

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR24FA105

METEOROLOGY

Specialist's Factual Report

April 23, 2024

TABLE OF CONTENTS

A. ACCIDENT.....	3
B. METEOROLOGY SPECIALIST	3
C. SUMMARY	3
D. DETAILS OF THE INVESTIGATION	3
E. FACTUAL INFORMATION.....	4
1.0 SYNOPTIC CONDITIONS	4
1.1 Surface Analysis Chart.....	4
1.2 Regional Weather Radar Image	5
2.0 SURFACE OBSERVATIONS	6
2.1 Madras, Oregon.....	6
2.2 NWS Aviation Weather Center METAR Depiction.....	8
3.0 SOUNDING.....	8
4.0 SATELLITE IMAGERY	10
5.0 WEATHER SURVEILLANCE RADAR IMAGERY	12
6.0 PILOT REPORTS	14
7.0 NWS FORECAST PRODUCTS	15
7.1 Graphic Forecast for Aviation.....	15
7.2 Winds Aloft Chart.....	17
7.3 Graphic Turbulence Guidance.....	18
7.4 Current Icing Product.....	20
7.4.1 Icing probability.....	21
7.4.2 Icing Severity	23
7.4.3 Supercooled Large Droplet Potential	25
8.0 NWS INFLIGHT WEATHER ADVISORIES	27
9.0 PILOT WEATHER BRIEFING	28
F. ATTACHMENTS.....	29

A. ACCIDENT

Location: Madras, Oregon
Date: March 10, 2024
Time: 1503 Pacific daylight time
2203 coordinated universal time (UTC)
Airplane: Piper PA-32-260 Cherokee Six; Registration: N3264W

B. METEOROLOGY SPECIALIST

Donald Eick
Senior Meteorologist
National Transportation Safety Board
Washington, D.C.

C. SUMMARY

On March 10, 2024, at 1503 Pacific daylight time, a Piper PA-32-260, N3264W, was destroyed when it was involved in an accident near Madras, Oregon. The pilot and passenger were fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

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 remotely, collecting data 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 report documents the general weather products and forecasts over the region during the period and documents the pertinent meteorological parameters to the accident. All times are reported as Pacific daylight time (PDT) based upon the 24-hour clock, local time is -7 hours from UTC, and UTC=Z. Airport and 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. continental 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 located at latitude 44.585397° N and longitude 121.04094° W, at an elevation of approximately 2,604 ft.

E. FACTUAL 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) and the WPC 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 and other products can be found in the Federal Aviation Administration (FAA) "Aviation Weather Handbook", FAA-H-8083-28¹.

1.1 Surface Analysis Chart

The northwest section of the NWS Surface Analysis Chart for 1500 PDT (2100Z) is included as figure 1 with the red star depicting the approximate accident site. The chart depicted an occluded front extending from a low-pressure system at 986-hectopascals (hPa)² over southeast Alaska (off the northwest portion of chart) through British Columbia, and into Washington, where the front was depicted as a cold front extending into Oregon southwestward into northern California. High pressure systems at 1009-hPa were depicted over the northern Idaho and Montana border, and at 1020-hPa over the southeast Idaho and Wyoming border. The accident site was located west of the cold front on the cold air side of the front.

The closest station model on the chart immediately south of the accident site depicted southerly wind at 10 knots, visibility restricted in drizzle, broken sky cover, with a temperature of 41°F, and a dew point of 37°F. Several other station models behind the front depicted light continuous rain or drizzle and overcast sky cover. Clear skies prevailed over eastern Oregon and southern Idaho under the influence of the high pressure systems.

¹ <https://www.faa.gov/regulationspolicies/handbooksmanuals/aviation/faa-h-8083-28-aviation-weather-handbook>

² Hectopascal (hPa) is the standard unit for reporting sea-level pressure and is interchangeable with the former term millibar (mb) with the same units. The International Standard Atmosphere (ISA) is based on a sea-level pressure of 1013.25-hPa at a temperature of 15° Celsius (C) or 59° Fahrenheit (F).

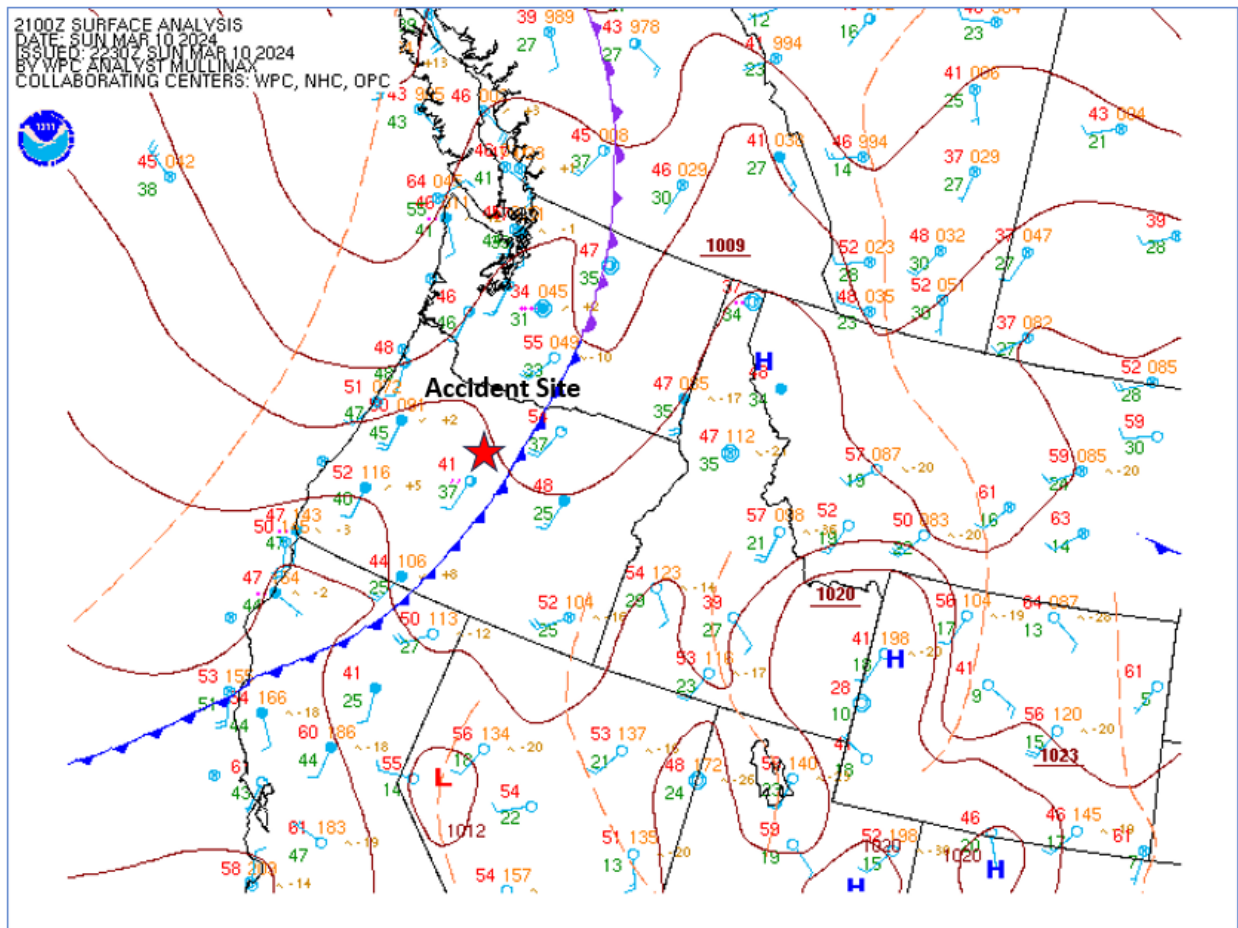


Figure 1 - NWS northwest regional Surface Analysis Chart for 1500 PDT with approximate accident site marked by red star.

1.2 Regional Weather Radar Image

A depiction of the NWS Composite Reflectivity Mosaic for 1505 PDT is included as figure 2 with the approximate accident site marked by a red star. The radar image depicted several bands of light precipitation over the western slopes of the Cascade Mountain range and over western Oregon with no echoes over the accident site. The NWS weather radar imagery will be further documented in section 5.0 of this report.

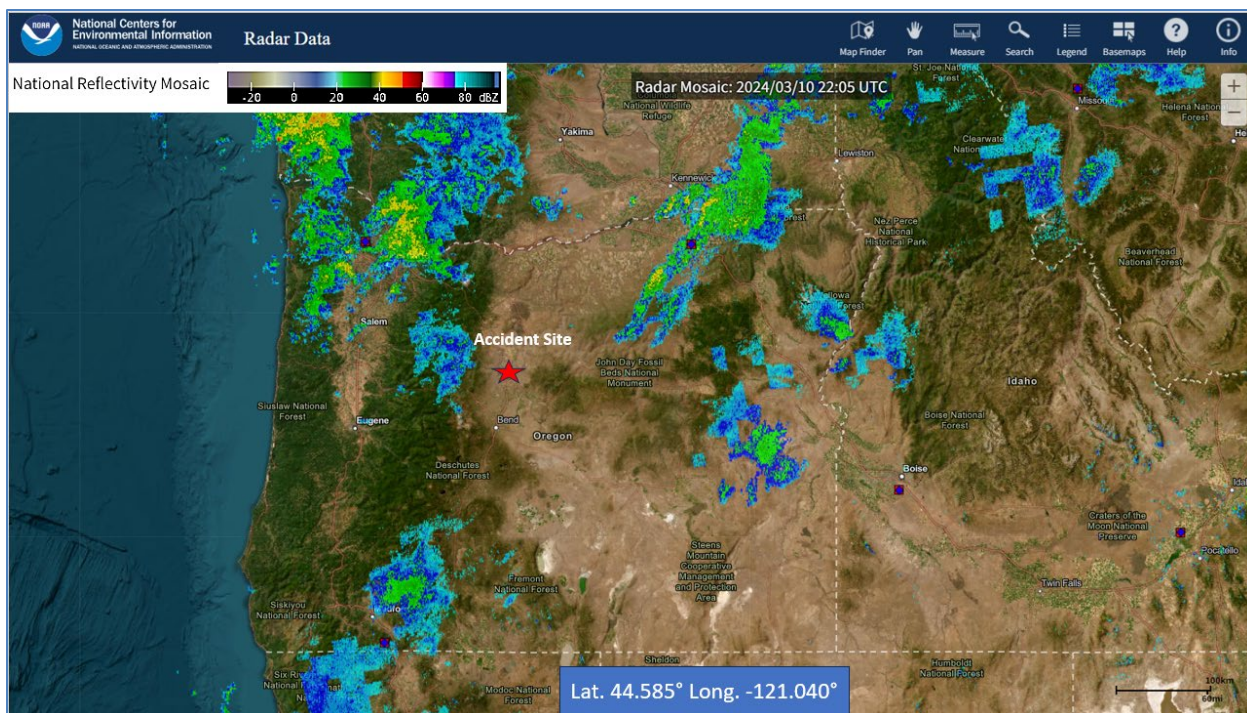


Figure 2 - NWS Composite Reflectivity Image for 1505 PDT with the approximate accident marked by the red star.

2.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METAR) and Aviation Selected Special Weather Reports (SPECI). Cloud heights are reported above ground level (agl) in the following section. The magnetic variation over the area was estimated at 14.5° West based on the latest sectional chart for the area.

2.1 Madras, Oregon

The closest official reporting location was from Madras Municipal Airport (KS33), Madras, OR, located about 7 miles northwest of the accident site at an elevation of 2,438 ft. The airport had an unattended Automated Weather Observation System (AWOS), which broadcasted observation line of sight on 132.425 VHF, and longline every 20-minutes. At the time of the accident KS33 was reporting the following conditions.

Weather observation for KS33 at 1455 PDT, automated, wind from 220° at 24 knots gusting to 30 knots, visibility 10 statute miles or more, scattered clouds at 5,000 ft agl, scattered clouds at 7,500 ft, and scattered at 9,000 ft, temperature of 10° Celsius (C) (50°F), dew point temperature of -2°C (28°F), altimeter setting

29.77 inches of mercury. Remarks: automated observation system with a precipitation sensor.

The general flight categories³ and raw observations in standard code and abbreviations with time referenced to UTC were as follows between 1255 through 1655 PDT. The observation in bold type is decoded above, with the time of the accident included.

VFR METAR KS33 101955Z AUTO 21015G21KT 10SM SCT050 BKN065 OVC095 08/00 A2978 RMK AO2=

VFR METAR KS33 102015Z AUTO 21026G33KT 10SM SCT040 SCT050 BKN095 08/00 A2979 RMK AO2=

VFR METAR KS33 102035Z AUTO 20017G26KT 10SM BKN120 08/00 A2978 RMK AO2=

VFR METAR KS33 102055Z AUTO 20014G24KT 10SM SCT120 10/00 A2978 RMK AO2=

VFR METAR KS33 102115Z AUTO 23015G21KT 10SM SCT050 SCT065 SCT080 10/M01 A2978 RMK AO2=

VFR METAR KS33 102135Z AUTO 22019G29KT 10SM SCT050 SCT065 SCT080 10/M02 A2978 RMK AO2=

VFR METAR KS33 102155Z AUTO 22024G30KT 10SM SCT050 SCT075 SCT090 10/M02 A2977 RMK AO2=

Accident 2203Z

VFR METAR KS33 102215Z AUTO 21017G31KT 10SM SCT090 10/M02 A2978 RMK AO2=

VFR METAR KS33 102235Z AUTO 22021G29KT 10SM BKN070 BKN085 09/M02 A2979 RMK AO2=

VFR METAR KS33 102255Z AUTO 21022G27KT 10SM BKN070 OVC080 10/M02 A2979 RMK AO2=

VFR METAR KS33 102315Z AUTO 21018G31KT 10SM SCT055 SCT070 SCT080 09/M02 A2981 RMK AO2=

VFR METAR KS33 102335Z AUTO 22019G27KT 10SM SCT055 BKN070 09/M02 A2981 RMK AO2

The observations indicated VFR conditions prevailing surrounding the period with southerly winds from 15 knots gusting upwards to 31 knots during the period, with scattered to broken clouds above 5,000 ft agl.

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. ** MVFR is a subset of VFR.

2.2 NWS Aviation Weather Center METAR Depiction

A depiction of the NWS Aviation Weather Center's METAR depiction⁴ for 1500 PDT is included as figure 1 with the approximate accident site marked by a red star. The regional radar mosaic for 1500 and the frontal positions from 1400 PDT are overlaid. The accident site was depicted behind the cold front and clear of any significant echoes. The station models depicted numerous stations over western Oregon reporting MVFR conditions due to low clouds and visibility restricted in light rain, with VFR conditions prevailing in the vicinity of the accident site.

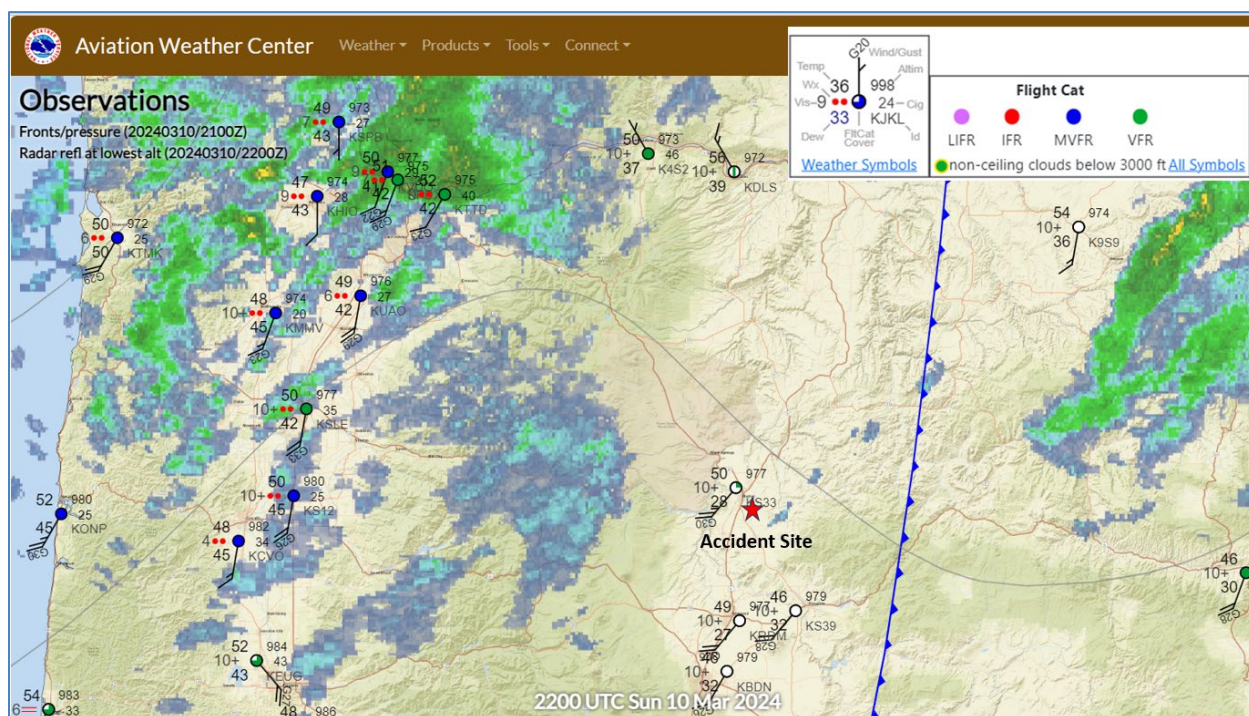


Figure 3 - NWS Aviation Weather Center's METAR display with fronts and regional radar display for 1500 PDT with the approximate accident site marked by the red star.

3.0 Sounding

A High-Resolution Rapid Refresh (HRRR) numerical model⁵ data file was obtained from the NOAA Air Resources Laboratory archive for 1500 PDT for the nearest grid point⁶ to the accident site. The data file was then plotted on a standard

⁴ <https://aviationweather.gov/gfa/#obs>

⁵ 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.

⁶ Grid point coordinates were latitude 44.59°N, and longitude 121.04°N.

Skew T/log P diagram⁷ using the RAOB Analysis software⁸ from the surface to 450-hPa (about 20,000 ft) and is included as figure 4.

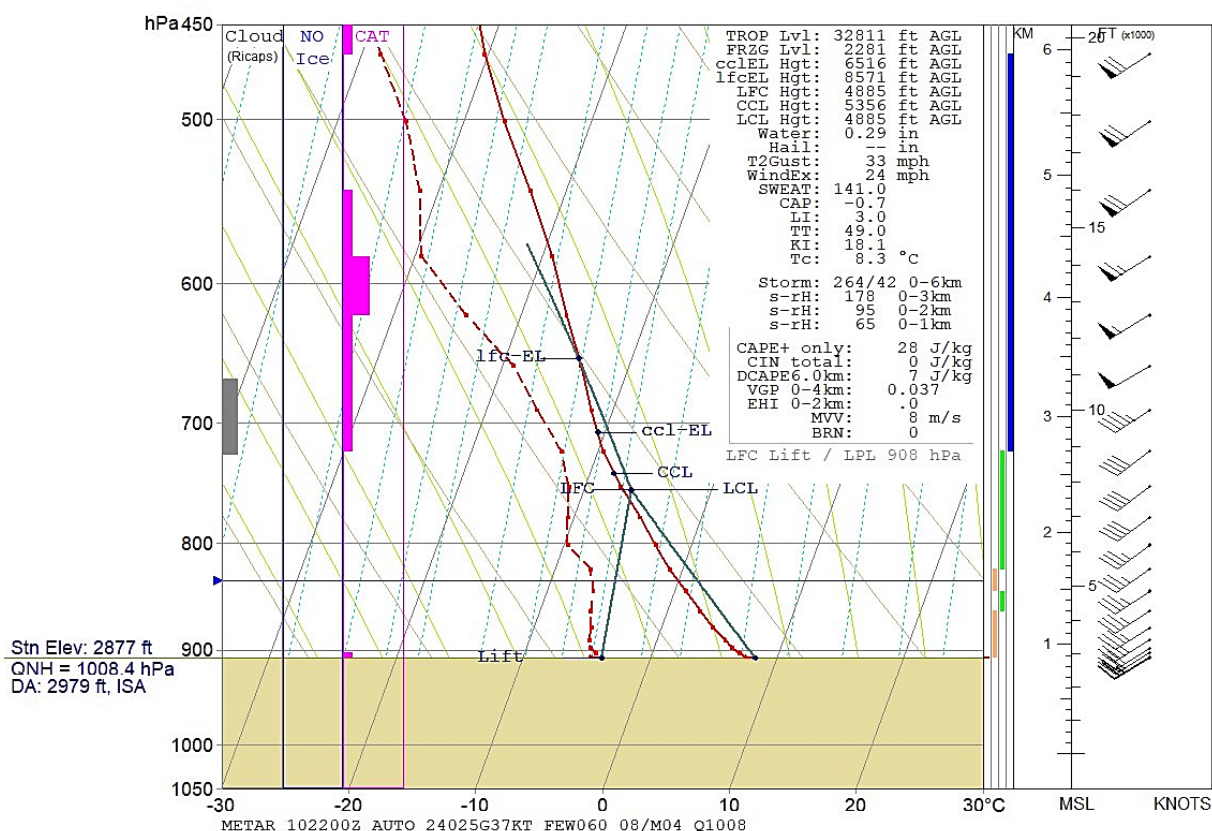


Figure 4 - HRRR numerical model sounding for 1500 PDT over the closest grid to the accident.

The sounding depicted an elevation of 2,877 ft over the grid point with a near-surface temperature of 8°C (47°F), a dew point temperature of -4°C (25°F), and a relative humidity of 42%. The freezing level was identified at 2,281 ft agl (5,158 ft msl), with the lifted condensation level (LCL)⁹ and level of free convection (LFC)¹⁰ at 4,885 ft agl; and the convective condensation level (CCL)¹¹ at 5,356 ft agl. The RAOB Analysis

⁷ 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.

⁸ RAOB -The Complete RAWinsonde OBservation program is an interactive sounding analysis program developed by Eosonde Research Services (ERS) previously known as Environmental Research Services, The Villages, Florida.

⁹ Lifted Condensation Level (LCL) - the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

¹⁰ Level of Free Convection (LFC) - the level where a parcel becomes buoyant, or "warmer" than the environmental temperature at the same level. The LFC represents the bottom of the layer containing CAPE.

¹¹ Convective Condensation Level (CCL) - the height at which a parcel of air, when heated sufficiently from below, rises and becomes saturated. It is where newly forming convective clouds should form bases.

supported scattered altocumulus clouds with bases near 5,600 ft agl with tops near 8,000 ft. The atmosphere at the accident airplane's cruising level of 12,500 ft was characterized as stable with a Lifted Index (LI) of 3.0. The precipitable water content was 0.29 inches.

The HRRR sounding wind profile indicated a near surface wind from 240° at 25 knots with gusts to 37 knots, with little directional variation with height and with wind speeds gradually increasing with height. The mean 0 to 6 kilometer (or 18,000 ft) wind was from 235° at 56 knots. At the accident airplane's maximum altitude of 12,800 ft¹², which was reached immediately prior to the loss of control, the wind was from about 240° at 56 knots with a temperature of -16°C and was in a region where the RAOB program indicated a high potential for moderate turbulence with a 6.4 kt/1000 ft vertical wind shear.

A table of the HRRR sounding parameters of height, pressure (Pres), temperature (T), dew point temperature (Td), relative humidity (RH%), wind direction and speed, and potential clear air turbulence (CAT), low-level wind shear (LLWS), and icing from the surface through 16,000 ft is included below.

Height (ft msl)	Pres (hPa)	T (C°)	Td (C°)	RH (%)	Wind (dir/kts)	CAT (FAA)	LLWS (FAA)	Icing (USAF)
2877	908	8.3	-3.8	42	237/ 25			
2907	907	7.5	-4.7	42	237/ 24	LGT	MODRT	
3026	903	6.9	-4.4	44	236/ 29		LIGHT	
3176	898	6.2	-5.0	44	236/ 31			
3416	890	5.4	-5.3	46	236/ 33			
3779	878	4.1	-5.5	50	236/ 34			
4269	862	2.6	-6.0	53	235/ 35			
4859	843	0.9	-6.4	58	234/ 35			
5490	823	-1.0	-7.2	63	233/ 36			
6197	801	-2.8	-9.7	59	231/ 37			
6985	777	-4.8	-10.5	64	231/ 38			
7860	751	-7.2	-11.3	72	230/ 39			
8863	722	-9.6	-12.9	77	230/ 40	LGT		
10008	690	-11.7	-16.0	70	234/ 43	LGT		
11235	657	-13.8	-19.1	64	238/ 48	LGT		
12633 621	-16.4	-24.3	50	237/ 56	MDT			
14225	582	-19.2	-29.5	40	235/ 66	LGT		
15996	541	-22.8	-31.5	45	233/ 72			

4.0 Satellite Imagery

The NOAA Geostationary Operational Environmental Satellite number 18 (GOES-18) infrared, water vapor, and visible imagery were obtained from an archive at

¹² The Piper PA-28 performance data indicated a maximum operating height or ceiling of 14,500 ft. Above 12,500 ft an aircraft after 30 minutes also requires supplement oxygen by CFR 91.211.

the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared band 13 at a wavelength of 10.3 microns (μm) and the low-level water vapor (band 10) at a wavelength of 7.3 μm provided imagery at a nominal spatial resolution of 2 kilometers (km). The visible band 2 at a wavelength of 0.64 μm provided imagery at a nominal spatial resolution of 0.5 km. Attachments 1-3 are the GOES-18 infrared, moisture channel, and GeoColor imagery animation from 1300 through 1530 PDT respectively.

Figure 5 is the GOES-18 infrared image for 1501 PDT at 6X magnification with a standard MB temperature enhancement curve applied and the fronts from 1400 PDT overlaid. The image depicted the accident site over an area of mid-level clouds with a radiative cloud top temperature of 257 kelvin or -16°C , which corresponded to cloud tops near the accident airplane's cruising level at 12,500 ft based on the HRRR sounding. Figure 6 is the GOES-18 visible image for the same period at 4X magnification and depicts an area of altocumulus clouds over the accident site. Most of the higher terrain is also covered in snow west of the accident site.

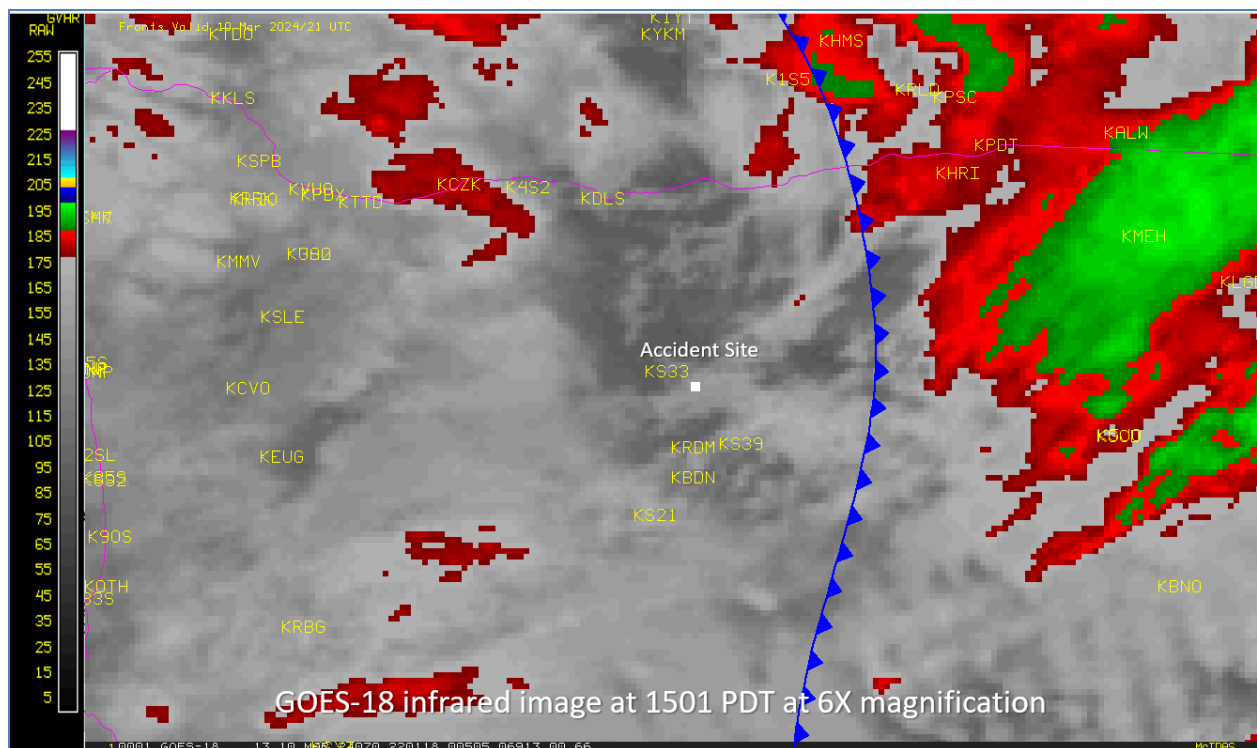


Figure 5 - The GOES-18 infrared image for 1501 PDT at 6X magnification with the accident site marked by the white square in an area of clouds with tops near 12,500 ft.

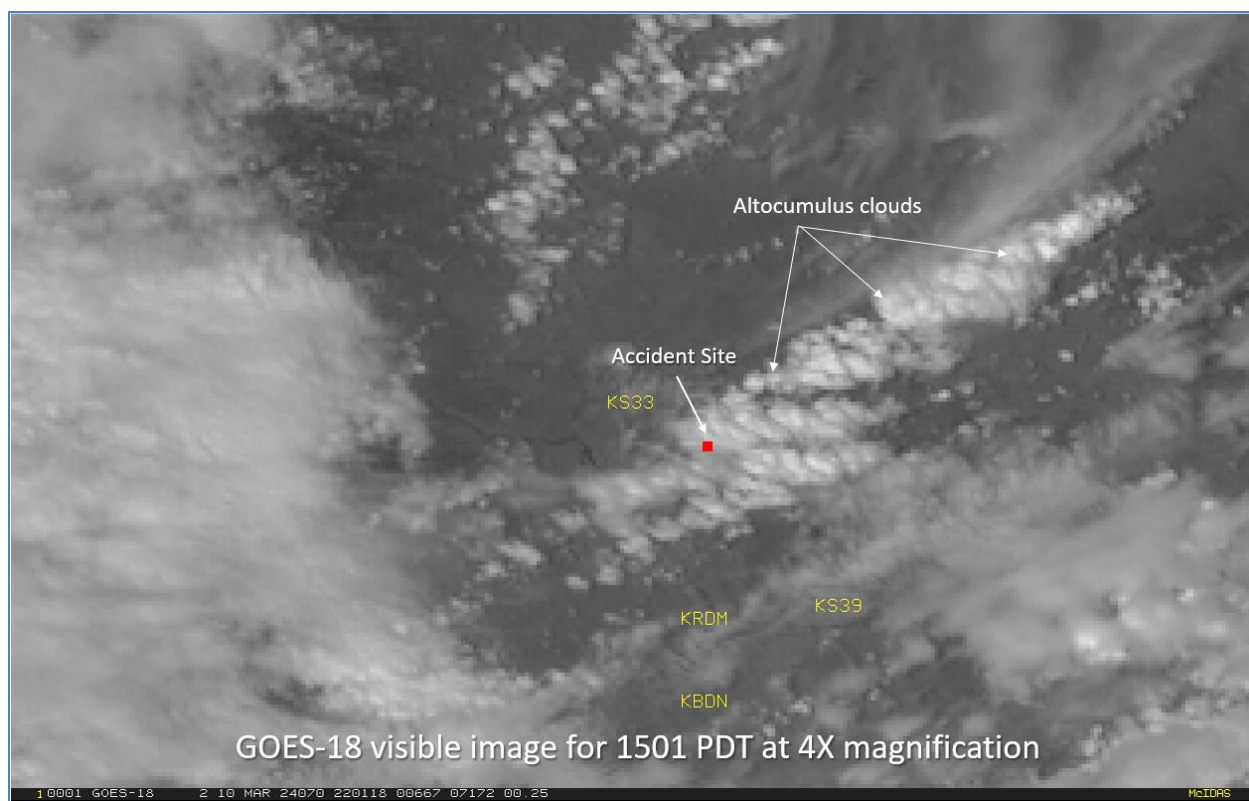


Figure 6 - The GOES-18 visible image for 1501 PDT at 4X magnification with the accident site marked by the red square in an area of altocumulus clouds.

5.0 Weather Surveillance Radar Imagery

The closest Weather Surveillance Radar 1988 Doppler (WSR-88D) was from the NWS Portland (KRDM) forecast office located about 106 miles northwest of the accident site. The Level II data was obtained and from the NCEI archive and displayed using the NOAA Weather and Climate Toolkit¹³. The WSR-88D is a S-band 10-centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width, with reflectivity being the most common display of data.

During the period, the KRDX WSR-88D was operating in the precipitation mode identified as volume scanning pattern 215 (VCP-215), where the radar makes 15 different elevation scans during the 6 minute volume scan. This volume scan is typically used in general precipitation situations and provides the most vertical resolution of any other scanning strategies. Based on the distance, an antenna height of 1,728 ft, the

¹³ NOAA's Weather and Climate Toolkit (WCT) is free, platform independent software distributed from NOAA's National Centers for Environmental Information (NCEI). The WCT allows the visualization and data export of weather and climate data, including Radar, Satellite and Model data.

lowest 0.48° elevation scan was centered near 14,570 ft over the accident site, and sampling the atmosphere between 9,230 and 19,910 ft.

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁴, it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ)¹⁵ and is a general measure of echo intensity. The FAA Aviation Weather Handbook¹⁶ defines echoes less than 30 dBZ as "light" in intensity, "moderate" echoes 30-40 dBZ, "heavy" with echoes of >40-50 dBZ, and "extreme" intensity with echoes above >50 dBZ. These are the new standard radio phraseology terms used by air traffic controllers to describe weather conditions to pilots as shown in figure 7. Light rain is typically reported at the surface when reflectivities reach 20 dBZ, while air traffic control weather displays typically do not display echoes less than 30 dBZ or light intensity echoes on their weather displays or disseminate alerts of any such echoes.

Reflectivity (dBZ) Ranges	Weather Radar Echo Intensity Terminology
< 30 dBZ	Light
30 – 40 dBZ	Moderate
>40 – 50 dBZ	Heavy
>50 dBZ	Extreme

Figure 7 - Reflectivity and radar echo intensity.

Figure 8 is the NWS KRDY WSR-88D 0.48° base reflectivity image for 1505 PDT and depicted no echoes over the last 13-minutes of the flight track. An area of very light intensity echoes of 30 dBZ or less were depicted over the western Cascade Mountain range and a few echoes of 0 to 15 dBZ were depicted immediately east and southwest of the accident site.

¹⁴ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at 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.

¹⁵ dBZ - Nondimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels, or dB) with respect to radar reflectivity factor, Z.

¹⁶ FAA Aviation Weather Handbook - WSR-88D Radar Precipitation Intensity Terminology (Table 24-8).

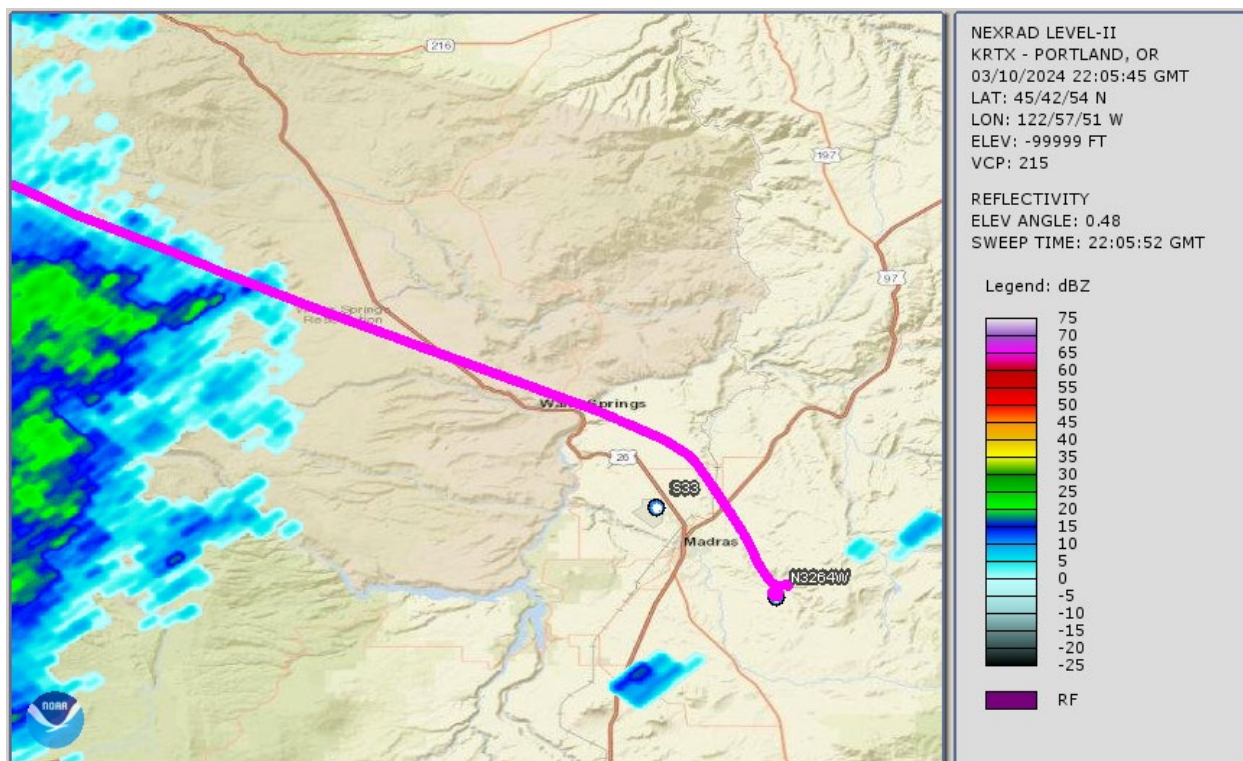


Figure 8 - NWS KRDM WSR-88D 0.48 base reflectivity image for 1505 PDT with the flight track of N3264W overlaid in magenta.

6.0 Pilot Reports

The following pilot reports (PIREPs) were disseminated longline¹⁷ within 100 miles of the accident site surrounding the period. The reports are in standard code and abbreviations with time referenced to UTC and were as follows.

PDX UA /OV PDX080020/TM 2025/FL130/TP B39M/TA M16/IC LGT OCNL MOD RIME/RM 130-060
DURD

PDX UA /OV BTG110035/TM 2037/FL100/TP E75L/TA M13/IC LGT-MOD CLR 100-120/RM WHAMY4
DURC ZSE

PDX UA /OV BTG145049/TM 2047/FL370/TP B789/SK LGT-MOD 370 LGT CHOP 380-390/RM ZSE

PDX UUA /OV KPDJ/TM 2047/FLDURGD/TP C56X/RM LLWS +/- 10 KTS

PDX UUA /OV KPDJ/TM 2105/FLDURGD/TP E75L/RM LLWS +/- 12 KTS

HIO UA /OV HIO/TM 2106/FLDURGD/TP C56X/RM DURD RY 13R CLOUD BASE 020

PDX UA /OV PDX080033/TM 2129/FL120/TP E75L/TA M11/IC LGT RIME 130-110

UAO UA /OV KUAO/TM 2148/FL025/TP SF50/SK BKN025-TOP033/IC NEG/RM DURC RY17

PDX UUA /OV KPDJ/TM 2150/FLDURGD/TP B739/TB MOD/RM LLWS +/-10

RDM UA /OV DSD303053/TM 2152/FL350/TP E75L/TB MOD/RM -ZSE

PSC UA /OV PDT260025/TM 2152/FL090/TP PC12/TB MOD 090-050

HIO UA /OV HIO31003/TM 2153/FLDURD/TP GLF6/SK OVC020/WX -RA/TB LGT

¹⁷ Includes only the reports official recorded and disseminated as a PIREP and may not include "ride reports" broadcasted or other conditions solicited by air traffic controllers and not entered in the formal PIREP format coding. These reports are available to user's in near real-time.

Accident 2203Z

EUG UA /OV EUG005045/TM 2207/FL330/TP E75L/TB LGT-MOD CAT 330/RM -ZSE
SLE UA /OV SLE/TM 2213/FL020/TP C680/SK BASE020/TB CONS CHOP 050 BLO/RM -ZSE
RDM UA /OV DSD300015/TM 2218/FL310/TP E75L/TB CONS LGT OCNL MOD/RM -ZSE
UAO UUA /OV KUAO/TM 2251/FL026/TP F2TH/SK BKN026-TOPUNKN/RM LLWS +/-15 KT 005-010
DURD RY17
CVO UA /OV CVO090030/TM 2256/FL100/TP BE20/TA M11/IC LGT MX/LGT CLR/RM DESCENDING
INTO CVO 100-045
PDX UA /OV BTG089023/TM 2301/FL280/TP E75L/TB MOD 280-330/RM ZSE
RDM UA /OV DSD200057/TM 2302/FL380/TP B738/TB LGT CHOP/RM MTN WAVE +/-10KTS ZSE
RDM UA /OV DSD345025/TM 2329/FL350/TP E75L/RM MTN WAVE +/-10KTS ZSE
PDX UA /OV PDX080020/TM 2330/FL110/TP E170/TA M10/IC MOD RIME/RM DURD 110-090
RDM UA /OV DSD320032/TM 2334/FL350/TP A321/RM MTN WAVE +/-15KTS ZSE

Most of the reports (9) noted encountering light-to-moderate turbulence over the region, with 3 additional reports of mountain wave at FL350¹⁸ and FL380 with airspeed changes +/- between 10 to 15 knots, with no appreciated turbulence. There were also 5 reports of light to moderate mixed icing in clouds below 13,000 ft. There were 2 urgent PIREPs from aircraft landing at KPDX reporting LLWS of +/- 12 knots.

7.0 NWS Forecast Products

7.1 Graphic Forecast for Aviation

The NWS Graphic Forecast for Aviation (GFA) is a graphical depiction of surface wind, thunderstorms, precipitation, color-coded general flight categories, and cloud cover bases and tops reported in msl heights, from graphical output from the NWS National Digital Forecast Database (NDFD) with the Graphic-Airmen's Meteorological Information (G-AIRMET) for IFR conditions, mountain obscuration, icing conditions, and strong surface wind overlaid. The GFA provides a forecast for the enroute phase of flight and for locations without a TAF. The GFA is available at the NWS AWC website and through other weather briefing services. The 9-hour GFA surface and cloud forecasts¹⁹ with the Graphic-AIRMETs valid for 1400 PDT are included below in figures 9 and 10. The GFA surface forecast (figure 9) indicated a chance of light rain over the region with south-southwesterly winds of 20 knots gusting to 25 knots, the chart also depicted Graphic-AIRMET for instrument flight rule (IFR) conditions over western Washington, Oregon, and northern California. While the GFA cloud forecast (figure 10) depicted a few clouds at 5,000 ft, and overcast clouds at 13,000 ft with tops to 20,000 ft. The image also included Graphic-AIRMET for occasional moderate icing conditions and mountain obscuration conditions over the accident site.

¹⁸ Flight Level (FL) used above 18,000 ft to report altitude referenced to pressure altitude in hundreds of feet.

¹⁹ Due to an archive issue with the NWS Aviation Weather Center these were the only images available for the accident period.

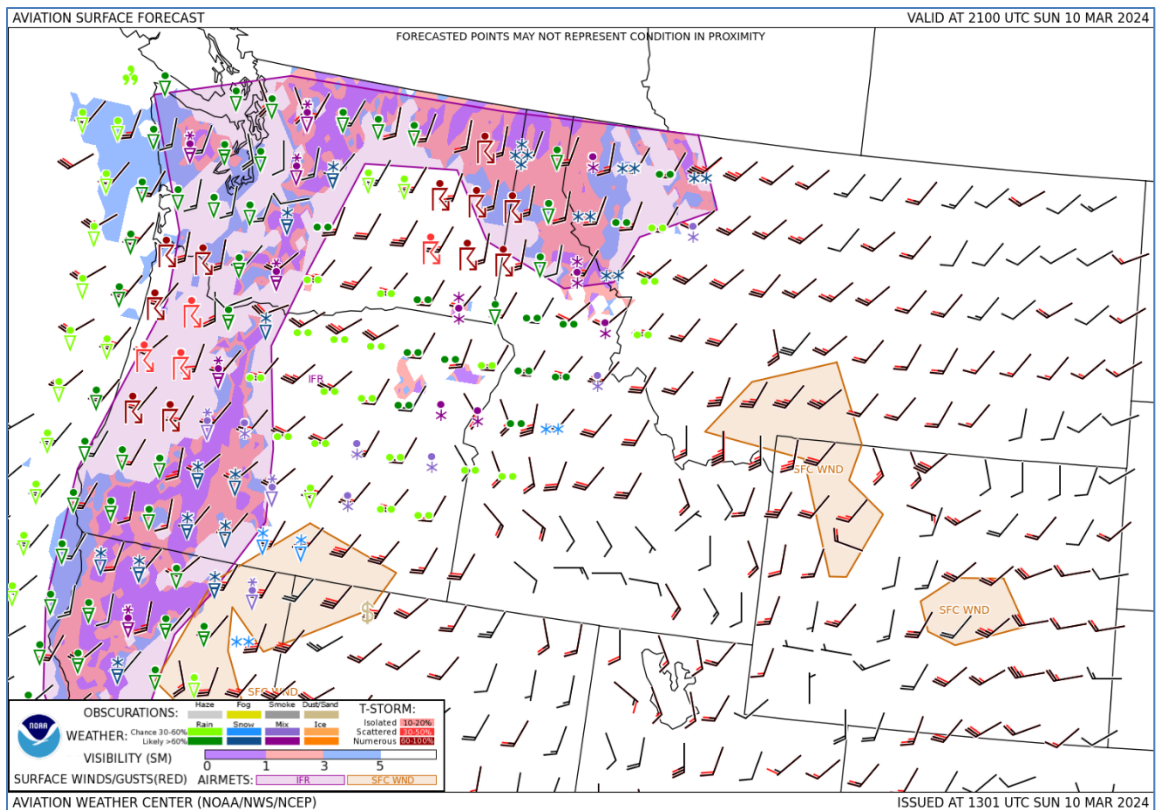


Figure 9 - Graphic Forecast for Aviation (GFA) Surface Forecast valid for the period.

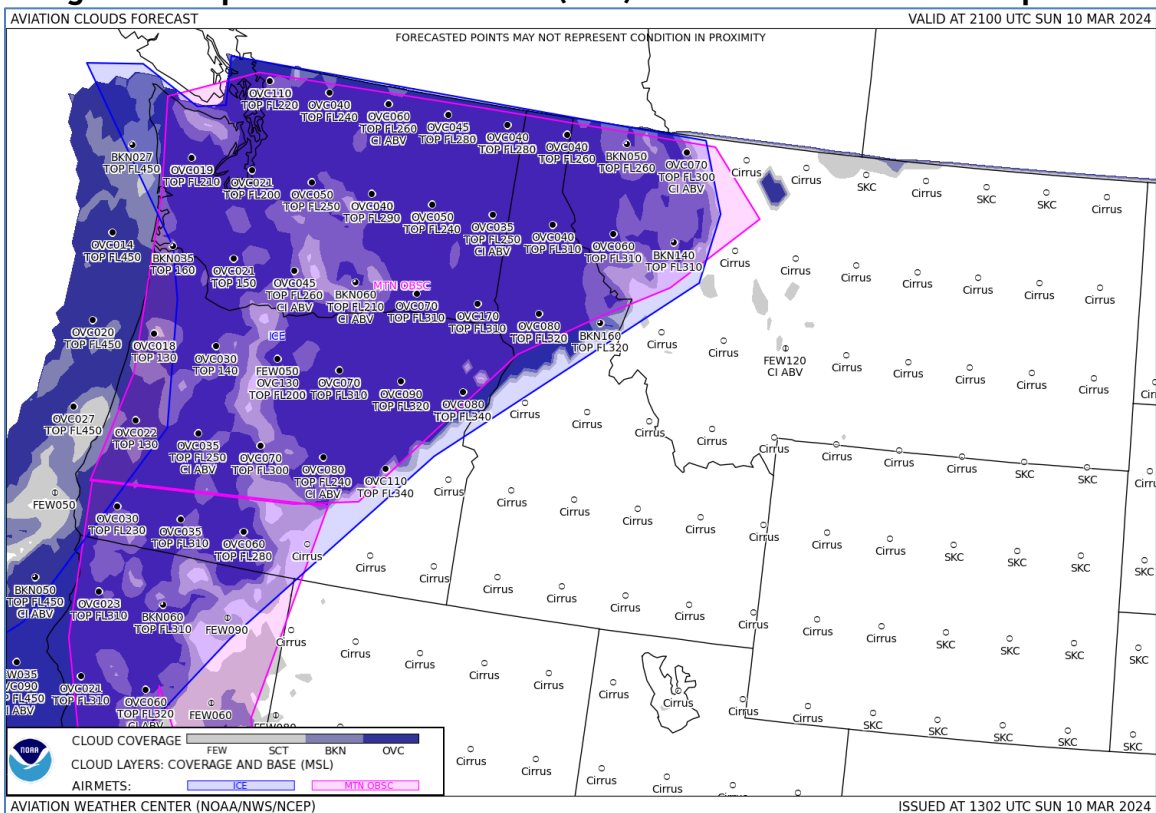


Figure 10 - Graphic Forecast for Aviation (GFA) Cloud Forecast valid for the period.

7.2 Winds Aloft Chart

The NWS AWC GFA winds at 12,000 ft over the region are depicted in figure 11, which depicted winds from the west-southwest at 60 knots over the accident site.

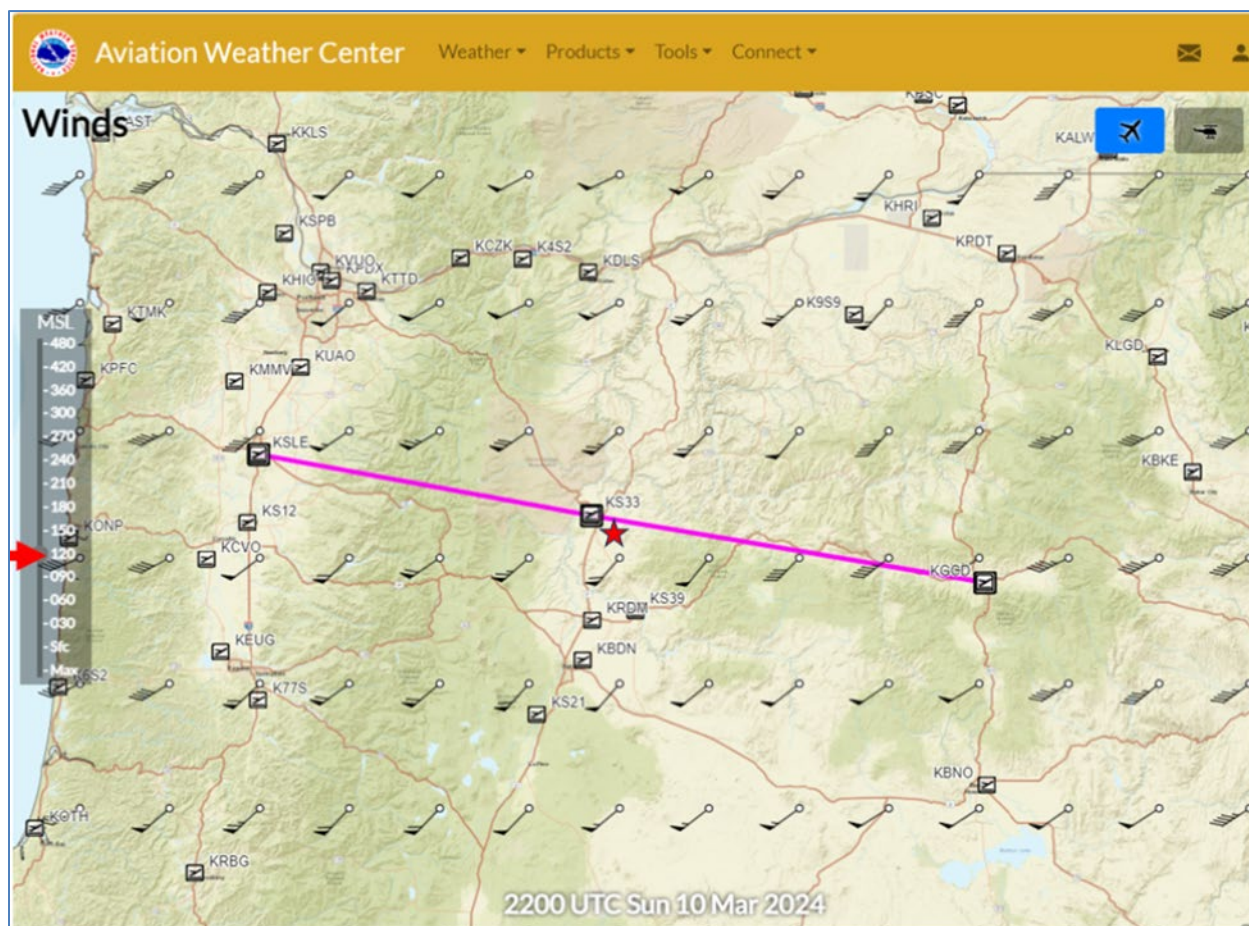


Figure 11 - NWS GFA winds aloft for 12,000 ft with the accident site marked by the red star and the general route across Oregon in pink for a cross sectional analysis.

The NWS Winds and Temperature Aloft Forecast current for the period and for use between 1300 through 2000 PDT for the 4 forecast points along the general route of flight were as follows.

FBUS31 KWNO 101957
FD1US1
-DATA BASED ON 101800Z
VALID 110000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
-PDX	2134	2345-04	2445-10	2444-16	2551-28	2751-33	255748	265654	244250
-RDM		2427-02	2447-09	2451-15	2463-23	2462-33	255148	254857	234555
-IMB			2533-07	2439-14	2364-26	2487-33	246948	246257	245557
-BOI		2122+05	2327-02	2436-10	2367-21	2480-33	248050	238160	256760

Stations

PDX - Portland, OR
RDM - Redmond, OR
IMB - Kimberly, OR
BOI - Boise, ID

The closest station to the accident site was Redmond (RDM) located about 25 miles south of the accident site. The forecast valid for 1700 PDT for 9,000 ft expected wind from 240° at 47 knots with a temperature of -9°C, and at 12,000 ft wind from 240° at 51 knots with a temperature of -15°C.

7.3 Graphic Turbulence Guidance

The current Graphic Turbulence Guidance (GTG) version 3.0 was developed by the National Center for Atmospheric Research (NCAR) and is run operationally at NOAA NCEP and is available to users on the NWS AWC website²⁰ over the continental United States. The GTG provides a computer-generated four-dimensional forecast related to the expected intensity of atmospheric turbulence provided in eddy dissipation rate (EDR)²¹. Typical EDR varies from close to 0 for "smooth", to near 1.0 for "extreme" for most aircraft types. NCAR defines the following EDR values to various aircraft weight classes and turbulence intensities and is included as figure 12, note the values are provided multiplied by 100 for ease of interpretation. The accident airplane fits into the lightweight category of less than 15,000 pounds.

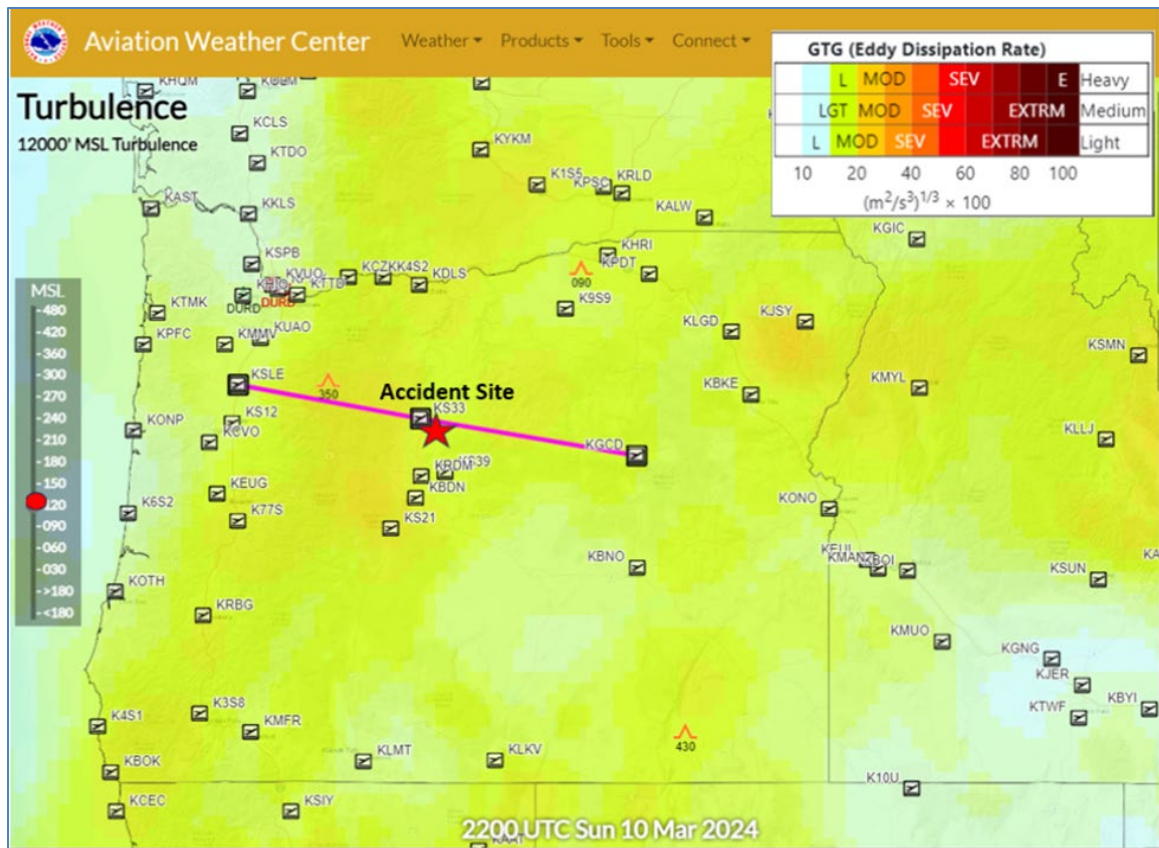
AC weight class	Estimated EDR Threshold * 100			
	Light	Moderate	Severe	Extreme
Light	13	16	36	64
Medium (Large)	15	20	44	79
Heavy	17	24	54	96

Figure 12 - Eddy Dissipation Rates (EDR) values versus turbulence potential.

The NWS AWC depiction of the Graphic Turbulence Guidance (GTG) at 1500 PDT for 12,000 ft is included as figure 13 and depicted EDR values consistent with light-to-moderate turbulence for a light-weight category aircraft. The purple line between KSLE, KS33, and KGCD was used to create a cross section over the general route of flight and is included as figure 14.

²⁰ <https://www.aviationweather.gov/turbulence>

²¹ EDR provided is actually the cube root of ϵ , or peak value of ϵ 1/3



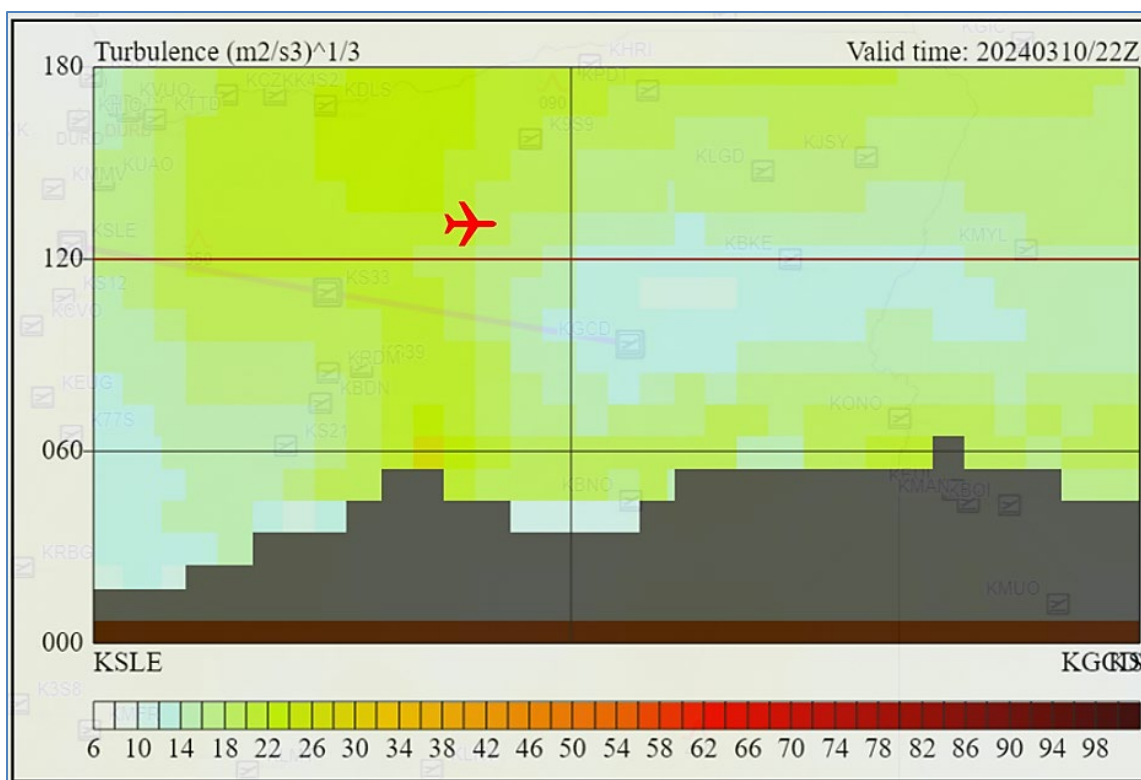


Figure 14 - NWS AWC GTG cross section between KSLE-KS33-KGCD, the aircraft position near 12,500 ft is depicted by the red aircraft symbol.

7.4 Current Icing Product

The NWS produces icing products that were developed by the Federal Aviation Administration and the National Center for Atmospheric Research (NCAR) computer models that describe the icing environment at the present and future periods based on National Weather Prediction (NWP) computer model data. These Current Icing Product (CIP) and Forecast Icing Product (FIP) products are available at the NWS AWC website and distributed by most weather briefing services. Information on the graphics are derived from NWP model output; and uses observational data, including WSR-88D, satellite, PIREPs, and surface weather reports, and lightning network data.

Based on an initial review of the weather conditions over the area the NTSB contacted the National Center for Atmospheric Research (NCAR) to provide a review of the icing products over the area during the period. NCAR provided the latest prototype CIP (PCIP) product which provided several enhanced features and enhanced resolution of 3 km over the current product being used by the NWS. The PCIP icing probability, icing severity, and supercooled large droplet (SLD) potential images for the period are included below for an enhanced analysis of the icing environment at the time of the accident.

7.4.1 Icing probability

The PCIP Icing Probability imagery for 11,000 ft, 12,000 ft and the maximum composite image for 1508 PDT are included as figures 15-18. The images depicted a large area of potential icing over western Oregon, over and west of the Cascades with a clear area, and then a narrow southwest to northeast band of icing that extending over the accident site. The imagery indicated a probability of 40% to 50% over the accident site at the time.

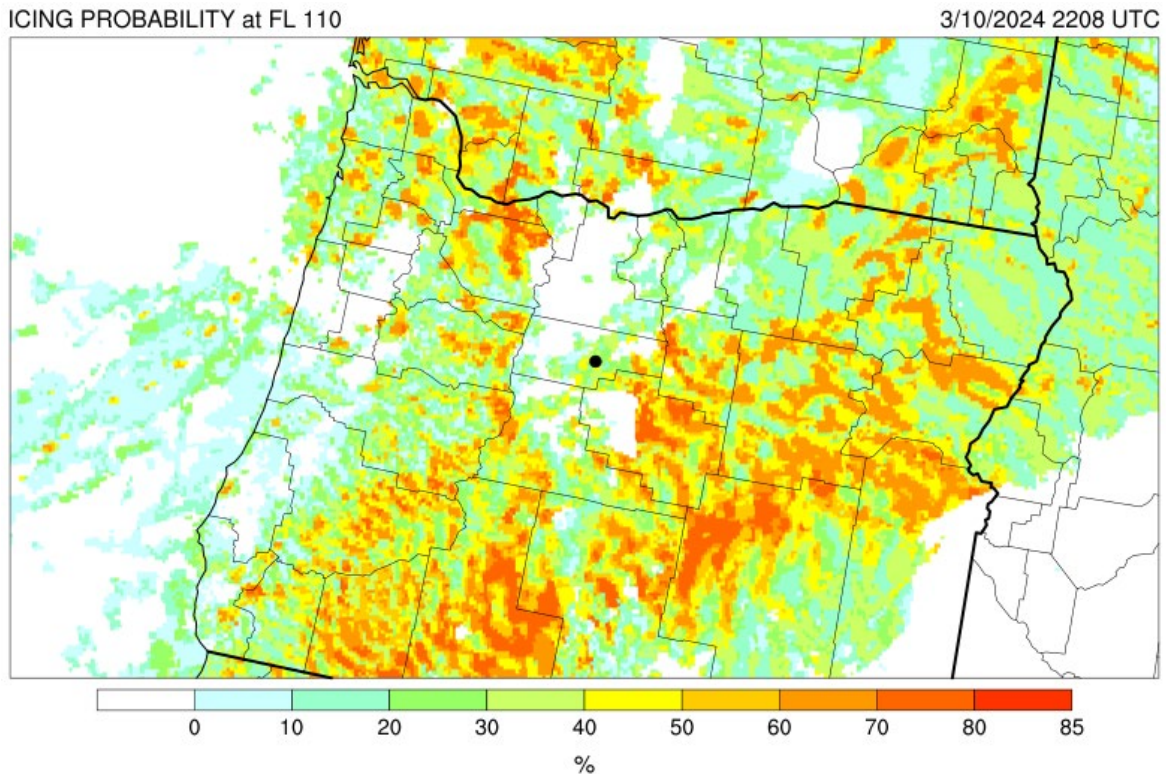


Figure 15 - NCAR Prototype-Current Icing Product (PCIP) Icing Probability at 11,000 ft for 1508 PDT.

ICING PROBABILITY at FL 120

3/10/2024 2208 UTC

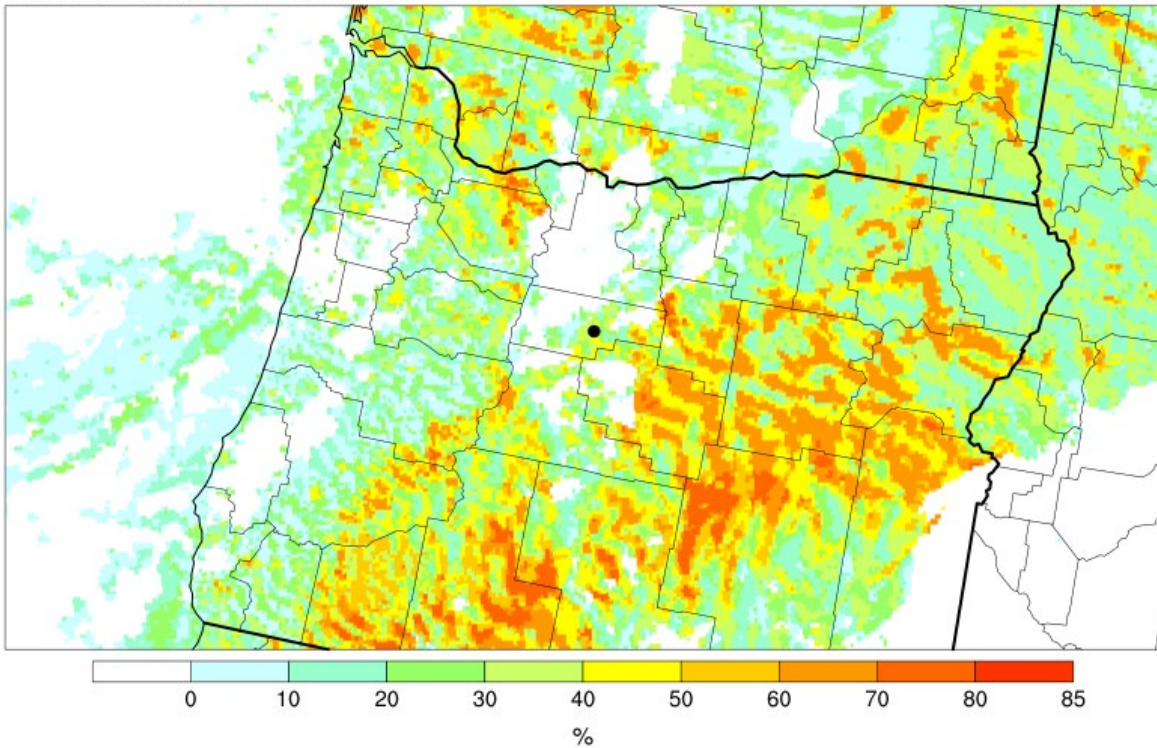


Figure 16 - NCAR Prototype-Current Icing Product (PCIP) Icing Probability at 12,000 ft for 1508 PDT.

ICING PROBABILITY COMPOSITE

3/10/2024 2208 UTC

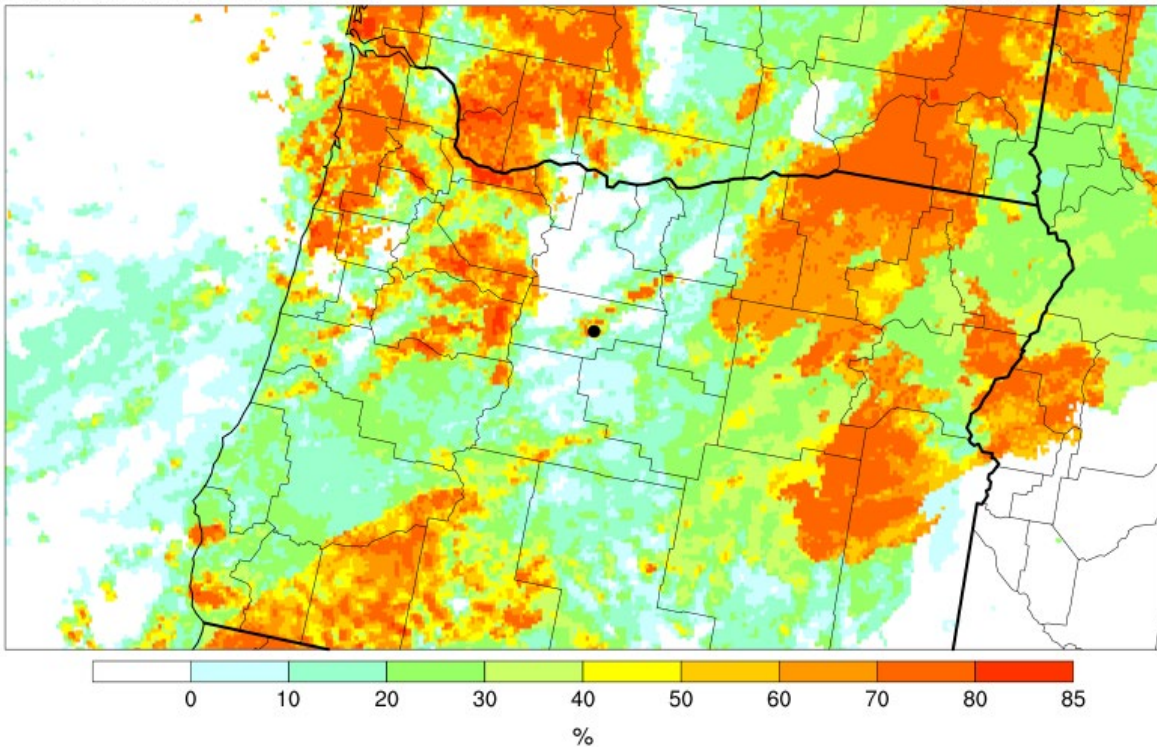


Figure 17 - NCAR Prototype-Current Icing Product (PCIP) Composite Icing Probability for 1508 PDT.

7.4.2 Icing Severity

The Icing Severity product depicts the icing intensity likelihood at locations where the Icing Probability product depicts possible icing. Icing intensity is displayed using icing intensity categories: trace, light, moderate, and heavy. The severity estimations 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 inch on ice: trace, 1 hour; light, 15 min-1 hour; moderate, 5-15 minutes; and heavy < 5 minutes. The rates are, in turn, estimated from the amount of supercooled liquid water expected with a nominal drop diameter of 15 microns (μm), and are further tuned by nearby pilot reports of encountered severity.

The NCAR PCIP Icing Severity depiction of the most likely icing intensity for 11,000 ft, 12000 ft, and the maximum category are included as figures 18-20. The images depict moderate to heavy icing intensity over the accident site at 1508 PDT.

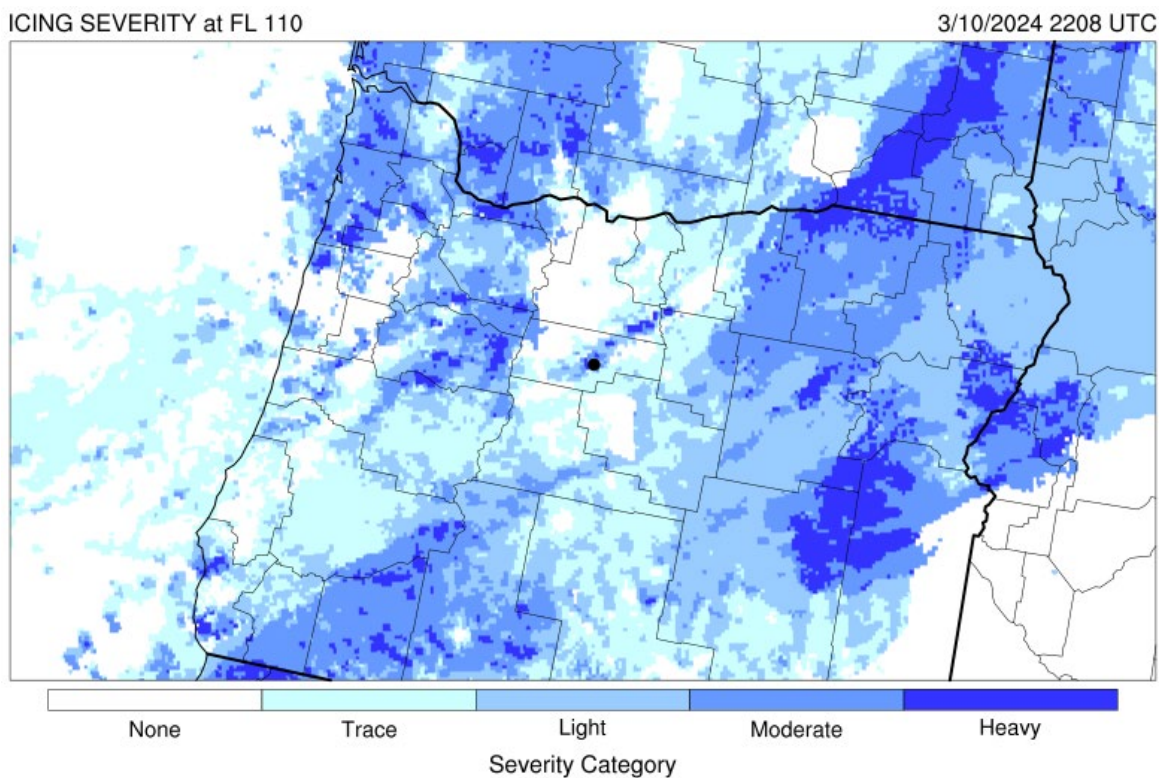


Figure 18 - NCAR Prototype-Current Icing Product (PCIP) Icing Severity at 11,000 ft for 1508 PDT.

ICING SEVERITY at FL 120

3/10/2024 2208 UTC

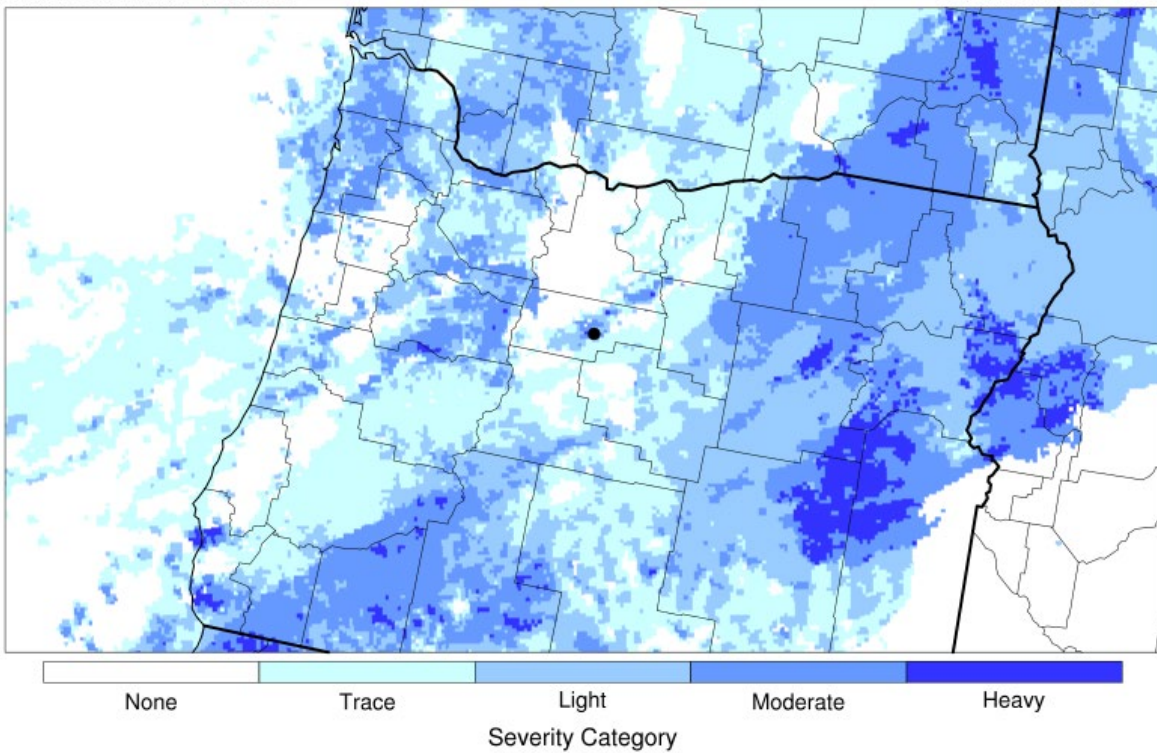


Figure 19 - NCAR Prototype-Current Icing Product (PCIP) Icing Severity at 12,000 ft for 1508 PDT.

ICING SEVERITY COMPOSITE

3/10/2024 2208 UTC

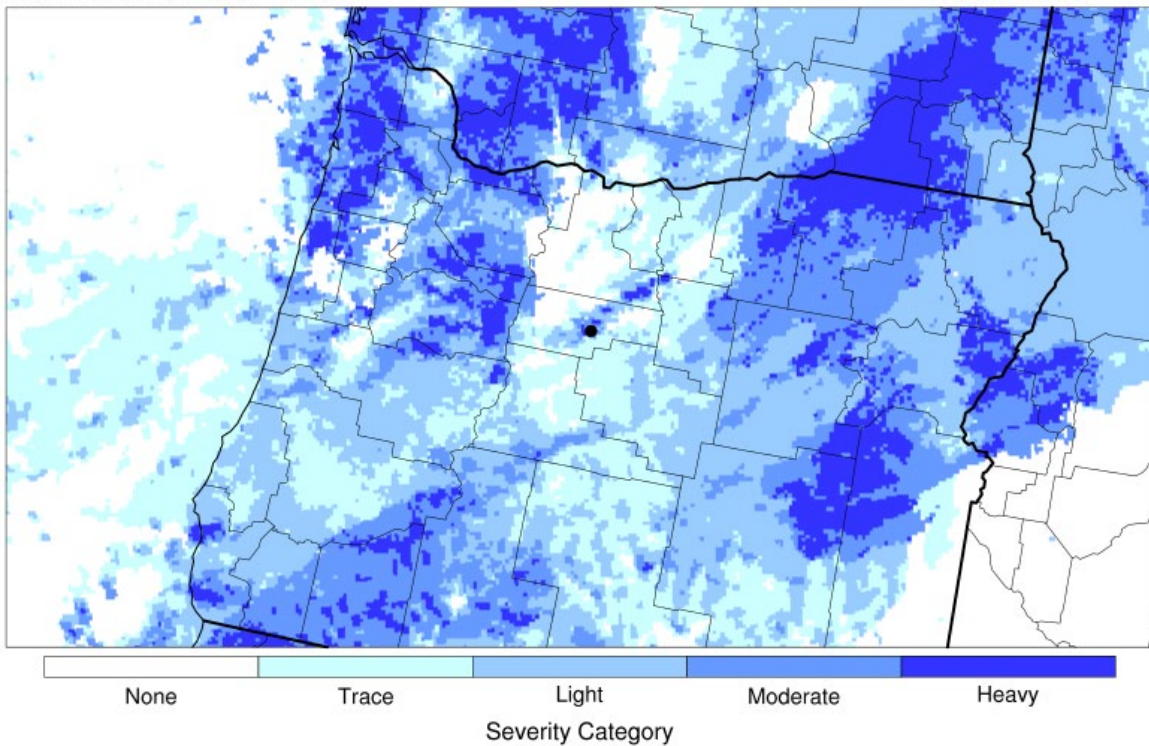


Figure 20 - NCAR Prototype-Current Icing Product (PCIP) Icing Severity Composite for 1508 PDT.

7.4.3 Supercooled Large Droplet Potential

Supercooled large droplets are defined as droplets with a median volumetric diameter of 50 microns in size and are in the liquid state with temperatures below 0°C. The PCIP SLD Potential charts for 11000 ft, 12000 ft, and the maximum composite charts for 1508 PDT are included as figures 21-23. The images depicted an approximately 20% probability of encountering SLD conditions over the accident site at altitude, with the maximum composite image depicting up to a 45% probability.

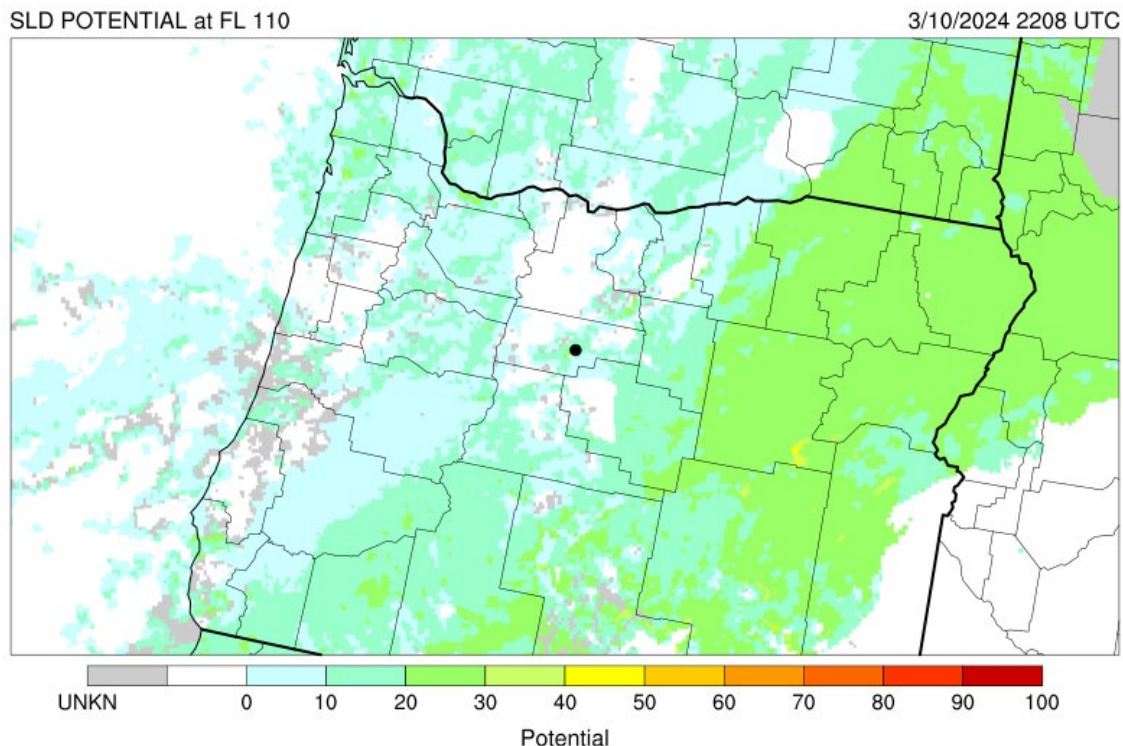


Figure 21 - NCAR Prototype-Current Icing Product (PCIP) Supercool Large Droplet (SLD) Potential at 11,000 ft for 1508 PDT.

SLD POTENTIAL at FL 120

3/10/2024 2208 UTC

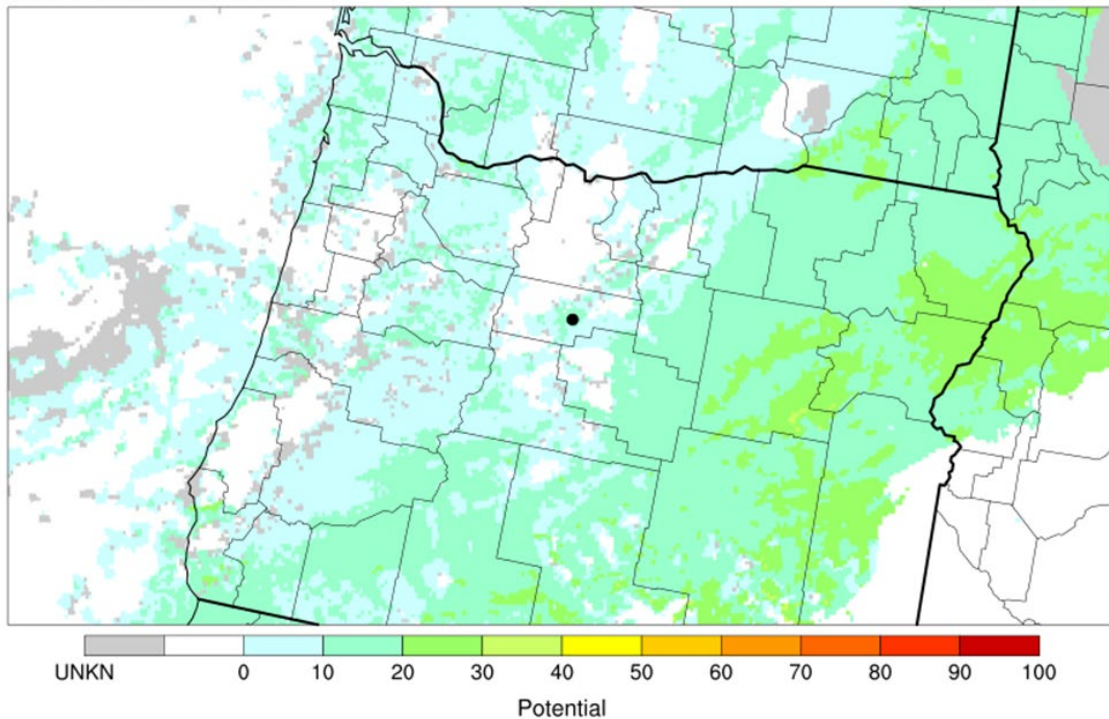


Figure 22 - NCAR Prototype-Current Icing Product (PCIP) Supercool Large Droplet (SLD) Potential at 12,000 ft for 1508 PDT.

SLD COMPOSITE

3/10/2024 2208 UTC

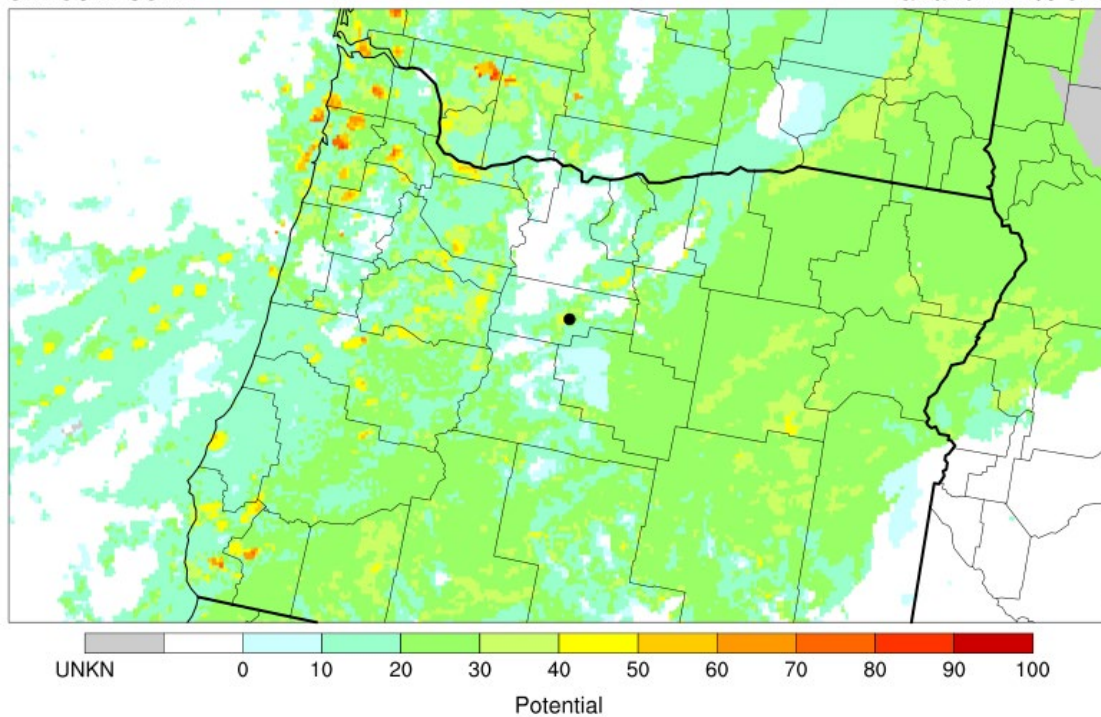


Figure 23 - NCAR Prototype-Current Icing Product (PCIP) Supercool Large Droplet (SLD) Maximum Composite Potential for 1508 PDT.

8.0 NWS Inflight Weather Advisories

In-flight Aviation Weather Advisories are forecasts that advise en route aircraft of the development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) at the various Air Route Traffic Control Centers (ARTCCs). There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the Graphic - Airmen's Meteorological Information (G-AIRMET), and the Center Weather Advisory (CWA). Inflight advisories serve to notify en-route pilots of the possibility of encountering hazardous flying conditions that 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 based on experience and the operational limits of the aircraft. Once issued they are broadcast by FAA air traffic controllers upon issuance and available on inflight weather broadcasts.

At the time of the accident the NWS did not have any SIGMETs, Convective SIGMETs, or CWAs current over the area. The NWS did have a series of G-AIRMETs current for mountain obscuration, low-level wind shear, occasional moderate turbulence below 18,000 ft, and moderate icing conditions between the freezing level and 18,000 ft over the region and are documented in figures 24-26. The G-AIRMETs are valid for specific time "snapshots". The advisories below were valid for the period of the accident.

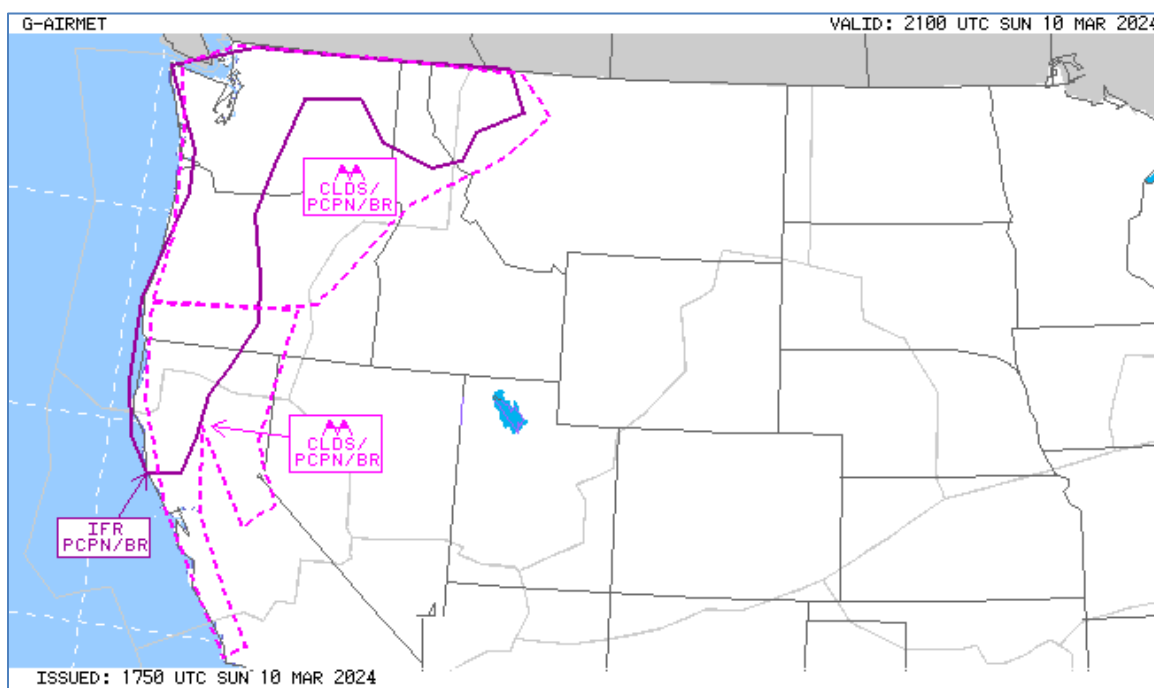


Figure 24 - Graphic-AIRMET Sierra for IFR and mountain obscuration conditions valid at the time.

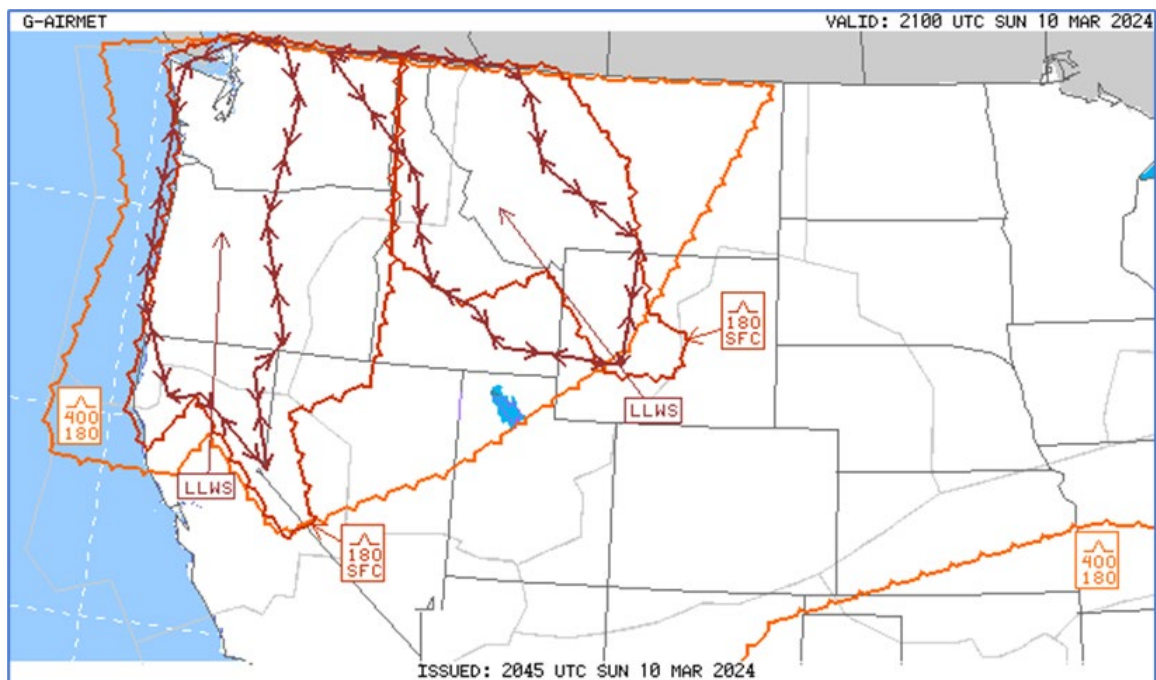


Figure 25 - Graphic-AIRMET Tango series for low-level wind shear and moderate turbulence.

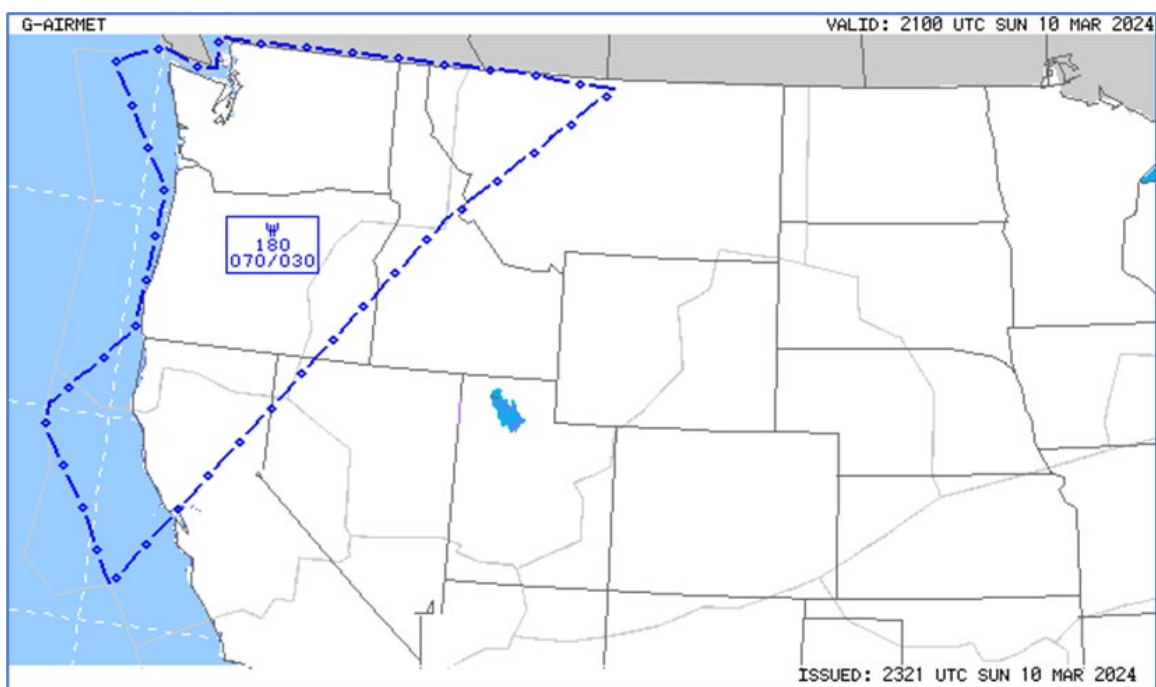


Figure 26 - Graphic-AIRMET Zulu for icing conditions between the freezing level and 18,000 ft.

9.0 Pilot Weather Briefing

There was no record of any contact from FAA contract Automated Flight Service Station (AFSS) provider Leidos or any 3rd party vendors using the Lockheed Flight Service System having any contact with the accident pilot on the day of the accident.

A separate search of ForeFlight and FlightPlan.com (fltPlan.Com) also indicated no requests for weather briefing services on the day of the accident. It is therefore unknown what weather information the pilot may have used to brief himself prior to departure on the reported and forecast conditions along the route.

F. ATTACHMENTS

Attachment 1 - GOES-18 infrared satellite imagery surrounding the period.

Attachment 2 - GOES-18 low-level water vapor imagery surrounding the period.

Attachment 3 - GOES-18 visible imagery surrounding the period.

Submitted by:

Donald Eick
NTSB Senior Meteorologist