



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 8, 2019

Weather Study

METEOROLOGY

WPR19FA083

Table Of Contents

A. ACCIDENT	3
B. METEOROLOGIST	3
C. SUMMARY	3
D. DETAILS OF THE INVESTIGATION	3
E. WEATHER INFORMATION	4
1.0 Synoptic Conditions.....	4
1.1 Surface Analysis Chart	4
1.2 National Composite radar Mosaic	5
1.3 12-Hour Surface Prognostic Chart.....	6
2.0 Observations	7
2.1 Hayward, California.....	7
2.2 Concord, California.....	9
2.3 Livermore, California	10
2.4 Lincoln, California.....	11
2.5 METAR Display	12
3.0 Sounding	13
4.0 Satellite Imagery	17
5.0 Pilot Reports.....	18
6.0 NWS Forecasts and Advisories	19
6.1 Terminal Aerodrome Forecast	19
6.2 Area Forecast Discussion.....	19
6.3 Graphic Forecast for Aviation	21
6.4 Winds and Temperatures Aloft Forecast	22
6.5 Inflight Weather Advisories.....	23
7.0 Preflight Weather Briefing.....	27
8.0 Astronomical Conditions	27

A. ACCIDENT

Location: Diablo, California
Date: February 8, 2019
Time: about 2010 Pacific standard time
0410 Universal Coordinated Time (UTC) on February 9, 2019
Airplane: Mooney M20F; Registration: N3270F

B. METEOROLOGIST

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National Transportation Safety Board

C. SUMMARY

On February 8, 2019, about 2010 Pacific standard time, a Mooney M20F airplane, N3270F, was destroyed when it impacted mountainous terrain near Mount Diablo, California. The student pilot was fatally injured. The airplane was registered to a private individual and operated by the pilot as a 14 *Code of Federal Regulations* Part 91, personal flight. Visual meteorological conditions prevailed at the takeoff location and no flight plan had been filed. The solo cross-country flight originated from the Hayward Executive Airport (HWD) Hayward, California, about 2002, with a planned destination of Lincoln Regional Airport (LHM), Lincoln, California.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are Pacific standard time (PST) based upon the 24-hour clock, local time is -8 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was based on the coordinates at latitude 37.872019° N and latitude 121.924576° W, at an elevation of about 2,820 ft. The accident site location was about 3/4 mile southwest of the Mount Diablo summit which lists a height of 3,849 ft.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular “Aviation Weather Services”, AC 00-45H.

1.1 Surface Analysis Chart

The west-central portion of the NWS Surface Analysis Chart for 1900 PST is included as figure 1 with the approximate accident site marked by the red star. The chart depicted a low-pressure system at 1012-hectopascals (hPa)¹ associated with an occluded front that extended southward along the California Pacific coast and become a cold front extending to the southwest over the Pacific Ocean. A secondary trough of low-pressure extended west from the low. Two high-pressure systems were located to the east over Wyoming and Utah at 1029-hPa and 1025-hPa respectively. The accident site was located immediately ahead or east of the low-pressure system and occluded front in an area of a general weak pressure gradient. Based on the previous surface analysis charts (not shown) the low-pressure system and occluded fronts were noted to be gradually weakening or filling², but still responsible for producing an extensive area of clouds and precipitation over the region.

¹ Hectopascal (hPa) is the new standard term for reporting sea-level pressure and is interchangeable with the former term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa with a temperature of 15° Celsius (C).

² Filling - An increase in the central pressure of a pressure system; opposite of a deepening or strengthening of the system.

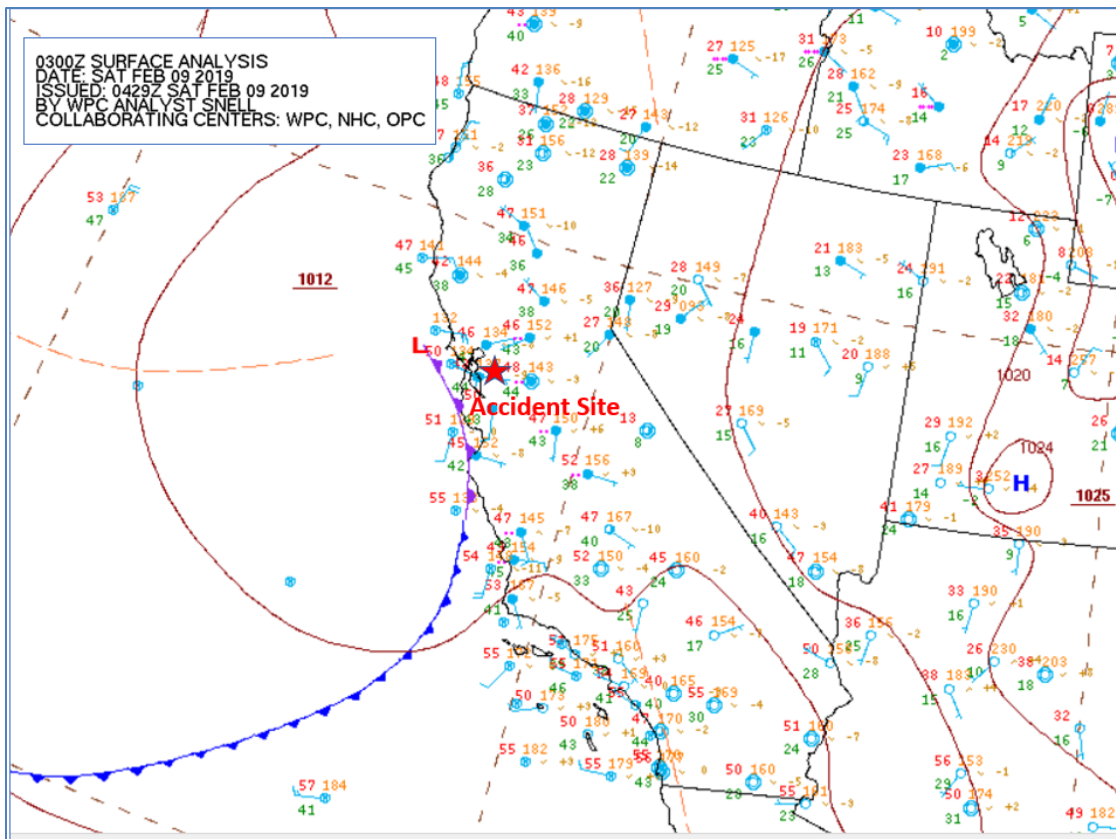


Figure 1 - west-central section of the NWS Surface Analysis Chart for 1900 PST

The station models in the immediate vicinity of the accident site, indicated a cyclonic or counter clockwise easterly wind flow in towards the low-pressure system with wind speeds of 10 knots or less, with broken to overcast cloud cover, with a temperature of 49° Fahrenheit (F), and a dew point temperature of 44° F. Multiple stations immediately northeast, east, and southeast of the accident site in the Sacramento Valley reported continuous light rain at the time.

1.2 National Composite radar Mosaic

The National Composite Radar Mosaic for 2010 PST is included as figure 2 with the accident site marked by a red star and the departure and planned destination airports marked by a yellow triangle. The image depicted no significant weather echoes over the departure airport or in the vicinity of the accident site, but several areas of echoes associated with rain showers over the Sacramento Valley and were between the accident site and the destination airport in Lincoln, California.

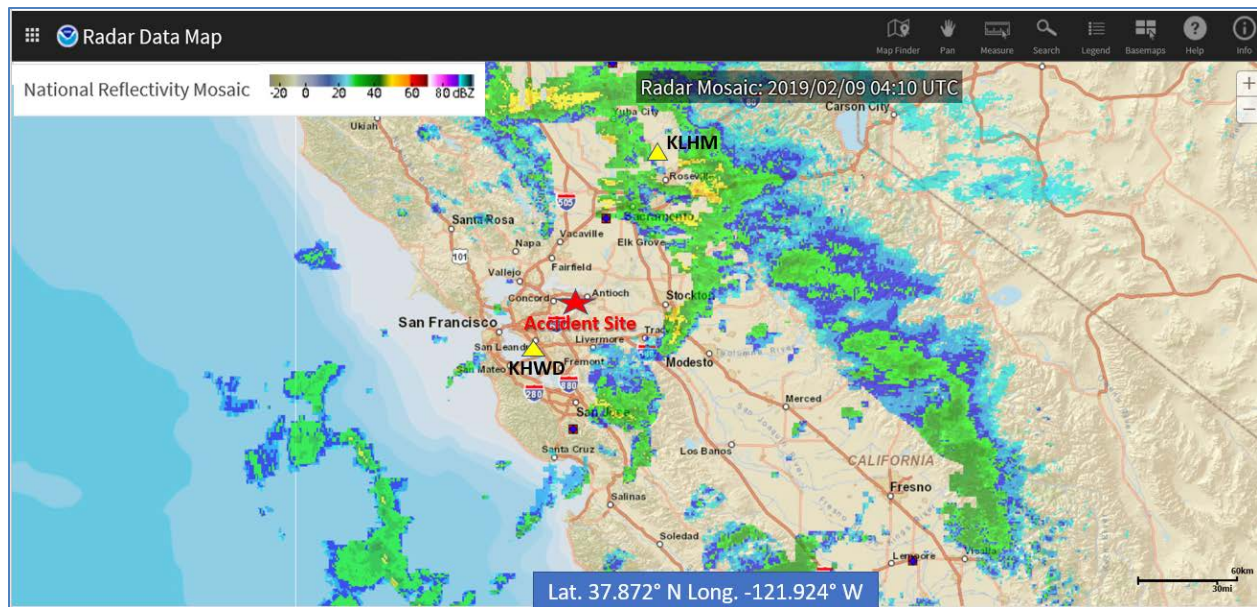


Figure 2 - National Composite Radar Mosaic image at 2010 PST

1.3 12-Hour Surface Prognostic Chart

The NWS 12-hour Surface Prognostic Chart current during the period is included as figure 3 with the approximate accident site marked by a red star. The chart continued to depict the low-pressure system and associated occluded front moving north-northeast into the Pacific northwest with an extensive area of precipitation associated with the system. Rain showers were expected over most of California from the Coastal Range mountain range into the Sacramento Valley, with snow over the Sierra Nevada mountain range over eastern California.

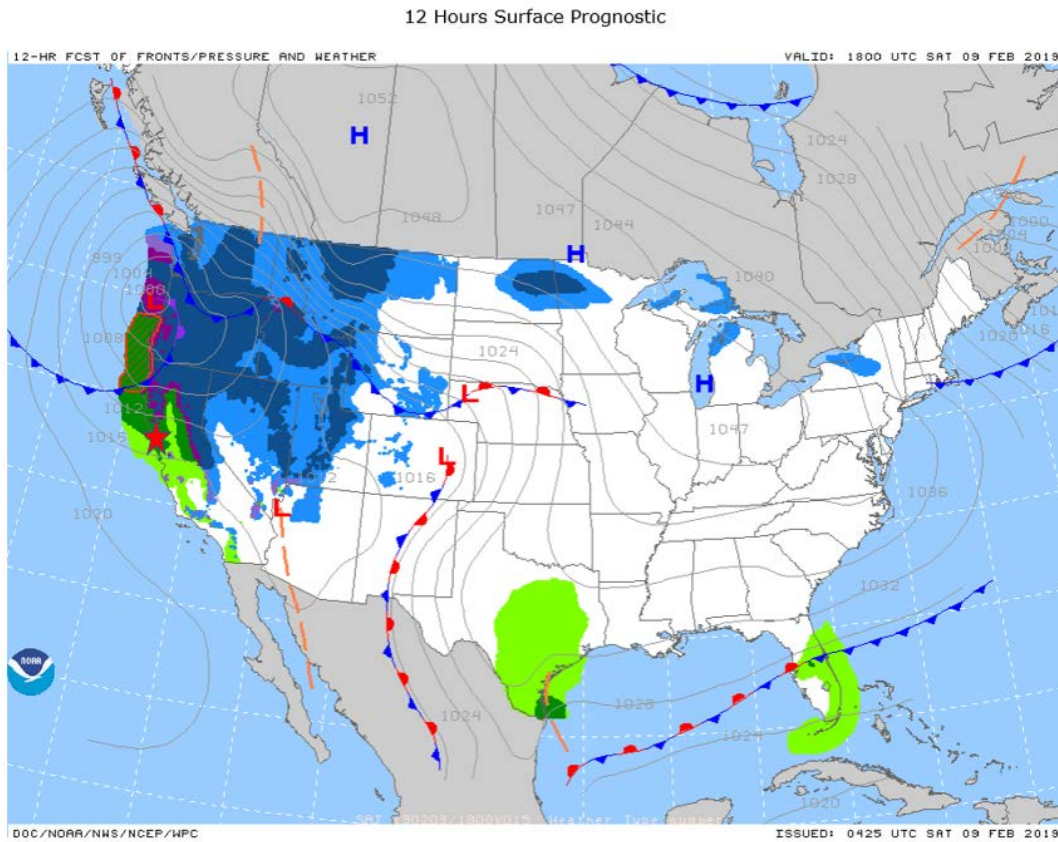


Figure 3 - 12-hour Surface Prognostic Chart valid during the period

2.0 Observations

The surrounding area was documented using Meteorological Aerodrome Reports (METAR) and Specials observations (SPECI). Cloud heights are reported in height above ground level (agl) in the following section. The magnetic variation was 14° E based on the latest sectional chart.

2.1 Hayward, California

The accident airplane departed from Hayward Executive Airport (KHWD), Hayward, California located approximately 16 miles southwest of the accident site at an elevation of 52 ft. The airport had an Automated Surface Observation System (ASOS) installed and reported the following conditions at the time of the accident:

KHWD weather observation at 1954 PST, wind from 070° at 4 knots, visibility 10 miles, scattered clouds at 5,000 ft agl, temperature 9° C, dew point temperature 6° C, altimeter 29.93 inches of mercury (Hg). Remarks: automated observation system with a precipitation discriminator, rain began at 1911 and ended at 1927 PST, sea-level pressure 1014.4-hPa, hourly precipitation less than 0.01 inches or a trace of precipitation, temperature 9.4° C, dew point 5.6° C.

The following general flight categories³ and raw observation reported surrounding the period from 1354 to 2154 PST were as follows:

IFR METAR KHWD 082154Z 14007KT 2 1/2SM RA OVC035 11/05 A2999 RMK AO2 RAB09 SLP167 P0005
T01060050

IFR METAR KHWD 082254Z 14005KT 2 1/2SM RA OVC033 09/06 A2998 RMK AO2 SLP162 P0017
T00940061

VFR SPECI KHWD 082325Z 12004KT 9SM BKN043 OVC050 09/07 A2997 RMK AO2 RAE20 P0001
T00940067

VFR METAR KHWD 082354Z 08004KT 10SM -RA FEW035 BKN046 OVC055 10/06 A2996 RMK AO2
RAE20B33 SLP155 P0001 60023 T01000061 10128 20094 58010

VFR METAR KHWD 090054Z 11008KT 10SM -RA SCT016 SCT030 OVC050 09/06 A2994 RMK AO2 SLP150
P0000 T00940061

VFR METAR KHWD 090154Z 10005KT 10SM -RA OVC034 09/06 A2993 RMK AO2 SLP146 P0000
T00940061

VFR METAR KHWD 090254Z 08004KT 10SM FEW030 BKN041 OVC050 09/06 A2993 RMK AO2 RAE0158
SLP144 P0000 60000 T00940061 56011

VFR METAR KHWD 090354Z 07004KT 10SM SCT050 09/06 A2993 RMK AO2 RAB11E27 SLP144 P0000
T00940056

Accident 0410Z

VFR METAR KHWD 090454Z 07003KT 10SM OVC043 09/06 A2993 RMK AO2 SLP144

VFR METAR KHWD 090554Z AUTO 06004KT 10SM BKN037 OVC047 09/06 A2993 RMK AO2 SLP144 60000
T00890056 10100 20089 50000

A review of the observation indicated that IFR conditions in moderate rain impacted the area during the early afternoon with rain ending at 1927 PST with 0.24 inches of precipitation. VFR conditions prevailed at the time of departure and the accident with multiple layers of clouds reported.

³ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

2.2 Concord, California

The closest official weather reporting location to the accident site was from Buchanan Field Airport (KCCR), located in Concord, California approximately 9 miles north-northwest of the accident site at an elevation of 26 ft. The airport had an ASOS and reported the following conditions:

KCCR weather observation at 1953 PST, wind from 020° at 6 knots, visibility 3 miles in moderate rain and mist, scattered clouds at 600 ft, ceiling broken at 1,300 ft, overcast at 2,800 ft, temperature 8° C, dew point 6° C, altimeter 29.95 inches of Hg. Remarks; automated observation system with a precipitation discriminator, rain ended at 1907 PST and rain began at 1943 PST, sea-level pressure 1012.8-hPa, hourly precipitation 0.02 inches, temperature 7.8° C, dew point 5.6° C.

The general flight categories and raw observation surrounding the period were as follows:

IFR METAR KCCR 082353Z 36004KT 2 1/2SM RA OVC032 08/06 A2998 RMK AO2 SLP138 P0021 60034 T00830056 10100 20083 56015

IFR METAR KCCR 090053Z 02003KT 2 1/2SM -RA BR SCT035 OVC045 08/06 A2996 RMK AO2 SLP133 P0004 T00830061

IFR METAR KCCR 090153Z 03003KT 2 1/2SM -RA BR FEW032 OVC050 08/06 A2995 RMK AO2 SLP128 P0004 T00830061

VFR METAR KCCR 090158Z 03006KT 5SM -RA BR FEW005 FEW030 OVC050 08/06 A2995 RMK AO2 P0000 T00830061

VFR METAR KCCR 090253Z 03004KT 7SM -RA FEW032 OVC044 08/06 A2995 RMK AO2 SLP128 P0003 60011 T00780056 56010

VFR SPECI KCCR 090334Z 04006KT 8SM SCT009 OVC032 08/06 A2995 RMK AO2 RAE07 P0000 T00780056

MVFR SPECI KCCR 090343Z 04006KT 6SM -RA BR SCT009 BKN013 OVC033 08/06 A2996 RMK AO2 RAE07B43 P0000 T00780056

MVFR METAR KCCR 090353Z 02006KT 3SM RA BR SCT006 BKN013 OVC028 08/06 A2995 RMK AO2 RAE07B43 SLP128 P0002 T00780056

Accident 0410Z

MVFR SPECI KCCR 090416Z 04008KT 3SM -RA BR FEW006 SCT013 OVC033 07/05 A2995 RMK AO2 P0001 T00720050

MVFR SPECI KCCR 090444Z 05007KT 3SM BR SCT006 OVC029 07/05 A2995 RMK AO2 RAE41 P0001 T00720050

MVFR METAR KCCR 090453Z 06007KT 7SM SCT006 OVC024 07/05 A2995 RMK AO2 RAE41 SLP127 P0001 T00720050

IFR METAR KCCR 090553Z 04009KT 8SM OVC005 07/05 A2995 RMK AO2 SLP128 60014 T00720050 10083 20072 50000

IFR METAR KCCR 090653Z AUTO 01005KT 8SM OVC006 07/05 A2995 RMK AO2 SLP126 T00720050

IFR METAR KCCR 090753Z AUTO 04005KT 9SM OVC007 07/04 A2994 RMK AO2 SLP124 T00720044
401000050

MVFR METAR KCCR 090822Z AUTO 03006KT 9SM FEW006 OVC011 07/04 A2994 RMK AO2 CIG 010V014
T00720044

2.3 Livermore, California

The next closest reporting station to the accident site was from Livermore Municipal Airport (KLVK), Livermore, California, located about 12 miles south-southeast at an elevation of 400 ft. The airport had an Automated Weather Observation System (AWOS) and reported the following conditions at the approximate time of the accident:

KLVK weather observation at 1953 PST, wind from 080° at 4 knots, visibility 10 miles or more, ceiling broken at 3,300 ft agl, temperature 7° C, dew point 6° C, altimeter 29.92 inches of Hg. Remarks: automated observation system with a precipitation discriminator, sea-level pressure 1013.2-hPa, temperature 6.7° C, dew point 5.6° C.

The following flight categories and raw observations surrounding the period were as follows:

IFR METAR KLVK 082353Z 00000KT 3/4SM -RA BR SCT029 OVC034 08/08 A2996 RMK AO2 SLP144 P0013
60028 T00830078 10106 20072 58012

IFR SPECI KLVK 090000Z 00000KT 2 1/2SM -RA BR FEW017 BKN029 OVC035 08/08 A2995 RMK AO2 P0000
T00830078

IFR SPECI KLVK 090021Z 00000KT 2 1/2SM -RA BR FEW017 OVC032 08/08 A2995 RMK AO2 P0000
T00830083

MVFR METAR KLVK 090053Z 4SM -RA BR FEW028 FEW047 OVC055 08/07 A2994 RMK AO2 SLP140 P0001
T00830072

VFR METAR KLVK 090153Z 11004KT 6SM -RA BR OVC043 07/06 A2993 RMK AO2 SLP136 P0005 T00670056

METAR KLVK 090253Z Missing

VFR METAR KLVK 090353Z 08004KT 10SM BKN033 07/06 A2992 RMK AO2 SLP132 T00670056

Accident 0410Z

VFR METAR KLVK 090453Z 06007KT 10SM FEW047 SCT055 BKN075 07/05 A2992 RMK AO2 SLP134
T00670050

VFR METAR KLVK 090553Z AUTO 00000KT 10SM CLR 07/05 A2993 RMK AO2 SLP135 60006 T00670050
10083 20061 55001

VFR METAR KLVK 090653Z AUTO 00000KT 6SM BR OVC037 06/04 A2991 RMK AO2 SLP131 T00610044

VFR METAR KLVK 090753Z AUTO 27003KT 6SM BR BKN035 OVC045 06/05 A2992 RMK AO2 SLP130

T00610050 401060028

IFR SPECI KLVK 090848Z AUTO 28004KT 2 1/2SM BR SCT033 BKN045 05/04 A2991 RMK AO2

IFR METAR KLVK 090853Z AUTO 28003KT 2 1/2SM BR BKN033 OVC045 05/04 A2991 RMK AO2 SLP130
T00500039 58000

A review of the observations indicated that IFR to MVFR conditions in rain showers were reported prior to the accident, with VFR conditions reported immediately surrounding the accident with mist and fog developing after 2200 PST with IFR conditions reported after midnight into the early morning hours.

2.4 Lincoln, California

The planned destination was Lincoln Regional Airport/Karl Harder Airport (KLHM), Lincoln, California, located 83 miles from the departure airport and 67 miles north-northeast of the accident site at an elevation of 121 ft. The airport had an ASOS without a precipitation discriminator, which prevented weather phenomena being reported. At the approximate time of the accident the following conditions were reported:

KLHM weather observation at 2215 PST, automated, wind from 210° at 4 knots, visibility of 10 miles or more, ceiling overcast at 2,800 ft agl, temperature 7° C, dew point 5° C, altimeter 29.97 inches of Hg. Remarks: automated observation system without a precipitation discriminator, hourly precipitation 0.01 inches.

The general flight categories and observations from approximately 1700 through 2300 PST were as follows:

VFR METAR KLHM 090115Z AUTO 35005KT 10SM OVC075 08/02 A2996 RMK AO1

VFR METAR KLHM 090135Z AUTO 34004KT 10SM SCT075 BKN085 08/03 A2995 RMK AO1

VFR METAR KLHM 090155Z AUTO 32003KT 10SM SCT075 BKN090 08/03 A2995 RMK AO1

VFR METAR KLHM 090215Z AUTO 34004KT 10SM OVC070 08/03 A2995 RMK AO1

VFR METAR KLHM 090235Z AUTO 19007KT 10SM BKN042 BKN050 OVC070 07/04 A2996 RMK AO1

VFR METAR KLHM 090255Z AUTO 00000KT 10SM BKN042 OVC049 08/03 A2996 RMK AO1

VFR METAR KLHM 090315Z AUTO 27006KT 10SM BKN038 BKN044 OVC049 08/04 A2996 RMK AO1

VFR METAR KLHM 090335Z AUTO 27006KT 10SM OVC036 07/05 A2997 RMK AO1

VFR METAR KLHM 090355Z AUTO 27006KT 10SM OVC032 07/05 A2997 RMK AO1

Accident 0410Z

MVFR METAR KLHM 090415Z AUTO 21004KT 10SM OVC028 07/05 A2997 RMK AO1 P0001

MVFR METAR KLHM 090435Z AUTO 00000KT 10SM BKN023 OVC029 07/06 A2998 RMK AO1 P0001

MVFR METAR KLHM 090455Z AUTO 35003KT 10SM SCT021 BKN029 OVC036 06/05 A2997 RMK AO1 P0001

MVFR METAR KLHM 090515Z AUTO 00000KT 10SM BKN015 BKN020 OVC038 06/06 A2998 RMK

MVFR METAR KLHM 090535Z AUTO 00000KT 7SM BKN013 OVC020 06/06 A2997 RMK AO1 P0003

MVFR METAR KLHM 090555Z AUTO 02005KT 10SM SCT011 SCT021 OVC030 06/06 A2997 RMK

MVFR KLHM 090615Z AUTO 01003KT 10SM OVC026 06/06 A2996 RMK AO1

MVFR METAR KLHM 090635Z AUTO 02003KT 5SM OVC024 06/06 A2997 RMK AO1

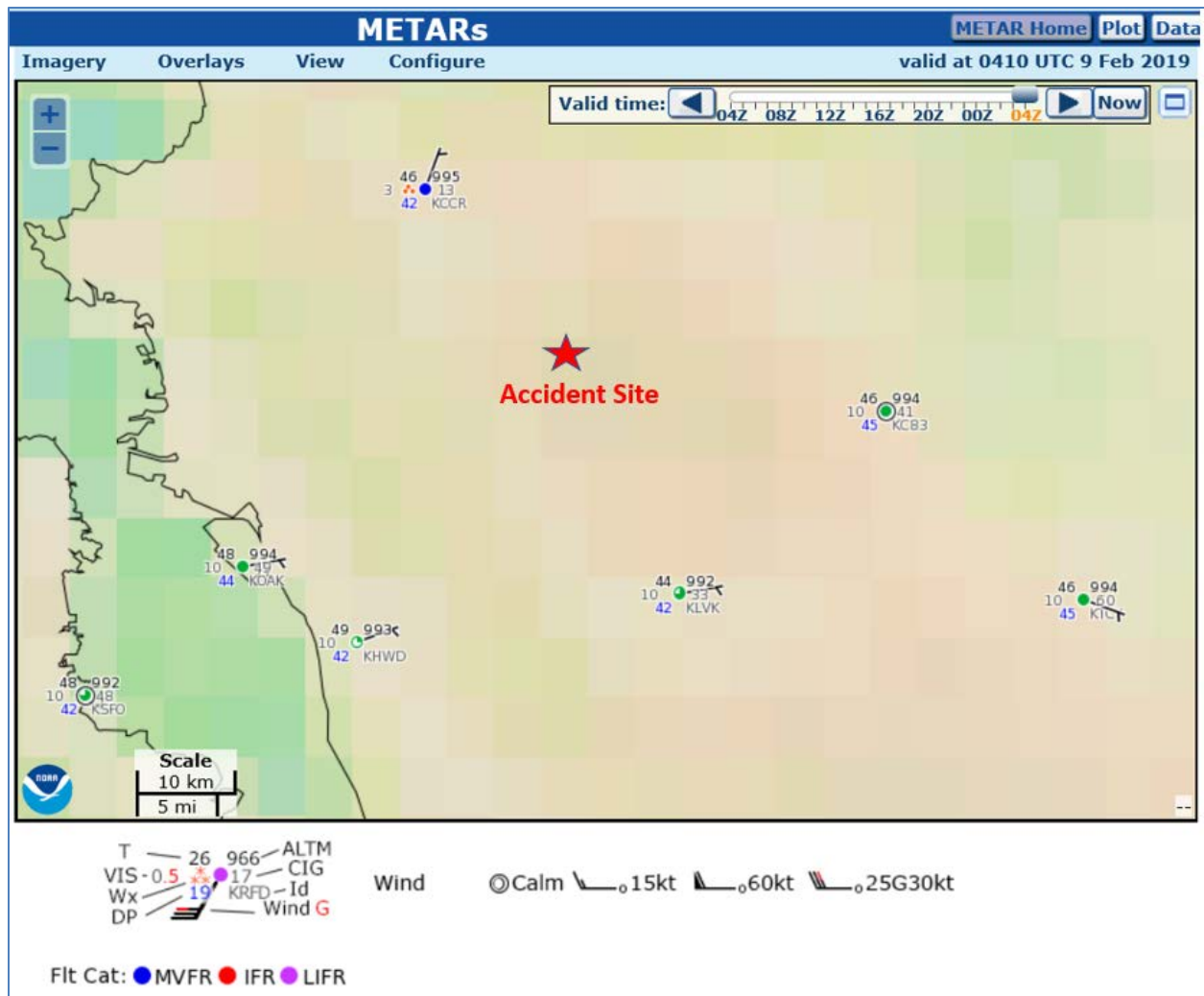
MVFR METAR KLHM 090655Z AUTO 01004KT 5SM OVC020 06/05 A2996 RMK AO1

A review of the observations indicated that VFR conditions prevailed prior to the accident airplanes departure, with MVFR conditions being reported near the time of the accident and continuing into the following morning hours due to lowering cloud ceilings with scattered rain showers noted by the measurable precipitation being reported during the hour.

2.5 METAR Display

The NWS Aviation Weather Center's website⁴ display of the METAR observations at the time of the accident of 2210 PST is included in figure 4 with the approximate accident site marked by the red star. The general flight categories are also depicted and indicated primarily VFR conditions prevailing at the reporting sites surrounding the accident site with the exception of a site immediately north-northwest at KCCR, which reported MVFR conditions with 3 miles in moderate rain with a ceiling at 1,300 ft agl.

⁴ <https://aviationweather.gov/metar>



3.0 Sounding

The NWS Oakland (KOAK) site number 72493, upper air sounding for 1600 PST (0000Z on February 9, 2019) was plotted on a standard Skew T log P diagram⁵ using the completed Rawinsonde Observation RAOB program software⁶ from the surface through 450-hPa (or approximately 21,000 ft) and is included as figure 5. The sounding site was located about 17 miles west-southwest of the accident site and represented the conditions prior to the accident.

⁵ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

⁶ RAOB software – The complete RAOBsonde OBServation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data.

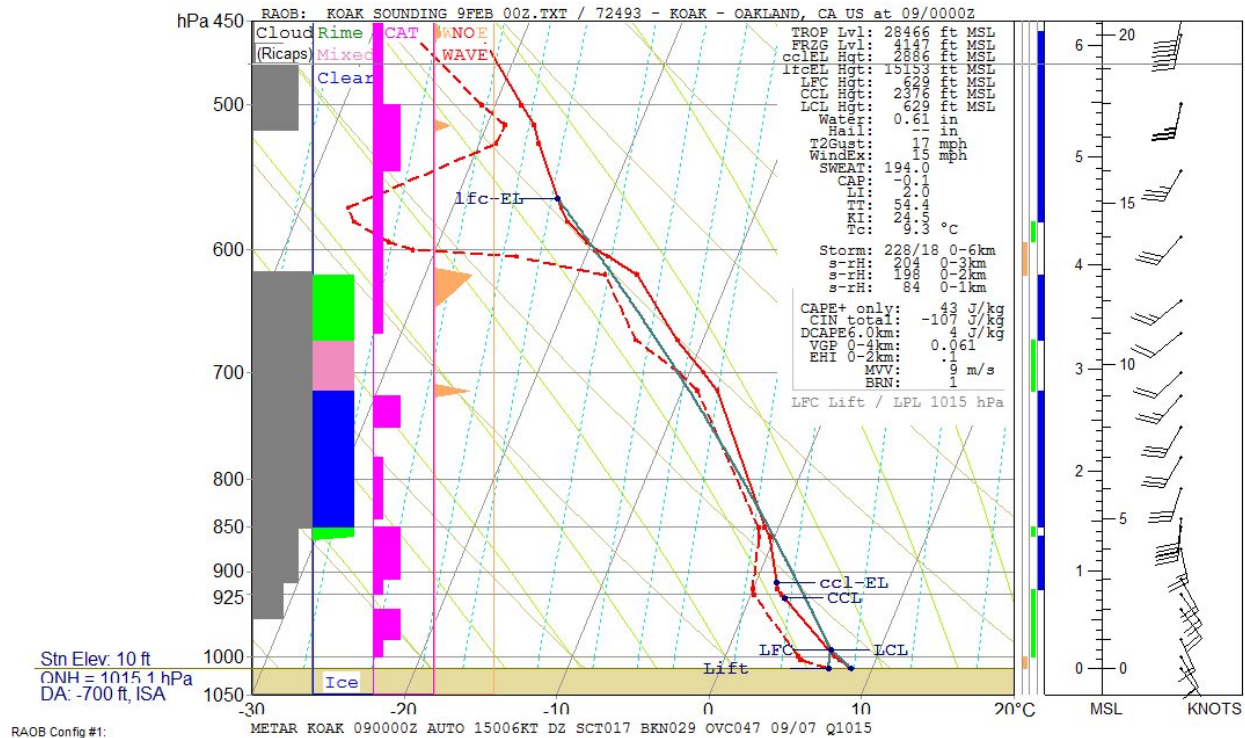


Figure 5 - KOAK 1600 PST sounding

The sounding indicated a lifted condensation level (LCL)⁷ and level of free convection (LFC)⁸ at 619 ft agl, with the convective condensation level (CCL)⁹ at 2,366 ft agl. The sounding supported multiple layers of clouds and was basically saturated from 2,900 ft through 13,00 ft, and between 17,000 ft through 19,000 ft. The freezing level was identified 4,147 ft and supported icing in clouds and in-precipitation above this level to approximately 13,000 ft, which is shown on the left side of the diagram. The precipitable water content was 0.61 inches. The atmosphere was characterized as stable with a Lifted Index of 2.0, and supported stratus and nimbostratus type clouds.

The KOAK wind profile indicated a surface wind from the south-southeast at 6 knots which veered clockwise to the south and southwest with height with increasing wind speeds with height immediately above the surface. The mean 0 to 6 kilometer (km) wind was from 200° at 25 knots. At the accident airplanes highest recorded altitude of 2,900 ft based on the air traffic control playback indicated the wind was from 150° at 20 knots with a temperature of 1.2° C.

⁷ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

⁸ Level of Free Convection (LFC) - The height at which a parcel of air, when lifted, becomes warmer than its surroundings and thus convectively buoyant. The parcel is lifted dry-adiabatically until saturated (at the LCL) and then moist-adiabatically thereafter.

⁹ Convective Condensation Level (CCL) - The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

Figure 6 is a table of the observed height, pressure (Pres), temperature (T), dew point (Td), relative humidity (RH%), wind direction and speed, and the RAOB algorithm derived clear air turbulence (CAT), low-level wind shear (LLWS), icing intensity and type, and mountain wave potential from the surface through 18,000 ft.

Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x--W---Turb nm fpm max
10	1015	8.6	7.1	90	150 / 6				
306	1004	7.6	5.0	84					
414	1000	7.2	4.8	85	155 / 8	LGT			
1000	978				160 / 13	MDT			
2000	942				150 / 19				
2501	925	2.0	0.2	88	150 / 18				
2673	919	1.6	0.0	89		LGT			
3000	908				155 / 21	MDT			
4000	874				170 / 27				
4423	860	-0.3	-1.0	95		MDT		LGT Rime	
4730	850	-0.9	-1.3	97	185 / 30			LGT Rime	
5000	841				185 / 31	LGT			
6000	809				195 / 29	LGT			
7000	779				205 / 30				
8000	749				205 / 28	MDT			
9000	721				215 / 23				
9171	716	-7.7	-9.0	90				LGT Clear	3.91 1199 MD-SV
9747	700	-9.1	-10.7	88	220 / 21			LGT Mixed	
10779	672	-11.7	-14.4	80				LGT Mixed	
11000	666				225 / 20	LGT			
12000	640				225 / 23				4.53 357 LIGHT
12828	619	-16.1	-18.2	84				LGT Rime	10.23 1833 MD-SV
13391	605	-18.5	-24.5	59					
13594	600	-19.5	-31.5	34					
13839	594	-20.3	-33.3	30		LGT			
14000	590				215 / 31				
14458	579	-22.1	-36.1	27					
14878	569	-22.9	-36.9	27		LGT			
16000	543				205 / 37				
16802	525	-26.1	-28.9	77					
17350	513	-26.9	-28.8	84		MDT			4.57 587 LT-MD
17956	500	-28.3	-30.9	78	190 / 26	LGT			

Figure 6 - KOAK sounding at 1600 PST

A High Resolution Rapid Refresh (HRRR)¹⁰ numerical model for the accident site was also obtained from archive data from the NOAA Air Resource Laboratory from data run from the 1600 PST initial model data and valid for 2000 PST is included in figure 7 on a similar Skew T log P diagram as the KOAK plot. The elevation of the model sounding was at 2,769 ft and was within 100 ft of the accident site elevation.

¹⁰ The HRRR is a National Oceanic and Atmospheric Administration (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.

Height (ft-MSL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x--W---Turb nm fpm max
2769	916	2.4	2.0	97	158 / 8				
2798	915	2.4	1.9	96	158 / 7	LGT	MODRT		
2885	912	2.3	1.8	96	160 / 11	LGT	LIGHT		
3060	906	2.0	1.6	97	162 / 14	LGT	LIGHT		
3295	898	1.6	1.3	98	166 / 17				
3651	886	0.9	0.7	99	173 / 18				
4132	870	0.1	0.1	100	179 / 17				
4743	850	-1.0	-1.0	100	185 / 15			LGT Rime	
5366	830	-2.1	-2.1	100	191 / 13			LGT Rime	
6066	808	-3.4	-3.4	100	196 / 14			LGT Rime	
6880	783	-4.9	-4.9	100	205 / 14	LGT		LGT Rime	2.49 299 LIGHT
7749	757	-6.7	-6.7	100	217 / 16			LGT Rime	
8747	728	-8.5	-9.6	92	226 / 15	LGT		LGT Rime	
9887	696	-10.8	-13.5	80	233 / 12			LGT Mixed	
11144	662	-13.6	-16.2	81	239 / 10			LGT Mixed	2.19 244 LIGHT
12531	626	-17.0	-17.9	93	239 / 12	LGT		LGT Rime	2.69 241 LIGHT
14103	587	-21.1	-21.8	94	233 / 17	LGT		LGT Rime	4.49 252 LIGHT
15842	546	-25.6	-26.7	90	223 / 23	LGT			
17562	508				211 / 25				
17684	505	-29.8	-31.1	88		LGT			

Figure 8 - HRRR numerical model sounding parameters for 2000 PST

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 17 (GOES-17) 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 (McIDAS) software. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km was obtained for times surrounding the time of the accident.

Figure 9 is the GOES-17 infrared image at 1212 PST at 4X magnification with a standard MB temperature enhancement curve applied to highlight the general higher and colder cloud tops associated with convective and high cirriform type clouds. The image depicted an extensive area of low stratiform clouds over the area, with the accident site on the western edge of a higher and thicker cloud area over the higher terrain and extending into the Sacramento Valley. The image depicted a radiative cloud tops temperature of 238° Kelvin or -35° C, which corresponded to cloud tops near 21,000 ft based on the KOAK observed sounding. Higher clouds tops (green areas) were located to the east of the accident site with temperatures near 229° K or -44° C, or cloud tops near 24,000 ft.

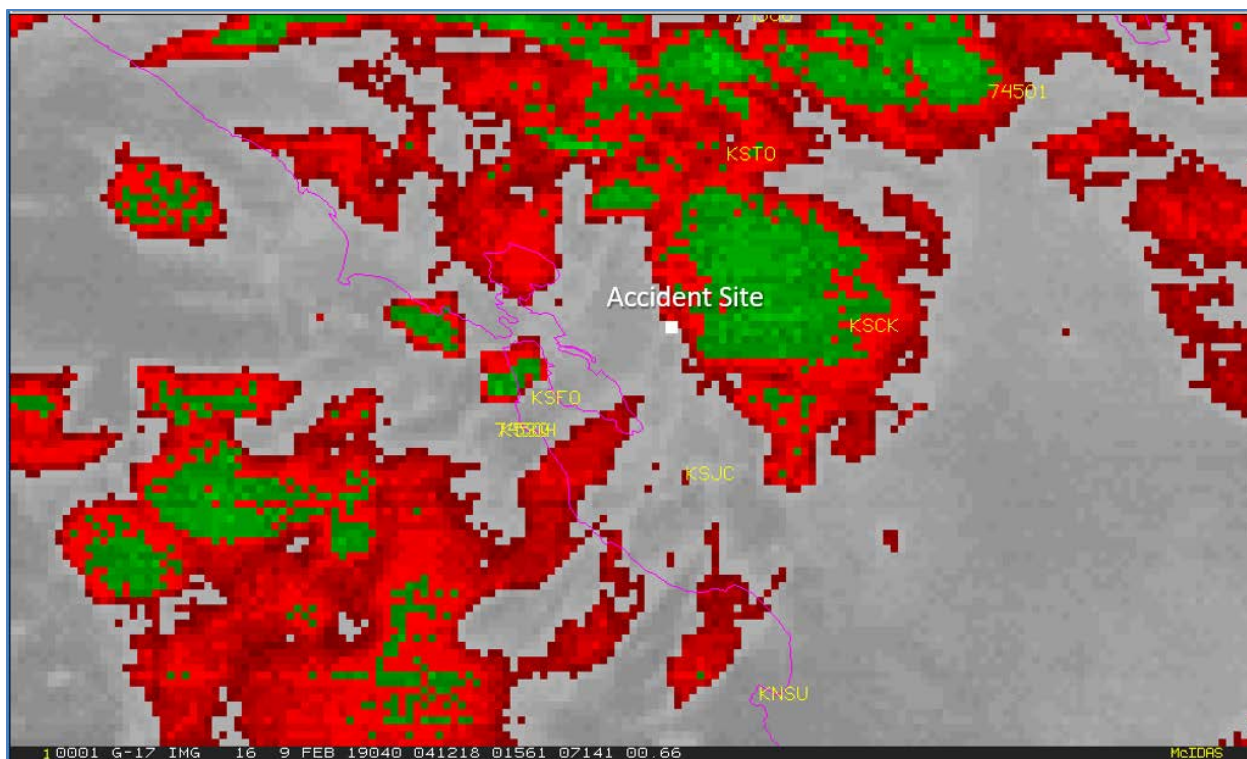


Figure 9 - GOES-17 enhanced infrared image at 2012 PST at 4X magnification

5.0 Pilot Reports

The following pilot reports or PIREPs were recorded within 100 miles of the accident site below 18,000 ft. The reports are in standard code and abbreviations with time in UTC. The reports were as follows:

SFO UA /OV SFO078050/TM 2232/FL160/TP B738/TA M18/IC LGT RIME/RM DURD
 SFO UA /OV OSI250020/TM 2232/FL260/TP B737/SK TOP260/RM ZOA CWSU
 LVK UA /OV LVK045007/TM 2240/FL026/TP C172/RM BASE 026
HWD UA /OV 3 EAST/TM 2246/FL023/TP PA46/SK OVC/WX VIS 3
 SCK UA /OV SCK350012/TM 2250/FL070/TP C560/SK BKN070/RM DURD SMOOTH
 OAK UA /OV OAK070020/TM 2357/FL105/TP A321/TA M01/IC LGT RIME
 LVK UA /OV 8 E OF LVK/TM 0027/FLDURD/TP C172/WX 5 SM/RM BASES 035
 SFO UA /OV SFO010017/TM 0031/FL070/TP A321/TA M07/IC LGT RIME/RM DURD
 MOD UA /OV MOD300030/TM 0034/FL130/TP E135/TA M17/IC LGT RIME
 STS UA /OV STS140015/TM 0038/FL190/TP B738/TA M10/IC LGT RIME 190/RM ZOA CWSU
 MOD UA /OV MOD230025/TM 0041/FL100/TP E135/TA M08/IC LGT RIME/RM 100-010 DURD
 LVK UA /OV LVK068005/TM 0130/FL090/TP B737/TA M09/IC LGT RIME/RM ALWAYS ARRIVAL
 SMF UA /OV ILA320020/TM 0142/FL100/TP C208/SK IMC/TA M12/IC LGT RIME 150-100/RM ZOA CWSU
 SCK UA /OV LIN360001/TM 0145/FL130/TP B737/TA M02/IC LGT RIME/RM 130 DURD OAK UA /OV
 OAK070028/TM 0148/FL130/TP E135/TA M06/IC LGT RIME/RM 130-070 DURD
 LVK UA /OV LVK045008/TM 0203/FL090/TP A320/TA M09/IC LGT RIME/RM SMOOTH RIDES/ JUST VERY
 COLD
 OAK UA /OV MOD260020/TM 0214/FL080/TP C208/TA M06/IC LGT RIME/RM DURD
 SMF UA /OV SAC115020/TM 0238/FL110/TP B737/TB LGT MOD CHOP/RM DURD 110-090
 SMF UA /OV SAC030020/TM 0320/FL120/TP B737/TA M24/IC LGT RIME/RM DURC

HWD UA /OV 6 EAST/TM 0324/FL035/TP TBM9/SK BKN

JAQ UA /OV SAC090035/TM 0407/FL220/TP PA46/SK SKC/TA M35/TB NEG/IC NEG

Accident 0410Z

Of the 21 PIREPs recorded during the period between 1400 through 0200 PST, the majority of the PIREPs (10) noted light rime type icing conditions above 7,000 ft, with only one PIREP of turbulence between 9,000 and 11,000 ft. A single PIREP at 1432 PST (2232Z) reported cloud tops at 26,000 ft. A PIREP from a pilot operating a SOCATA TBM-900 single engine turboprop aircraft at 1924 PST (0324Z) 6 miles east of KHWD reported the bases of a broken cloud layer at 3,500 ft. There were no reports of LLWS or any significant low-level turbulence noted with the exception of the one report near Sacramento International Airport (KSMF), which was reporting rain at the time of the report.

6.0 NWS Forecasts and Advisories

The NWS aviation forecasts and advisories current during the period were as follow.

6.1 Terminal Aerodrome Forecast

The NWS does not issue a Terminal Aerodrome Forecast (TAF) for KHWD. The closest TAF to the accident site was for KLVK immediately south. TAFs are valid for a 5 mile radius around an airport's center point. When planning a flight to an airport that does not have a TAF, pilots typically refer to the closest available TAFs to supplement the information in weather forecast products that cover large areas, such as the Graphic Aviation Forecast (GFA), Airmen's Meteorological Information (AIRMET) bulletins, and other graphical products. The NWS San Francisco Bay Area (KMTR) Weather Forecast Office (WFO) was responsible for the KLVK TAF. The forecast current at the time of the accident was issued at 1529 PST and was as follows:

TAF KLVK 082329Z 0900/0924 07010KT 5SM -RA BKN040 OVC060

TEMPO 0900/0901 2SM RA OVC030

FM090400 VRB05KT P6SM VCSH SCT020 BKN035

FM091400 22005KT P6SM VCSH FEW025 BKN050

FM092100 24010KT P6SM VCSH BKN050

The TAF for KLVK from 1600 through 2000 PST expected MVFR conditions in light rain with a temporary period of IFR conditions in moderate rain between 1600 and 1700 PST. From 2000 through 0600 PST the forecast expected VFR conditions to prevail with wind variable at 5 knots, visibility 6 miles or more with rain showers in the vicinity or within 10 miles of the station, scattered clouds at 2,000 ft agl, ceiling broken at 3,500 ft.

6.2 Area Forecast Discussion

The NWS Area Forecast Discussion issued by the NWS KMTR WFO at 1628 PST was as follows. While the AFD is not a typical aviation weather product, the plain language forecast discusses the general synoptic conditions, short term forecast, and includes an aviation section

discussing the meteorological reasoning and details in the TAFs issued. The AFD current at the time of departure was as follows:

*FXUS66 KMTR 090028
AFDMTR
Area Forecast Discussion
National Weather Service San Francisco Bay Area
428 PM PST Fri Feb 8 2019*

.SYNOPSIS...Rain will dominate the weather over the Bay Area this afternoon followed by showers this evening as a slowly weakening disturbance moves across the region. Lingering showers are likely into Saturday with another round of widespread rainfall and lowering snow levels on Sunday. Cool and unsettled conditions appear likely during next week with the potential for more widespread precipitation late in the week.

.DISCUSSION...as of 12:04 PM PST Friday...Low pressure circulating offshore of the Golden Gate will transition inland toward San Mateo County this evening as it slowly fills. The front associated with this low has begun to bring rain to the region this afternoon. This rain is expected to continue through much of the afternoon, transitioning to showers in the evening. Models continue to show marginal instability with the boundary, so have opted to leave slight chance of thunderstorms in the forecast for the afternoon and early evening. In addition, there has been some moderate convective activity offshore which is showing some weak rotation. This is a tell that the atmosphere is unstable around the boundary. Some of the heavier showers that move over the area may contain some small hail, but confidence is not high enough that this will occur to include it in the forecast.

Satellite imagery this afternoon shows a nice area of clearing behind the front before the core of the low slides across the region. This clearing will occur this evening and south of San Mateo County. It will be brief as showers will follow quickly for the overnight periods. On the north side of the low, clearing will not readily occur, but light rain should continue through the evening. After a brief break Sunday morning, showers will return Sunday afternoon and evening. Sunday will also see the introduction of another cold air mass that will lower snow levels down to around 1000-2000 feet with the lowest levels in North Bay. What we'll be watching is if the cold air will be in place when the moisture is around to cause some snow again in the hills and mountains. This is not expected to be a repeat of the early week snow event. That said, we will likely see some light accumulation along routes like highway 17. Maybe a dusting. We'll be refining the forecast over the next 24 hours to dial this in. The main change in this forecast package around Sunday was to lower snow levels by a couple hundred feet. Models seem to be trending downward and it looks like the upstream air mass supports a lower snow level.

After another break for part of Monday, models continue to bounce around with the possibility of an atmospheric river or a cold front. There has been such an large amount of uncertainty in this forecast, it remains untouched from the previous shift. The 12Z EC has bounced back to an AR impacting the Central Coast Tuesday into Wednesday, while the GFS drops a cold front through the area on Tuesday. Which scenario will prevail is still anyones guess. We are looking for markers in observational data, but projecting that out is tough. Starting with this early week rain threat, models are diverging all over the place causing a significant amount of uncertainty and very low confidence in the forecast. As such, the previous forecast remains in place as no amount of changing the forecast would add any value at this point.

Short of the long, the overall weather pattern remains progressive with pulses of rain moving through the area and unseasonably cool temperatures.

.AVIATION...As of 4:25 PM PST Friday...Upper low is just west of the Bay Area and will move onshore early this evening. Main rain band has moved through but we can expect showers through

06Z with cigs just above the official MVFR category. Shower activity decreases after 06Z and there may be breaks in the cigs Saturday. Southeast winds will shift to west to northwest tonight.

Vicinity of KSFO...Showery with cigs gradually lowering into MVFR range. Some breaks in the showers and cigs expected on Saturday. Southeast winds 5-10 kt switching to west to northwest after 06Z.

SFO Bridge Approach...Similar to SFO.

Monterey Bay Terminals...Cigs around 4000 ft lowering to 3000-4000 ft tonight. Shower activity decreasing after 03Z.

6.3 Graphic Forecast for Aviation

The southwest Graphical Forecast for Aviation (GFA) forecast for surface wind, visibility and weather, with the AIRMET Sierra for IFR conditions valid for 1900 PST is included as figure 10, with the accident site located within the red circle. The GFA expected a southeast wind at less than 5 knots, visibility less than 5 miles in rain showers. An AIRMET for IFR conditions extended over the area.

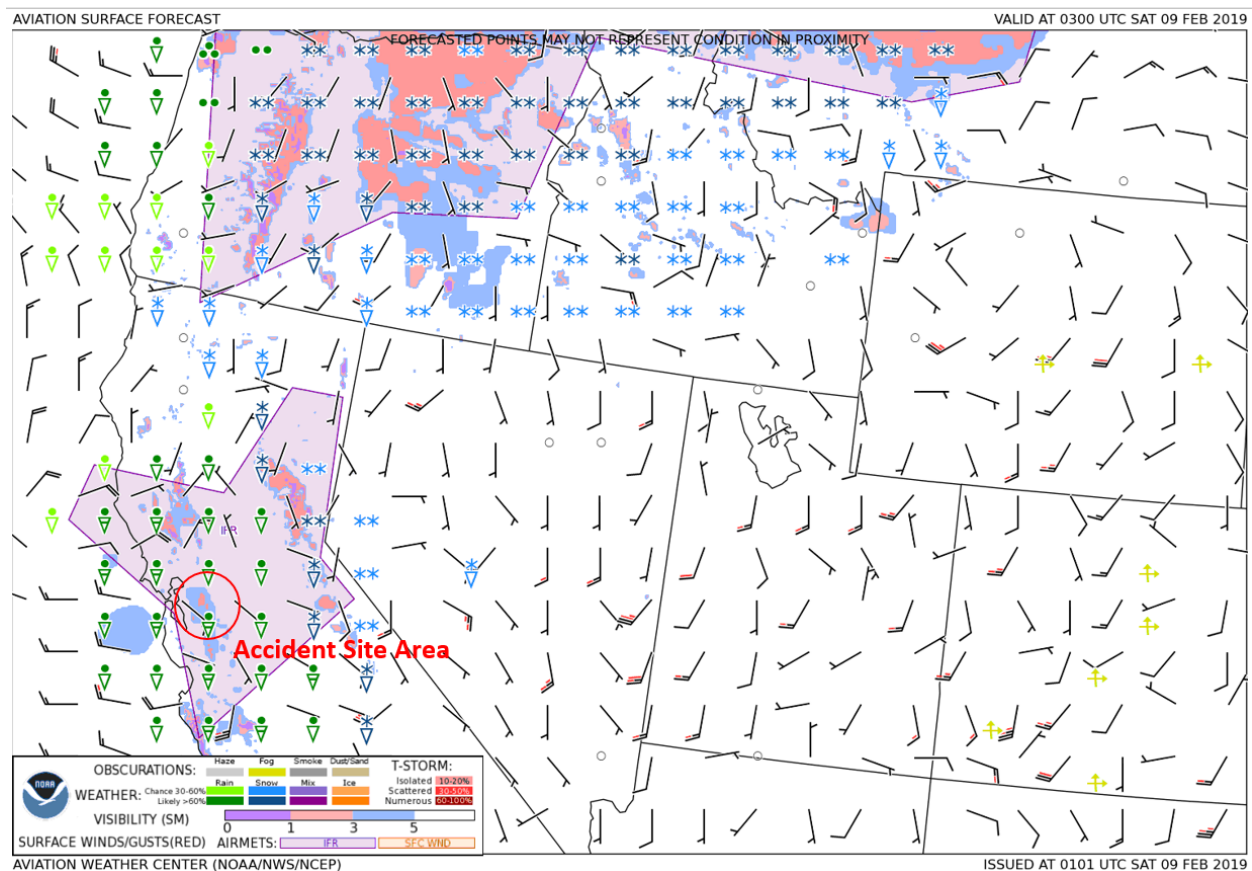


Figure 10 - GFA forecast for surface wind, visibility, and weather with the AIRMET Sierra for IFR conditions valid for 1900 PST

Figure 11 is the southwest section of the GFA forecast for clouds with the AIRMET for icing and mountain obscuration overlaid. The image depicted overcast clouds with bases near 1,600 ft msl and tops near 24,000 ft. An AIRMET for mountain obscuration and icing conditions also extended over the accident site.

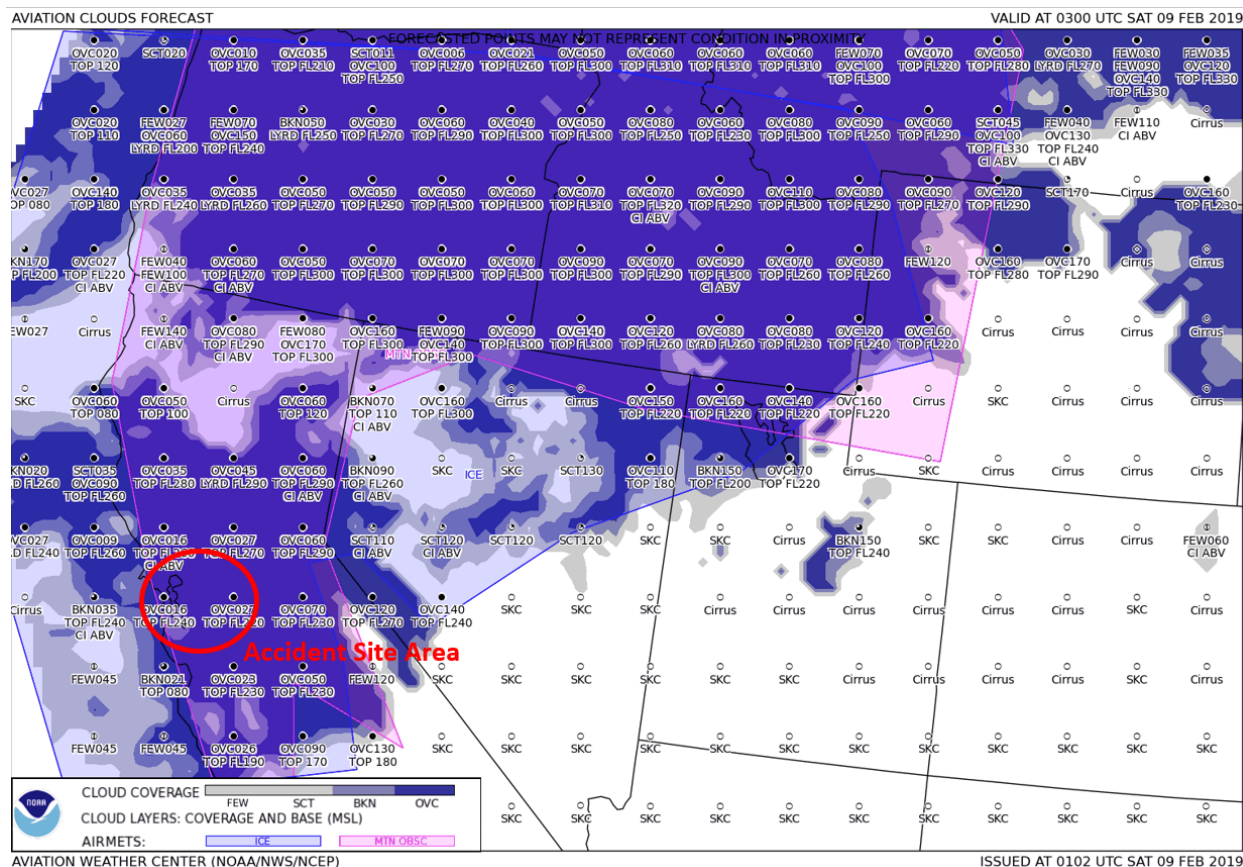


Figure 11 - GFA cloud forecast valid for 1900 PST with a red circle over the area of the accident

6.4 Winds and Temperatures Aloft Forecast

The NWS Winds and Temperature Aloft Forecast current for period for the area is included below. The forecast was valid for 2200 PST and for use between 2000 through 0100 PST surrounding the time of the accident.

WINDS ALOFT FORECASTS

DATA BASED ON 090000Z

VALID 090600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
SFO	2314	2514-04	2313-10	2211-17	2210-32	2216-42	243946	264347	275048
SAC	1713	2316-03	2113-10	1918-16	1722-31	1822-42	233549	254049	274649
RBL	9900	1811-04	2206-10	2408-16	2611-30	2615-44	302054	282752	284049
RNO		1707	2119-09	2224-15	2319-29	2319-43	244553	254352	264750

The following low-level conditions were forecasted:

Station	Altitude	Wind (direction and speed)
San Francisco (SFO)	3,000 ft	230° at 14 knots
Sacramento (SAC)	3,000 ft	170° at 13 knots
Red Bluff (RBL)	3,000 ft	light and variable at less than 5 knots
Reno (RNO)	6,000 ft	170° at 7 knots

6.5 Inflight Weather Advisories

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

During the period the NWS had no Severe Weather Forecast Alerts or Convective SIGMETs valid for any organized thunderstorms over the region, and no SIGMETs for any severe turbulence or icing conditions over the western United States, and the NWS Oakland (KZOA) Center Weather Service Unit issued no CWA's during the period. The only advisories current over the California during the period were a complete series of AIRMETs, of which AIRMET Sierra for mountain obscuration conditions and AIRMET Zulu for moderate icing in clouds above the freezing level to 17,000 ft were current. The Graphic AIRMETs following by the respective text bulletins are included below as figure 12 through 14.

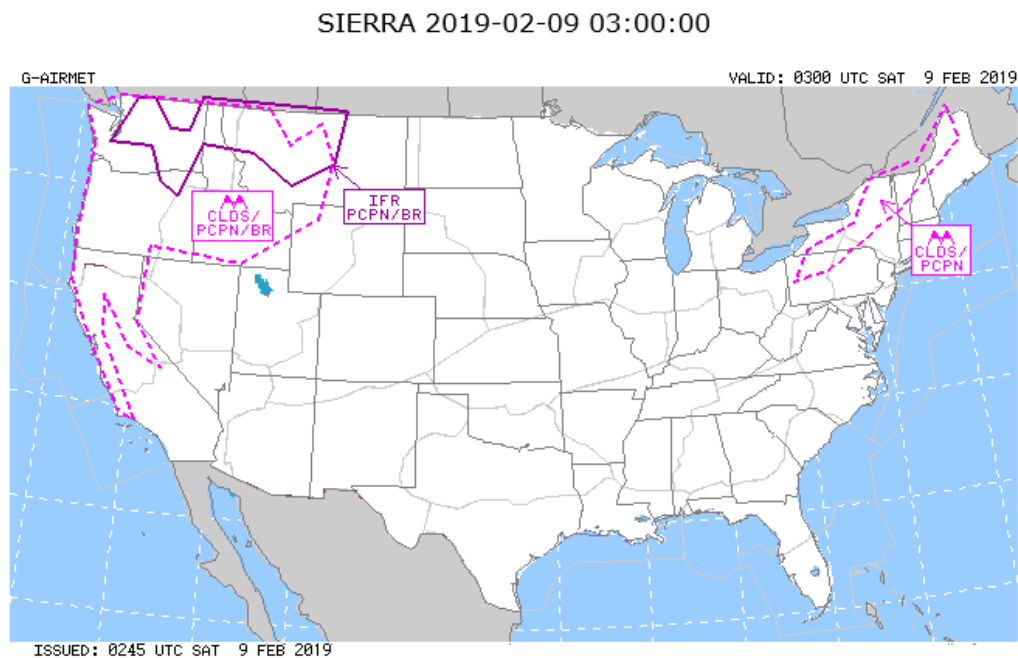


Figure 12 - G-AIRMET Sierra for IFR and mountain obscuration conditions valid for 1900 PST

WAUS46 KPCI 090245

WA6S

-SFOS WA 090245

AIRMET SIERRA FOR IFR AND MTN OBSCN VALID UNTIL 090900

.

AIRMET IFR...WA OR ID MT WY AND CSTL WTRS

FROM 30SSW YDC TO 60NE GGW TO 20W JAC TO 20N DBS TO 20E DLN TO
80SSW MLP TO 40NW PIH TO 40SE LKV TO 70WSW OED TO 20N HQM TO
30WSW HUH TO 30SSW YDC

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.

.

AIRMET IFR...CA

FROM 50SE OED TO 50SSW LKV TO 70ENE RBL TO 40SSW FMG TO 60W OAL
TO 70WSW BTY TO 20ESE EHF TO 20E SAC TO 20SSE RBL TO 50SE OED

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 03-06Z. CONDS CONTG
BYD 09Z THRU 15Z.

.

AIRMET MTN OBSCN...WA OR CA

FROM 50WSW YXC TO 50SE REO TO 40SE LKV TO 40SSW FMG TO 20NNW TOU
TO 50WSW YXC

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.

.

AIRMET MTN OBSCN...WA OR CA

**FROM 20NNW TOU TO 40SSW FMG TO 40SW BTY TO 60W HEC TO 60S TRM TO
20S MZB TO 20W LAX TO 40WSW RZS TO 20S FOT TO 20NNW TOU
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.**

.

OTLK VALID 0900-1500Z...MTN OBSCN WA OR CA ID MT WY NV UT

BOUNDED BY 40S YQL-30N GTF-20NE HVR-30NNW SHR-30NW BOY-40SE MTU-
30NW BVL-40SW BTY-50NNW HEC-60S TRM-20S MZB-LAX-40WSW RZS-30S
FOT-40S HQM-20NW TOU-40S YQL

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG THRU 15Z.

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TANGO 2019-02-09 03:00:00

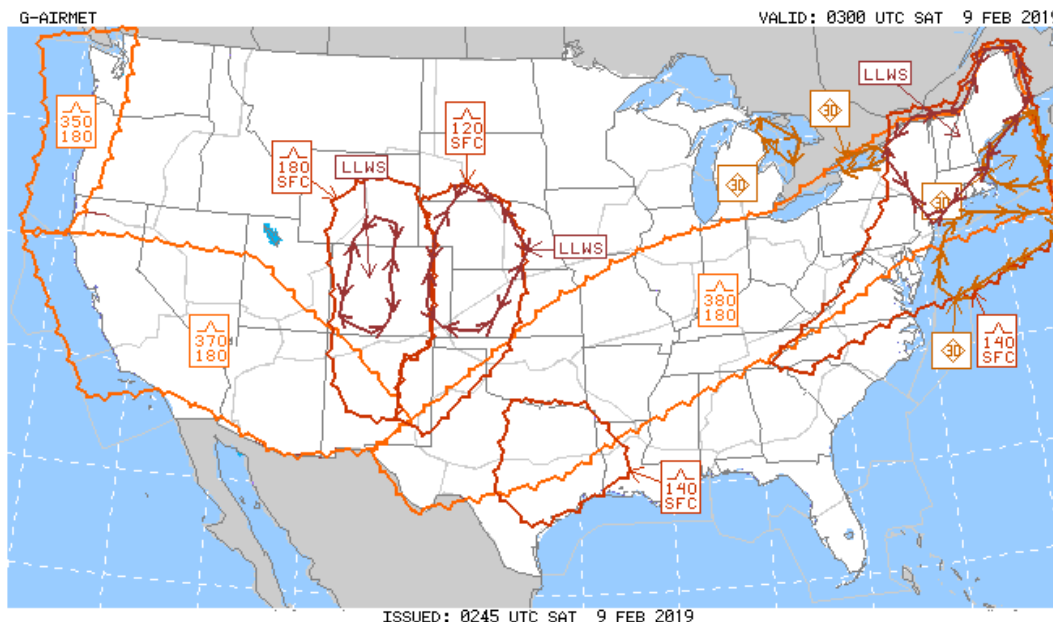


Figure 13 - G-AIRMET Tango for turbulence valid at 1900 PST

WAUS46 KPCI 082045

WA6T

-SFOT WA 082045

AIRMET TANGO UPDT 3 FOR TURB VALID UNTIL 090300

AIRMET TURB...WA OR CA AND CSTL WTRS

FROM 30NE HUH TO 30NE BTG TO 20N OED TO 40SSW FOT TO 140WSW FOT
TO 130WSW ONP TO 110WNW ONP TO 140W TOU TO 30NE HUH
MOD TURB BTN FL180 AND FL350. CONDS CONTG BYD 03Z THRU 09Z.

AIRMET TURB...CA NV UT AZ NM AND CSTL WTRS

FROM 30NNE RBL TO 60ENE OAL TO 30SSE BCE TO 60SW RSK TO 20SE CME
TO ELP TO 50S TUS TO BZA TO 50SE LAX TO 170SW RZS TO 140WSW FOT
TO 40SSW FOT TO 30NNE RBL
MOD TURB BTN FL180 AND FL370. CONDS CONTG BYD 03Z THRU 09Z.

OTLK VALID 0300-0900Z

AREA 1...TURB CA WY NV UT CO AZ NM AND CSTL WTRS

BOUNDED BY 40E OCS-20SSW CYS-30NE LAA-50W LBL-30ESE TBE-20NE TCC-
30ESE CME-ELP-50S TUS-BZA-20ESE LAX-150SW RZS-140WSW FOT-70WNW
BAM-20NW SLC-40E OCS
MOD TURB BTN FL180 AND FL370. CONDS CONTG THRU 09Z.

AREA 2...TURB CA

BOUNDED BY 60WSW FMG-30SSW FMG-50SSE OAL-40SW BTY-20ENE EHF-50SE
CZQ-20W SAC-60WSW FMG
MOD TURB BLW FL180. CONDS DVLPG 03-06Z. CONDS CONTG THRU 09Z.

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ZULU 2019-02-09 03:00:00

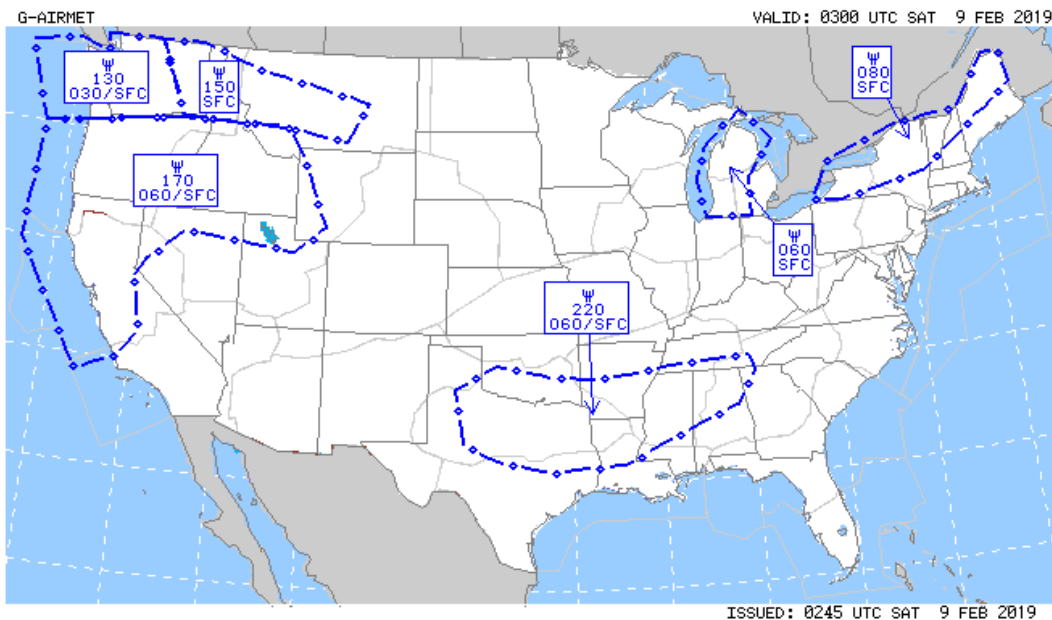


Figure 14 - G-AIRMET Zulu for icing conditions valid for 1900 PST

WAUS46 KPCI 090245

WA6Z

-SFOZ WA 090245

AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 090900

AIRMET ICE...WA OR AND CSTL WTRS

FROM 60ESE YDC TO 20WNW GEG TO 60NNE BKE TO 20E PDT TO 60S YKM TO
60WSW BTG TO 110WNW ONP TO 140W TOU TO 30NW TOU TO 60ESE YDC
MOD ICE BTN FRZLVL AND 140. FRZLVL SFC-030. CONDS CONTG BYD 09Z
THRU 15Z.

AIRMET ICE...WA OR ID MT WY

FROM 60ESE YDC TO 50SE YXC TO 40NW GTF TO 60SSW HVR TO 60SSW ISN
TO 70NW RAP TO SHR TO 50SSE HLN TO 60NNE BKE TO 20WNW GEG TO 60ESE YDC
MOD ICE BLW 150. CONDS CONTG BYD 09Z THRU 15Z.

AIRMET ICE...WA OR CA AND CSTL WTRS

FROM 60WSW BTG TO 50SSW FOT TO 60SW PYE TO 120WSW PYE TO 140WSW
FOT TO 110WNW ONP TO 60WSW BTG
MOD ICE BTN FRZLVL AND 120. FRZLVL SFC-060. CONDS DVLPG 06-09Z.
CONDS CONTG BYD 09Z THRU 15Z.

AIRMET ICE...WA OR CA ID MT WY NV UT CO AND CSTL WTRS

FROM 50SSE HLN TO SHR TO DDY TO 30SSE CHE TO 20E BAM TO 70S FMG
TO 20NNW EHF TO 20S RZS TO 150WSW RZS TO 120WSW PYE TO 60SW PYE
TO 50SSW FOT TO 60WSW BTG TO 60NNE BKE TO 50SSE HLN
MOD ICE BTN FRZLVL AND 170. FRZLVL SFC-070. CONDS CONTG BYD 09Z
THRU 15Z.

FRZLVL...RANGING FROM SFC-090 ACRS AREA

MULT FRZLVL 060-090 BOUNDED BY 20NE LAX-30SSW MZB-220SW MZB-
 170SW RZS-70S RZS-20NE LAX
 SFC ALG 120W TOU-20WNW BTG-60S BTG-70S OED-30NNW RBL-50ESE
 CZQ-40WSW LAS
 040 ALG 150SW FOT-120W ENI-90SW PYE-60W SNS-40SW MOD-50NE MOD
 080 ALG 220SW MZB-20SE TRM-50S EED

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7.0 Preflight Weather Briefing

Leidos Flight Services and third party vendors utilizing the LFS system had no contacts with N3270F on 2/8/2019. A check of ForeFlight also indicated that they had no contact or flight weather briefing request from the pilot during the period.

8.0 Astronomical Conditions

The United States Naval Observatory's website provided the following astronomical conditions for the departure of Hayward, Alameda County, California, on the day of the accident. The accident time has been added in bold italic print for reference.

Sun	Time (PST)
Beginning civil twilight	0638
Sunrise	0706
Sun transit	1222
Sunset	1740
End civil twilight	1807
<i>Accident</i>	<i>2010</i>

Moon	Time (PST)
Moonrise	0919
Moon transit	1517
<i>Accident</i>	<i>2010</i>
Moonset	2122

At the time of the accident official nighttime conditions prevailed, the Moon was 12° above the horizon at an azimuth of approximately 267°. The Moon phase was a waxing crescent with 16% of the Moon's visible disk illuminated at the time of the accident. The closest primary Moon phase of a New Moon had occurred on February 4, 2019 at 1303 PST. Figure 15 is a picture of the Moon phase on February 8, 2019.



Figure 15 - Moon phase at the approximate time of the accident

Submitted by:

Don Eick
Senior Meteorologist