

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR24FA124

METEOROLOGY

Specialist's Factual Report

July 16, 2024

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A. ACCIDENT

Location: San Bernardino, California
Date: April 13, 2024
Time: 2019 Pacific daylight time
0319 coordinated universal time (UTC), on April 14, 2024
Airplane: Gulfstream Corporation 695A; Registration: N965BC

B. METEOROLOGY SPECIALIST

Paul Suffern
Senior Meteorologist
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

The NTSB's Senior Meteorologist did not travel for this investigation but gathered all data remotely. Data for this investigation were collected from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). This Specialist's Factual Report contains the meteorological factors pertinent to the weather surrounding the accident time. All times are Pacific daylight time (PDT) and are based upon the 24-hour clock, where local time is -7 hours from UTC. Directions are referenced to true north and distances are in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS 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.

The accident site was located at approximate latitude 34.21064° N, longitude 117.34217° W, at an elevation of 2,540 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large-scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the WPC, 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 Federal Aviation Administration (FAA) "Aviation Weather Handbook", FAA-H-8083-28.¹

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart centered over the southwestern United States for 2000 PDT is provided as figure 1 with the location of the accident site within the black circle. The chart depicted a low-pressure center over western Nevada at 1003-hectopascals (hPa) with a cold front extending southward across southern California and in the vicinity of the accident site. Another low-pressure system at 1005-hPa was identified over southern Nevada not associated with any frontal boundaries. A high-pressure system was located in central California at 1018-hPa. Fronts can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present.

The station models closest to the accident site depicted air temperatures of 36 to 49 degrees Fahrenheit (°F), dew point temperatures of 32 to 47°F, overcast sky cover, light rain, and a southwest to west wind at 10 knots.

¹ [FAA-H-8083-28](#)

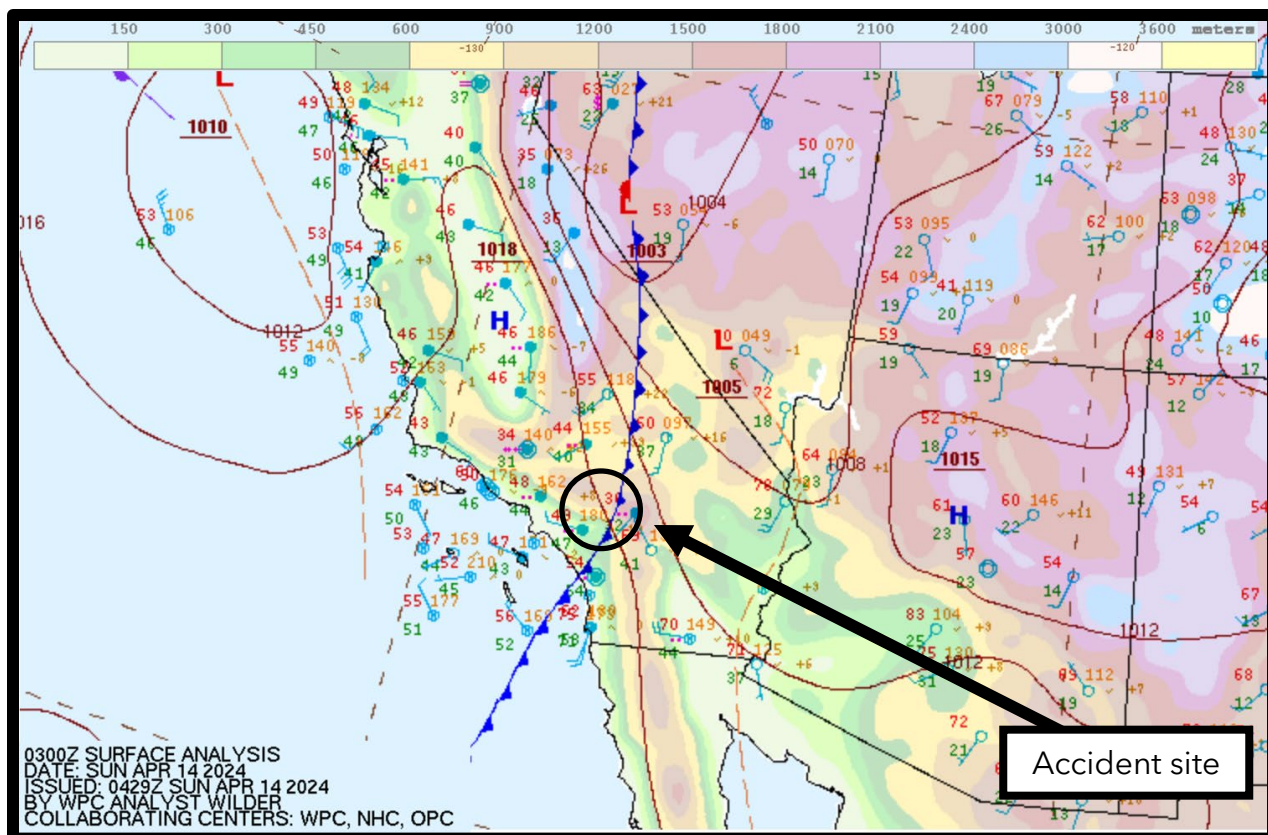


Figure 1. NWS Surface Analysis Chart for 2000 PDT.

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1700 PDT at 925-, 850-, 700-, 500-hPa are presented in figures 2 through 5. The charts indicated a low- and mid-level trough² at 850- through 500-hPa (figures 3 through 5) in the eastern Pacific Ocean just west of the accident site. The 925-hPa constant pressure chart depicted a south wind around 10 knots (figure 2) becoming a southwest 40 knot wind by 700-hPa (figure 4). By 500-hPa, the wind remained from the southwest, but increased to 65 knots (figure 5).

² Trough - An elongated area of relatively low atmospheric pressure or heights.

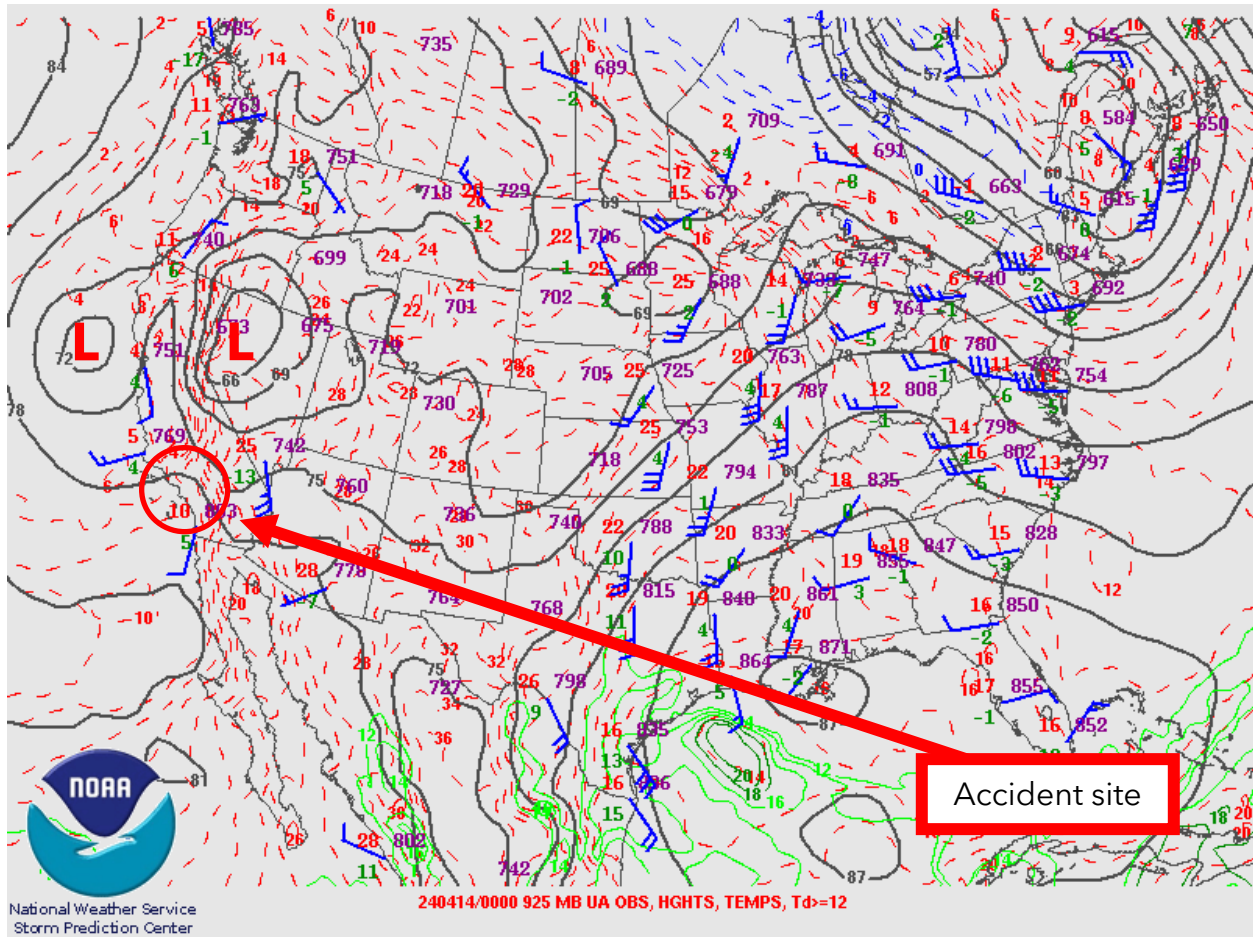


Figure 2. 925-hPa Constant Pressure Chart for 1700 PDT.

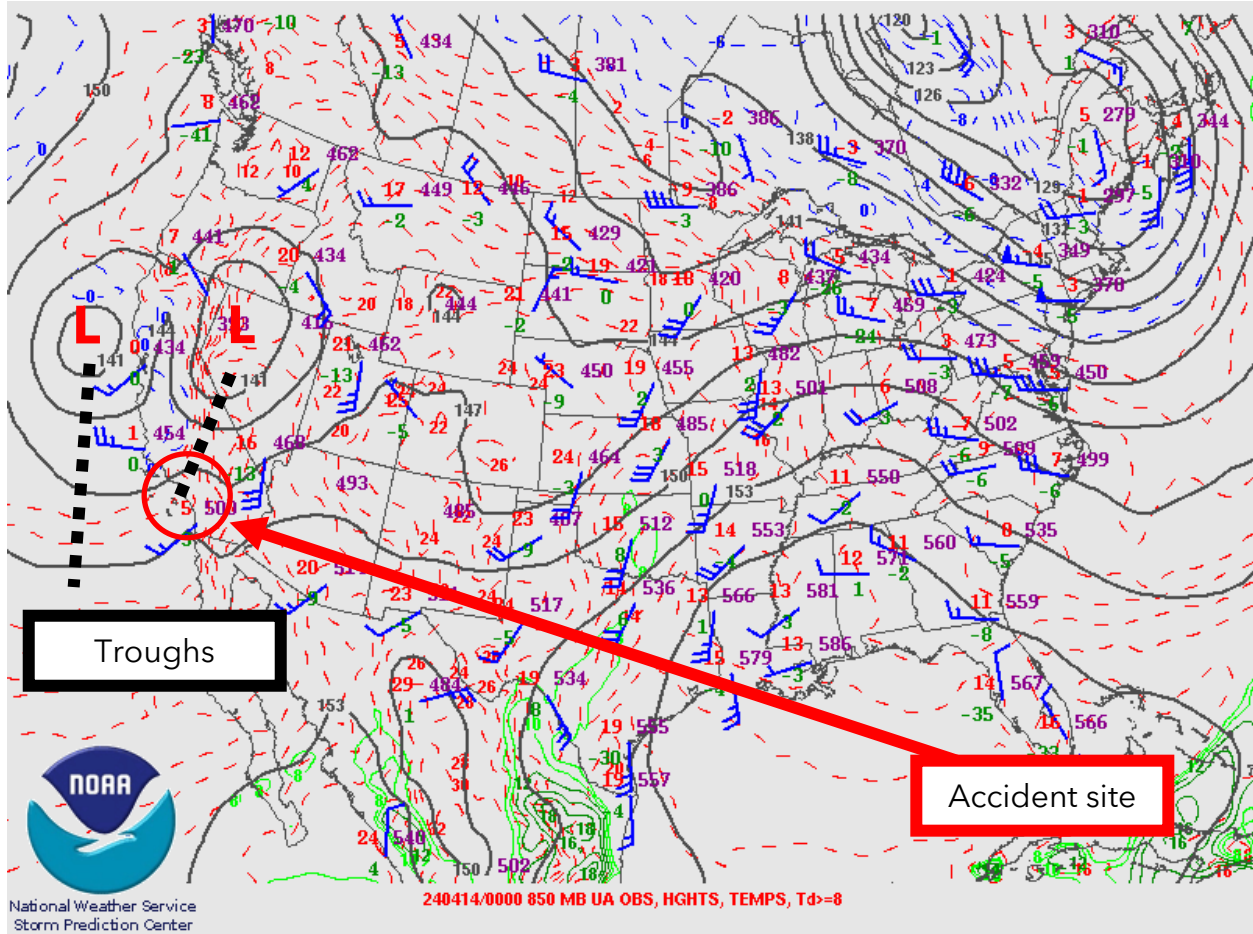


Figure 3. 850-hPa Constant Pressure Chart for 1700 PDT.

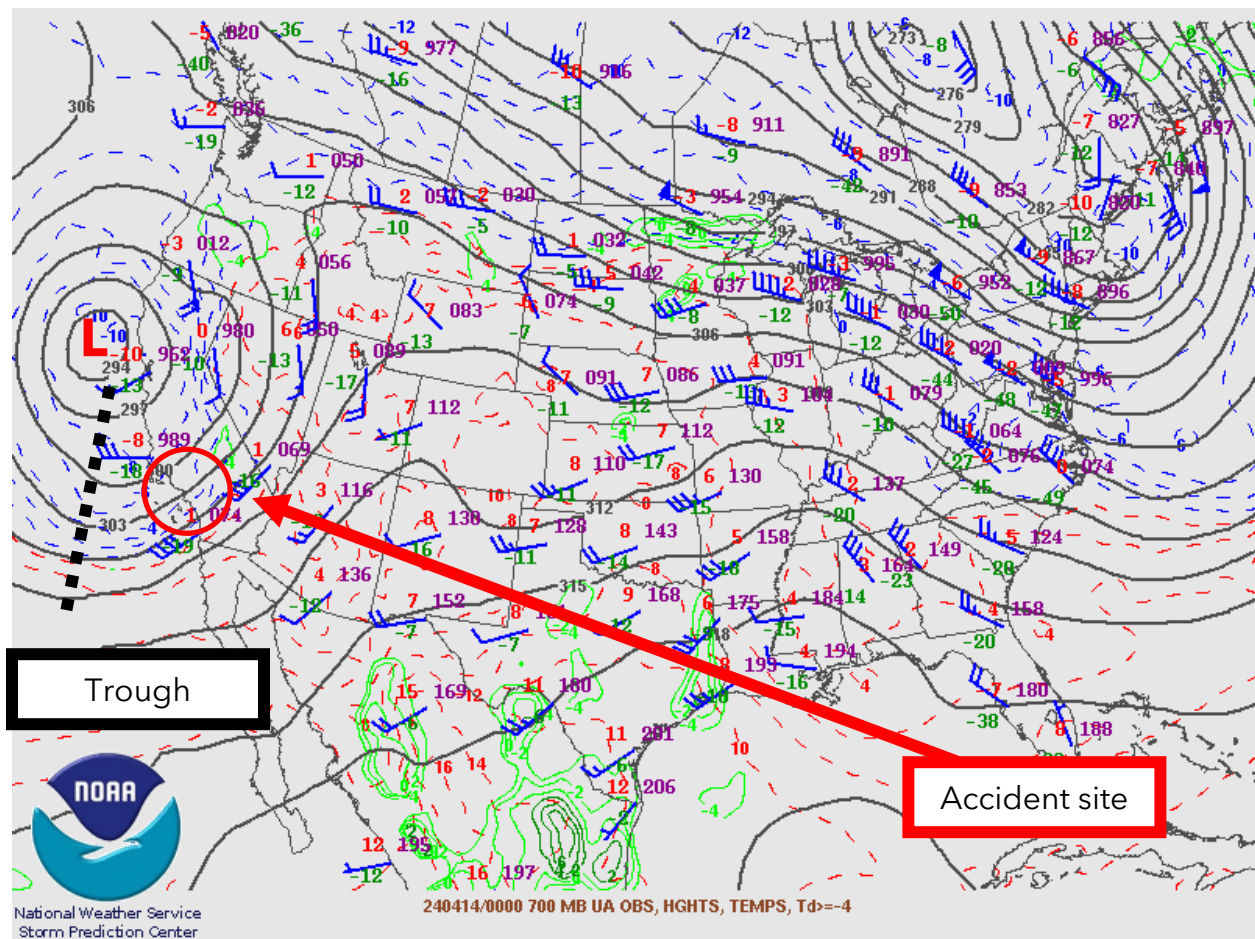


Figure 4. 700-hPa Constant Pressure Chart for 1700 PDT.

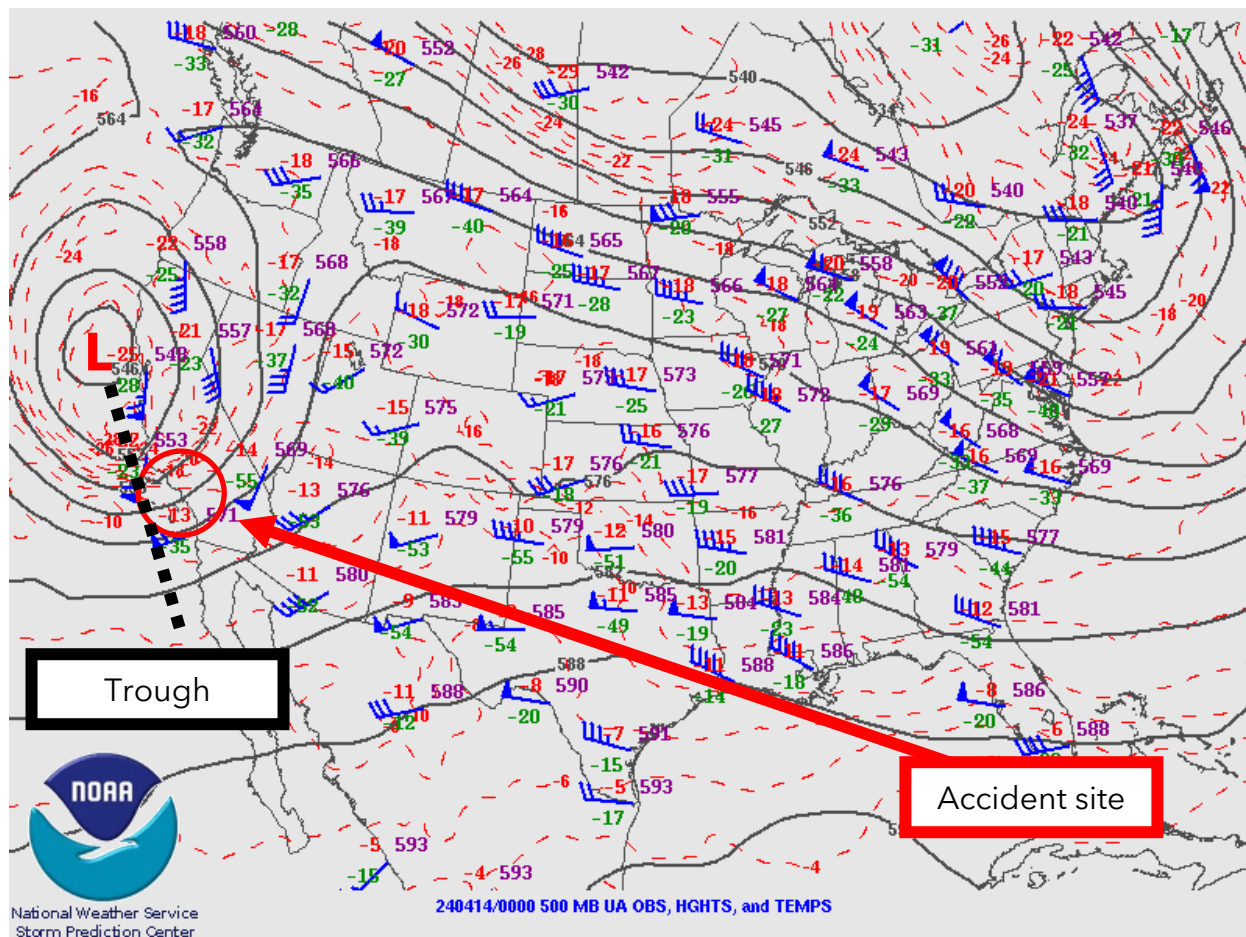


Figure 5. 500-hPa Constant Pressure Chart for 1700 PDT.

2.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METARs) and Special Reports (SPECIs)³. The following observations were taken from standard code and are provided in plain language. Figure 6 is a local sectional chart with the accident site and the closest weather reporting location marked. A magnetic variation⁴ of 11.5° east was indicated over the area.

³ Latest criteria for SPECIs can be found in the Federal Meteorological Handbook: [Federal Meteorological Handbook Number 1, Surface Weather Observations and Reports \(icams-portal.gov\)](https://www.federalregister.gov/documents/2018/01/16/2018-01-16-federal-meteorological-handbook-number-1-surface-weather-observations-and-reports)

⁴ Magnetic variation - The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

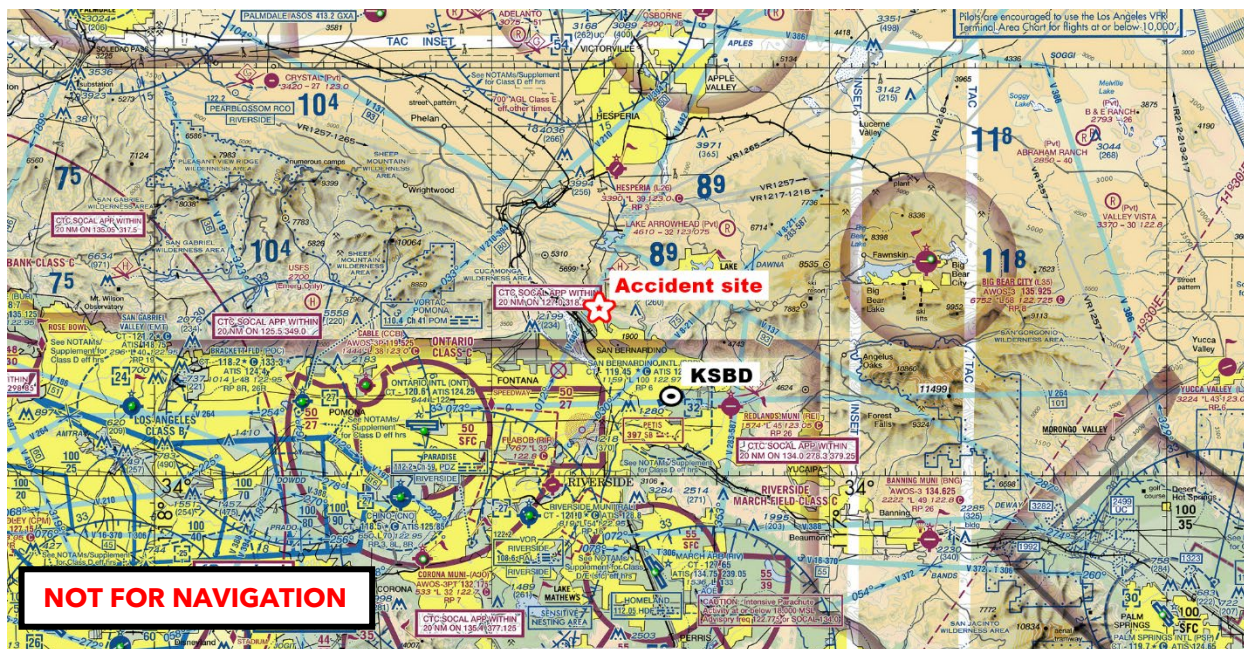


Figure 6. FAA sectional aeronautical chart of the accident area with the location of the accident site and surface observation site noted.

San Bernardino International Airport (KSBD) had the closest official weather station to the accident site. KSBD had an Automated Weather Observing System (AWOS⁵) and its longline reports⁶ were augmented by air traffic control (ATC) when the tower was in operation⁷. The KSBD AWOS was located 9 miles southeast of the accident site (figure 6) at an elevation of 1,159 ft, and issued the following observations surrounding the accident time:⁸

[1359 PDT] METAR KSBD 132059Z 17007KT 5SM HZ BKN050 18/02 A3004

[1455 PDT] METAR KSBD 132155Z 26006KT 5SM HZ BKN050 19/02 A3002

⁵ AWOS - Automated Weather Observing System is equipped with meteorological instruments to typically observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting. AWOS are maintained by the FAA. Certain AWOS may have different reporting or observational equipment.

⁶ "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline dissemination of weather observations is the primary vehicle through which the weather observations are distributed.

⁷ ATC operation hours between 0700 and 2100 local.

⁸ The bold sections of products in this report are intended to highlight the text that directly reference the weather conditions that affected the accident region around the accident time. The local times in this section next to the METARs are provided for quick reference between UTC and local times.

[1555 PDT] METAR KSBD 132255Z 21007KT 10SM OVC060 18/03
A3001

[1852 PDT] METAR KSBD 140152Z 24015G18KT 3SM RA OVC037
15/06 A3001

**[1958 PDT] METAR KSBD 140258Z 18005KT 6SM -DZ SCT034
BKN041 OVC050 13/07 A3002**

ACCIDENT TIME 2019 PDT

**2032 PDT] SPECI KSBD 140332Z 24015G23KT 4SM RA SCT008
BKN011 OVC022 10/06 A3006**

[2053 PDT] METAR KSBD 140353Z 25015KT 4SM -RA SCT008 BKN017
OVC032 09/06 A3008

[2140 PDT] METAR KSBD 140440Z AUTO 20003KT 5SM RA SCT010
BKN028 OVC038 09/06 A3009 RMK AO2 P0002 T00870057=

The bold type observations decoded in plain language were as follows:

KSBD weather at 1958 PDT, wind from 180° at 5 knots, visibility 6 miles, light drizzle, scattered clouds at 3,400 ft above ground level (agl), broken ceiling at 4,100 ft agl, overcast clouds at 5,000 ft agl, temperature of 13° Celsius (C), dew point temperature of 7°C, and an altimeter setting of 30.02 inches of mercury (inHg).

KSBD weather at 2032 PDT, wind from 240° at 15 knots with gusts to 23 knots, visibility 4 miles, moderate rain, scattered clouds at 800 ft agl, broken ceiling at 1,100 ft agl, overcast clouds at 2,200 ft agl, temperature of 10°C, dew point temperature of 6°C, and an altimeter setting of 30.06 inHg.

The observations from the KSBD reported MVFR⁹ conditions prevailing at the time of the accident with winds gusting as high as 23 knots at the surface in moderate rain.

⁹ 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.

3.0 Upper Air Sounding

A High-Resolution Rapid Refresh (HRRR)¹⁰ model sounding was created¹¹ for the approximate accident site coordinates for 2000 PDT. The HRRR sounding was plotted on a standard Skew-T Log P diagram¹² from the surface to 500-hPa (or approximately 18,000 ft) using the RAOB¹³ software package and is included as figure 7. The sounding depicted an elevation of 2,690 ft over the grid point. The sounding depicted the lifted condensation level (LCL)¹⁴ and the level of free convection (LFC)¹⁵ at 209 ft agl (2,899 ft msl), and the convective condensation level (CCL)¹⁶ at 1,481 ft agl (4,171 ft msl). The freezing level was located at 6,654 ft. The precipitable water value was 0.56 inches.

* 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.

¹⁰ 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.

¹¹ HRRR sounding was created using NOAA Air Resource Laboratory: [READY Archived Meteorology \(noaa.gov\)](https://ready.arl.noaa.gov/).

¹² 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.

¹³ RAOB - (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Esonde Research Services, The Villages, Florida.

¹⁴ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁵ LFC - The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

¹⁶ 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.

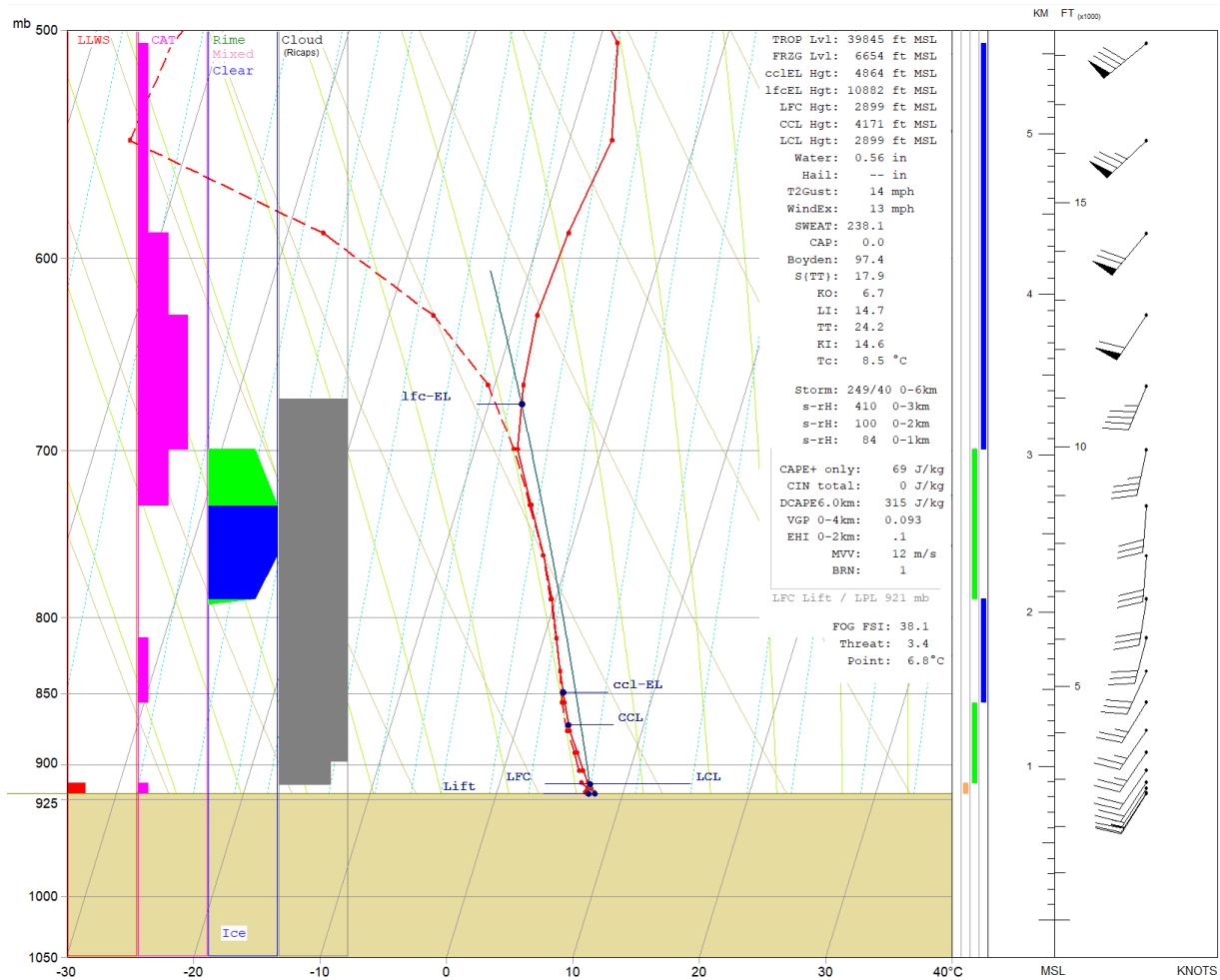


Figure 7. 2000 PDT HRRR sounding.

The 2000 PDT HRRR sounding identified both conditionally unstable and stable environments from the surface through 10,000 ft, then a stable layer above 10,000 ft through 18,500 ft. RAOB indicated a cloud layer (gray bar on left axis) between 2,800 ft (~200 ft agl) and 11,000 ft. Moderate clear and rime icing (indicated on left axis) was indicated by RAOB between 7,000 and 10,000 ft.

The 2000 PDT HRRR sounding wind profile indicated a near-surface wind from 210° at 15 knots with the wind remaining southwesterly through 5,000 ft. The wind speed increased to 30 knots by 5,000 ft. The wind backed¹⁷ to the south between 5,000 and 10,000 ft with the wind speed increasing to 35 knots by 10,000 ft. The wind then veered¹⁸ back to the southwest between 10,000 and 18,500 ft. Around 18,500 ft the wind was from the southwest at 81 knots. Light low-level wind shear (LLWS) was indicated by RAOB below 200 ft agl. RAOB indicated light to moderate clear air turbulence (CAT) in several layers between the surface and 18,500 ft with strongest turbulence indicated between 9,000 and 14,000 ft. At the accident aircraft altitude before descent¹⁹ at approximately 7,200 ft, the wind was from 186° at 28 knots, the temperature was around -1.0°C, and the dew point temperature was around -1.0°C.

4.0 Satellite Data

Geostationary Operational Environmental Satellite number 18 (GOES-18) visible and infrared data were 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, water vapor, and infrared imagery (GOES-18 bands 2, 10, and 13, respectively) at wavelengths of 0.64 microns (μm), 7.3 μm, and 10.3 μm, respectively, were retrieved for the period from 1500 PDT through 2300 PDT and reviewed, and the closest images to the time of the accident were documented.

¹⁷ Backed - Wind turning counter-clockwise with height.

¹⁸ Veered - Wind turning clockwise with height.

¹⁹ For more information please see the ATC and track data in the docket for this accident.

The low-level water vapor imagery indicated a transverse banding²⁰ in the cloud cover including above the accident site (attachment 1). Figures 8 and 9 present the GOES-18 infrared image at 2016 and 2021 PDT at 6X magnification with the accident site highlighted with a red square. Cloud cover was indicated above the accident site with lower brightness temperatures (brighter yellow colors; higher cloud tops) located west and north of the accident site. The cloud cover was moving from west to east. The brightness temperature above the accident site was 267 Kelvin²¹ which would have been near 9,500 ft based on the vertical temperature profile provided by the 2000 PDT HRRR sounding. It should be noted these figures have not been corrected for any parallax error. The Nighttime Microphysics Red, Green, Blue (RGB) imagery²² indicated there were two different levels of cloud cover above the accident site with a combination of low-level water clouds and another layer of high cirriform clouds composed of ice crystals, with both layers of cloud moving eastward with time (attachment 2). The low-level water clouds were in place above the accident site at the start of the animation around 1901 PDT with the higher ice clouds spreading across the accident site at the accident time.

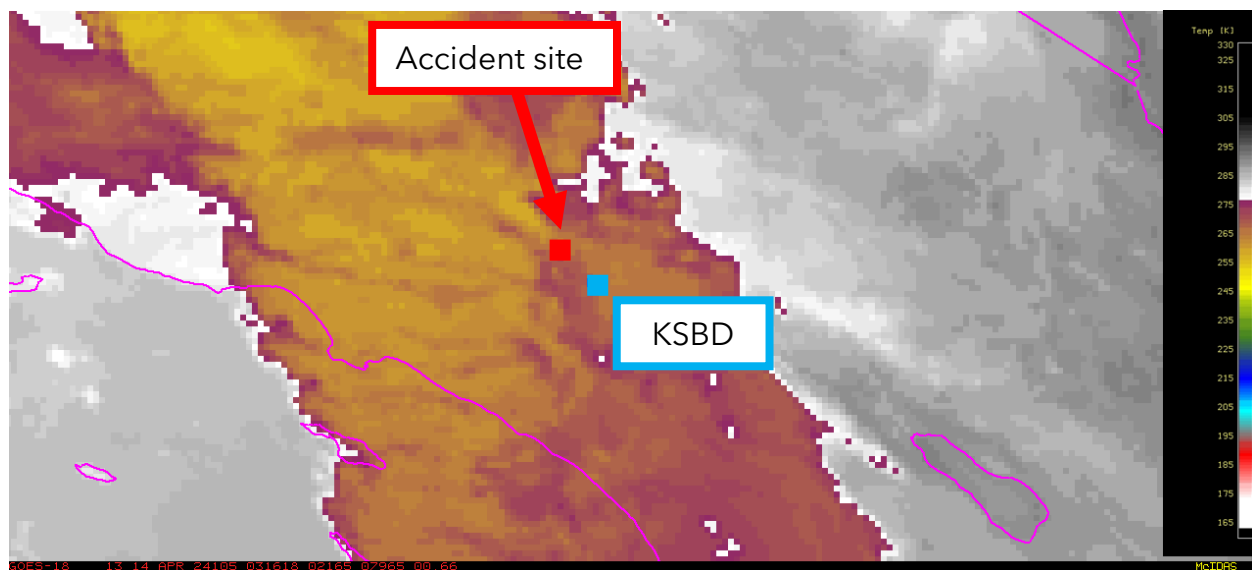


Figure 8. GOES-18 infrared image at 2016 PDT.

²⁰https://www.weather.gov/source/zhu/ZHU_Training_Page/Miscellaneous/gravity_wave/gravity_wave.html

²¹ around -6°C

²²https://weather.msfc.nasa.gov/sport/training/quickGuides/rgb/QuickGuide_NtMicro_GOESR_NASA_SPoRT_20191206.pdf

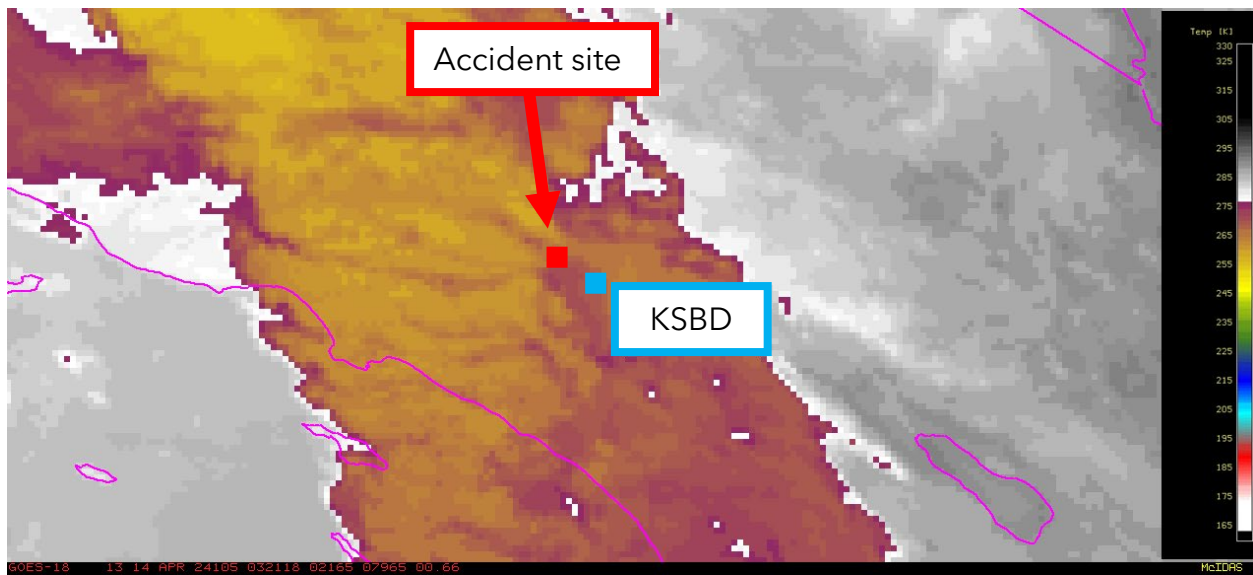


Figure 9. GOES-18 infrared image at 2021 PDT.

5.0 National Radar Imagery

A regional view of the NWS National Reflectivity Mosaic is included as figure 10 for 2020 PDT with the approximate location of the accident site marked by a red circle. The mosaic imagery depicted 20 to 30 dBZ²³ echoes above the accident site.

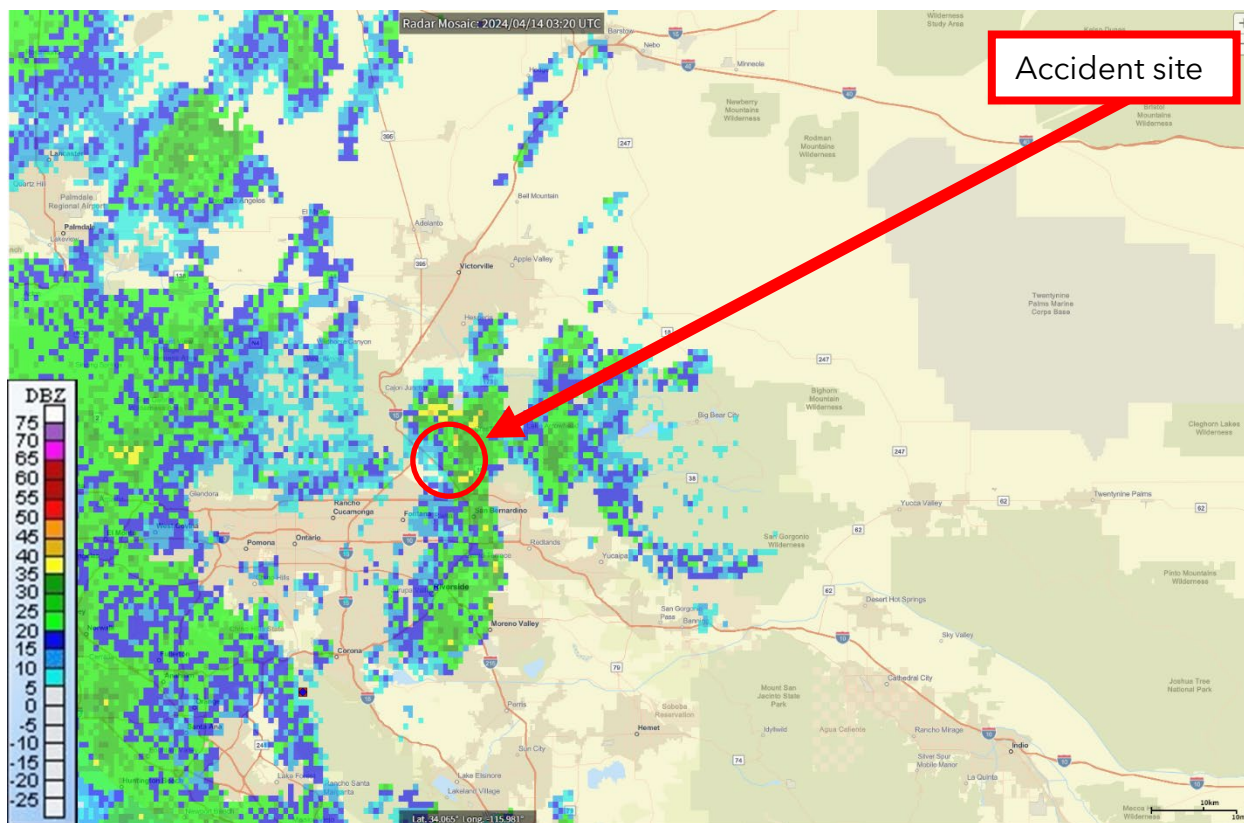


Figure 10. National Reflectivity Mosaic for 2020 PDT.

6.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar-1988 Doppler (WSR-88D)²⁴ to the accident site was from the Santa Ana Mountains location (KSOX), California, located 28 miles southwest of the accident site. The 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.

²³ dBZ - A non-dimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels or dB) with respect to radar reflectivity factor, Z.

²⁴ 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.

6.1 Volume Scan Strategy

During the period surrounding the accident, the KSOX WSR-88D radar was operating in the precipitation mode VCP-215²⁵ (figure 11). The following figure provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

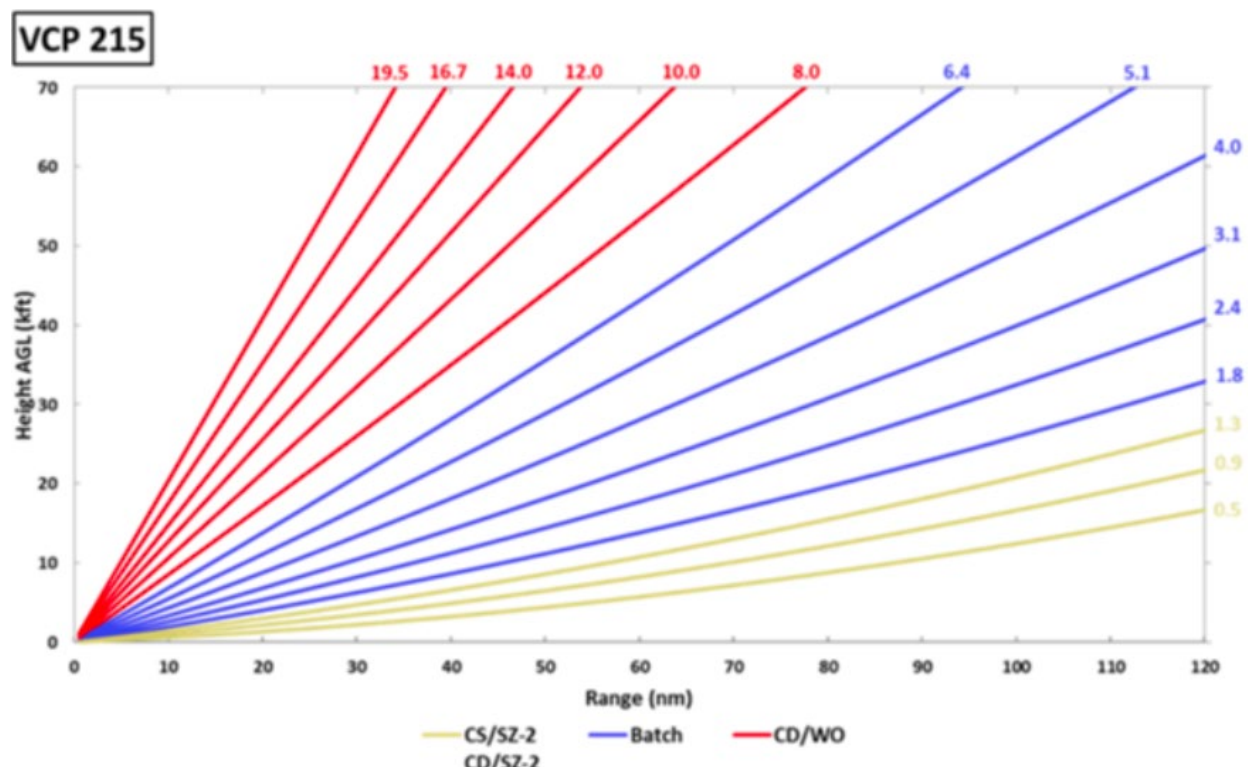


Figure 11. VCP-215 precipitation Mode Scan Strategy.

²⁵ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured.

Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values. Batch Mode - Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity.

Used in the middle elevation angles.

W - With range unfolding (W)

WO - Without range unfolding (WO)

6.2 Beam Height Calculation

Assuming standard refraction²⁶ of the KSOX WSR-88D radar beam with the antenna elevation at 3,105 ft, and considering a beamwidth²⁷ of 0.95°, the following table shows the approximate heights for the 1.27° radar beams' center, top and base for certain antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KSOX 1.27°	7,400 ft	5,990 ft	8,810 ft

Based on the radar height calculations, the 1.27° elevation scan reviewed from KSOX listed in the above table combined to depict conditions between 5,990 ft and 8,810 ft over the accident site.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁸ it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in dBZ and is a general measure of echo intensity. The FAA Aviation Weather Handbook also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be "light." For dBZ values between 30 and 40, the terminology should be "moderate." "Heavy" terminology is used for dBZ values greater than 40 dBZ to 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as "extreme."

²⁶ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁷ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

²⁸ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth's surface; also, any water particles blown by the wind from the earth's surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist, or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth's surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glazed ice.

6.4 Base Reflectivity Data

Figures 12, 13, and 14 present the KSOX WSR-88D base reflectivity images for the 1.27° elevation scan initiated at 2011:58, 2016:34, and 2021:09 PDT with resolutions of 0.5° X 250 m. These images depicted reflectivity values between 10 and 30 dBZ above the accident site with the accident flight in a region of 20 to 30 dBZ values from 2015 PDT through the end of the flight track. The reflectivity targets were moving from southwest to northeast at the time of the accident (attachment 3).

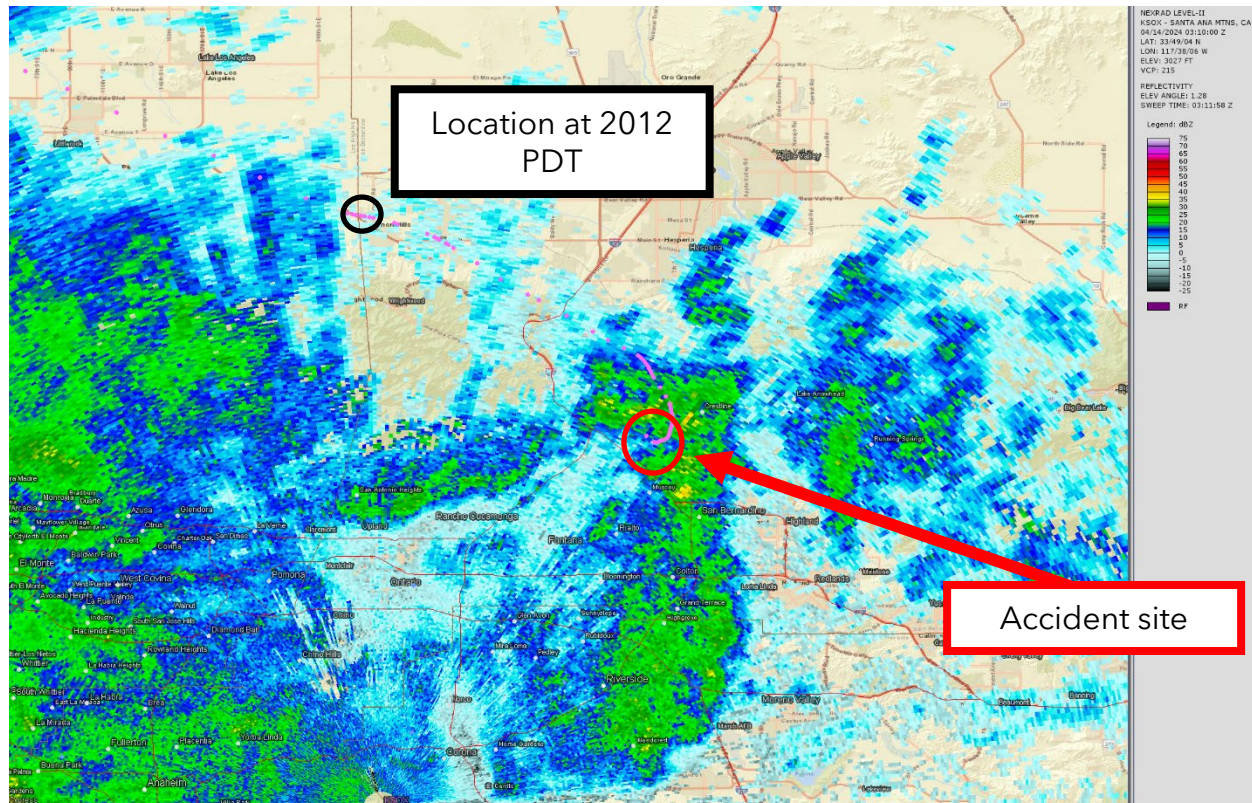


Figure 12. KSOX WSR-88D reflectivity for the 1.27° elevation scan initiated at 2011:58 PDT with the accident site marked with the red circle and the location of the accident aircraft in the black circle. The pink is the airplane flight track.

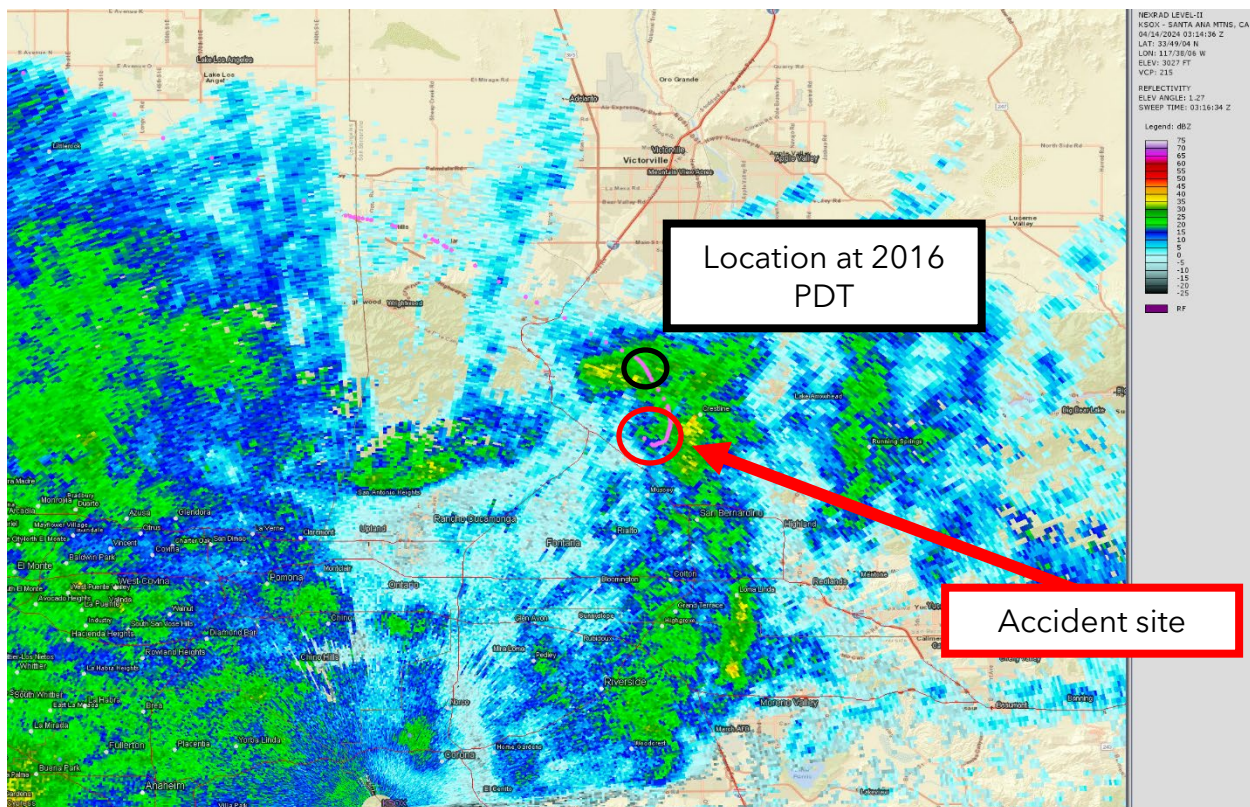


Figure 13. KSOX WSR-88D reflectivity for the 1.27° elevation scan initiated at 2016:34 PDT with the accident site marked with the red circle and the location of the accident aircraft in the black circle. The pink is the airplane flight track.

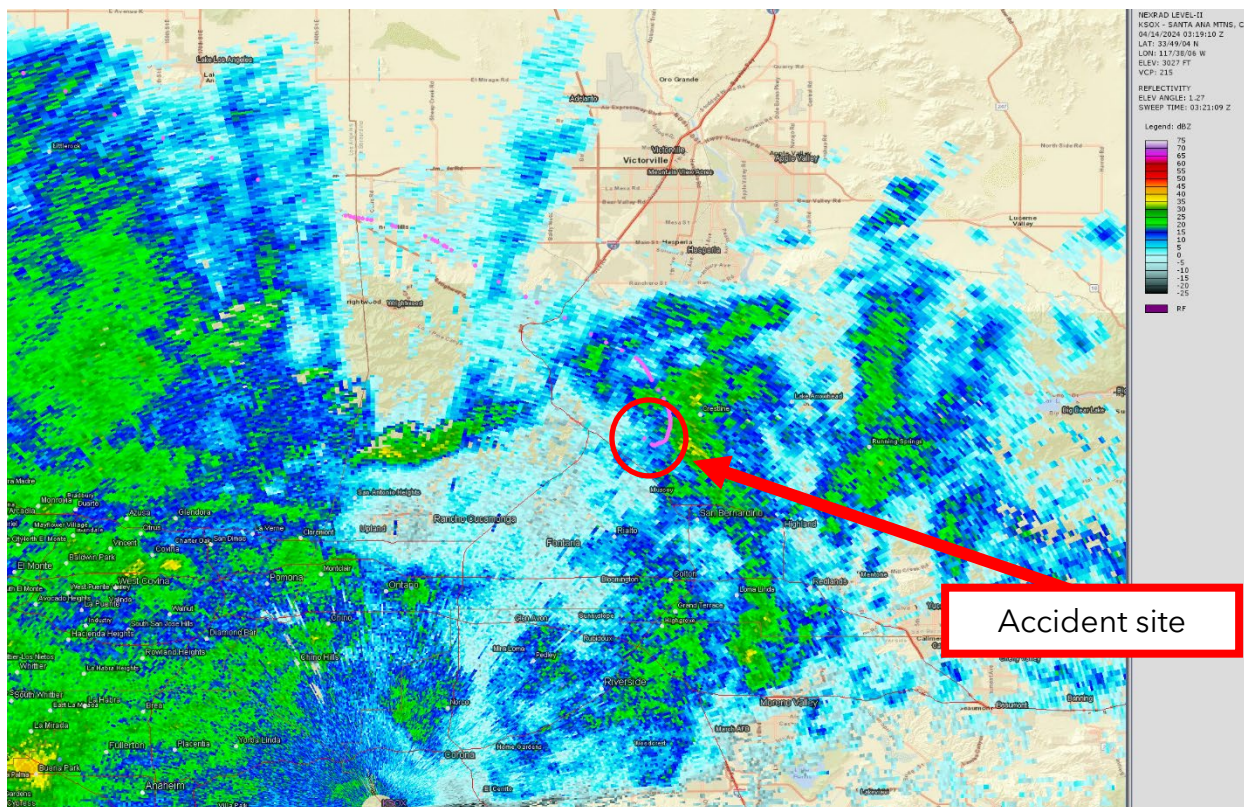


Figure 14. KSOX WSR-88D reflectivity for the 1.27° elevation scan initiated at 2021:09 PDT with the accident site marked with the red circle. The pink is the airplane flight track.

7.0 Pilot Reports

The longline-disseminated pilot reports²⁹ (PIREPs) distributed into the national airspace system (NAS) within 2 hours of the accident time and within 100 miles of the accident site are shown here. The accident aircraft provided a PIREP that was put into the NAS at 2015 PDT that indicated moderate rime icing. The accident pilot also mentioned turbulence to ATC, but that portion of the weather information was not included in the PIREP:

SAN UUA /OV SAN/TM 0415/FL005/TP B737/RM LLWS +10KT DURD

PSP UA /OV PSP/TM 0400/FL040/TP PA44/TB SEV/RM DEPARTING PSP SFC -040

SNA UA /OV KSNA/TM 0335/FL020/TP B738/SK BKN020/RM BRAKING ACTION

GOOD

ONT UA /OV 15NM NORTH OF ONT/TM 0315/FL120/TP AC95/IC MOD RIME

VNY UA /OV VNY27007/TM 0240/FL130/TP E75L/TB MOD TURB

²⁹ Only PIREPs with the World Meteorological Organization headers UBCA**, UBNV**, and UBAZ** were considered. These do not include pilot reports only broadcast via radio.

LAX UA /OV LAX26010/TM 0235/FL060/TP E75L /TB MOD TURB
LAX UA /OV LAX26010/TM 0235/FL6000/TP E75L/TB MOD TURB
VNY UA /OV VNY34005/TM 0151/FL020/TP GLF5/RM WIND SHEAR +/- 15 TO 30 KTS
ON 6 MILE FINAL
LGB UA /OV LGB120007/TM 0148/FL030/TP A21N/RM BASES DURD 040
VNY UA /OV VNY/TM 0145/FLSFC/TP C550/RM BRAKING ACTION MEDIUM RW16R
SNA UA /OV KSNA/TM 0142/FL006/TP E75L/SK BKN006
VNY UA /OV VNY360015/TM 0138/FL060/TP C56X/TB LGT-MOD TURB
VNY UA /OV VNY 15 N/TM 0138/FL060/TP C56X/TB LGT-MOD TURB
VNY UA /OV FIM315002/TM 0130/FL130/TP B737/TA M01/IC LGT-MOD RIME/RM
DURC
VNY UA /OV FIM 2NW/TM 0130/FL130/TP B737/TA M01/IC LGT-MOD RIME/RM
DURC
BUR UA /OV KBUR/TM 0125/FL000/TP B737/WX 4/WV 30004/RM BREAKING ACTION
GOOD
SNA UA /OV KSNA/TM 0121/FL005/TP B737/SK BKN005/RM BRAKING ACTION
GOOD

8.0 Significant Meteorological Information

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

9.0 Center Weather Service Unit Advisories

The Los Angeles (ZLA) Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) was responsible for the accident region. There was no Center Weather Advisory (CWA) valid for the accident site at the accident time. The Pre-Duty Weather Briefings (PDWB) provided by ZLA CWSU for April 13 can be found in attachment 4.

10.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products issued by the NWS Aviation Weather Center (AWC) around 1500 PDT and valid at 2000 PDT are shown in figures 15 and 16 (additional GFA forecast products produced after 1500 PDT were not available due to AWC archiving constraints). The GFA surface forecasts applicable at 2000 PDT for the accident site indicated VFR conditions with likely (greater than 60 percent) of rain showers and a southwest wind of 25 knots with gusts to 35 knots. The GFA cloud forecast applicable to the accident site for 2000 PDT indicated scattered to overcast cloud cover at the accident site with cloud bases around 2,400 ft and cloud tops to 18,000 ft. Graphical AIRMETS³⁰ (G-AIRMET) Sierra and Zulu were valid for 2000 PDT for the accident site (figure 16). The only human-generated information reflected in the two GFA products were the G-AIRMETS. G-AIRMETS Sierra, Tango, and Zulu issued at 1945 PDT and valid for 2000 PDT can be found in figures 17 through 19.

³⁰ Graphical AIRMETS (G-AIRMETS), found on the Aviation Weather Center webpage at <http://aviationweather.gov>, are graphical forecasts of en-route weather hazards valid at discrete times no more than 3 hours apart for a period of up to 12 hours into the future (for example, 00, 03, 06, 09, and 12 hours). G-AIRMETS are snap shots at discrete time intervals as defined above. The text AIRMET is the result of the production of the G-AIRMET but provided in a time smear for a 6hr valid period.

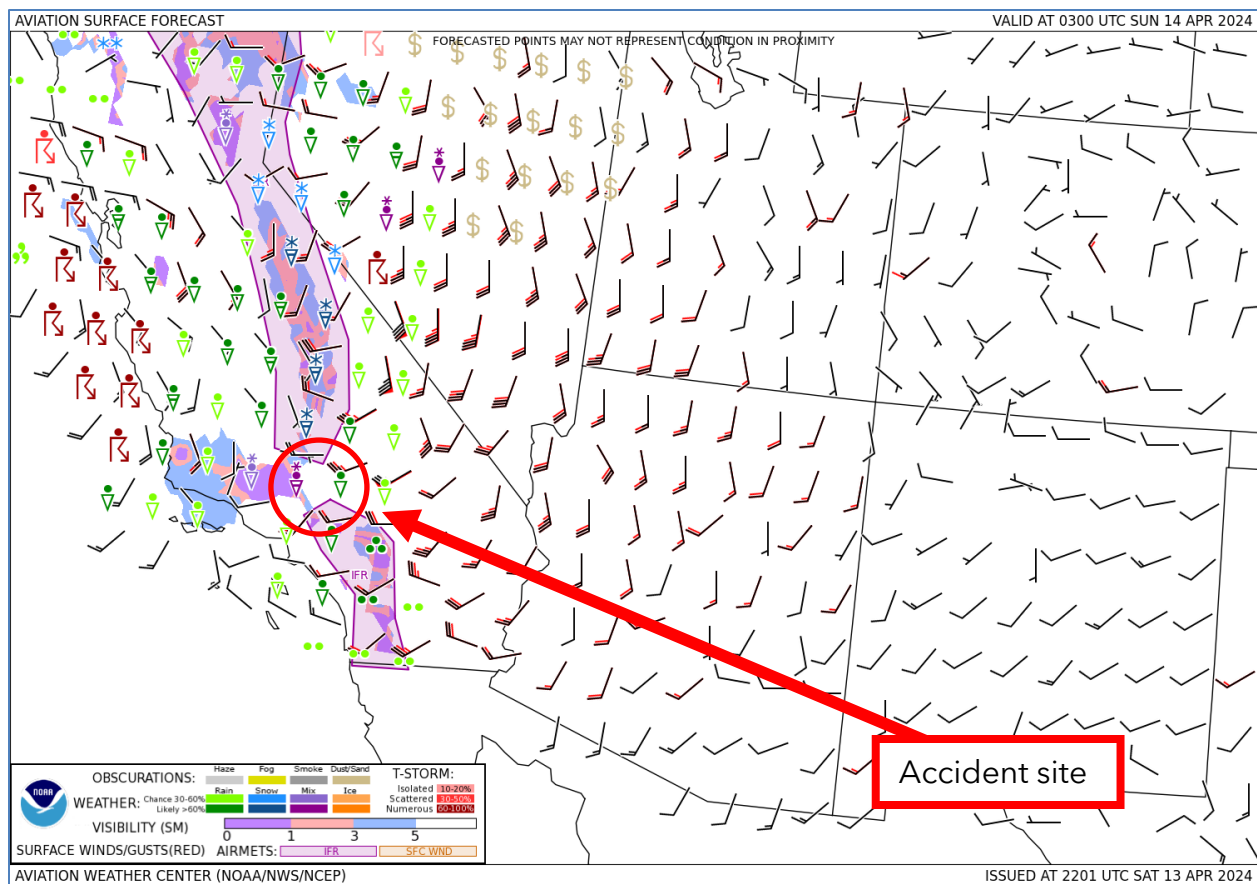


Figure 15. GFA Surface Forecast valid at 2000 PDT with forecast issued at 1501 PDT.

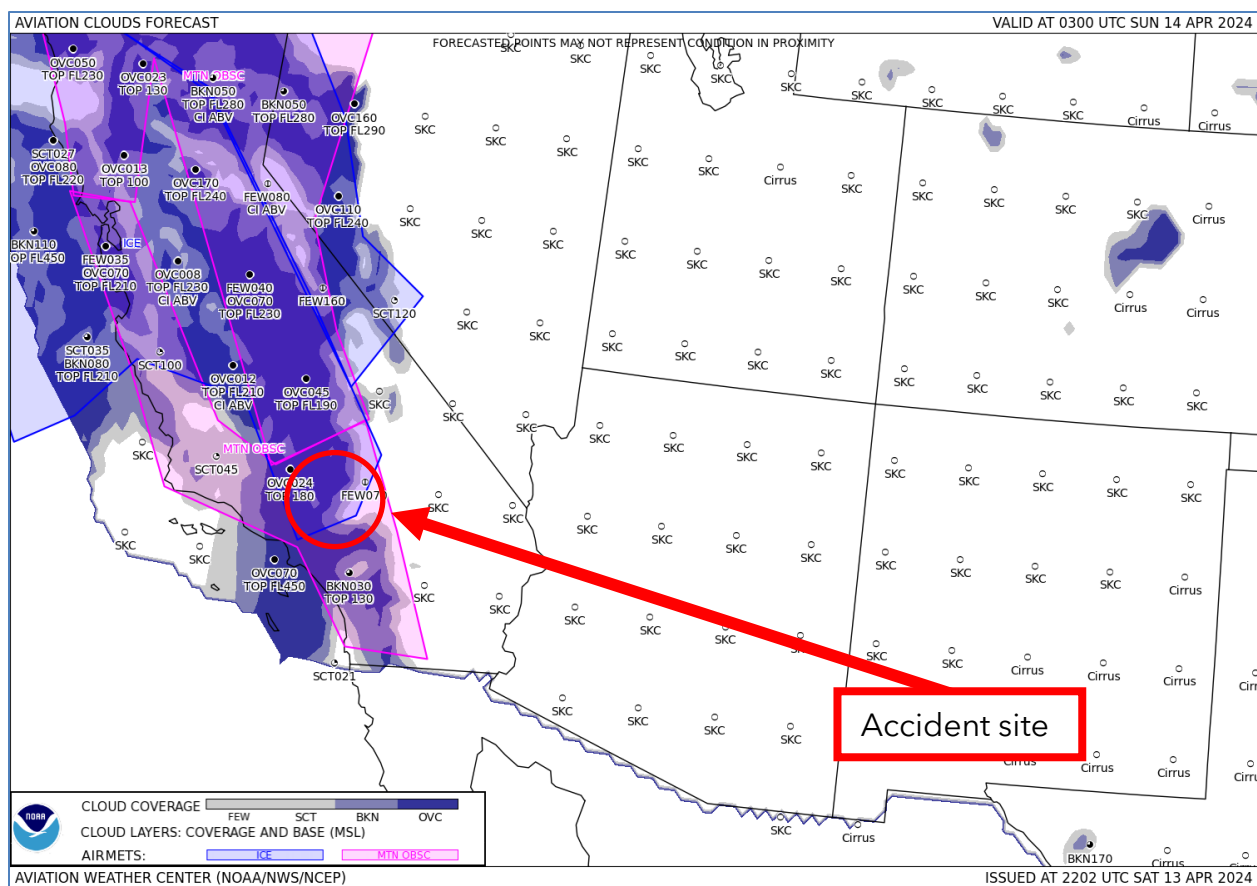


Figure 16. GFA Aviation Clouds Forecast valid at 2000 PDT with forecast issued at 1502 PDT.

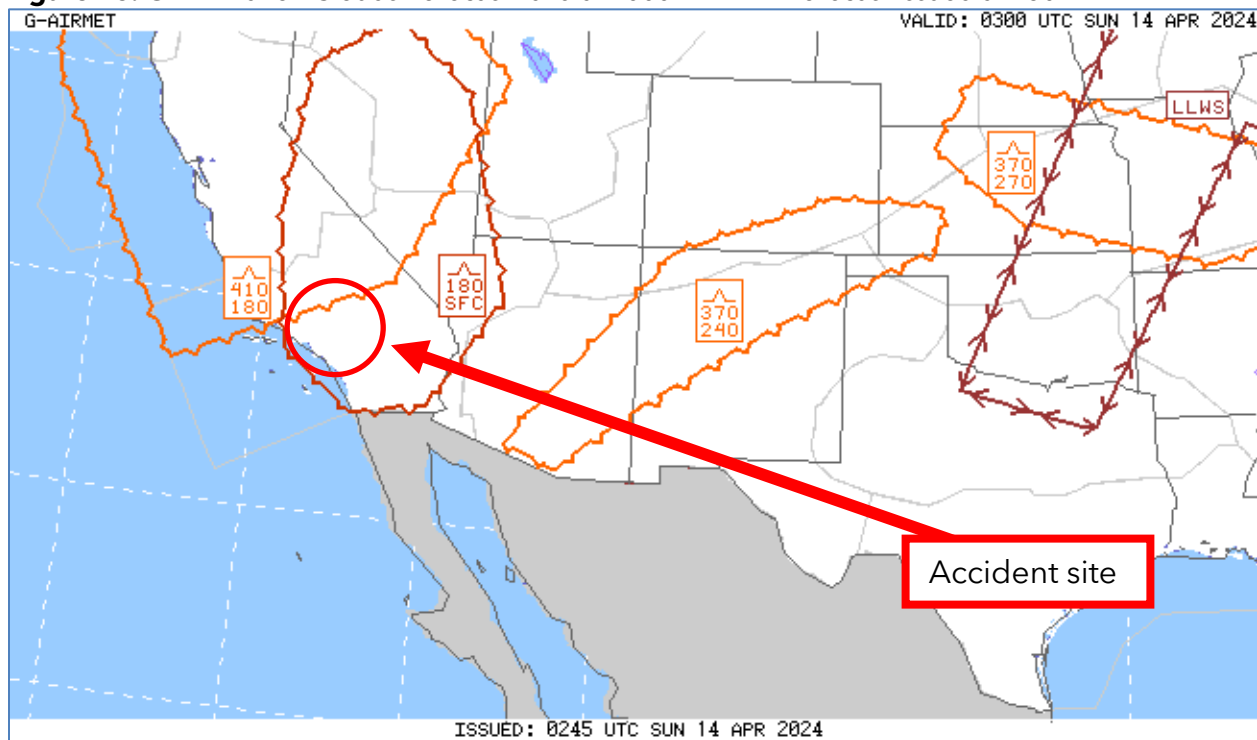


Figure 17. G-AIRMET Tango valid at 2000 PDT with forecast issued at 1945 PDT.

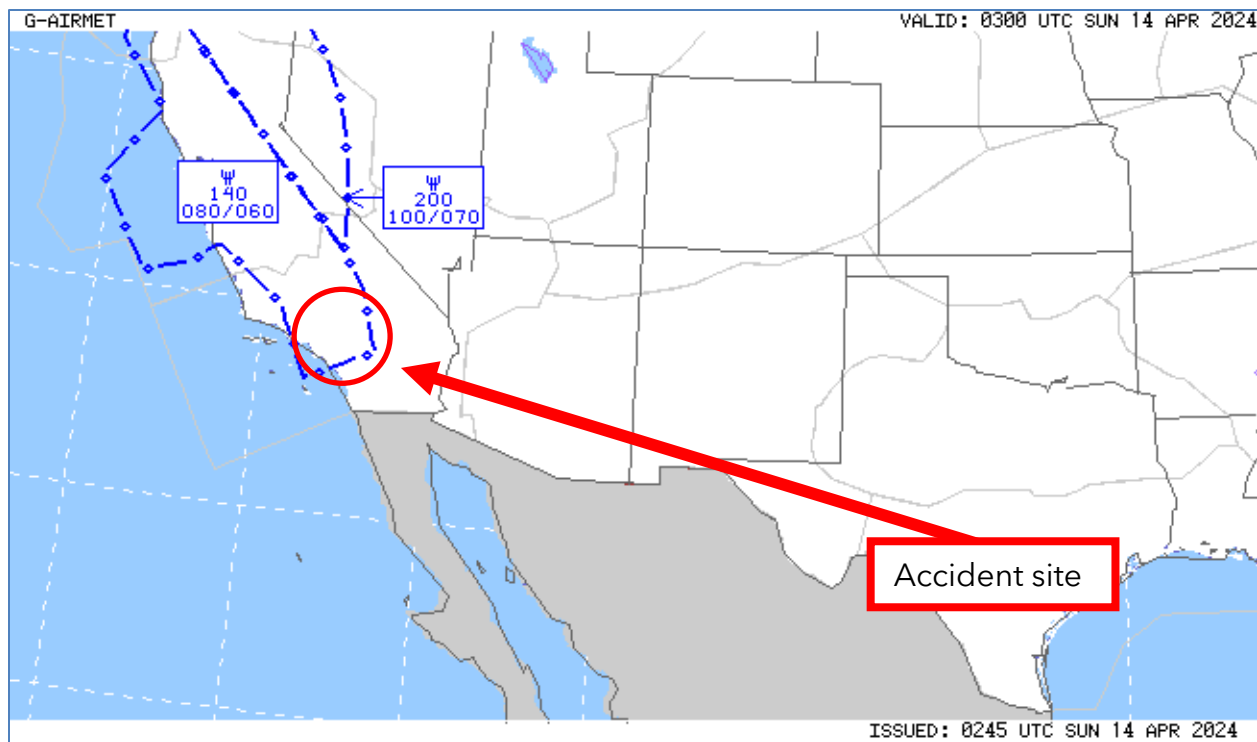


Figure 18. G-AIRMET Zulu valid at 2000 PDT with forecast issued at 1945 PDT.

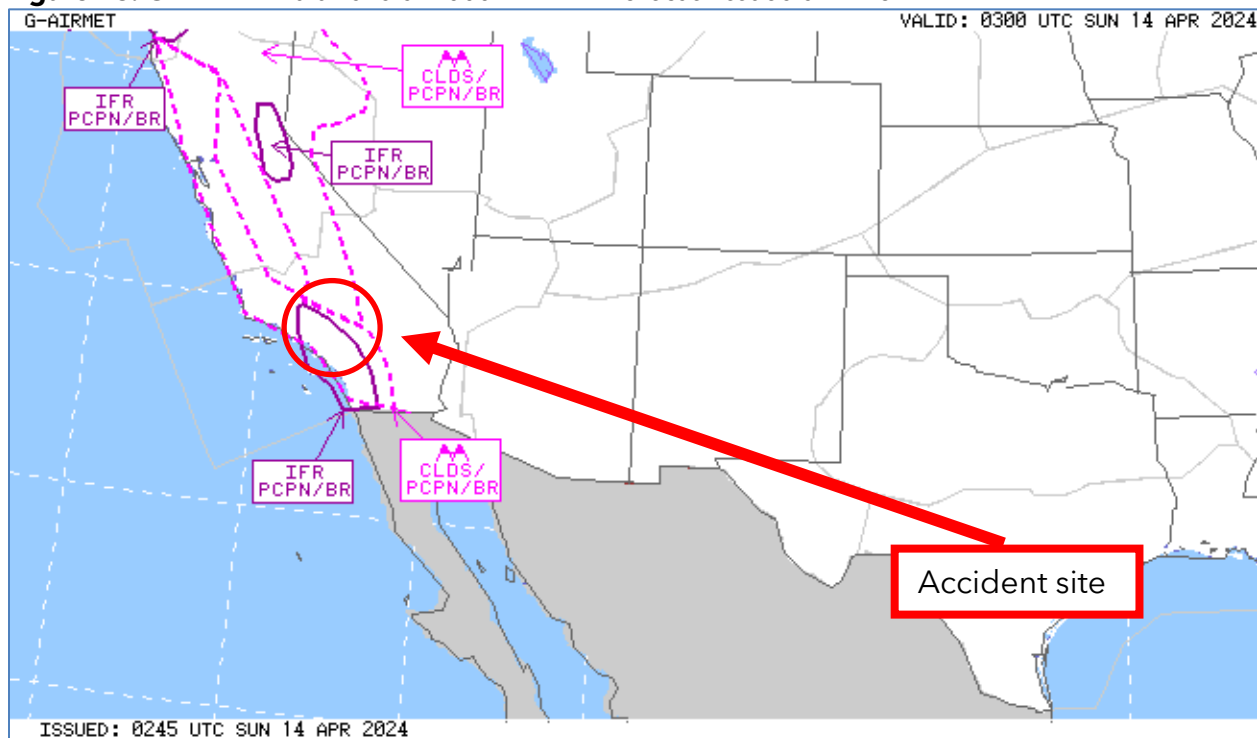


Figure 19. G-AIRMET Sierra valid at 2000 PDT with forecast issued at 1945 PDT.

11.0 Text Airmen's Meteorological Information

The AWC had text Airmen's Meteorological Information (AIRMET) advisory Sierra, Tango, and Zulu valid for the accident site at the accident time. The text AIRMETs were issued at 1945 PDT (similar text AIRMET information was valid in the 1345 PDT forecast) and forecast IFR and mountain obscuration conditions due to clouds, precipitation, and mist, moderate turbulence below 18,000 ft, and moderate icing between the freezing level³¹ and 14,000 ft:

WAUS46 KPCI 140245

WA6S

-SFOS WA 140245

AIRMET SIERRA FOR IFR AND MTN OBSCN VALID UNTIL 140900

.

AIRMET IFR...OR CA AND CSTL WTRS

FROM 70WSW ONP TO 20WSW EUG TO 30ENE OED TO 40SE LKV TO FMG TO
50ENE CZQ TO 40ESE MOD TO 40S RBL TO 20SW FOT TO 120WSW FOT TO
140WNW FOT TO 70WSW ONP

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

.

AIRMET IFR...CA AND CSTL WTRS

**FROM 30S EHF TO 20S HEC TO 60SSE TRM TO 20S MZB TO 30SSW LAX TO
30S EHF**

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS ENDG 06-09Z.

.

AIRMET MTN OBSCN...CA

**FROM FOT TO RBL TO 30SW SAC TO 40W EHF TO 30SSE EHF TO 30S HEC
TO 60SSE TRM TO MZB TO LAX TO 50W RZS TO PYE TO FOT
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.**

.

AIRMET MTN OBSCN...OR CA NV

FROM 40N ONP TO 20ENE DSD TO 50ESE LKV TO BAM TO 60SW ELY TO
30NNE BTY TO 50WNW OAL TO 30S HEC TO 30SSE EHF TO RBL TO FOT TO
70WNW OED TO 40N ONP

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

.

OTLK VALID 0900-1500Z...IFR CA AND CSTL WTRS

BOUNDED BY 50SSW CZQ-20SW EHF-50W HEC-20NNE LAX-30SSE RZS-30WSW
RZS-80S SNS-50SSW CZQ

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 09-12Z. CONDS CONTG
THRU 15Z.

....

WAUS46 KPCI 140245

WA6T

-SFOT WA 140245

AIRMET TANGO FOR TURB VALID UNTIL 140900

.

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

³¹ Freezing level ranging from 6,000 to 8,000 ft.

**FROM 20SSE BTG TO 60SW LKT TO 20W MLD TO 70SSW DVC TO 40SW SJN
TO 40ESE BZA TO 20S MZB TO 30SSE RZS TO 40W RZS TO 30SSW SNS TO
80SSE LKV TO 40S EUG TO 20SSE BTG
MOD TURB BLW FL180. CONDS CONTG BYD 09Z THRU 15Z.**

.
AIRMET TURB...WA OR CA ID NV UT AND CSTL WTRS
FROM 80E YDC TO 20W GEG TO 30SSE YKM TO 50S BKE TO 20WNW DBS TO
20WNW BPI TO 60S BCE TO 150SW RZS TO 140WSW FOT TO 140W TOU TO
30W HUH TO 80E YDC
MOD TURB BTN FL180 AND FL410. CONDS CONTG BYD 09Z THRU 15Z.

.
OTLK VALID 0900-1500Z
AREA 1...TURB OR CA ID WY NV UT CO AZ NM AND CSTL WTRS
BOUNDED BY 40ENE BOI-30WSW OCS-20S JNC-70S SJN-BZA-30SSW MZB-
30SSE RZS-40W RZS-40SW SNS-40NE SAC-60S OED-40ENE BOI
MOD TURB BLW FL180. CONDS CONTG THRU 15Z.

.
AREA 2...TURB WA OR CA ID NV UT AND CSTL WTRS
BOUNDED BY 90WSW YXC-20E PDT-70SSW LKT-30WNW DBS-20WNW BPI-50SSE
DTA-60W HEC-170SW RZS-140WSW FOT-140W TOU-20W HUH-90WSW YXC
MOD TURB BTN FL180 AND FL410. CONDS CONTG THRU 15Z.

....

WAUS46 KPCI 140245
WA6Z
-SFOZ WA 140245
AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 140900

.
AIRMET ICE...WA OR CA NV AND CSTL WTRS
FROM 30NE BTG TO 60SSW YKM TO 30SE LKV TO 30NNW BAM TO 40WSW ELY
TO 60SSE BTY TO 50W BTY TO 50E FOT TO 130WNW FOT TO 50NNW ONP TO
30NE BTG
MOD ICE BTN FRZLVL AND FL200. FRZLVL 060-100. CONDS CONTG BYD 09Z
THRU 15Z.

.
**AIRMET ICE...CA AND CSTL WTRS
FROM 130WNW FOT TO 50E FOT TO 50W BTY TO 20NW TRM TO 70SSW LAX
TO 20NNW RZS TO 90SW RZS TO 160SW SNS TO 150SW FOT TO 130WNW FOT
MOD ICE BTN FRZLVL AND 140. FRZLVL 060-080. CONDS CONTG BYD 09Z
THRU 15Z.**

.
FRZLVL...RANGING FROM 045-120 ACRS AREA
080 ALG 190SSW RZS-40WNW MZB-40WNW TRM-40WSW LAS
080 ALG 40SE LKV-70SSW ONP-130WSW ONP-150W ONP
080 ALG 160W HQM-70WNW TOU

....

12.0 Terminal Aerodrome Forecast

KSBD was the closest site with an NWS Terminal Aerodrome Forecast³² (TAF) current at the time of the accident. The KSBD TAF valid at the accident time was issued at 1635 PDT and was valid for a 24-hour period beginning at 1700 PDT. The 1635 PDT TAF for KSBD was as follows:

FTUS46 KSGX 132335
TAFSBD
TAF
KSBD 132335Z 1400/1424 **24011G17KT P6SM VCSH SCT025 OVC060**
TEMPO 1402/1406 6SM -SHRA BKN020
FM140600 23005KT P6SM VCSH SCT025 BKN040
FM140700 VRB04KT P6SM SCT025 BKN040
FM142100 23012KT P6SM VCSH SCT025 OVC040=

Between 1700 and 2300 PDT the KSBD forecast expected a wind from 240° at 11 knots with gusts to 17 knots, greater than 6 miles visibility, vicinity³³ showers, scattered clouds at 2,500 ft agl, and an overcast ceiling at 6,000 ft agl. Temporary conditions³⁴ were forecast between 1900 and 2300 PDT with 6 miles visibility, light rain shower, and a broken ceiling at 2,000 ft agl.

13.0 National Weather Service Area Forecast Discussion

The NWS weather forecast office in San Diego, California, (WFO SGX) was responsible for the public forecast in the region of the accident site. WFO SGX issued the following Area Forecast Discussion (AFD) at 1348 PDT. This was the AFD issued closest to the accident time with an aviation section:

FXUS66 KSGX 132048
AFDSGX

Area Forecast Discussion
National Weather Service San Diego CA
148 PM PDT Sat Apr 13 2024

.SYNOPSIS...
Periods of rain, mountain snow, and gusty winds are expected through

³² According to NWS Instruction 10-813: "An NWS TAF consists of the expected meteorological conditions significant to aviation at an airport for a specified time period. For the U.S., this is the area within five (5) statute miles (SM) of the center of an airport's runway complex."

www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

³³ "In the vicinity" is defined as a weather phenomenon within 5-10 statute miles from the point of observation.

³⁴ The TEMPO group is used for any conditions in wind, visibility, weather, or sky condition which are expected to last for generally less than an hour at a time (occasional), and are expected to occur during less than half the time period.

this evening and again Sunday afternoon and evening. Below average temperatures will prevail this weekend. Dry and warming conditions expected for next week.

&&

.DISCUSSION...FOR EXTREME SOUTHWESTERN CALIFORNIA INCLUDING ORANGE...
SAN DIEGO...WESTERN RIVERSIDE AND SOUTHWESTERN SAN BERNARDINO
COUNTIES...

As of 1 PM, light showers were moving into LA County as the low pressure system continues to spin off the coast of Northern California, just west of San Francisco. As the system moves east and south, two embedded shortwaves will bring periods of precipitation and gusty westerly winds to Southern California through Sunday night.

The first shortwave will arrive late this afternoon, bringing a narrow ribbon of weak IVT with it. Showers will begin in Orange and San Bernardino counties first, with showers expected to reach Riverside and San Diego Counties by this evening. Showers will diminish around midnight. Precipitation will be generally light, with peak rainfall rates of 0.10-0.15 inches per hour for lower elevations with rates up to 0.20 inches per hour in the mountains.

A dry period can be expected for Sunday morning ahead of the second shortwave. The second shortwave is forecast to arrive Sunday afternoon. There will be less available moisture associated with the second wave, so showers will not be as widespread and more scattered in coverage. Precipitation on Sunday will again be generally light with similar rain rates to today.

Rainfall totals will range from 0.05-0.30" in the coastal and valley zones, with the higher end of the range in Orange and San Bernardino Counties, and the lower amounts in San Diego County. In the mountains from 0.25-1.00", locally up to 1.50", is forecast, highest in San Bernardino County and lowest in the San Diego County mountains. A few hundredths of an inch is all that will fall in the High Deserts. The Lower Deserts will remain dry. Snow levels around 5500-6500 feet today will fall to 4500-5500 feet Sunday. Snow totals of 3-7", locally up to 10", expected above 7000 feet in San Bernardino County Mountains. The higher values listed are most likely in the San Gabriel Mountains. 2-5" of snow expected between 5000-7000 feet.

Periods of gusty winds are expected this weekend. Peak gusts of 40-60 mph are expected in the afternoons and evenings through Sunday. Strongest winds will occur in the mountains, deserts, and through mountain passes. Breezy southwest winds will also impact the coastal and valley zones with gusts to 25 mph.

The low quickly moves to the east on Monday, and ensemble guidance supports warming over Southern California through the middle of next

week.

&&

.AVIATION...

132030Z...Coast/Valleys...Widespread BKN/OVC clouds will prevail through Sun morning with bases 2500-4000 ft MSL and tops to 6000-10000 ft MSL. Local VIS 3-5 mi could occur in SHRA mainly 22Z Sat-05Z Sun.

Mountains/Deserts...Areas of terrain obscurations will occur at times mainly on the coastal slopes in clouds/SHRA/SHSN through Sun morning. Surface gusts 25-45 kt from the S/W will continue from the mountain crests through the desert slopes and into the deserts through 12Z Sun, with increasing winds again after 18Z Sun, along with LLWS and MOD UDDFS.

&&

.MARINE...

South winds will develop this morning and will be associated with gusts between 20 and 25 knots at times, including near Zuniga Jetty/San Diego Bay Entrance, until the front arrives from the west late this afternoon/early this evening when a few gusts 20 to 25 knots will also occur. A Small Craft Advisory has been issued for these gusts 8 AM-8 PM for the inner/outer coastal waters (0-60 NM from the coast). Otherwise, a couple periods of rain showers will occur late today/this evening and Sunday late afternoon/evening. Local gusts over 20 knots could also occur Sunday and Monday from the west. Winds will be lighter beginning Tuesday.

&&

.SKYWARN...

Skywarn activation is not requested. However weather spotters are encouraged to report significant weather conditions.

&&

.SGX WATCHES/WARNINGS/ADVISORIES...

CA...Wind Advisory until 11 PM PDT this evening for Apple and Lucerne Valleys-San Bernardino County Mountains.

Winter Weather Advisory until 8 PM PDT Sunday for San Bernardino County Mountains.

Wind Advisory until 2 AM PDT Monday for Riverside County Mountains-San Diego County Deserts-San Diego County Mountains-San Gorgonio Pass Near Banning.

PZ...Small Craft Advisory until 8 PM PDT this evening for Coastal Waters from San Mateo Point to the Mexican Border and out

to 30 nm-Waters from San Mateo Point to the Mexican Border
Extending 30 to 60 nm out including San Clemente Island.

&&

\$\$

14.0 Winds and Temperature Aloft Forecast

The NWS 1859 PDT Winds and Temperature Aloft forecast, which was intended for use between 1900 on April 13 and 0200 PDT on April 14 and was valid for the closest point to the accident site, is included below:

FBUS31 KWNO 140159

FD1US1

DATA BASED ON 140000Z

VALID 140600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

ONT 2406 2222+01 2229-05 2338-07 2373-11 2274-25 237939 238149 237456

15.0 Icing Potential

The Current Icing Product (CIP) and Forecast Icing Product (FIP³⁵) imagery provided information on expected icing severity as five categories: none, trace, light, moderate, and heavy. The severity estimates are roughly based on the accretion rate of ice on an airplane, and the levels are determined by the time it would take for an airfoil to accrete 1/4 of an inch of ice: trace = 1 hour; light = 15 minutes to 1 hour; moderate = 5 to 15 minutes; severe = less than 5 minutes. Note that these are general values. Users should always consider the icing susceptibility of their airframe and availability of icing protection provided by their aircraft. Different aircraft and different flight configurations (airspeed, angle of attack, etc.) will experience variations in accretion rate.

The images presented in this report show data from National Center for Atmospheric Research (NCAR)'s prototype CIP and FIP algorithms, generated using NCAR's visualization software. These algorithms differ in various ways from the operational CIP and FIP³⁶ that provided data used to generate the publicly available images accessible through the AWC on the accident day. NCAR's prototype CIP and FIP represent the latest research and development conducted by their team of in-flight icing scientists, and have passed internal validation exercises using voice pilot reports (PIREPs) of icing conditions and scientific airborne research observations of in-flight icing (when available). Through coordination with the FAA and NOAA, NCAR provides the prototype CIP and FIP for an independent validation exercise to determine their suitability for operational use. Pending the outcome of that validation, the operational versions are replaced with the prototype versions. The frequency with which the operational versions are updated is dependent upon the research and development advancements in the prototype versions and available resources to support the operational upgrade.

³⁵ B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cuning, 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. Cuning, 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>

Wolff, C. A., D. R. Adriaansen, and M. K. Politovich, 2014: Diagnosing and Forecasting In-Flight Icing Conditions in Alaska. Preprints, 6th AIAA Atmospheric and Space Environments Conference, Atlanta, GA, Amer. Inst. Aero. Astro., 2014-2070, available at: <http://arc.aiaa.org/doi/abs/10.2514/6.2014-2070>.

[Icing Product Alaska \(IPA\) - Experimental | NCAR Research Applications Laboratory | RAL \(ucar.edu\)](http://arc.aiaa.org/doi/abs/10.2514/6.2014-2070)

³⁶ <https://www.aviationweather.gov/icing/fip>

The FIP icing probabilities and icing severity products for the 1-hour forecast valid at 2000 and 2100 PDT at 7,000 through 15,000 ft indicated a 10% to 85% probability of trace to heavy icing above the accident site (attachment 5) with the highest probability and intensities between 7,000 and 10,000 ft. The FIP indicated an 80 to 100% probability of Supercooled Large Droplets (SLD)³⁷ above the accident site at 8,000 through 11,000 ft at 2000 PDT. The CIP products indicated a 30 to 85% probability of trace to moderate icing from 7,000 ft through 15,000 ft at 2000 and 2100 PDT above the accident site (attachment 5). The highest CIP probability and intensities were between 8,000 and 11,000 ft. The CIP indicated a 10 to 60% probability of SLD above the accident site between 8,000 and 11,000 ft at 2000 and 2100 PDT. For more FIP and CIP data and imagery please see attachment 5.

16.0 Pilot Weather Information

Title 14 CFR 91.103 states that “Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight.” FAA AC 91-92 “Pilot’s Guide to a Preflight Planning” (dated March 15, 2021) provided pilot guidance on preflight self-briefings, including planning, weather interpretation, and risk identification/mitigation skills. The AC further stated in part:

Pilots adopting these guidelines will be better prepared to interpret and utilize real-time weather information before departure and en route, in the cockpit, via technology like Automatic Dependent Surveillance-Broadcast (ADS-B) and via third-party providers.³⁸

A search of archived information indicated that the accident pilot did not request weather information from Leidos Flight Service. The accident pilot did have an account with ForeFlight and did file their flight plan through ForeFlight and received a weather briefing (attachments 6 and 7) around 1807 PDT. The accident pilot updated their route string several times on April 13, including 9 times between 1806 and 1933 PDT. The ForeFlight weather briefing contained all the standard weather forecast information prior to 1807 PDT, including G-AIRMETs, PIREPs, and METARs. The ForeFlight Vertical Cross Section Chart indicated moderate icing on descent. For more information please see attachments 6 and 7.

³⁷ [GFA Help \(aviationweather.gov\)](https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf) and [Icing Hazards \(weather.gov\)](https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf)

³⁸ https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf. The AC also listed multiple online FAA resources for aviation flight planning services for adverse weather.

17.0 Astronomical Data

The astronomical data obtained³⁹ for the accident site on April 13, 2024, indicated the following:

SUN

Begin civil twilight	0554 PDT
Sunrise	0620 PDT
Sun transit	1250 PDT
Sunset	1920 PDT
End civil twilight	1946 PDT
Accident time	2019 PDT ⁴⁰

At the time of the accident the Sun was below the horizon.

MOON

Moonrise	0951 PDT
Moon transit	1736 PDT
Accident time	2019 PDT ⁴¹
Moonset	0119 PDT on April 14, 2024

At the time of the accident the Moon was above the horizon at an altitude of 55.47° and an azimuth of 271.44° with 33.5% of the Moon's disk illuminated.

³⁹ <https://www.suncalc.org/> and <https://www.mooncalc.org/>

⁴⁰ Inserted accident time for reference and context.

⁴¹ Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 - GOES-18 low-level water vapor animation from 1901 to 2101 PDT

Attachment 2 - GOES-18 Nighttime Microphysics RGB animation from 1901 to 2101 PDT

Attachment 3 - KSOX WSR-88D base reflectivity animation from 2000 to 2045 PDT

Attachment 4 - ZLA CWSU PDWB for April 13

Attachment 5 - FIP and CIP information valid for the accident site

Attachment 6 - ForeFlight Information

Attachment 7 - ForeFlight correspondence

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