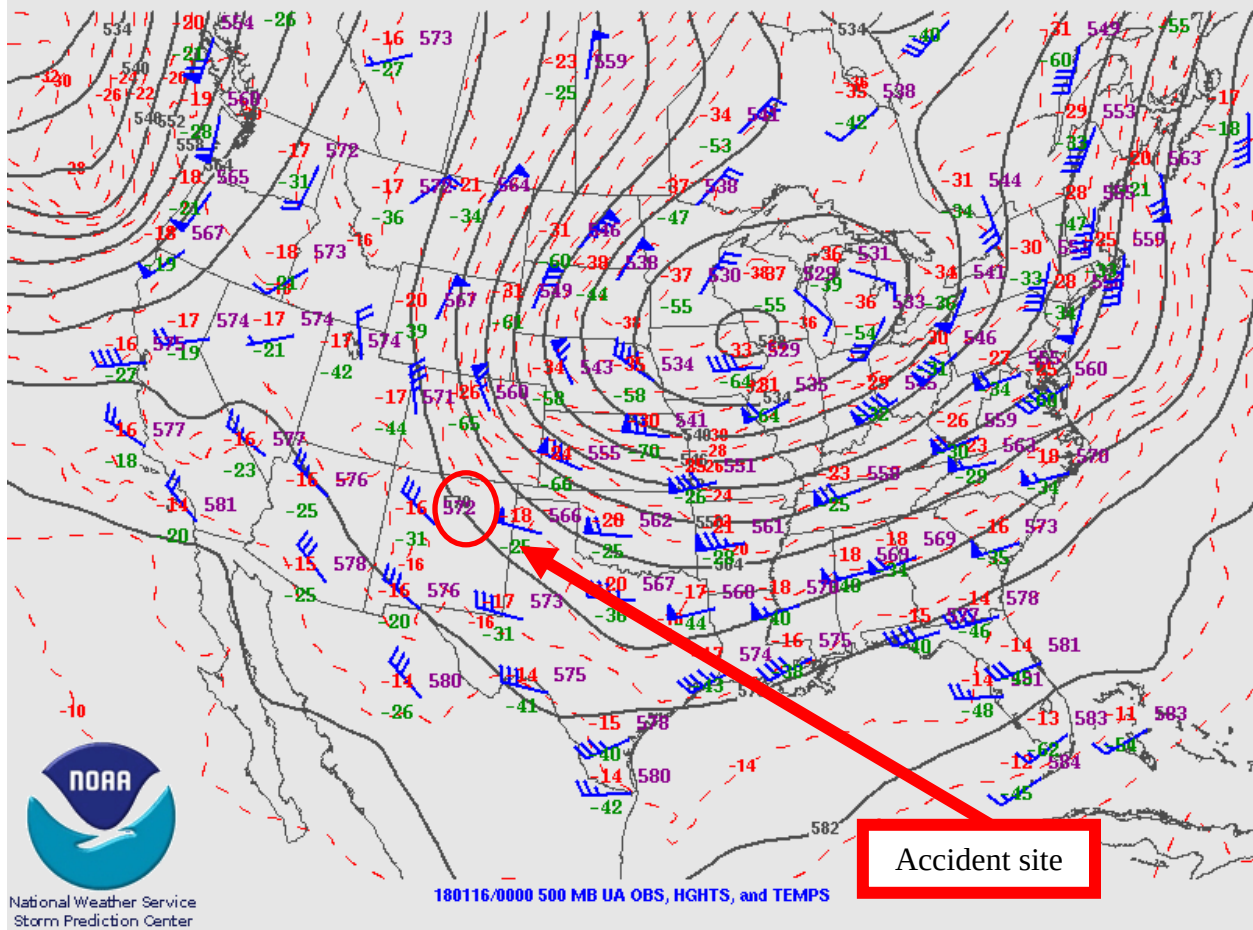


Figure 3 – 500-hPa Constant Pressure Chart for 1700 MST

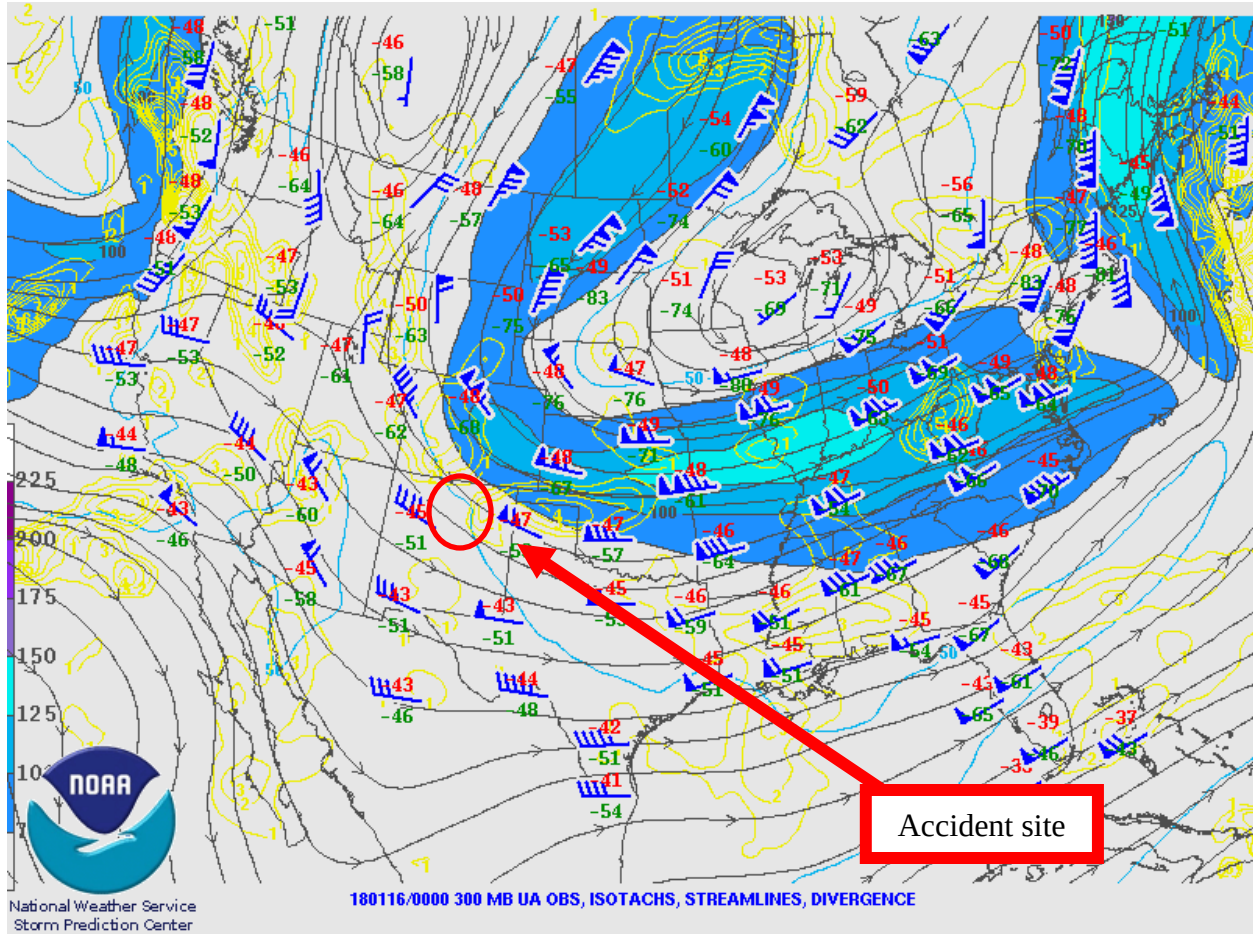


Figure 4 – 300-hPa Constant Pressure Chart for 1700 MST

2.0 SPC Products

No thunderstorms were forecast by SPC for the accident site on the accident day.

3.0 Surface Observations

The area surrounding the accident site was documented using official 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 local sectional chart with the accident site and the closest weather reporting location marked.

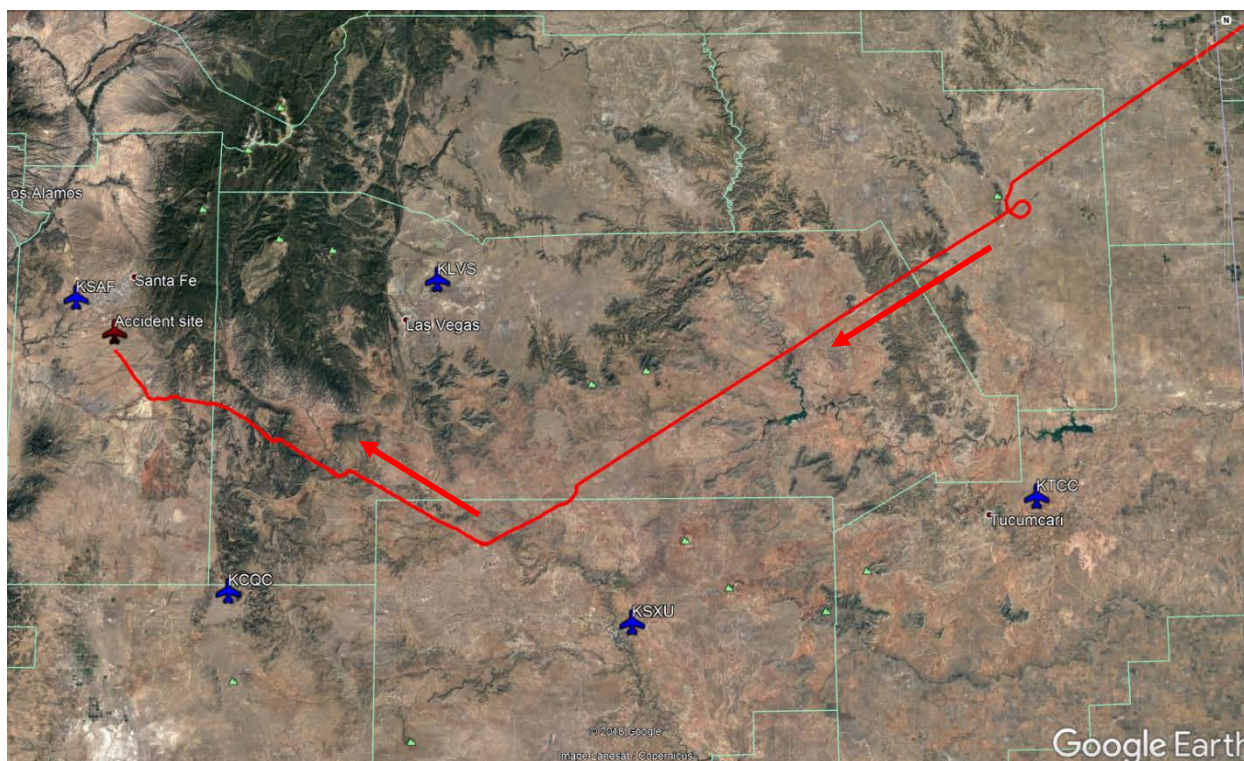


Figure 5 – Google Earth map of the accident area with the location of the accident site, surface observation sites, and the air traffic control flight track data points (red line)

Santa Fe Municipal Airport (KSAF) had the closest official weather station to the accident site. KSAF had an Automated Surface Observing System (ASOS²) whose reports were supplemented by air traffic control (ATC) when the ATC tower was open. KSAF was located 7 miles northwest of the accident site, at an elevation of 6,349 ft, and had an 8° easterly magnetic variation³ (figure 5). The following observations were taken and disseminated during the times surrounding the accident:⁴

[1253 MST] METAR KSAF 151953Z 14018G25KT 10SM CLR 07/M07 A3019 RMK AO2 SLP215 T00721067=

[1353 MST] METAR KSAF 152053Z 14020G26KT 10SM CLR 07/M06 A3019 RMK AO2 PK WND 14031/2040 SLP208 T00671056 56019=

[1453 MST] METAR KSAF 152153Z 14022G30KT 10SM CLR 04/M05 A3019 RMK AO2 PK WND 14030/2147 SLP230 T00441050=

² ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

³ Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <http://airnav.com/airport/KSAF>

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 effected 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.

[1553 MST] METAR KSAF 152253Z 14022G27KT 10SM CLR 03/M05 A3021 RMK AO2 PK WND 13030/2211 SLP233 T00331050=

[1653 MST] METAR KSAF 152353Z 13019G25KT 10SM CLR 00/M05 A3025 RMK AO2 PK WND 13029/2302 SLP259 T00001050 10072 20000 53019=

[1753 MST] METAR KSAF 160053Z 13021G29KT 10SM CLR M02/M04 A3027 RMK AO2 PK WND 13029/0048 SLP270 T10221044=

[1848 MST] SPECI KSAF 160148Z 13017G25KT 10SM BKN020 M03/M05 A3031 RMK AO2 PK WND 13029/0056=

[1853 MST] METAR KSAF 160153Z 13020G25KT 10SM BKN020 M03/M05 A3031 RMK AO2 PK WND 13029/0056 SLP285 T10281050=

ACCIDENT TIME 1935 MST

[1953 MST] METAR KSAF 160253Z 13021G27KT 10SM OVC020 M03/M06 A3033 RMK AO2 PK WND 13028/0227 SLP292 T10331061 51016=

[2053 MST] METAR KSAF 160353Z AUTO 14020G27KT 10SM OVC020 M04/M07 A3037 RMK AO2 PK WND 13029/0310 SLP299 T10441072=

[2153 MST] METAR KSAF 160453Z AUTO 14018G26KT 10SM OVC022 M05/M08 A3039 RMK AO2 PK WND 15031/0411 SLP298 T10501083=

[2253 MST] METAR KSAF 160553Z AUTO 13017KT 10SM OVC023 M06/M09 A3040 RMK AO2 PK WND 14027/0459 SLP297 T10561089 10000 21056 51021=

KSAF weather at 1848 MST, wind from 130° at 17 knots with gusts to 25 knots, 10 miles visibility or greater, broken ceiling at 2,000 ft above ground level (agl), temperature of -3° Celsius (C), dew point temperature of -5° C, and an altimeter setting of 30.31 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1756 MST from 130° at 29 knots.

KSAF weather at 1853 MST, wind from 130° at 20 knots with gusts to 25 knots, 10 miles visibility or greater, a broken ceiling at 2,000 ft agl, temperature of -3° C, dew point temperature of -5° C, and an altimeter setting of 30.31 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1756 MST from 130° at 29 knots, sea level pressure 1028.5 hPa, temperature -2.8° C, dew point temperature -5.0° C.

KSAF weather at 1953 MST, wind from 130° at 21 knots with gusts to 27 knots, 10 miles visibility or greater, overcast ceiling at 2,000 ft agl, temperature of -3° C, dew point temperature of -6° C, and an altimeter setting of 30.33 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1927 MST from 130° at 28 knots, sea level pressure 1029.2 hPa, temperature -3.3° C, dew point temperature -6.1° C, 3-hourly pressure increase of 1.6 hPa.

KSAF weather at 2053 MST, automated, wind from 140° at 20 knots with gusts to 27 knots, 10 miles visibility or greater, overcast ceiling at 2,000 ft agl, temperature of -4° C, dew point temperature of -7° C, and an altimeter setting of 30.37 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 2010 MST from 130° at 29 knots, sea level pressure 1029.9 hPa, temperature -4.4° C, dew point temperature -7.2° C.

The observations from KSAF surrounding the accident time indicated MVFR⁵ ceiling conditions with a gusty surface wind from the southeast. Cloud ceiling heights were reviewed for several addition METAR locations along the route of flight (figure 5). The cloud ceilings at Tucumcari Municipal Airport (KTCC) remained at or above 5,000 ft agl for the entire accident flight, which would have put cloud ceilings above KTCC around 9,000 ft msl. Cloud ceiling heights at Santa Rosa Route 66 Airport (KSXU) were similar to KTCC cloud ceilings heights. Las Vegas Municipal Airport (KLVS) had cloud ceilings between 400 and 800 ft agl for the accident flight timeframe, which would have put cloud ceilings around 7,300 to 7,700 ft msl at KLVS for the accident flight. Finally, Clines Corner (KCQC) had cloud ceiling heights around 200 ft agl for the timeframe of the accident flight which would have put cloud ceilings around 7,500 msl at KCQC. KCQC was located approximately 26 miles south of the accident flight track at 1923 MST.

⁵ Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 ft agl and/or 3 to 5 miles visibility.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)⁶ model sounding was created for the accident site for 2000 MST with station elevation of 6,558 ft. The 2000 MST HRRR sounding was plotted on a standard Skew-T Log P diagram⁷ with the derived stability parameters included in figure 6 (with data from the surface to 500-hPa, or around 19,000 ft msl.) This data was analyzed using the RAOB⁸ software package. The sounding depicted the lifted condensation level (LCL)⁹ at 7,737 ft msl (1,179 ft agl) and the convective condensation level (CCL)¹⁰ at 16,673 ft msl (10,115 ft agl). The sounding had a greater than 80 percent relative humidity from the surface to about 9,000 ft. The freezing level was the surface. The precipitable water value was 0.24 inches.

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, Matamoras, Pennsylvania.

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

¹⁰ 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.

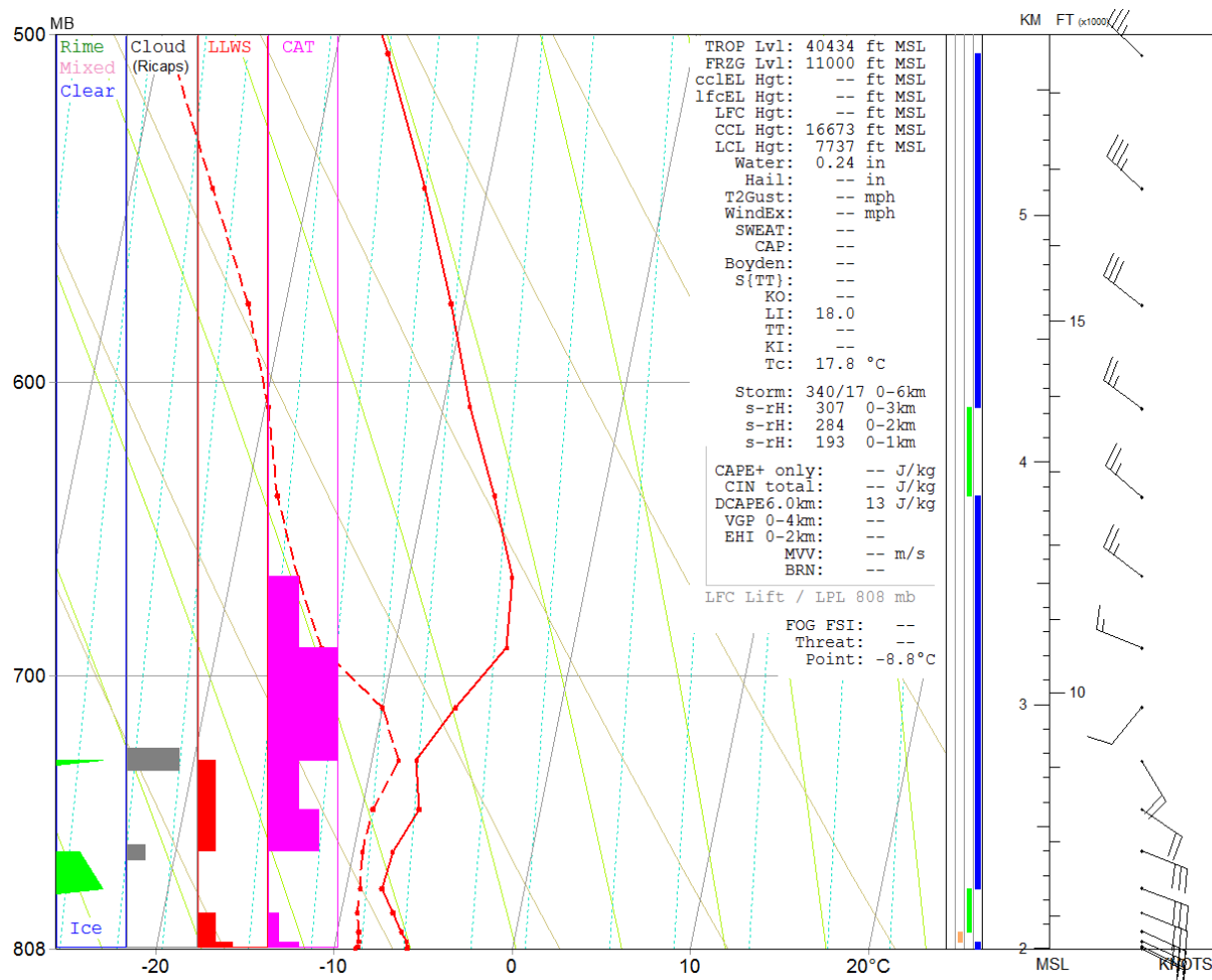


Figure 6 – 2000 MST HRRR sounding for the accident site

The 2000 MST HRRR sounding indicated a conditionally unstable environment from the surface through 7,250 ft and a stable environment from 7,250 ft through 12,000 ft. RAOB identified the possibility of clouds between 8,000 ft through 10,000 ft. Light to moderate rime icing was indicated by RAOB between 7,000 and 9,000 ft msl (around 1,500 to 3,500 ft agl). Icing potential will be further discussed in section 17.0.¹¹

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, 2015), pp 573-595.

The 2000 MST HRRR sounding wind profile indicated a surface wind from 118° at 17 knots with the wind remaining southeasterly through 9,000 ft. The wind speed was as high as 30 knots between the surface and 9,000 ft. Above 9,000 ft the wind became northwesterly through 19,000 ft. By 19,000 ft the wind speed had increased to 35 knots. RAOB indicated the possibility of low-level wind shear (LLWS) between the surface and 9,000 ft. RAOB indicated a high probability of clear-air turbulence in a layer between the surface and 11,500 ft.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 16 (GOES-16) 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-16 bands 2 and 13) at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1500 MST through 2200 MST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here. Due to the low light conditions at the time of the accident, only the infrared imagery was documented below.

Figures 7, 8, and 9 present the GOES-16 infrared imagery from 1907, 1922, and 1937 MST at 3X magnification, respectively, with the accident site highlighted with a red square. Inspection of the infrared imagery indicated cloud cover over the accident site with the cloud cover moving from northwest to southeast (attachments 1 and 2). The lower brightness temperatures (green and yellow colors; higher cloud tops) were located east of the accident site and east and northeast of where the accident flight made a northwest turn (in its flight track) towards KSAF (attachment 9).¹² Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 2000 EST HRRR sounding, the approximate cloud-top heights over the accident site were 16,000 ft msl at 1937 MST. It should be noted these figures have not been corrected for any parallax error.

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

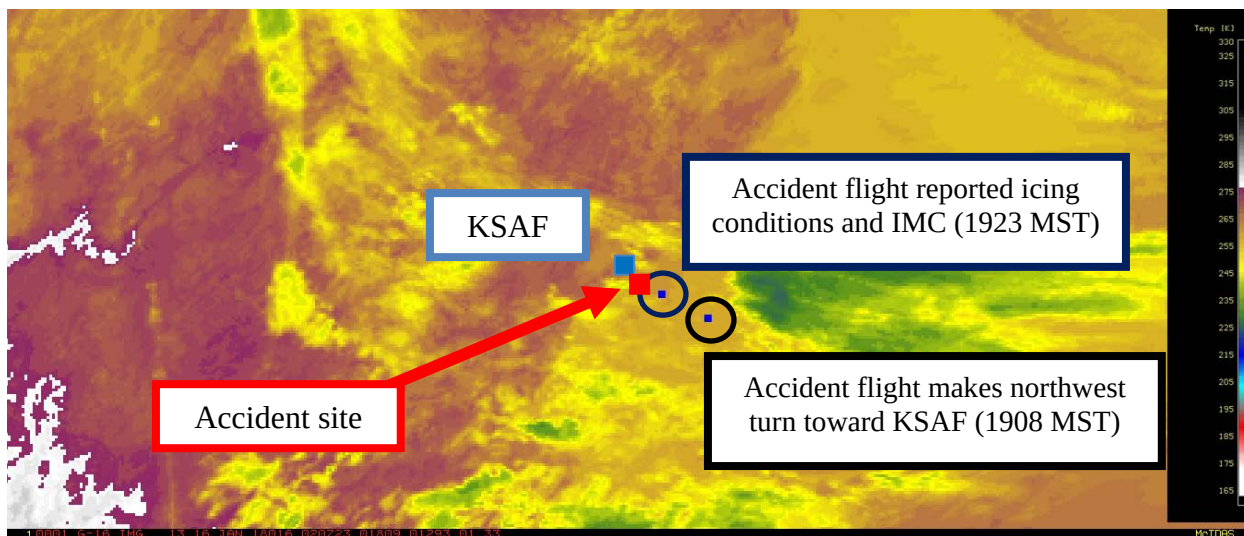


Figure 7 – GOES-16 infrared image at 1907 MST

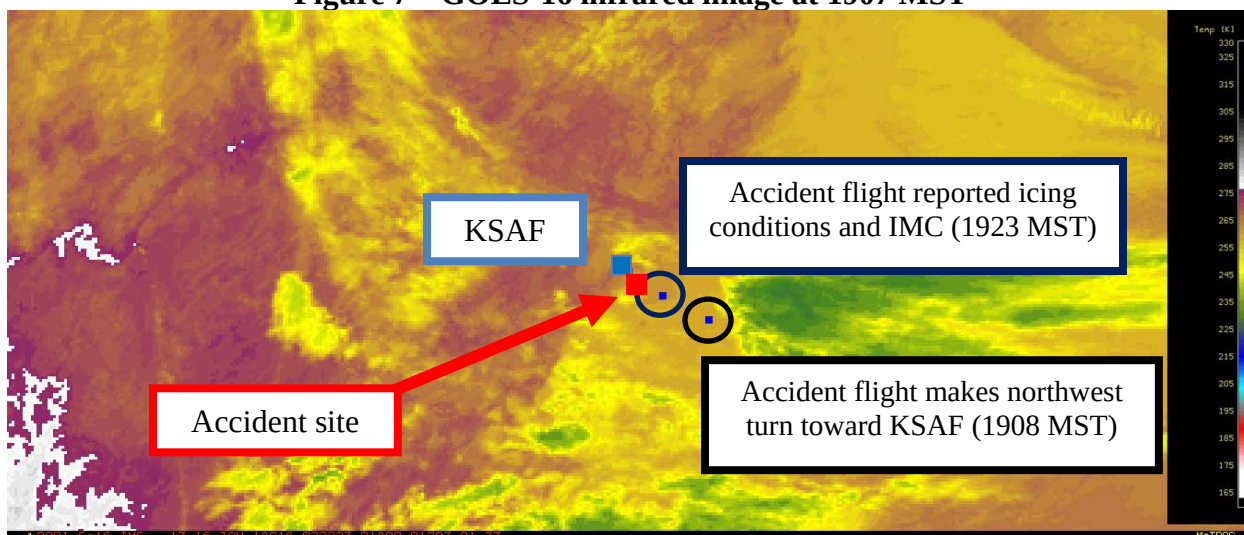


Figure 8 – GOES-16 infrared image at 1922 MST

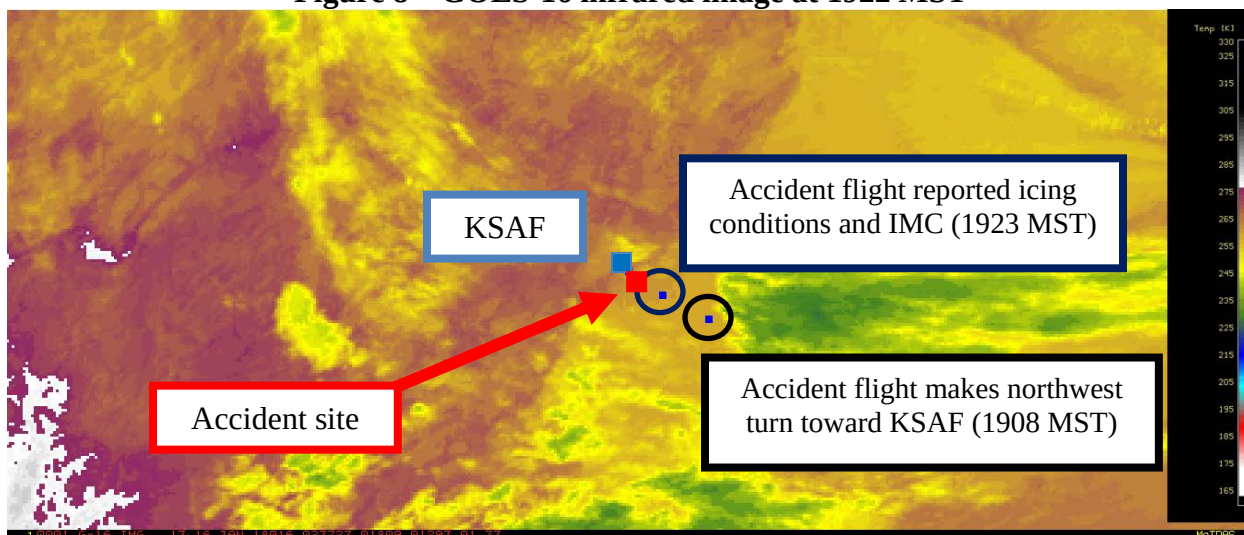


Figure 9 – GOES-16 infrared image at 1937 MST

Additional data from GOES-16 was obtained from the SSEC and processed using the McIDAS at wavelengths of 3.9 μm , 10.4 μm , and 12.4 μm , and then a band differencing technique was applied consistent with the Nighttime Microphysics RGB imagery described in attachment 3.

Figures 10, 11, 12, and 13 present the GOES-16 Nighttime Microphysics RGB imagery from 1907, 1922, 1932, and 1937 MST at 4X magnification, respectively, with the accident site highlighted in a green circle. Inspection of the Nighttime Microphysics RGB imagery indicated light green to tan colors with the clouds located above the accident site around the accident time. These light green to tan colors on the Nighttime Microphysics RGB imagery indicate mid-level water clouds and thick mid-level water or ice clouds (attachment 3). These cloud types were present along the accident flight track from when the accident flight turned northwestward around 1908 MST through the accident time (attachment 4). For more information on the Nighttime Microphysics RGB please see attachment 3.¹³

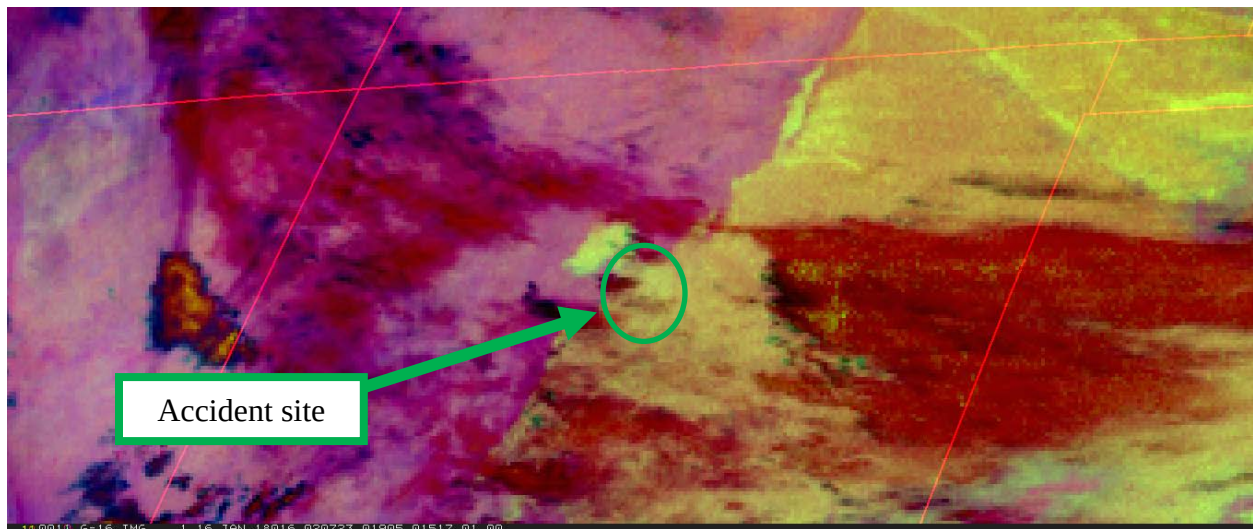


Figure 10 – GOES-16 Nighttime Microphysics RGB image at 1907 MST

¹³ Also see: <https://nasasporttraining.wordpress.com/2017/02/23/nighttime-microphysics-rgb-application-aviation-module-2/>

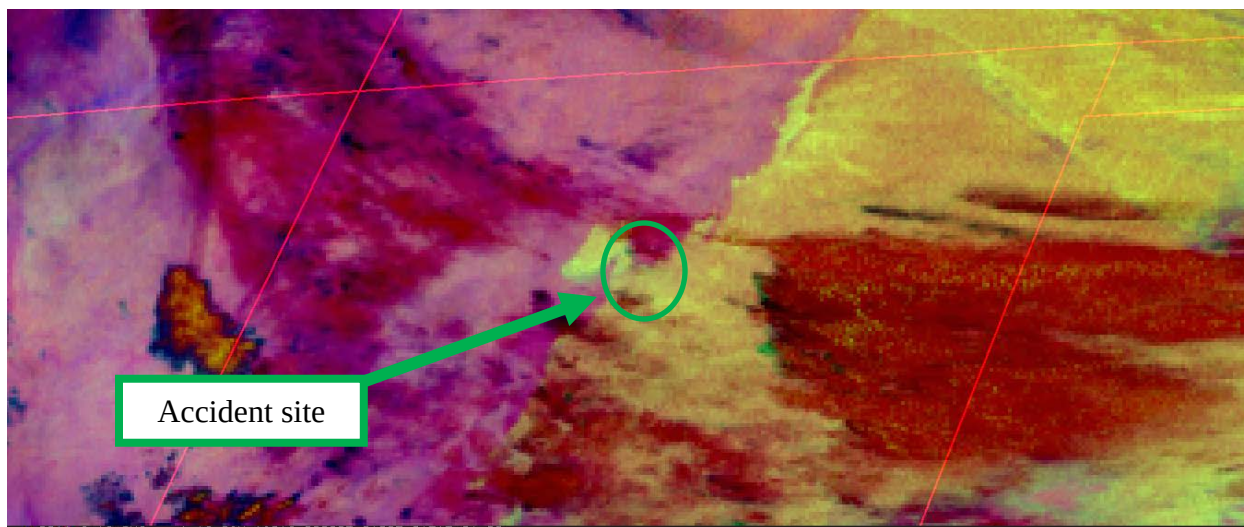


Figure 11 – GOES-16 Nighttime Microphysics RGB image at 1922 MST

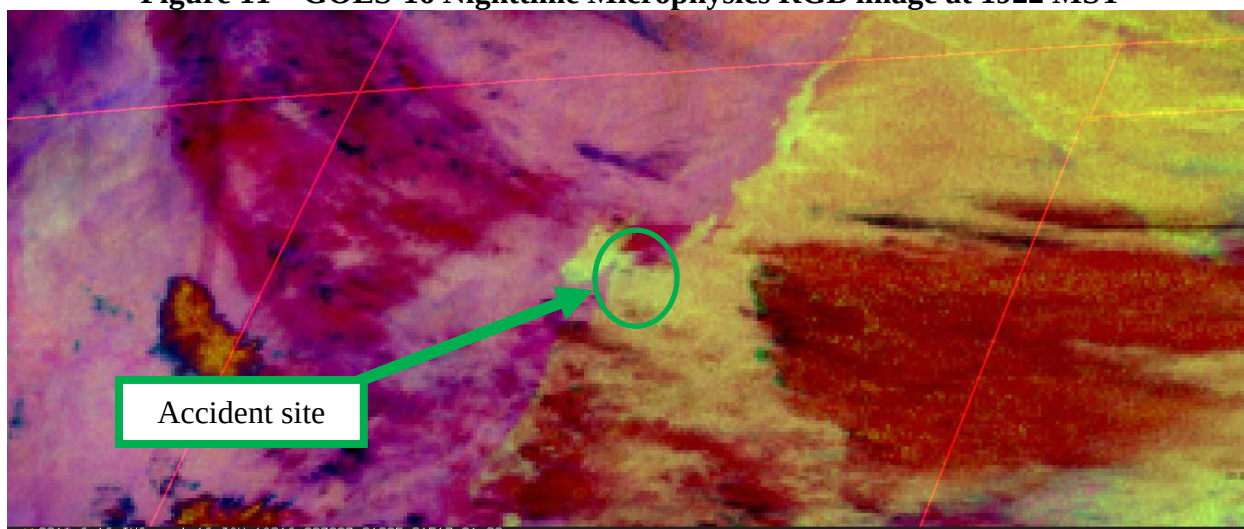


Figure 12 – GOES-16 Nighttime Microphysics RGB image at 1932 MST

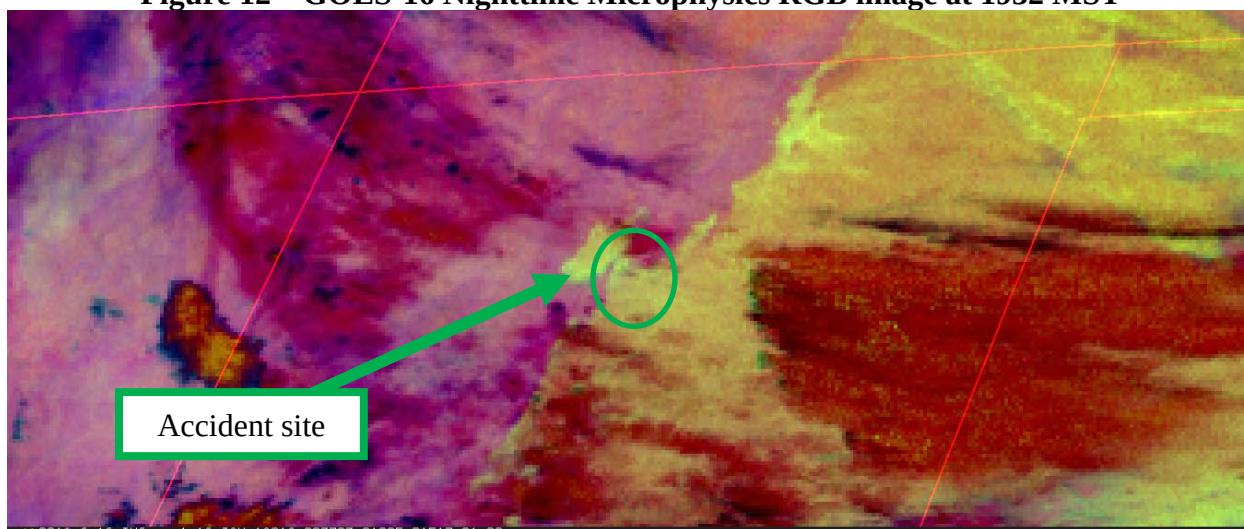


Figure 13 – GOES-16 Nighttime Microphysics RGB image at 1937 MST

Additional GOES-16 data was provided by the National Aeronautics and Space Administration (NASA) Langley Research Center Climate Science Branch (LARC-E302). LARC-E302 made an animation of the GOES-16 Nighttime Microphysics RGB imagery from 1902 through 1957 MST and an animation of the GOES-16 infrared imagery from 1902 MST through 1957 MST with the accident flight track superimposed on both animations for reference (attachments 4 and 5). The imagery indicated light green to tan Nighttime Microphysics RGB imagery (attachment 4) and cloud top temperatures between -10° and -15° C (attachment 5) above the accident flight track from 1908 MST onward.

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁴ to the accident site was the Albuquerque, New Mexico, radar (KABX), which was located 47 miles southwest of the accident site at an elevation of 5,951 ft. Level II 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. No precipitation targets were located above the accident site at the accident time. There were no lightning strikes around the accident site at the accident time.¹⁵

7.0 Pilot Reports¹⁶

All pilot reports (PIREPs) within 150 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time for below FL180¹⁷ are provided below:

ABQ UA /OV RWY 8/TM 0041/FL070/TP E75/TB MOD TURB/RM MOD TURB REPORTED IN CLIMBOUT BETWEEN 070 AND 080

CVN UA /OV CVN/TM 0123/FL090/TP C501/IC NEG/RM ZAB/FDCS

ROW UA /OV ROW045010/TM 0150/FL080/TP C208/SK OVC034/TA M08/IC LGT RM/RM B079 T097

Routine pilot report (UA) Albuquerque, New Mexico (ABQ); Over runway 8; Time – 1741 MST (0041Z); Altitude – 7,000 ft; Type aircraft – Embraer 175; Turbulence – Moderate turbulence; Remarks – Moderate turbulence reported in climb out between 7,000 and 8,000 ft.

Routine pilot report (UA) Clovis, New Mexico (CVN); Over CVN; Time – 1823 MST (0123Z); Altitude – 9,000 ft; Type aircraft – Cessna 501; Icing – Negative; Remarks – Albuquerque Air Route Traffic Control Center Flight data (ZAB/FDCS).

¹⁴ 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.

¹⁵ A review of data from the Earth Networks Total Lightning Network was performed.

¹⁶ Only pilot reports with the WMO header UBNM** identifier were considered.

¹⁷ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. 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) Roswell, New Mexico (ROW); 10 miles from ROW, on the 045° radial; Time – 1850 MST (0150Z); Altitude – 8,000 ft; Type aircraft – Cessna 208; Sky – Overcast at 3,400 ft agl; Temperature – -8° C; Icing – Light; Remarks – Bases 7,900 ft and tops at 9,700 ft.

8.0 SIGMET

There were no convective or non-convective Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time.

9.0 CWSU Advisories

There were no Center Weather Service Unit (CWSU) Meteorological Impact Statements that were valid for the accident site at the accident time. No Center Weather Advisories (CWA) were valid for the accident site at the accident time. ZAB CWA 101 was valid along the accident route between 1730 and 1915 MST and warned of areas of IFR¹⁸ and patchy LIFR¹⁹ conditions with visibilities below 1 mile and ceilings below 500 ft agl in mist and fog. In addition, ZAB CWA 201 was valid along the accident route between 1750 and 1915 MST and warned of occasional moderate turbulence between the surface and 10,000 ft with surface wind gusts to 35 knots and LLWS possible:

FAUS21 KZAB 160031
ZAB1 CWA 160030
ZAB CWA 101 VALID UNTIL 160215
FROM 15NNE CIM-20SSW FTI-50ESE ABQ-35WSW CME
AREA IFR/PATCHY LIFR CONDS 30NM WIDE. VIS BLW 1SM AND CIG BLW 005 IN
BR FG.
=

FAUS22 KZAB 160052
ZAB2 CWA 160050
ZAB CWA 201 VALID UNTIL 160215
FROM 45WNW FTI-40NE ABQ-5ESE ABQ-60S ABQ-90SSE ABQ-85N ELP
AREA OCNL MOD TURB 30NM WIDE. SFC-100. SFC WND GUSTS TO 35KTS. LLWS
POSS.
=

10.0 AIRMETs

There was only an Airmen's Meteorological Information (AIRMET) Sierra that was valid for the accident site at the accident time. This AIRMET Sierra warned of IFR conditions due to precipitation and mist and mountain obscuration conditions due to clouds, precipitation, and mist. AIRMET Zulu was valid for only the northeastern corner of New Mexico and not valid for the accident site. The advisories were as follows:

¹⁸ Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 ft agl and/or less than 3 miles visibility.

¹⁹ Low Instrument Flight Rules (LIFR) – Refers to the general weather conditions pilots can expect at the surface. LIFR criteria means a ceiling below 500 ft agl and/or less than 1 mile visibility.

WAUS45 KPCI 152321 AAA

WA5Z

-SLCZ WA 152321 AMD

AIRMET ZULU UPDT 5 FOR ICE AND FRZLVL VALID UNTIL 160300

.
AIRMET ICE...NV WA OR CA AND CSTL WTRS

FROM 20NW HUH TO 50WSW YKM TO 70NW REO TO 50WNW BAM TO 40NNE FMG
TO 80NNW FMG TO 20SE ENI TO 120WSW PYE TO 140WSW FOT TO 110WNW
ONP TO 140W TOU TO 20NW HUH
MOD ICE BTN FRZLVL AND FL220. FRZLVL 060-120. CONDS CONTG BYD 03Z
THRU 09Z.

.
AIRMET ICE...CO NM

FROM 40SE OCS TO 50SSW BFF TO 20NW LAA TO 40E LAA TO 50W LBL TO
30ESE TBE TO 20ESE TCC TO 40SE FTI TO 20W ALS TO 20NE HBU TO JNC
TO 40SE OCS
MOD ICE BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.

.
OTLK VALID 0300-0900Z...ICE NV WA OR CA AND CSTL WTRS

BOUNDED BY 20SE YDC-40SW GEG-40WSW BOI-60WNW BAM-40SW FMG-50ENE
MOD-20NNE SNS-130SW SNS-160WSW FOT-80W OED-60WNW ONP-150W
TOU-20NW HUH-20SE YDC
MOD ICE BTN FRZLVL AND FL220. FRZLVL 060-100. CONDS CONTG THRU
09Z.

.
FRZLVL...RANGING FROM SFC-135 ACRS AREA

MULT FRZLVL BLW 110 BOUNDED BY 20NNE HUH-20N HVR-50SSE HLN-
40ESE SLC-40SE BVL-30W MLD-20E BOI-80S MLP-30SSW GEG-20ENE
PDT-20ESE DSD-30SW DSD-60S BTG-20E SEA-20NNE HUH
MULT FRZLVL BLW 110 BOUNDED BY 40SE RSK-30NE ABQ-60SSE FTI-
20W TXO-INK-ELP-50W TCS-70SSW RSK-40SE RSK
SFC ALG 40SE GEG-50SW MLP-50N DNJ-60SSE BKE-50SW CME-30N INK
080 ALG 40SSE RSK-50W ABQ-ELP
080 ALG 50SW BOI-40SSW BOI-20W BVL-20ESE HVE-DVC
120 ALG 30SSE BTY-40NNW LAS-50NNW PGS-30NNE DRK-50SSE SSO

....

WAUS45 KPCI 152045

WA5T

-SLCT WA 152045

AIRMET TANGO UPDT 3 FOR TURB VALID UNTIL 160300

.
AIRMET TURB...ID NV UT CO AZ NM WA OR CA AND CSTL WTRS

FROM 20N HUH TO 20ESE BOI TO 60NNE TWF TO 60SSW MLD TO DVC TO
30NNW RSK TO ELP TO 70SSW DMN TO 40SSE TUS TO BZA TO 40SSW MZB
TO 220SW MZB TO 140WSW FOT TO 110WNW ONP TO 140W TOU TO 20N HUH
MOD TURB BTN FL200 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.

.
AIRMET TURB...NV WA OR CA AND CSTL WTRS

FROM 50ESE YDC TO 60SE LKV TO 80ENE RBL TO 50NNE SAC TO 20SW RBL
TO 140WSW ENI TO 140WSW FOT TO 120WNW ONP TO 150W TOU TO 20WNW
HUH TO 50ESE YDC
MOD TURB BLW 150. CONDS CONTG BYD 03Z THRU 09Z.

.
AIRMET TURB...ID MT WY UT CO NM

FROM 40SSW YQL TO 50NNW ISN TO 70SW RAP TO BFF TO GLD TO 50W LBL

TO 30ESE TBE TO 30ESE TCC TO DVC TO 60SSW MLD TO 60NNE TWf TO
40NW LKT TO 40SSW YQL
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 03Z THRU 09Z.

....

046

WAUS45 KPCI 160001 AAA

WA5S

-SLCS WA 160001 AMD

AIRMET SIERRA UPDT 6 FOR IFR AND MTN OBSCN VALID UNTIL 160300

.

AIRMET IFR...ID WY UT

FROM 50N JAC TO 60ENE JAC TO 50NE OCS TO 40S BPI TO 50ESE MLD TO
50SSE DBS TO 50N JAC

CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z ENDG 03-06Z.

.

AIRMET IFR...CO

FROM 60SSW LAR TO 30NNE DEN TO 50SSE DEN TO 20SSE TBE TO 30SE
ALS TO 60SW DEN TO 60SSW LAR

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS ENDG 00-03Z.

.

AIRMET IFR...NM

**FROM 30SW CIM TO 50NNE TCC TO TXO TO INK TO 50W INK TO 50E ELP
TO 50ENE TCS TO 40NW ABQ TO 30SW CIM**

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...WY CO NM

**FROM LAR TO 30SSE CYS TO TBE TO CME TO 50WNW INK TO 30NE ELP TO
60SSE ABQ TO 50SE HBU TO DBL TO 50SW CHE TO 40SSW OCS TO 40NNW
CHE TO LAR**

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.

AIRMET MTN OBSCN...ID MT WY

FROM 40NW GTF TO 50W BIL TO 70SSW BIL TO 20WNW DDY TO 40NNW CHE
TO 40SSW OCS TO 50E SLC TO 30WSW JAC TO 50SW LKT TO 50N LKT TO
50SE MLP TO 40NW GTF

MTNS OBSC BY CLDS/PCPN/BR. CONDS ENDG 21-00Z.

....

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident time and before the accident flight departed Liberal Mid-America Regional Airport (KLBL) in Liberal, Kansas, indicated cloud cover between 8,000 ft and 10,000 ft msl with mountain obscuration conditions and light snow conditions possible from northeastern New Mexico southwestward to the accident site and then southward into southern New Mexico (attachment 6).

12.0 Terminal Aerodrome Forecast

KSAF was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident (and valid before departure from KLBL) was issued at 1636 MST and was valid for a 24-hour period beginning at 1700 MST. The TAF for KSAF was as follows:

TAF KSAF 152336Z 1600/1624 14018G28KT P6SM SCT040 BKN150
FM160200 14020G30KT P6SM BKN025
FM160900 15012G20KT P6SM OVC019
FM161700 12010KT P6SM SCT025
FM162100 18008KT P6SM FEW050=

After 1900 MST, the forecast expected a wind from 140° at 20 knots with gusts to 30 knots, greater than 6 miles visibility, and a broken ceiling at 2,500 ft agl.

13.0 NWS Area Forecast Discussion

The NWS office in Albuquerque, New Mexico, issued the following Area Forecast Discussion (AFD) at 1701 MST (closest AFD to the accident time). The aviation section of the AFD discussed a strong cold front moving southward into the area with a strong east to southeast wind and wind gusts at KSAF with possible MVFR to IFR ceilings after 1700 MST:

126
FXUS65 KABQ 160001
AFDABQ

Area Forecast Discussion
National Weather Service Albuquerque NM
501 PM MST Mon Jan 15 2018

.AVIATION...
00Z TAF CYCLE

The strong backdoor cold front continues to move to the west this evening and is near the continental divide at 00Z. The front will continue to move slowly westward to near the AZ/NM border by late tonight/early Tuesday. East to southeast upslope flow will continue east of the central mountains overnight with widespread MVFR ceilings across most of the area and localized IFR ceilings and fog along the eastern foothills. East to southeast canyon winds will gust to between 25 and 35 knots on the west slopes of the central mountains, including at KABQ and KSAF through 12Z Tuesday. Winds will diminish Tuesday in the eastern plains and central mountains, with VFR conditions returning to the eastern plains and eastern foothills of the central mountains from mid to late morning Tuesday.

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.PREV DISCUSSION...340 PM MST Mon Jan 15 2018...
.SYNOPSIS...

A strong backdoor cold front will continue to push westward through the state this evening and overnight. Much colder air will continue to move in behind the front, especially across eastern New Mexico. Tuesday will be the coldest day of the week areawide with temperatures across the eastern plains as much as 25 degrees below average. Central and western areas will be 10 to 15 degrees cooler. A slow warm-up is expected Wednesday and more so on Thursday as high pressure builds overhead. A Pacific storm system remains on track for the weekend.

&&

.DISCUSSION...

Modified Arctic backdoor cold front is now moving into the eastern side of the RGV. The front has made it through the Gallisteo drainage and to the Santa Fe and Los Alamos airports. Winds at ABQ Sunport just turned southeast so the front is here. Expect cold air to continue pushing wwd this evening and into tonight, reaching the AZ border around midnight. Areas of light snow and fog will develop over the northeast quarter this evening. Light snow (less than 2") accumulation may impact travel in Union and western Colfax Counties overnight and into Tuesday morning, including along I-25 near Raton and Raton Pass. Low temperatures across the eastern plains will drop into the single digits and lower teens by Tuesday morning. Tuesday still on track to be the coldest day of the week areawide with temperatures modifying Wednesday and especially Thursday. The weak upper level trough/closed low forecast to drop southeastward from the Great Basin and into western NM Tuesday night and Wednesday now appears so weak it may just result in some mid clouds and perhaps virga over the west- central and southwest mountains. Models agree that the weak trough/closed low sill drop southeast into TX Wednesday night as an upper level ridge folds over NM.

GFS and ECMWF agree that the above mentioned ridge slides east of NM Friday, allowing southwest flow aloft to move over NM. Winds increase most areas Friday as a Pacific trough and associated surface cold front approach from the west. GFS and ECMWF are in very good agreement with regard to timing and strength of this upper trough for Saturday night. Both models paint the heaviest precip over the northwest quarter. Typically, with a strong southwest flow aloft, portions of the Sangres can do well with regard to snow in addition to the Chuska, northwest Jemez and Tusas Mountains. There is, however, a good amount of uncertainty as to how far south this upper trough will swing through the state. Global models agree that this upper trough will close off over ern CO Sunday morning with a wrap-around area of snow across far northeast NM Sunday morning.

Operational GFS and ECWMF solutions diverge after Sunday. ECWMF digs the upper level trough over the Intermountain West farther south, developing a deep closed low over Four Corners late-day Tuesday. The GFS, however, keeps the trough an open wave that remains mainly north of NM. Both models keep the upper level pattern across the western U.S. progressive into early next week.

33

&&

.FIRE WEATHER...

Strong cold front has reached the east slopes of the central mt chain and pushed into the Santa Fe area. The front is expected to push into the rest of the RGV by this evening. There may be some light snow in the northeast and along the east slopes of the central mountain chain into tonight but any accumulations are not expected to amount to more than an inch or so and mainly over the Northeast Highlands. Humidities will be increased tonight especially central

and east with colder overnight low temperatures.

Tuesday will be dry but cold. Clouds will reluctantly give way to sunshine, mainly north of Interstate 40. Widespread poor ventilation expected.

A weak upper level disturbance will track over western and southern New Mexico Tuesday night into Wednesday. This looks to be a very light precipitation producer for the western mountains. Temperatures will moderate some, but it will remain cool on Wednesday with below normal highs across the south and east. Widespread poor ventilation expected again Wednesday.

A ridge of high pressure will temporarily build over New Mexico Thursday then exit in favor of increasing southwest to westerly flow Friday. Both days will be dry with a warming trend as highs climb above normal again. Widespread poor vent rates continue Thursday but increasing winds and mixing heights will improve rates to fair to good Friday over the western and central higher terrain. Relative humidities will decrease Wednesday and Thursday before changing little Friday. That said, with increasing winds Friday, isolated critical fire weather conditions could develop in the afternoon over the East Central Plains.

A more substantial storm system could impact northern and central New Mexico this weekend with the hope for a more widespread and significant precipitation event. So far, the northern mountains could be the favored areas for snow, but winds could be strong south of Interstate 40. There is plenty of time for the forecast models to change their outlook though.

&&

.AVIATION...

18Z TAF CYCLE

Northwest flow aloft with sct-bkn high clouds. Strong cold front plunging through the eastern plains at 17Z and has already passed KROW. Terrain obscurations in widespread MVFR to IFR cigs and lcl vsbys in br along and north of a line from KRTN-KLVS-KCQC-KSXU-KCVN at 17Z will continue to spread south and westward to KSRR vcnty and KROW by 21Z and persist through 16/12Z. Expect the front to push into the RGV between 19Z and 22Z, **but strongest east to southeast sustained wind and gusts at KSAF and KABQ not anticipated til aft 16/00Z. MVFR to IFR cigs may also bleed into the KSAF and KLAM area aft 16/00Z as the front progresses wwd.**

&&

.ABQ WATCHES/WARNINGS/ADVISORIES...

None.

&&

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14.0 Winds and Temperature Aloft Forecast

The NWS 1901 MST Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

```
FBUS31 KWN0 160201
FD1US1
DATA BASED ON 160000Z
VALID 160600Z   FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT  3000    6000    9000    12000    18000    24000    30000    34000    39000
ABQ                2405-05 2819-05 3129-17 3133-30 314146 304755 314865
```

The accident site was closest to the Albuquerque, New Mexico, (ABQ) forecast point. The 1901 MST ABQ forecast for use between 1900 MST January 15 and 0200 MST January 16 indicated a wind at 9,000 ft from 240° at 5 knots with a temperature of -5° C and a wind at 12,000 ft from 280° at 19 knots with a temperature of -5° C.

15.0 Pilot Weather Briefing and Witness Information

The accident pilot did not request a weather briefing from Leidos or DUATS.

A search of archived ForeFlight information indicated that ForeFlight did not have any record of the accident pilot accessing weather information. With no internet access while in flight, ForeFlight is still able to access weather information directly from the FAA, but it leaves no remote record of such access. ForeFlight is still able to access weather information through FIS-B/TIS-B feeds provided by the FAA up to the cockpit. However, ForeFlight is only able to archive pilot data reviewed when the electronic flight bag or ForeFlight account is directly linked to the internet via cell phone connection or something similar. There is no record of the accident pilot receiving or retrieving any other weather information before or during the accident flight.

The accident pilot was interviewed on August 9, 2018, regarding his recollection of the accident flight and events leading up to the accident time. The pilot specifically stated that he did not check the weather conditions before departing KLBL. The pilot recalled during the accident flight seeing an approximately one-foot-diameter mass of supercooled liquid on the windscreen of the airplane shortly before reporting being in IMC.²⁰ About 2 to 3 seconds later the supercooled liquid water had crystallized across the entire windscreen and subsequently the accident flight went into a momentary steep dive. He recalled that the airplane encountered icing conditions less than 5 minutes after the airplane had entered IMC. Additionally, he did not recall any weather issues, other than being physically cold, before the airplane encountered IMC. When asked how quickly the ice had accumulated on the airframe, the accident pilot stated that the gelatinous super cooled water on the windscreen crystalized the whole windscreen in about 5 seconds from the time he first saw the gelatinous formation. The accident pilot stated that he normally would check aviationweather.gov for preflight weather information and review the weather information for 1 to 1.5 hours while flight planning. The accident pilot said he typically checked weather using his Apple MacBook computer; however, in his rush to get inside the warm FBO, he had left his Apple

²⁰ According to ATC communication took place around 1922:46 MST

MacBook inside the airplane after landing at KLBL and did not retrieve it from the airplane during his time on the ground in Liberal, Kansas. The accident pilot stated that he did not ask ATC about the weather ahead of the airplane (on the accident flight), despite having plenty of available time and opportunity to do so. When the accident pilot was asked what could be improved about weather forecast information, he stated nothing realistically could be improved and the accident pilot believes the weather information currently available is great, including the icing tools available on aviationweather.gov. However, he has noticed the cloud tops and cloud bottoms in the GFA tool on aviationweather.gov are often inconsistent with METARs. Specifically, that the GFA tool can show clear skies in areas that clearly were not. He remarked that if pilots solely relied on that tool (GFA tool) they would potentially have incorrect information. When the accident pilot did review the weather during flight planning he would review the weather in a sequence to remain as methodical as possible. For more information please see attachment 7.

A partial ATC communication summary was compiled for the transmissions between the accident pilot and ATC audio after approximately 1922 MST (attachment 9). At 1922:46 MST, the accident pilot reported having icing and being in IMC to ATC for the accident plane located approximately 26 miles east-southeast of the accident site at 8,800 ft msl. At 1928:20 MST, the accident pilot reported that he was unable to maintain altitude when located approximately 11 miles southeast of the accident site at 7,500 ft msl. At 1931:01 MST, the accident pilot declares “emergency” when located approximately 7 miles south-southeast of the accident site at 7,100 ft msl. The accident pilot stated he was trying to hold or maintain altitude at 1931:41, 1932:02, and 1933:17 MST, with the airplane located 2 miles south-southeast of the accident site at 6,800 ft at 1933:17 MST. The 1933:17 MST transmission was the last transmission to ATC by the accident pilot. For more information please see attachment 9.

16.0 Accident Scene Pictures

Several accident scene pictures were taken by an FAA inspector the morning after the accident and show the ice accretion on the accident airplane (figures 14, 15, 16, 20, and 21). In addition, chunks of ice that had been on the accident airplane were found on the ground located near the final accident site location (figures 17, 18, and 19).



Figure 14 – Accident scene picture of ice accretion on the left wing



Figure 15 – Accident scene picture of ice accretion on the left wing



Figure 16 – Accident scene picture of ice accretion on the left wing



Figure 17 – Accident scene picture of ice chunks that had fallen off the accident plane on the ground



Figure 18 – Accident scene picture of an ice chunk that had fallen off the accident plane on the ground



Figure 19 – Accident scene picture of an ice chunk that had fallen off the accident plane on the ground



Figure 20 – Accident scene picture of ice accretion on the left wing



Figure 21 – Accident scene picture of ice accretion on the front windshield

17.0 Icing Potential²¹

Current Icing Potential (CIP) and Forecast Icing Potential (FIP) products are created by the NWS Aviation Weather Center (AWC) and are intended to be supplemental to other icing advisories (e.g. AIRMETs and SIGMETs). Figures 22 through 24 were the FIP icing probabilities and icing severity products, 1-hour forecast valid at 2000 MST at 7,000, 8,000, and 9,000 ft msl (similar values in the FIP are seen in the 2-hour forecast valid at both 1900 and 2000 MST, attachment 8). The FIP images indicated between a 40 to 80 percent probability of icing at 8,000 and 9,000 ft at 2000 MST at the accident site (figures 23 and 24). The 7,000 ft FIP and CIP levels were below the level of the terrain (in the FIP and CIP model) and therefore the accident site and the surrounding terrain have no icing probability. The FIP also indicated that the icing severity near the accident site would likely have been trace to moderate (figures 23 and 24). The FIP indicated no potential for any Supercooled Large Droplet (SLD) over the accident area around the accident time (attachment 8). Additional FIP information was available on the NWS AWC website before the accident flight departed KLBL.²²

The CIP product indicated between a 30 to 50 percent probability of icing at 8,000 and 9,000 ft at 2000 MST at the accident site. The CIP also indicated that the icing severity near the accident site would likely have been trace to light intensity (figures 26 and 27). The CIP also indicated an unknown chance of SLD near the accident site around the accident time (attachment 8). For more FIP and CIP information and altitudes please see attachment 8.

²¹ 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.

<https://arc.aiaa.org/doi/abs/10.2514/6.2009-3531>

²² <https://www.aviationweather.gov/icing/fip>

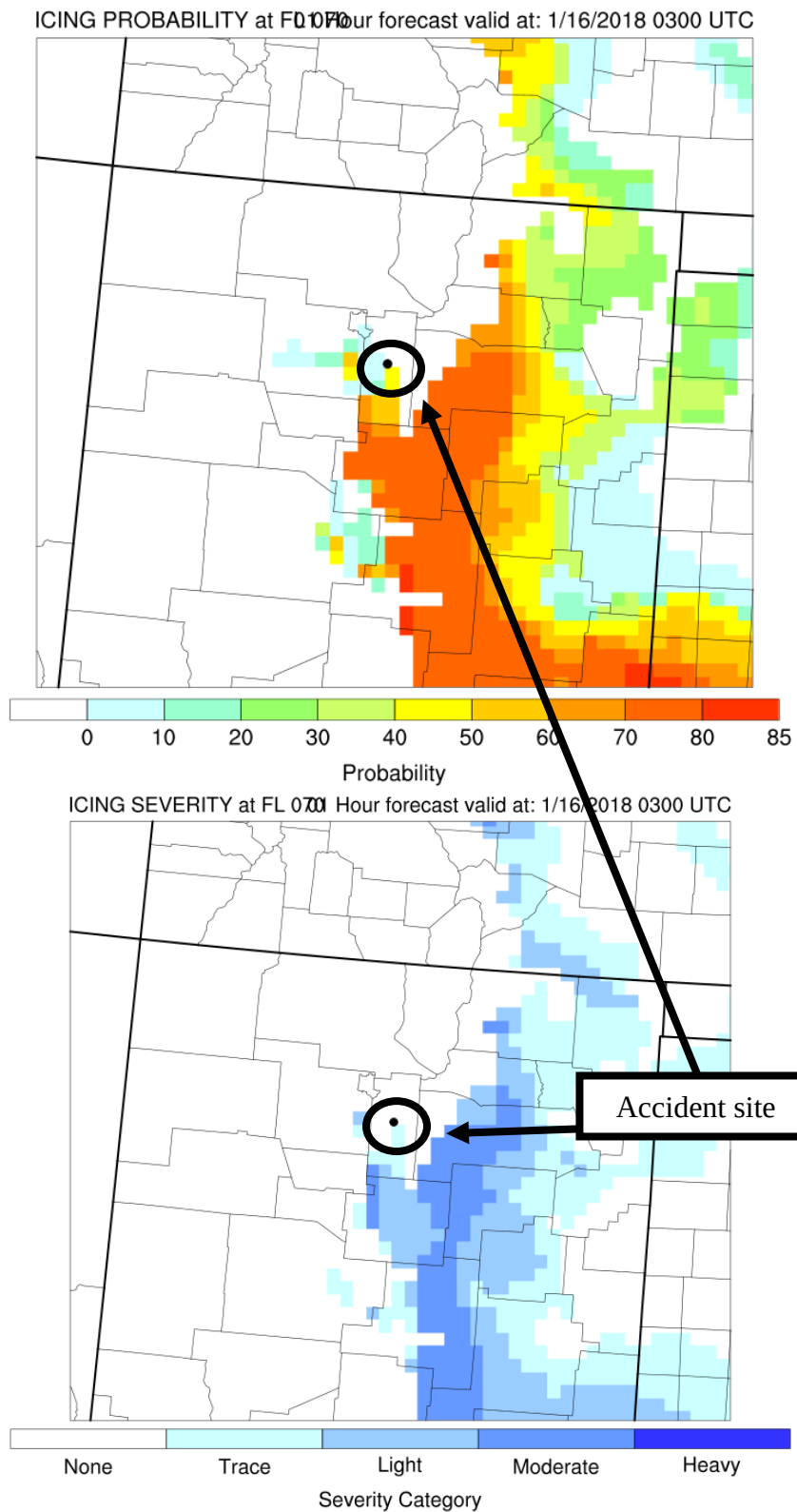


Figure 22 – (top) FIP probability of icing at 7,000 ft msl and (bottom) FIP severity of icing at 7,000 ft msl 1-hour forecast valid for 2000 MST

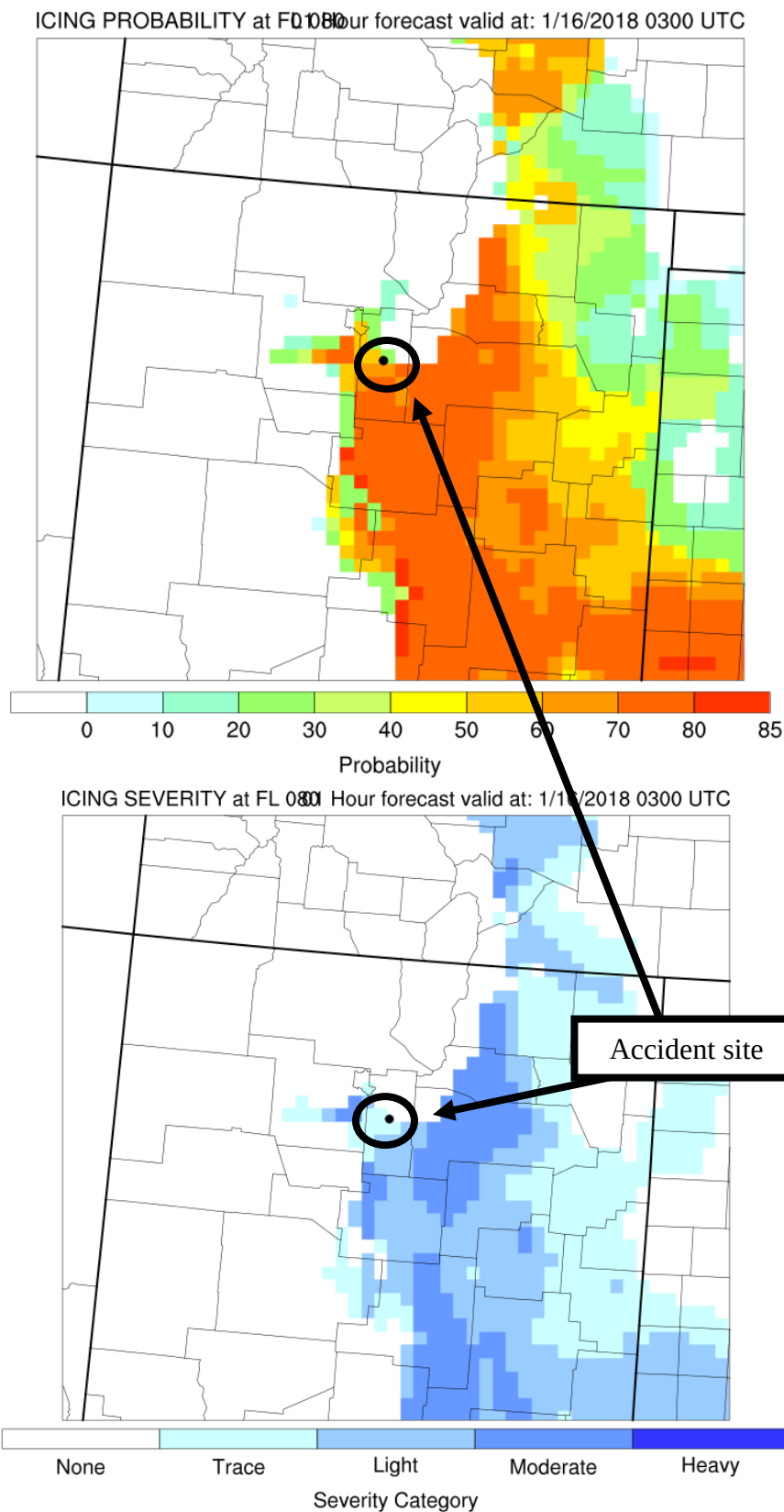


Figure 23 – (top) FIP probability of icing at 8,000 ft msl and (bottom) FIP severity of icing at 8,000 ft msl 1-hour forecast valid for 2000 MST

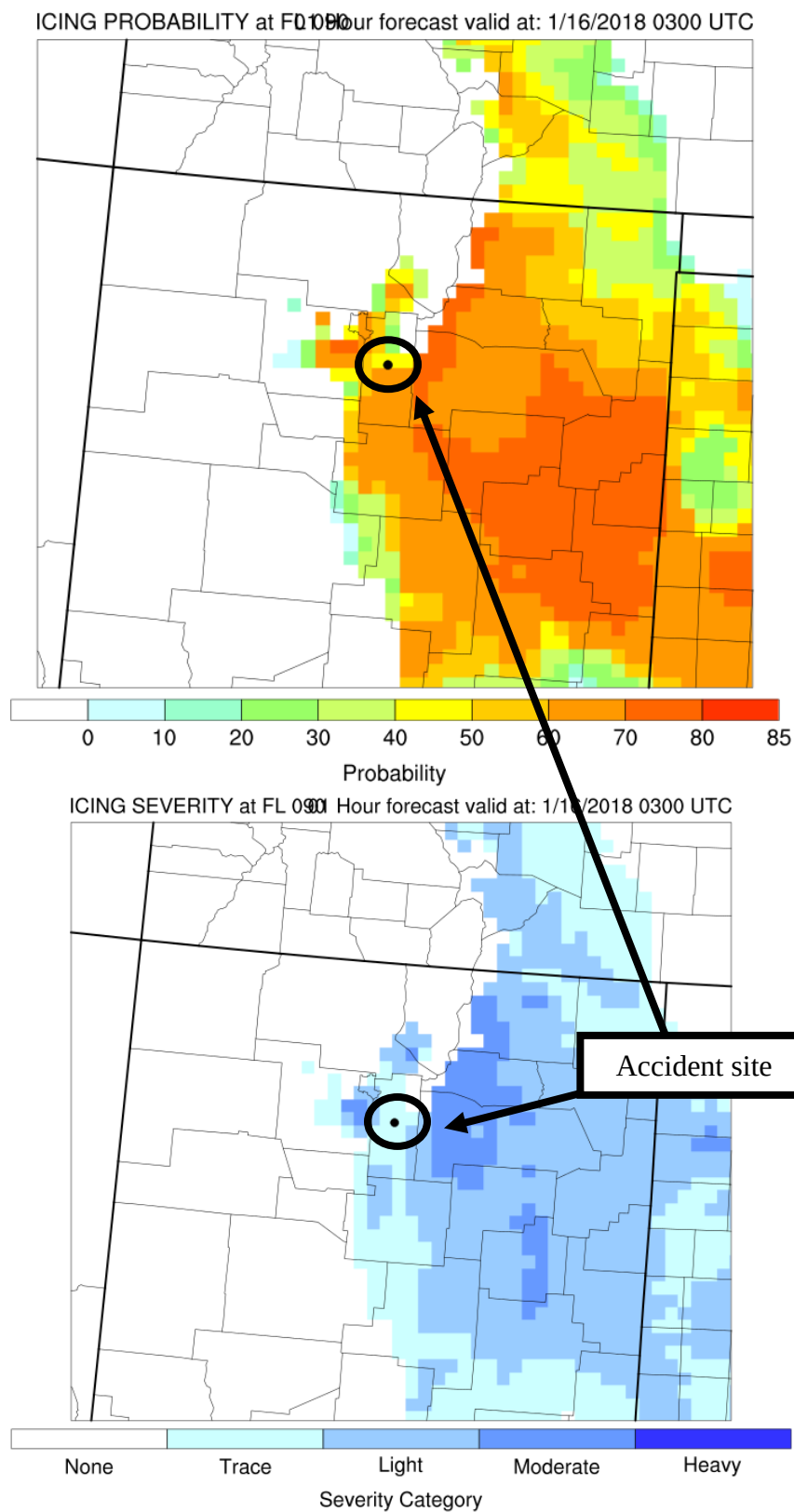


Figure 24 – (top) FIP probability of icing at 9,000 ft msl and (bottom) FIP severity of icing at 9,000 ft msl 1-hour forecast valid for 2000 MST

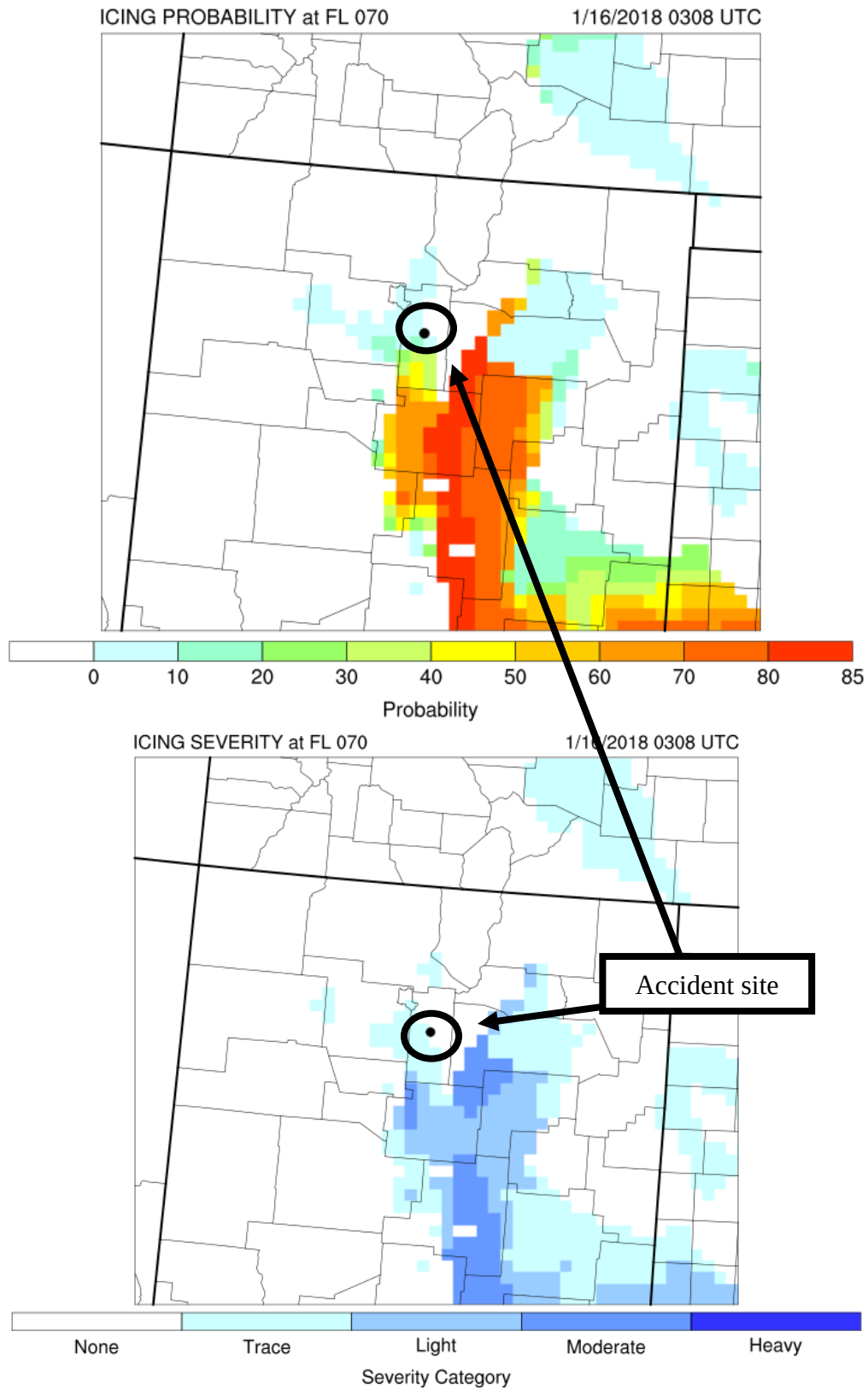


Figure 25 – (top) CIP probability of icing at 7,000 ft msl and (bottom) CIP severity of icing at 7,000 ft msl valid for 2000 MST

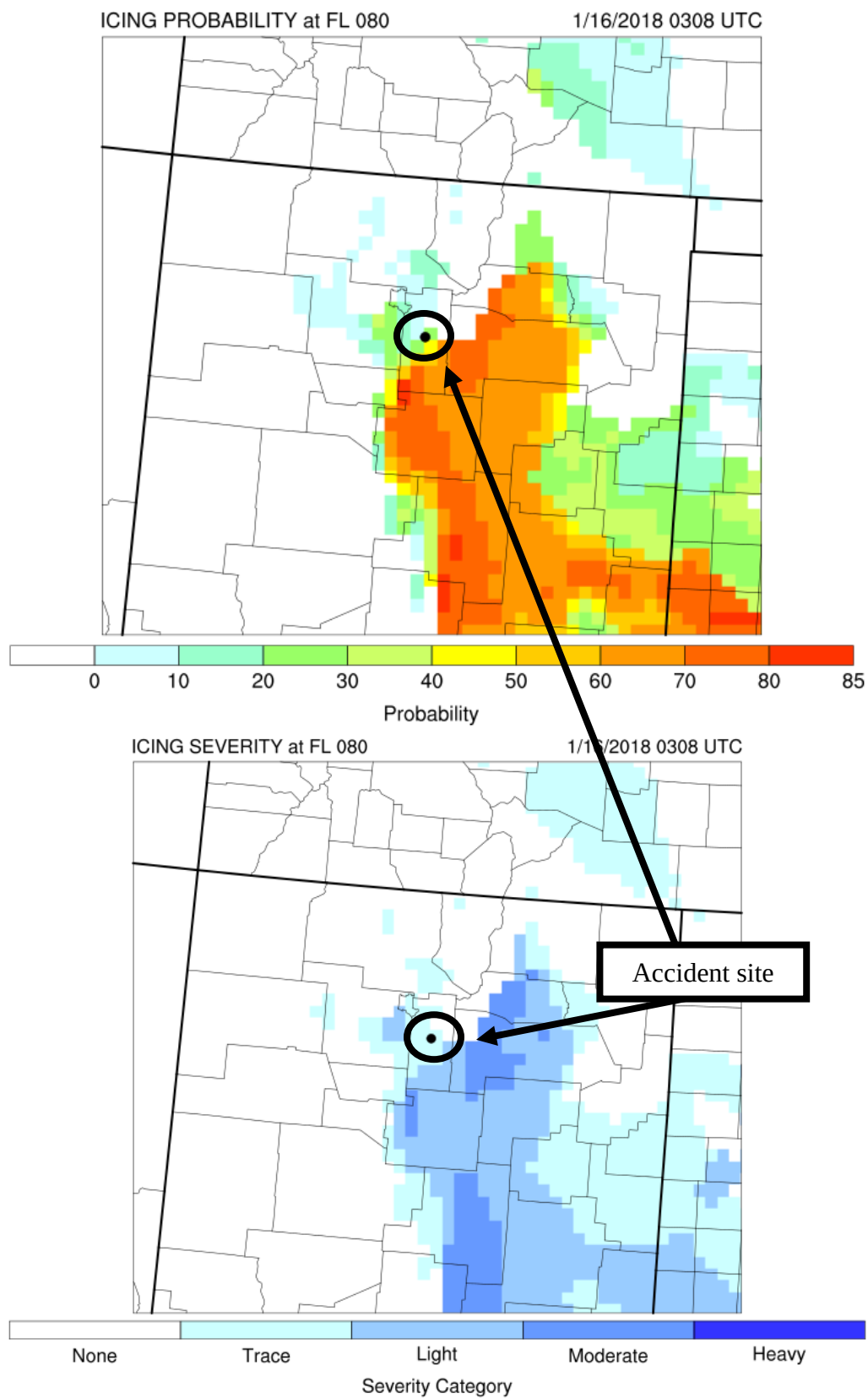


Figure 26 – (top) CIP probability of icing at 8,000 ft msl and (bottom) CIP severity of icing at 8,000 ft msl valid for 2000 MST

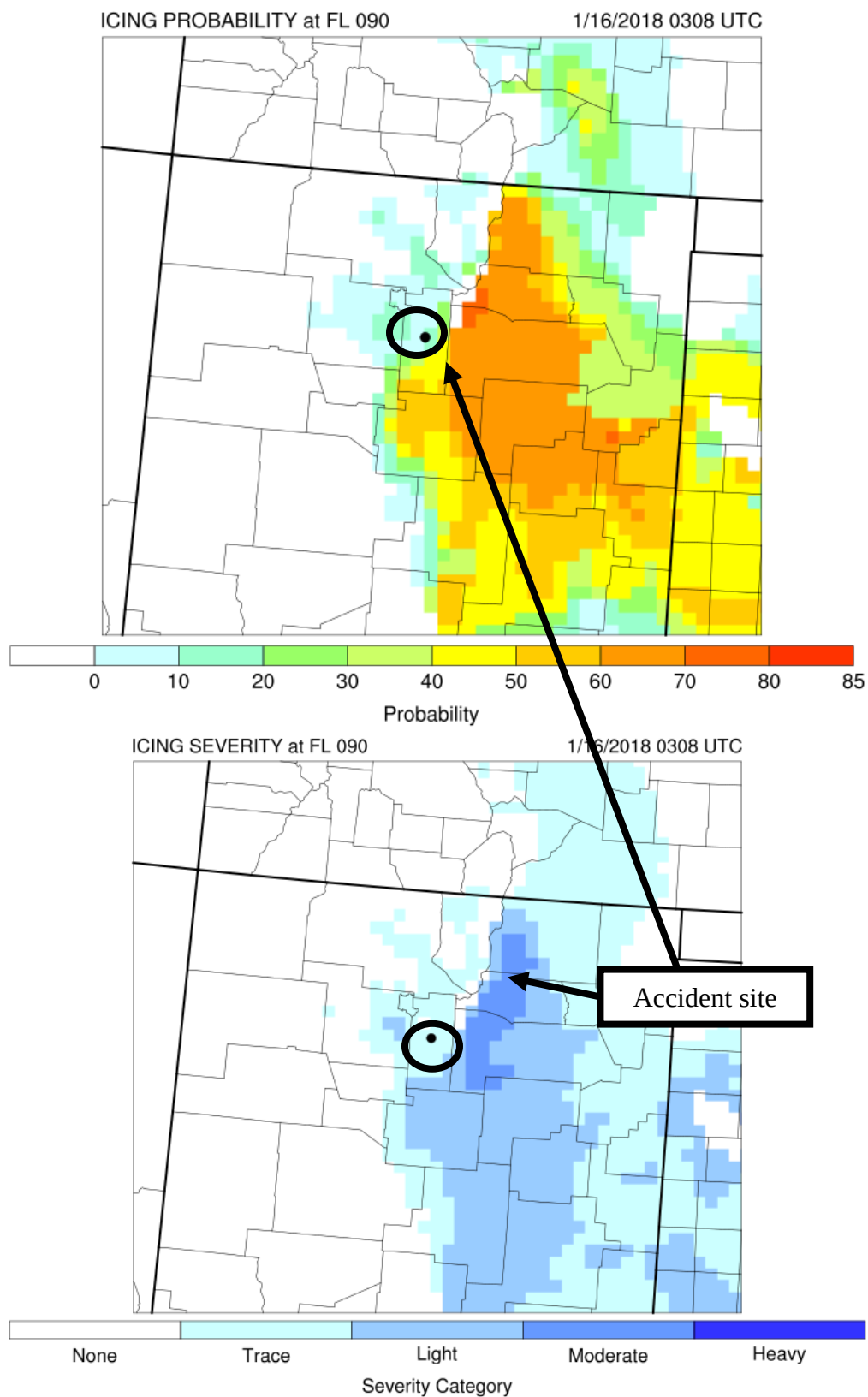


Figure 27 – (top) CIP probability of icing at 9,000 ft msl and (bottom) CIP severity of icing at 9,000 ft msl valid for 2000 MST

18.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on January 15, 2018, indicated the following:

SUN

Begin civil twilight	0645 MST
Sunrise	0713 MST
Sun transit	1213 MST
Sunset	1714 MST
End civil twilight	1742 MST
Accident time²³	1935 MST

MOON

Moonrise	0601 MST
Moon transit	1110 MST
Moonset	1620 MST
Accident time²⁴	1935 MST

E. LIST OF ATTACHMENTS

Attachment 1 – GOES-16 Infrared satellite animation from 1707 to 2207 MST

Attachment 2 – GOES-16 Infrared satellite animation zoomed from 1907 to 1942 MST

Attachment 3 – NASA SPoRT Nighttime Microphysics RGB quick guide

Attachment 4 – GOES-16 Nighttime Microphysics RGB satellite animation from 1902 MST through 1957 MST

Attachment 5 – GOES-16 Infrared satellite animation from 1902 MST through 1957 MST

Attachment 6 – GFA products valid for the accident site around the accident time and before the accident flight departed KLBL

Attachment 7 – Memorandum of Conversation with the accident pilot from August 9, 2018

Attachment 8 – CIP and FIP products valid at 1900 and 2000 MST for the accident flight

Attachment 9 – Partial ATC Communication Summary

²³ Inserted accident time for reference and context.

²⁴ Inserted accident time for reference and context.

Submitted by:

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