

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ANC24FA063

METEOROLOGY

Specialist's Factual Report

August 6, 2024

TABLE OF CONTENTS

A. ACCIDENT.....	3
B. METEOROLOGY INVESTIGATOR	3
C. SUMMARY	3
D. DETAILS OF THE INVESTIGATION	3
E. FACTUAL INFORMATION.....	4
1.0 SYNOPTIC CONDITIONS	4
1.1 Pacific Surface Analysis Chart.....	4
2.0 SURFACE OBSERVATIONS	5
2.1 Kekaha, Hawaii	5
2.2 Lihue, Hawaii	7
2.3 NWS Aviation Weather Center Depiction	8
2.4 Lower Limahuli, Hawaii.....	9
3.0 FAA WEATHER CAMERA IMAGERY	9
3.1 Makaha Ridge, Hawaii	10
3.2 Princeville, Hawaii	11
4.0 HANALIE BUOY DATA.....	13
5.0 PILOT REPORTS	13
6.0 ATMOSPHERIC SOUNDING.....	13
7.0 SATELLITE IMAGERY	16
8.0 WEATHER RADAR IMAGERY	19
9.0 WEATHER RESEARCH AND FORECAST MODEL.....	22
10.0 NWS FORECAST PRODUCTS	25
10.1 Terminal Aerodrome Forecast.....	26
10.2 Area Forecast Discussion.....	26
10.3 Graphic Forecast for Aviation.....	27
10.4 Inflight Weather Advisories	27
11.0 WITNESS STATEMENTS	29
F. ATTACHMENTS.....	29

A. ACCIDENT

Location: Kekaha, Hawaii
Date: July 11, 2024
Time: 1305 Hawaiian standard time (HST)
2305 coordinated universal time (UTZ)
Helicopter: Robinson R44; Registration: N144KW

B. METEOROLOGY INVESTIGATOR

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

C. SUMMARY

On July 11, 2024, about 1305 Hawaii-Aleutian standard time, a Robinson R44 helicopter, N144KW, sustained substantial damage when it was involved in an accident near Kekaha, Hawaii. The pilot and two passengers were fatally injured. The helicopter was operated as a Title 14 Code of Federal Regulations Part 91 sightseeing flight.

The accident helicopter, owned by Aloha Helicopter Tours LLC, dba Ali'I Air Tours, was conducting a doors-off, sightseeing flight around the island of Kauai. The helicopter departed from the Lihue Airport (PHLI), at about 1230 for a one-hour tour of the island of Kauai.

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 HST based upon the 24-hour clock, local time is -10 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 and "P" for Pacific region

and followed by “H” for Hawaii. 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 22.183594° north and longitude 159.64597° west, at sea level.

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 Pacific Surface Analysis Chart

The NWS Pacific Surface Analysis Chart for 1400 HST (0000Z July 12, 2024) is included as Figure 1. The chart depicted a high-pressure system at 1031-hectopascals (hPa)² located near 44°N and 137°W extended off the eastern Pacific with a ridge extending southwestward. A normal trade wind³ flow of easterly winds extended over the Hawaiian Islands with no tropical disturbances or frontal systems depicted over the region.

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

² Hectopascal (hPa) is the standard unit for reporting 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 15° Celsius (C) or 59° Fahrenheit (F).

³ The trade winds or “easterlies” are permanent east-to-west prevailing winds that flow in the Earth’s equatorial region. In the northern hemisphere, the trade winds blow mainly from the northeast. In meteorology, they act as the steering flow for tropical storms. The trade winds are characterized by shallow cumulus clouds that are capped by a trade wind inversion, which is caused by descending air aloft from within the subtropical ridge.

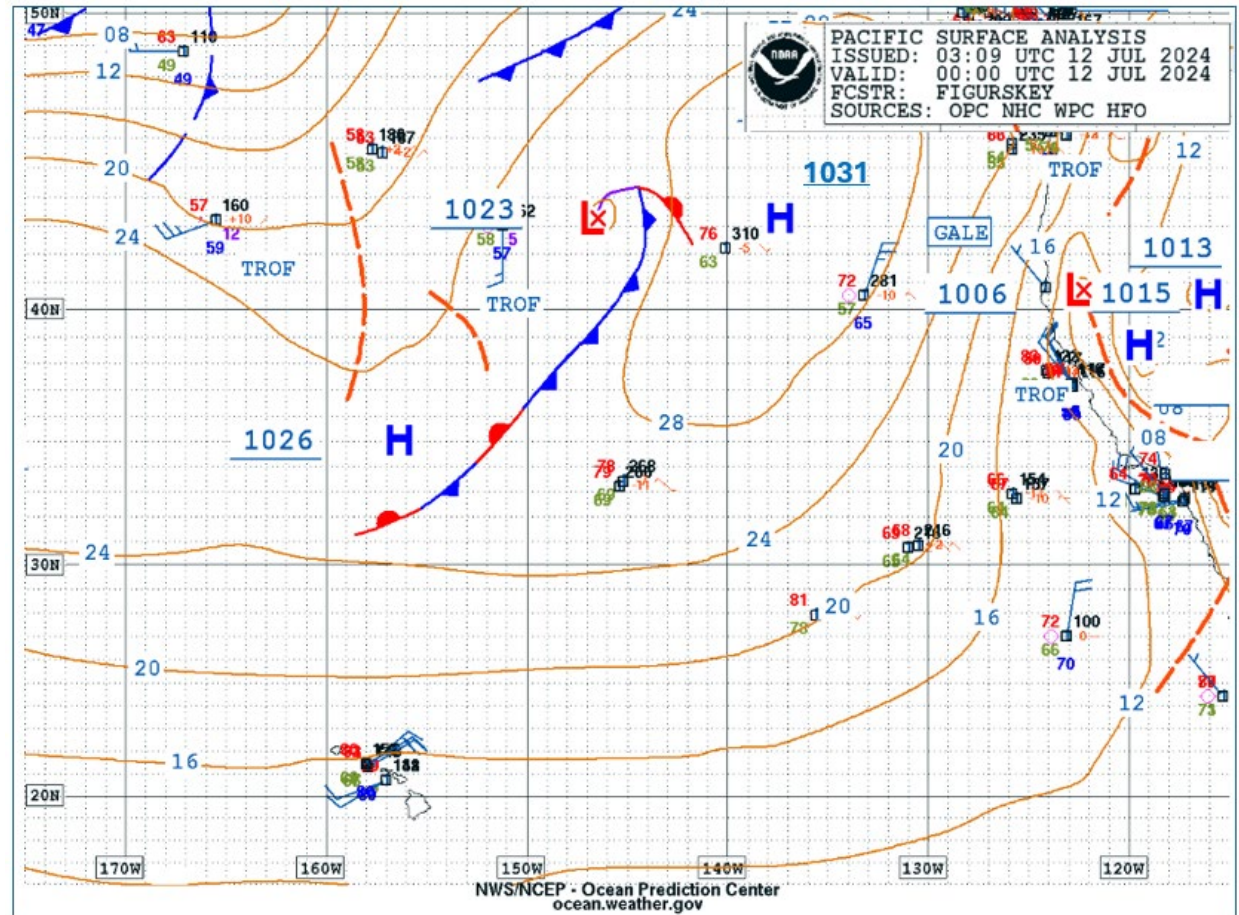


Figure 1 - NWS Pacific Surface Analysis for 1400 HST on July 11, 2024.

2.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METAR⁴), 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 9.5° east based on the latest sectional chart for the area.

2.1 Kekaha, Hawaii

The closest weather reporting station was from Barking Sands Pacific Missile Range Facility Airport (PHBK), Kekaha, HI, located about 14 miles southwest of the accident site at an elevation of 23 ft. The military airport had an Automated Surface Observation System (ASOS), which was not augmented by any personnel during the period. The following conditions were reported surrounding the time of the accident:

⁴ METAR is an abbreviation for Meteorological Aerodrome Report.

PHBK weather observation at 1251 HST, automated, wind from 020° at 11 knots gusting to 25 knots, visibility 10 miles or greater, ceiling broken at 5,500 ft agl, temperature 32°C (90°F), dew point temperature 21°C (70°F), altimeter setting 29.99 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, peak wind from 360° at 27 knots recorded at 1222 HST, sea-level pressure 1015.6-hPa, temperature 32.2°C, dew point 20.6°C.

PHBK special weather observation at 1308 HST, automated, wind from 340° at 10 knots gusting to 21 knots, visibility 10 miles or greater, ceiling overcast at 5,000 ft agl, temperature 31°C (88°F), dew point temperature 21°C (70°F), altimeter setting 29.98 inHg. Remarks: automated station with a precipitation discriminator, temperature 31.1°C, dew point 21.1°C.

The general flight categories⁵ and raw observation in standard METAR format surrounding the period from about 1100 through 1530 HST were as follows, the observations in bold type have been decoded above:

VFR *METAR PHBK 112051Z AUTO 34010G22KT 300V360 10SM SCT055 33/21 A3000 RMK AO2 SLP162
T03280206 58006=*

VFR *SPECI PHBK 112125Z AUTO VRB04KT 10SM BKN050 BKN060 33/21 A3000 RMK AO2 T03280206=*

VFR *SPECI PHBK 112128Z AUTO VRB05KT 10SM BKN055 32/21 A3000 RMK AO2 T03220211=*

VFR *METAR PHBK 112151Z AUTO 33015G20KT 10SM BKN055 33/21 A2999 RMK AO2 SLP157 T03280206=*

**VFR METAR PHBK 112251Z AUTO 02011G25KT 10SM BKN055 32/21 A2999 RMK AO2 PK WND
36027/2222 SLP156 T03220206=**

Accident 2305Z

VFR SPECI PHBK 112308Z AUTO 34010G21KT 10SM OVC050 31/21 A2998 RMK AO2 T03110211=

VFR *SPECI PHBK 112338Z AUTO 27008G19KT 10SM SCT050 32/21 A2997 RMK AO2 T03170206=*

VFR *METAR PHBK 112351Z AUTO 27011G17KT 10SM SCT055 32/21 A2997 RMK AO2 SLP149 T03220211
10350 20289 58013=*

⁵ 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 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.

VFR METAR PHBK 120051Z AUTO VRB05KT 10SM 34/21 A2994 RMK AO2 SLP140 T03390206 \$=
VFR SPECI PHBK 120106Z AUTO 10SM BKN050 33/20 A2994 RMK AO2 T03330200 \$=
VFR SPECI PHBK 120125Z AUTO 30007G17KT 10SM BKN055 33/21 A2994 RMK AO2 T03280206 \$=

A review of the observations surrounding the period indicated that VFR conditions prevailed surrounding the period with generally northwesterly winds at 5 to 10 knots with gusts upwards to 27 knots, with a ceiling broken to overcast layer of clouds near 5,000 ft agl. No rain was detected at the station surrounding the period.

2.2 Lihue, Hawaii

The next closest weather reporting station was Lihue Airport (PHLI), located about 24 miles southeast of the accident site at an elevation of 152 ft. The accident helicopter departed from PHLI at about 1230 HST. The airport had an Automated Surface Observation System (ASOS) and was augmented by air traffic controllers during normal operating hours reported the following conditions surrounding the period.

PHLI weather observation at 1253 HST, wind from 020° at 17 knots, visibility 10 miles or greater, a few clouds at 4,800 ft agl, scattered at 6,000 ft, temperature 28°C (82°F), dew point temperature 21°C (70°F), altimeter setting 30.04 inHg. Remarks: automated station with a precipitation discriminator, peak wind from 060° at 29 knots recorded at 1155 HST, rain ended at 1209 HST, sea-level pressure 1017.0-hPa, hourly precipitation 0.01 inches, temperature 27.8°C, dew point 21.1°C.

The general flight categories and raw observation in standard METAR format surrounding the period from about 0800 through 1600 HST were as follows, the observations in bold type have been decoded above:

VFR METAR PHLI 111753Z 05019G25KT 9SM FEW019 BKN032 OVC055 26/22 A3007 RMK AO2 RAB42E52 SLP178 P0000 60000 T02560222 10256 20250 51016=
VFR METAR PHLI 111853Z 04014KT 10SM FEW021 SCT055 27/22 A3007 RMK AO2 SLP179 T02720217=
MVFR SPECI PHLI 111943Z 07017G27KT 4SM -RA FEW017 SCT022 BKN029 26/22 A3008 RMK AO2 PK WND 06027/1943 RAB10 P0000 T02560217=
MVFR METAR PHLI 111953Z 05014KT 3SM -RA BR FEW022 BKN035 OVC048 25/23 A3007 RMK AO2 PK WND 06027/1943 RAB10 SLP179 P0001 T02500228=

VFR METAR PHLI 112053Z 03017KT 10SM FEW016 SCT024 28/22 A3007 RMK AO2 RAE05 SLP178 P0000
60001 T02780222 50000=

MVFR METAR PHLI 112153Z 05022KT 5SM -RA FEW023 BKN038 OVC047 25/22 A3007 RMK AO2 PK WND
05030/2146 RAB06E17B48 SLP178 P0000 T02500217=

Departed 2231Z

VFR METAR PHLI 112253Z 02017KT 10SM FEW048 SCT060 28/21 A3004 RMK AO2 PK WND
06029/2155 RAE09 SLP170 P0001 T02780211=

Accident 2305Z

VFR METAR PHLI 112353Z 04016KT 10SM FEW060 29/22 A3002 RMK AO2 SLP164 60002 T02940222
10294 20239 58014=

VFR METAR PHLI 120053Z 05016KT 10SM SCT026 BKN032 28/22 A3002 RMK AO2 SLP161 T02830217=

VFR METAR PHLI 120153Z 05017KT 10SM FEW022 28/22 A3001 RMK AO2 SLP157 T02780217=

A review of the observations surrounding the period indicated that VFR conditions with brief MVFR conditions in light rain showers prevailed surrounding the period with generally northeasterly winds at 10 knots gusting upwards to 30 knots, with scattered to broken clouds between 2,500 ft to 5,500 ft agl.

2.3 NWS Aviation Weather Center Depiction

A depiction from the NWS Aviation Weather Center's (AWC) METAR display⁶ for 1315 HST is included as figure 2 with the approximate accident site marked by the red star. The NWS lowest radar elevation scan for 1230 HST is also overlaid and showed a few scattered light intensity echoes of 20 dBZ⁷ or less scattered across the island. The METAR observations are shown in graphic format with temperature and dew point temperatures in degrees Fahrenheit (°F).

⁶ <https://aviationweather.gov/gfa/#obs>

⁷ dBZ - Nondimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels, or dB) with respect to radar reflectivity factor, Z.

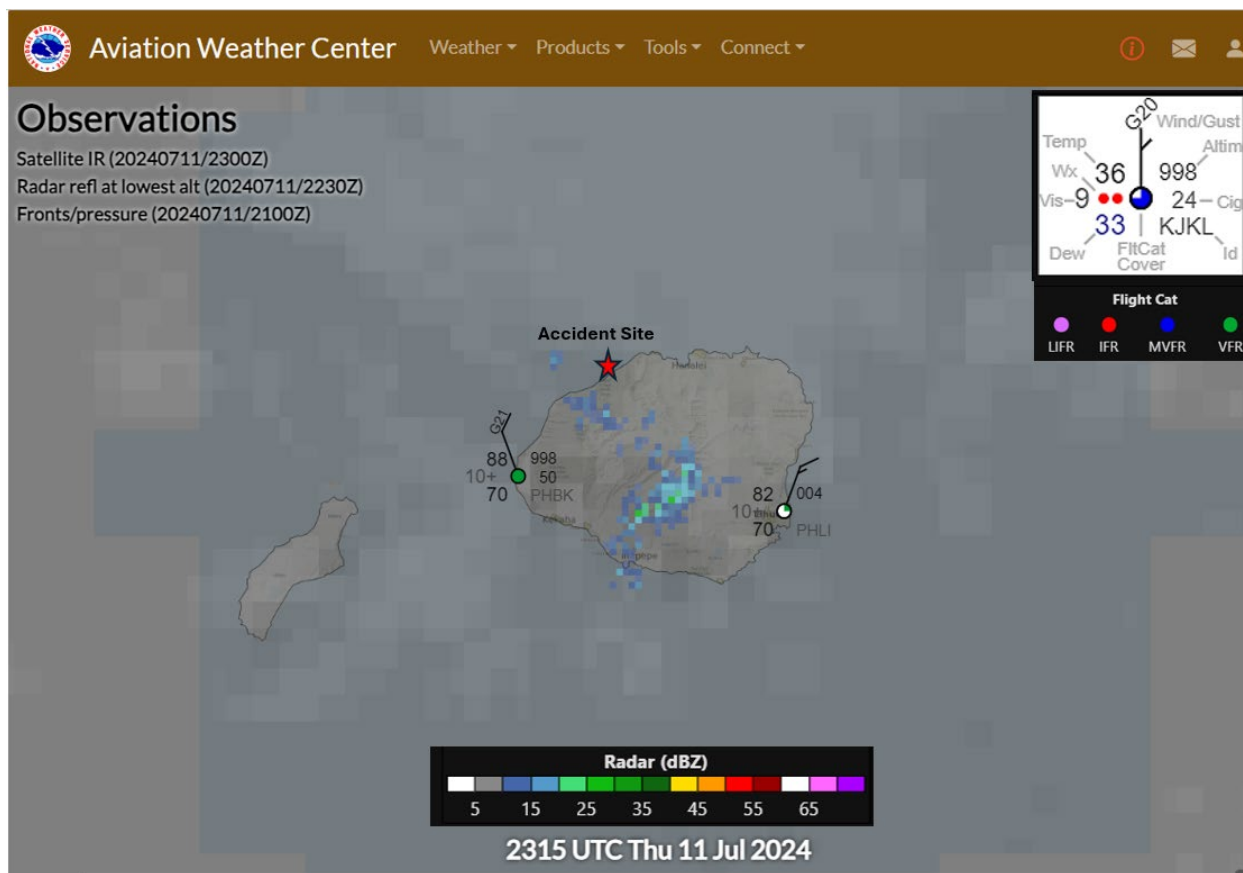


Figure 2 - NWS Aviation Weather Center METAR display for 1315 HST with the approximate accident site noted by the red star. Image includes a satellite and radar overlaid for the period.

2.4 Lower Limahuli, Hawaii

A non-federal weather station was located approximately 5 miles east-northeast (061°) of the accident site at Lower Limahuli (024HI) at latitude 22.2198° north and longitude 159.5752° west, with an elevation of 102 ft. The station was operated by the University of Hawaii's Mesonet⁸ and was not approved for aviation use. At 1315 HST the station reported a wind from the north at 3 knots with peak gusts to 10 knots, a temperature of 81°F, a dew point temperature of 69°F, with a relative humidity of 69%. No significant wind gusts over 12 knots were noted surrounding the period.

3.0 FAA Weather Camera Imagery

The FAA Weather Camera imagery⁹ for the two closest stations from 1200 through 1330 HST at approximately every 10-minutes were captured and reviewed.

⁸ <https://www.wrrc.hawaii.edu/hawaii-mesonet/>

⁹ <https://weathercams.faa.gov/>

Pilots are encouraged to use the weather camera images to improve situational awareness of the weather conditions and in addition the camera location provide basic weather conditions at the site.

3.1 Makaha Ridge, Hawaii

The Makaha Ridge (PHBK) weather camera was location was approximately 6 miles southwest of the accident site at an elevation of 1,800 ft. Figure 3 is a depiction of PHBK weather camera location and viewing capability with the approximate accident site marked by a red star. The PHBK north camera viewed the conditions in the general direction of the accident, which was just right of the field of view.



Figure 3 -FAA Makaha Ridge Weather Camera location and viewing capability and accident site.

Figure 4 is a still image of PHBK north camera view on a clear day (left) with distance markers and at 1307 HST immediately after the accident (right) on July 11, 2024. The image depicted a layer of low stratiform clouds offshore with scattered clouds extending over the area near the general accident site and the camera location with visibility unrestricted at the time. White caps¹⁰ are observed on the ocean surface.

¹⁰ White caps also known as "white horses" result from wave breaking caused by steepness in deeper water. They occur when the height of the waves is larger than the wavelength. They are typically formed when wind speed reaches Beaufort scale 5 or more (wind speeds of 7 to 10 knots). The higher the wind speed, the more whitecaps are formed. They indicate a higher wind speed and may indicate worsening

Attachment 1 is an animation of the FAA PHBK north weather camera imagery during the period.

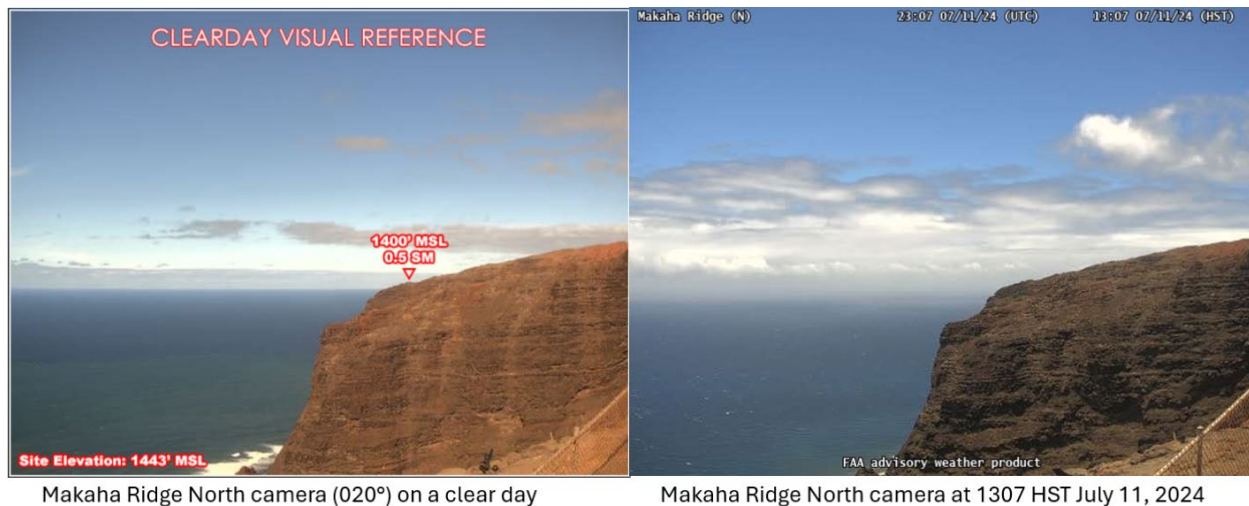


Figure 4 - Makaha Ridge North image on a clear day (left) and at 1307 HST (right), accident is off the right of the viewing image.

At 1311 HST PHBK recorded a temperature of 83°F, a dew point temperature of 67°F, a relative humidity of 59%, with a wind from 060° at 2 knots with gusts to 9 knots. A review of the winds indicated no recorded wind gusts over 12 knots surrounding the period.

3.2 Princeville, Hawaii

The FAA Princeville (QQK) weather camera was located about 10 miles east-northeast of the accident site at an elevation of 151 ft. Figure 5 is a depiction of QQK weather camera location and viewing capability with the approximate accident site marked by a red star. The QQK west camera was viewing in the direction of the accident but was obscured by the high ridge near Makana point about 5.3 miles west of the camera.

Figure 6 is a depiction of the FAA QQK west camera view on a clear day (left) with visibility markers identified and at 1305 HST (right) or at the time of the accident. The image depicted a broken layer of stratocumulus type clouds with relatively clear skies near the Makana point and towards the accident site with visibilities unrestricted. Attachment 2 is an animation of the FAA QQK west weather camera from about 1130 through 1335 HST. The imagery depicts rain showers and clouds obscuring the higher terrain earlier between 1132 and 1245 HST, with rain showers noted offshore north of the Makana point at 1335 HST and approaching the coast. No white caps were noted other than those breaking near the coast.

weather conditions.

No station weather information for QOK was recorded.

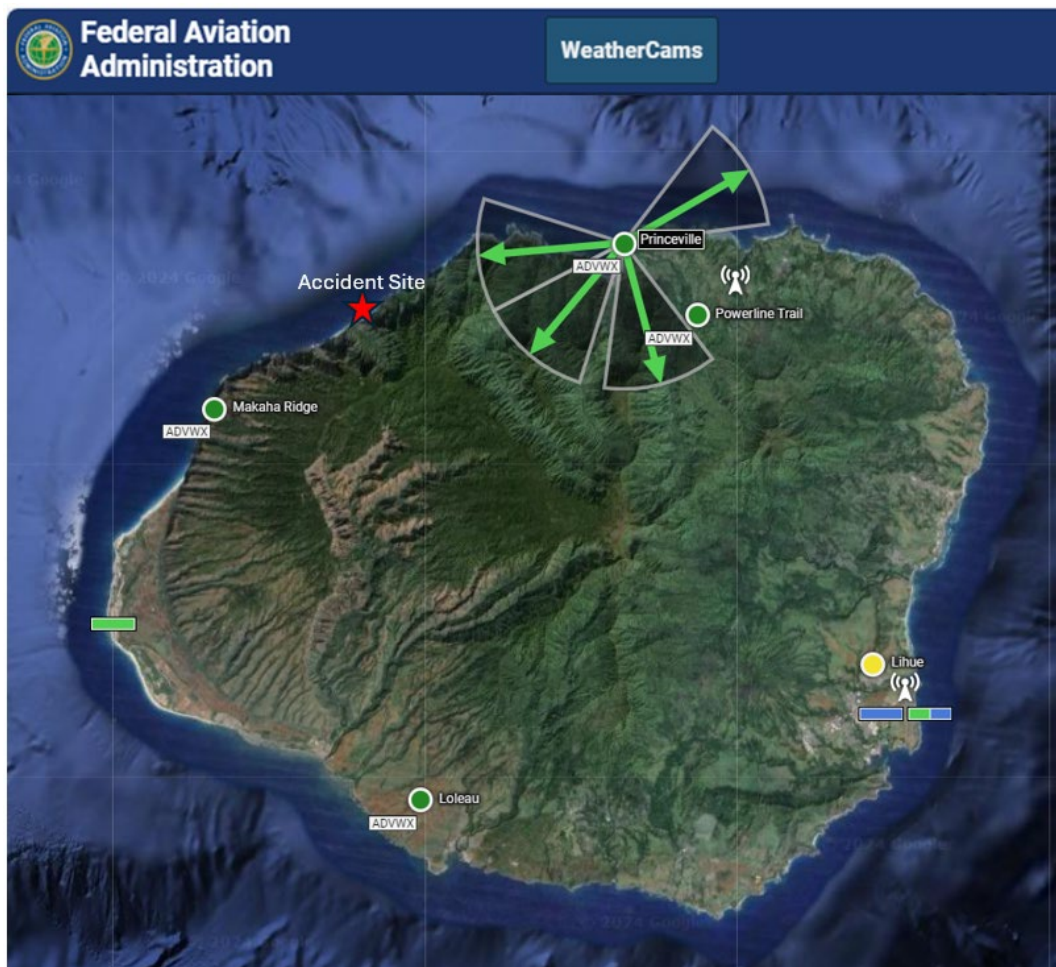


Figure 5 - FAA Princeville Weather Camera location and viewing capability and accident site.

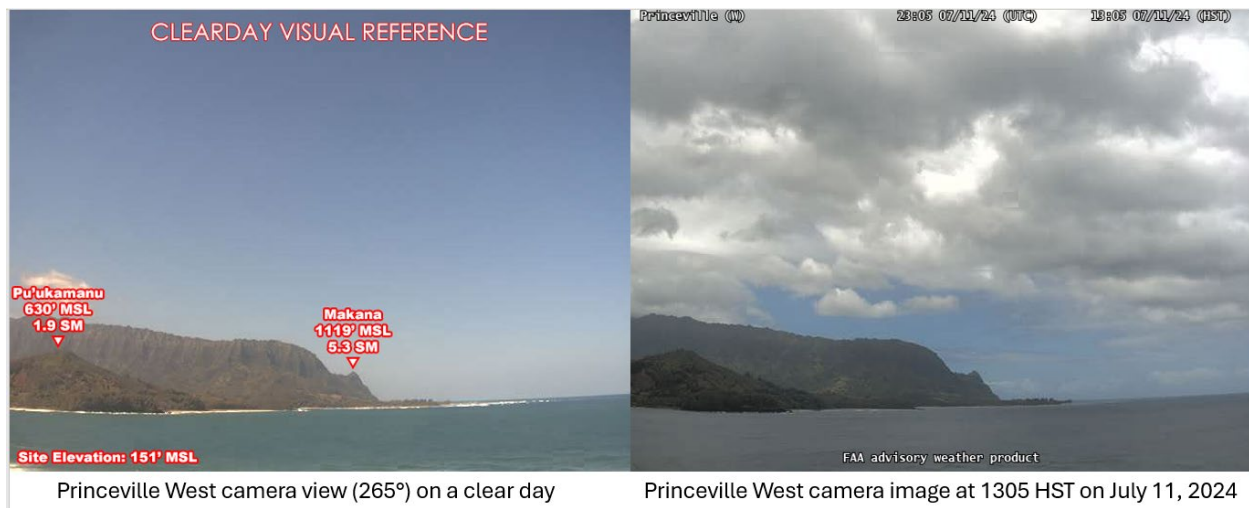


Figure 6 - FAA Princeville West camera view on a clear day (left) and at 1305 HST (right) at the time of the accident.

4.0 Hanalie Buoy Data

The Hanalie marine buoy (station 51208) located about 4 miles north of Kailiu Point at latitude 22.285° north and longitude 156.574° west, or about 8 miles northeast of the accident site was also documented. At 1256 HST the Hanalie buoy reported the significant wave height¹¹ of 2 ft, the mean wave direction from the east-northeast, and a water temperature of 25.2°C (77°F). The buoy did not have wind reporting capability.

5.0 Pilot Reports

The following pilot reports (PIREPs) were disseminated longline¹² into the national database within 120 miles of the accident site and within 2 hours prior to and after the accident.

HNL UA /OV PHNL /TM 2329 /FLUNKN /TP C208 /RM RA IN THE MTNS

HNL UA /OV PHNL /TM 2331 /FLUNKN /TP C208 /RM RA IN THE MTNS

LIH UA /OV LIH150015/TM 0200/FL0401/TP CLR/TB SMOOTH

6.0 Atmospheric Sounding

The closest NWS upper air sounding was launched from PHLI, site number 91165, on the eastern side of the airport. The sounding data was obtained from the University of Wyoming archive¹³ for 1400 HST and then plotted on a standard Skew T/log P diagram¹⁴ using the RAOB Analysis software¹⁵ from the surface to 500-hectopascals or about 18,000 ft and is included as Figure 7.

¹¹ Significant wave height refers to the average of the highest one third of waves.

¹² Includes PIREPs disseminated longline and may not include "ride reports" or other reports made on radio frequency to air traffic control.

¹³ <https://weather.uwyo.edu/upperair/sounding.html>

¹⁴ 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.

¹⁵ RAOB -The Complete RAOwinsonde OBservation program is an interactive sounding analysis program developed by Eosonde Research Services (ERS) previously known as Environmental Research Services, The Villages, Florida.

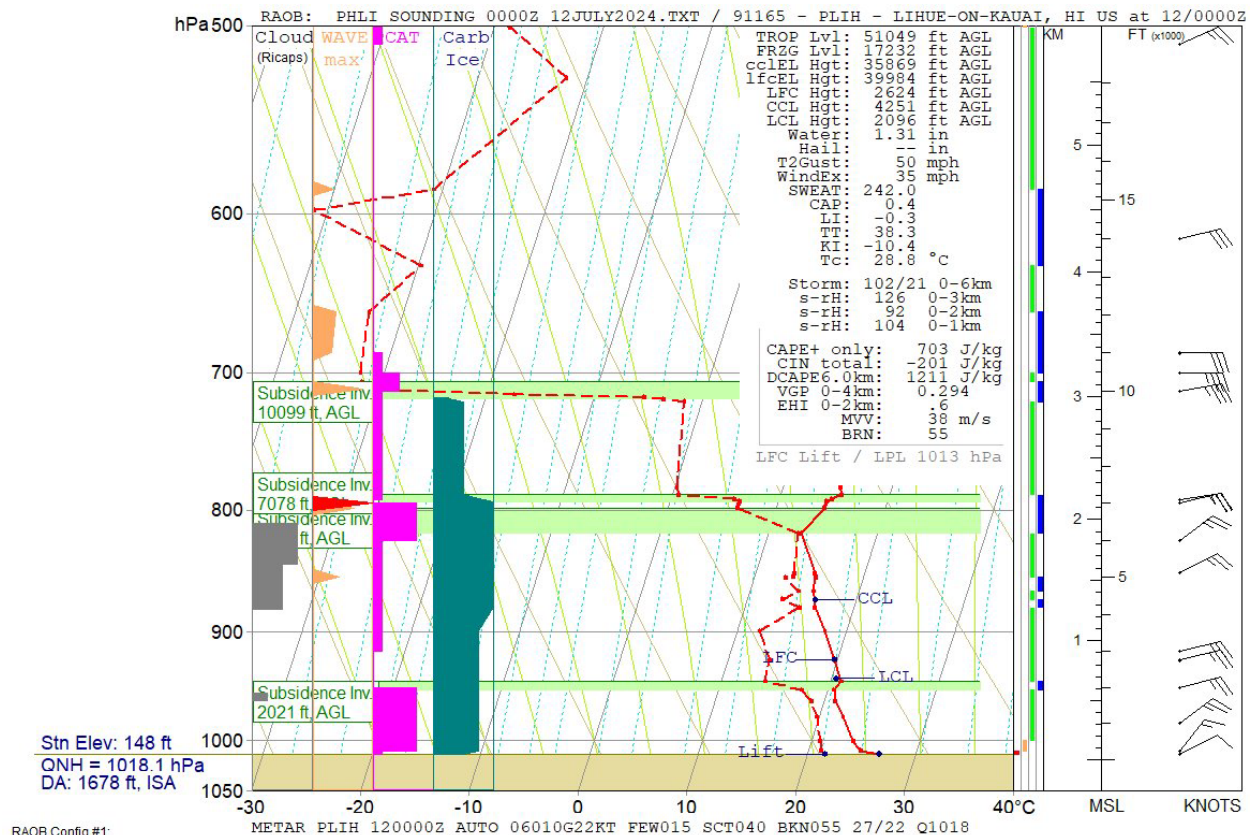


Figure 7 - NWS PHLI sounding for 1400 HST from the surface to 500 hPa or about 18,000 ft.

The PHLI sounding depicted an elevation of 148 ft at the launch site, with a near surface temperature of 26.6°C (80°F), a dew point temperature 21.6°C (71°F), a relative humidity of 74%, with a sea-level pressure of 29.91 inHg or 1013-hPa. The lifted condensation level (LCL)¹⁶ was at 2,096 ft agl, the level of free convection (LFC)¹⁷ at 2,624 ft agl, and the convective condensation level (CCL)¹⁸ at 4,261 ft agl. The sounding depicted several temperature inversions, with the predominant trade wind inversion noted between 6,000 and 7,000 ft, with drier air above that level. The precipitable water value was 1.31 inches. The RAOB Analysis program supported a scattered to broken layer of stratocumulus type clouds between 4,000 ft with tops near 6,300 ft (gray bar on left axis), with a high layer of scattered cirriform clouds above 32,000 ft (not shown). The atmosphere was characterized as conditionally unstable

¹⁶ Lifted Condensation Level (LCL) - the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

¹⁷ 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 Convective Available Potential Energy (CAPE).

¹⁸ 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.

with a Lifted Index (LI)¹⁹ of -0.3, a K-Index²⁰ of -10.5, and a positive Convective Available Potential Energy (CAPE+)²¹ of 703 Joules/kilogram, which supported only weak²² convection over the area during the period. The freezing level was identified at 17,232 ft, with no structural icing indicated. The RAOB Analysis program did depict a moderate to severe potential for carburetor or induction system icing (dark green on left axis) from the surface through 7,000 ft.

The sounding wind profile indicated a surface wind from 060° at 10 knots with gusts to 22 knots, with little directional variation with height and wind speeds increasing with height immediately above the surface. At 1,000 ft the winds were observed from 050° at 24 knots and increased to 37 knots at 10,000 ft. The mean 0 to 6 km (approximately 18,000 ft) steering wind was from 070° at 28 knots. The sounding thermal and wind profile supported mountain wave conditions with a predominate wave near 7,000 ft. The RAOB analysis for the worst case mountain wave scenario indicated a potential wavelength of 2.66 miles, an amplitude of 1,308 ft, and a maximum vertical velocity (MVV) of 1,238 feet per minute (fpm). The RAOB Analysis program also indicated the potential for moderate-to-severe turbulence at 7,000 ft associated with that wave.

The following sounding parameters of height, pressure (Pres), temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and speed, and derived Clear Air Turbulence (CAT), Low-Level Wind Shear (LLWS), and Mountain Wave potential from the surface to 11,000 ft.

Heigh (ft msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (dir/kts)	CAT (FAA)	LLWS (FAA)	Wave nm-fpm-max
148	1013	26.6	21.6	74	060/ 10	LGT	MODRT	
234	1010	24.8	21.2	80	035/ 13			
521	1000	23.8	20.8	83	n/a	SVR	LIGHT	
1000	983				050/ 24			
1189	977	22.2	19.8	86	n/a			
1631	962	21.0	18.8	87	n/a			
1929	952	20.6	17.6	83	n/a	SVR	LIGHT	

¹⁹ Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

²⁰ K-Index - The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The higher the K-Index value the greater the probability of air mass type thunderstorm development across the region.

²¹ Convective Available Potential Energy (CAPE) - is a measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.

²² Storm category used by RAOB Analysis program reviews various atmospheric parameters in the Severe Storm Parameter Table summary. The categories are ranked as weak, moderate and strong for producing organized severe thunderstorms.

2000	950				075/ 26		
2169	944	21.0	14.0	64	n/a		
2746	925	19.8	13.8	68	075/ 25		
3000	917				075/ 27		
3551	899	18.0	12.0	68	n/a		
4183	879	16.4	15.0	91	n/a		
4407	872	16.2	13.2	82	n/a		
4633	865	15.8	14.4	91	n/a		
4991	854	15.6	12.9	84	n/a		
5024	853	15.6	13.5	87	n/a	LGT	3.16 744 LT-MD
5122	850	15.4	13.5	88	060/ 25	LGT	
6000	824				050/ 26		
6189	818	13.0	12.7	98	n/a		
6875	798	14.4	6.4	59	n/a		2.66 1238 MD-SV
6980	795	14.4	6.4	59	n/a	SVR	
7000	794				075/ 24		16.02 10457 SEVERE
7050	793	14.4	6.4	59	n/a		
7085	792				080/ 26		
7120	791	14.8	5.8	55	n/a		
7226	788	15.6	0.6	36	n/a		
7439	782	15.2	0.2	36	n/a		
9711	720	9.4	-1.6	46	n/a		
9787	718	9.4	-3.6	40	n/a		
9825	717	9.6	-5.4	34	n/a		
9901	715	10.6	-17.4	12	n/a	LGT	
10000	712				080/ 37		
10054	711	12.0	-32.0	3	n/a		4.34 2299 SEVERE

At about 1,000 ft the PHLI sounding observed a wind from 050° at 24 knots, and at 2,000 ft a wind from 075° at 26 knots, with a potential for moderate to severe turbulence.

7.0 Satellite Imagery

The NOAA Geostationary Operational Environmental Satellite number 18 (GOES-18) infrared, water vapor, and visible imagery were obtained from an archive at 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 (μ m) and the low-level water vapor (band 10) at a wavelength of 7.3 μ m provided a resolution of 2 kilometers (km). While the visible (band 2) at a wavelength of 0.64 μ m provided a resolution of 0.5 km.

Figure 8 is the GOES-18 infrared image for 1306 HST at 8X magnification with a standard MB temperature enhancement curve applied to high light the higher and colder cloud tops typically associated with deep cirriform clouds and convection. The image depicted a large area of low to mid-level stratiform type clouds extending over Kauai and over the Pacific waters predominately north of the accident site and on the

windward or eastern side of the island. The radiative cloud top brightness temperature over the accident site was 294 Kelvin or 20.8°C, which corresponded to cloud tops near 2,500 ft based on the GDAS sounding. Several parallel bands of clouds were noted downwind of higher terrain in what is typically referred to as transverse bands²³. Attachment 3 is an animation of the GOES-18 infrared imagery from 1100 through 1320 HST.

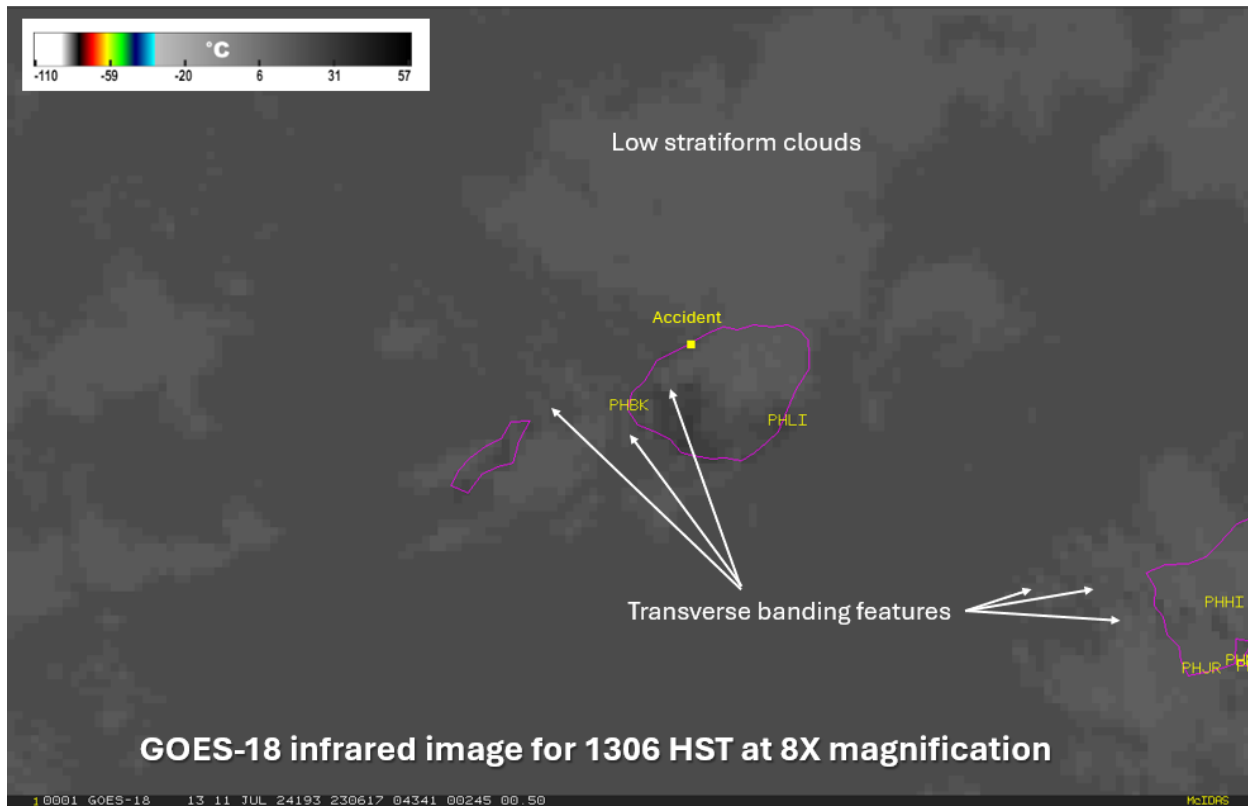


Figure 8 - GOES-18 infrared image for 1306 HST at 8X magnification with accident site.

Figure 9 is the GOES-18 visible image for 1306 HST at 6X magnification. The image depicted a break in the stratiform cloud cover over the accident site with several bands of clouds predominately south and east of the accident site over the northern section of Kauai. Attachment 4 is an animation of the visible (GeoColor²⁴) imagery from 1100 through 1320 HST.

²³ Transverse Bands - are bands of clouds oriented perpendicular to the flow in which they are embedded. They often are seen best on satellite photographs. When observed at high levels (i.e., in cirrus formations), they may indicate severe or extreme turbulence.

²⁴ For the daytime imagery, channels 1, 2, and 3 (0.47 -blue, 0.64 - red, and 0.86 μm - near IR) are first corrected for Rayleigh scattering; this is a key step in order to maximize the contrast between clear sky and clouds, and it results in vibrant colors.

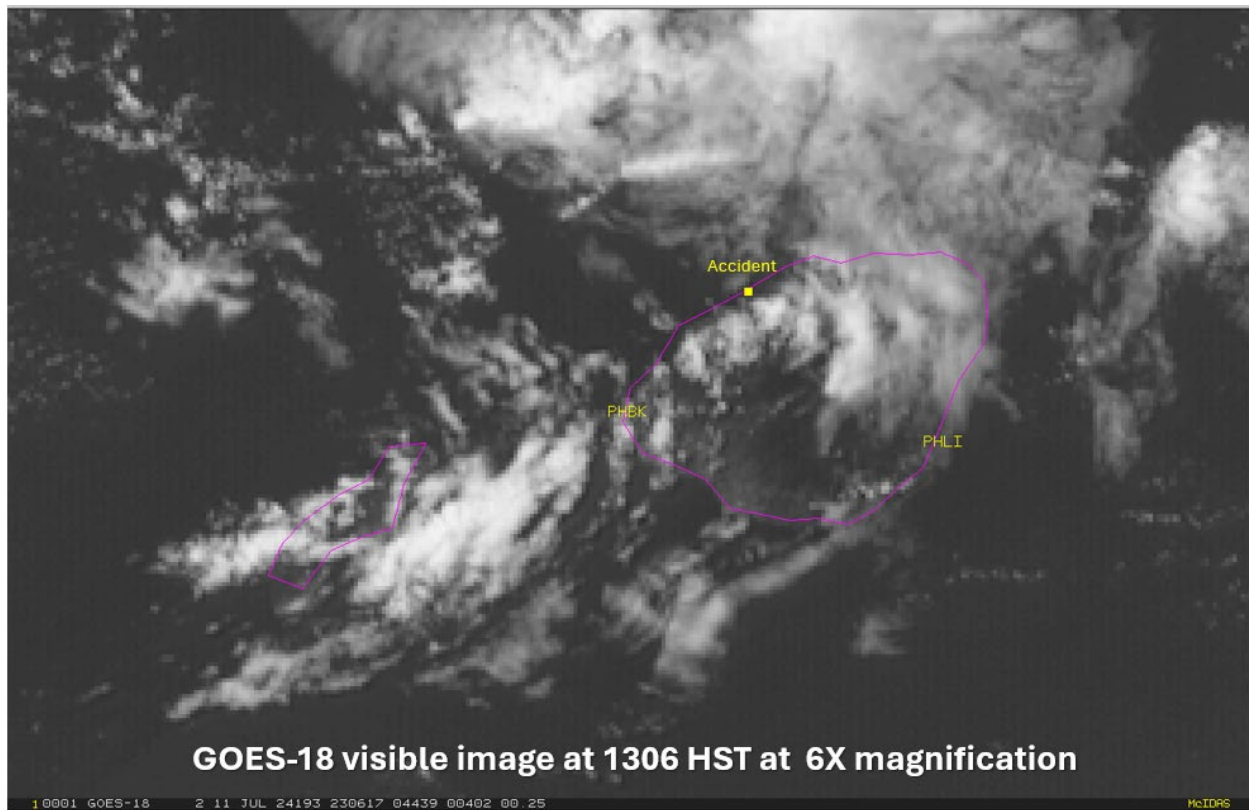


Figure 9 - GOES-18 visible image for 1306 HST at 6X magnification with accident site.

Figure 10 is the GOES-18 low-level water vapor imagery at 1310 HST with an enhancement curve applied to highlight the drier conditions (dark) and low-level moisture (red's). It is usually used to track low-level winds, identify jet streaks, and identify regions where the potential for turbulence exists. Attachment 5 is an animation of the low-level water vapor imagery from 1100 through 1320 HST.

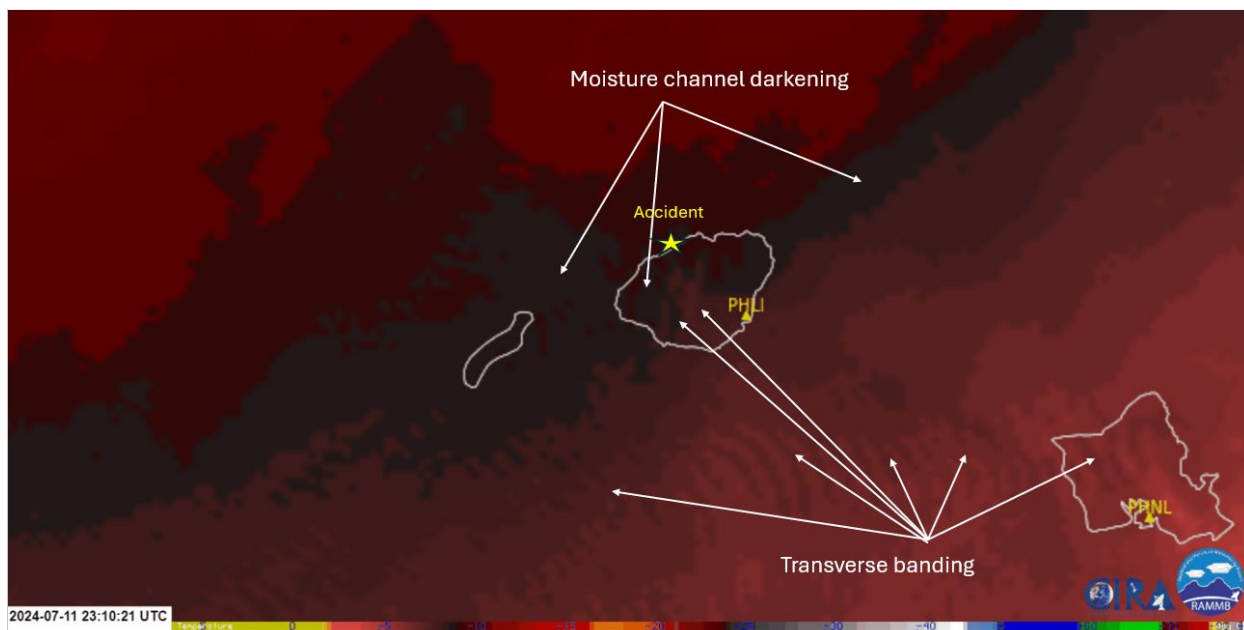


Figure 10 - GOES-18 low-level water vapor image for 1310 HST with accident site in yellow.

8.0 Weather Radar Imagery

The NWS South Kauai (PHKI)²⁵ Weather Surveillance Radar 1988 Doppler (WSR-88D)²⁶ was located about 18 miles south-southeast of the accident site or about 15 miles west of PHLI on the south side of the island of Kauai. The Level II radar data was obtained from the NWS NCEI and plotted using the NOAA Weather Tool kit software²⁷. During the period the PHKI WSR-88D was operating in the clear air mode, volume coverage pattern (VCP) 35 where the radar makes 9 elevation scans during a 7-minute period.

The NWS PHKI WSR-88D antenna was at a height of 340 ft and based on the distance of 18 miles from the accident site, the following table provides the estimated height of the center, base and tops of the radar's beam over the accident site. The lowest six elevation scans sampled the air space were reviewed, with the heights rounded to the nearest 10 ft. A review of the topographical chart of the island indicated terrain upwards to 3,500 ft between the radar antenna and the accident site. Above 7,000 ft no clouds were expected based on the sounding and satellite imagery.

²⁵ The NWS PHKI weather station is not collocated at the Lihue Airport which was located about 15 miles east-northeast of the radar antenna.

²⁶ 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.

²⁷ 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.

Elevation	Beam Center	Base of beam	Top of Beam
0.48°	1,510 ft	600 ft	2,420 ft
0.83°	2,140 ft	1,230 ft	3,050 ft
1.27°	2,980 ft	2,070 ft	3,890 ft
1.76°	3,910 ft	3,010 ft	4,820 ft
2.37°	5,080 ft	4,170 ft	5,980 ft
3.08°	6,430 ft	5,520 ft	7,340 ft

To ensure the beam of the WSR-88D was not blocked by the high terrain between the radar and the accident site, the lowest elevation scans were not used in this case. The PHKI WSR-88D 2.37° base reflectivity image was documented, which assuming standard refraction was sampling the atmosphere between 4,170 ft and 5,980 ft above the accident site and where clouds were expected.

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 dBZ²⁹ and is a general measure of echo intensity. The FAA Aviation Weather Handbook³⁰ 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 11. Light rain is typically reported at the surface when reflectivities reach 20 dBZ, while air traffic control weather displays, and airborne weather radar typically do not display echoes less than 30 dBZ or light intensity echoes on their weather displays.

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

Figure 11 - WSR-88D reflectivity values and intensity terminology.

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. 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.

²⁹ dBZ is a nondimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels, or dB) with respect to radar reflectivity factor, Z.

³⁰ FAA Aviation Weather Handbook - WSR-88D Radar Precipitation Intensity Terminology (Table 24-8).

Figures 12 and 13 are the NWS PHKI WSR-88D 2.37° base reflectivity images for 1300 and 1307 HST. The images depict no echoes over the accident site immediately surrounding the period, while an area of scattered light reflectivity echoes of 10 to 30 dBZ extended about 4 miles west and south of the accident site across western Kauai. Light intensity echoes between 10 to 25 dBZ were observed between the accident site and Makaha Ridge between 1205 through 1246 HST and had dissipated at the time of the accident. The echoes appeared to parallel the higher terrain to the east and did not appear to propagate westward with the mean winds with time. Attachment 6 is an animation of the PHKI WSR-88D during the period.

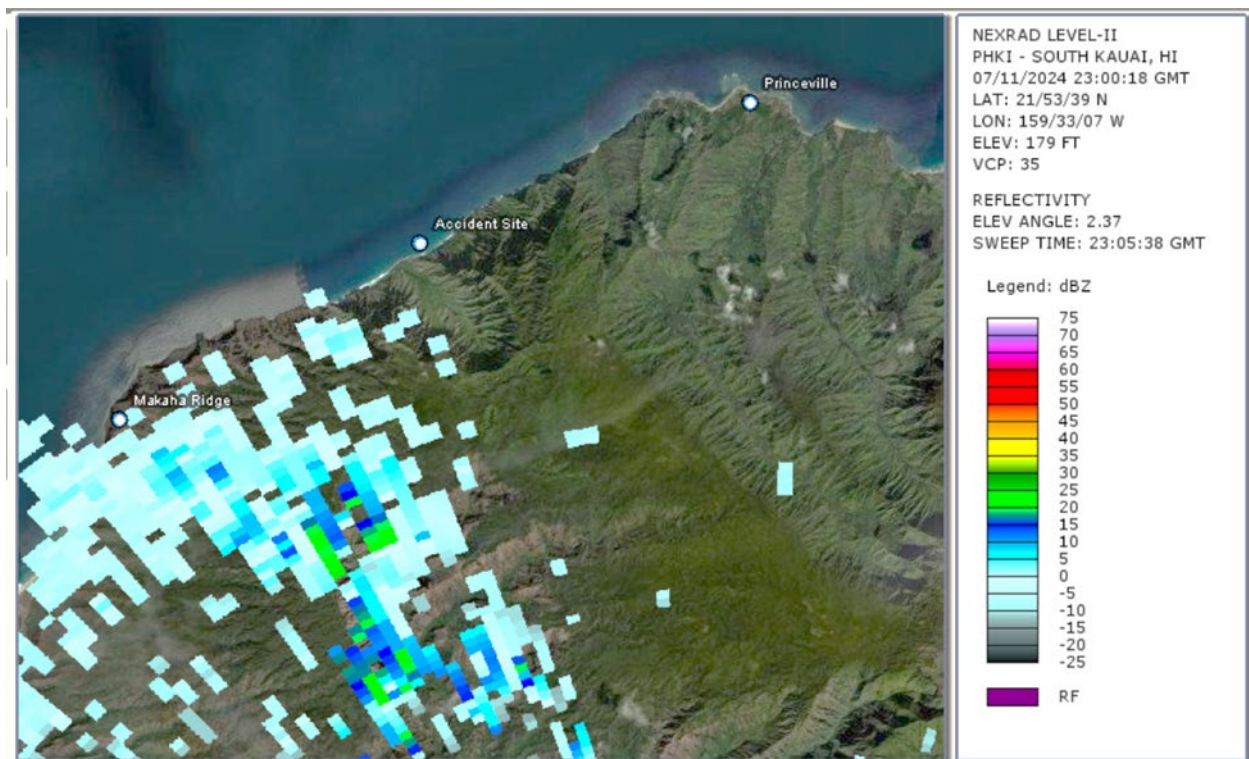


Figure 12 - NWS PHKI WSR-88D 2.37° base reflectivity image for 1300 HST with the accident site and Makaha Ridge and Princeville weather camera locations.

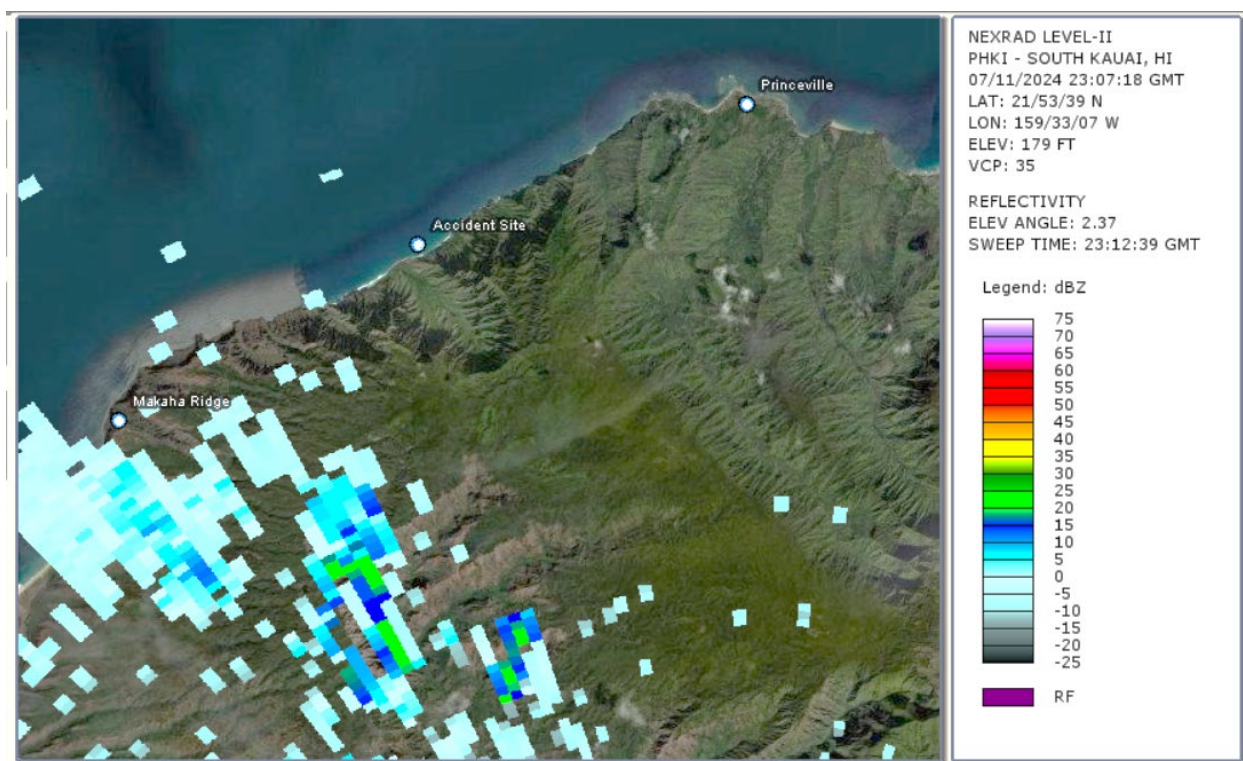


Figure 13 - NWS PHKI WSR-88D 2.37° base reflectivity image for 1307 HST with the accident site and Makaha Ridge and Princeville weather camera locations.

9.0 Weather Research and Forecast Model

A Weather Research and Forecast (WRF) model simulation³¹ surrounding the time of the accident was run using initialization data from the Global Forecast System (GFS) 0.5° grid. A west-to-east cross-section was made across the accident site from the coordinates 22.183594°N, 159.74597°W to 22.183594°N, 159.54597°W, and depicted as Figure 14. The two grid points were approximately 13 miles apart with the terrain reaching about 3,695 ft about 2.4 miles east of the accident site. The highest elevation on Kauai was recorded at 5,144 ft.

³¹ WRF ARW (Advanced Research WRF core) version 4.1.2 was run with 3 domains with horizontal grid spacing of 8 km, 1.6 km, and 240 m. Other WRF simulation parameters included: 60 vertical levels, the multi-scale Kain-Fritsch cumulus parameterization scheme used on the outer domain, a Lin et al. microphysics scheme, a Yonsei University boundary layer scheme, Noah land surface physics, the Dudhia scheme used for short wave radiation, and the RRTM scheme for the long wave radiation.

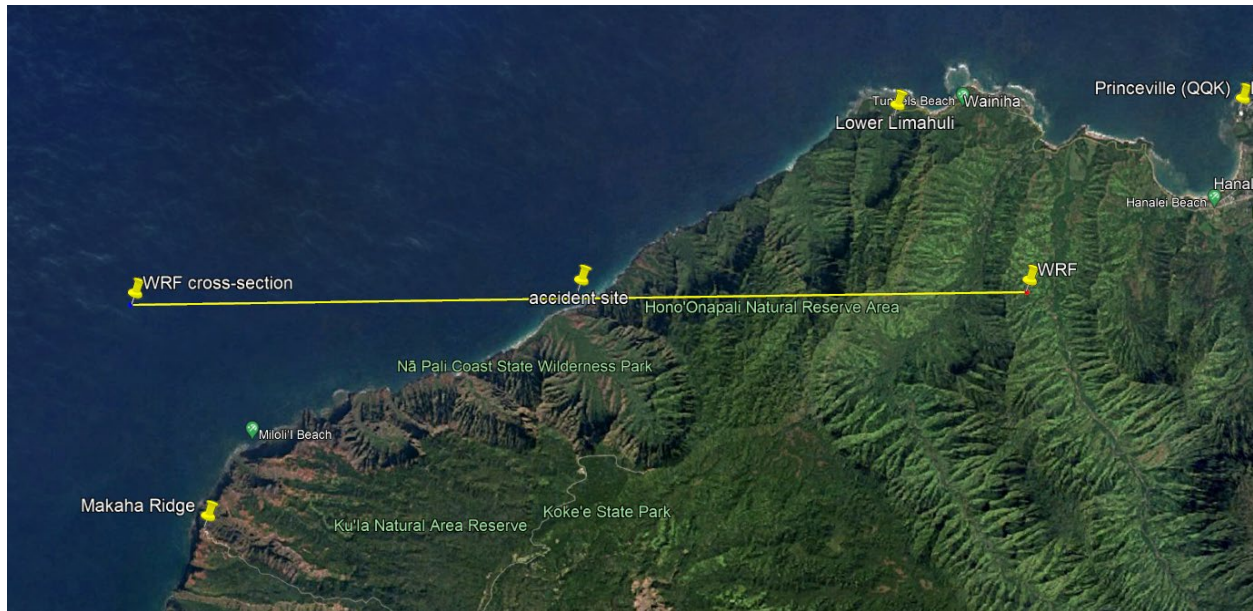


Figure 14 - Plot of WRF model cross-section points used the accident site and general topography.

Figures 15 and 16 are a west-to-east cross section depicting the WRF highest domain topography from 1010-hPa to 850-hPa or about 5,000 ft, with the accident site located in the middle at grid point³² 30 and the higher terrain near grid point 45, for the period from 1230, 1240, 1250 HST (Figure 15) and for 1300, 1310, and 1320 HST (Figure 16). The images depict the isentropes or lines of potential temperature (degrees Kelvin) and the horizontal wind speeds in knots. The image depicts the general easterly winds over the high terrain with maximum winds near 38 knots above the ridge and between 26 to 32 knots over the accident site and increasing further west to 34 knots offshore.

Figures 17 and 18 are the WRF numerical model cross section of the isentropes and the vertical velocity in feet per minute (fpm) during the period from 1230 through 1320 HST, every 10-minutes. The image depicted upward vertical velocities east of the high terrain up to 600 fpm (updrafts) and downward (downdrafts) at 500 fpm near the ridge and decreasing to 100 fpm over the accident site and then upward and downward further westward. This wave like pattern is common with mountain wave activity or gravity waves.

³² Horizontal axis grid points or "tick marks" are at 320 meters (0.17 nm or 1,050 ft), the grid spacing in domain 3 model.

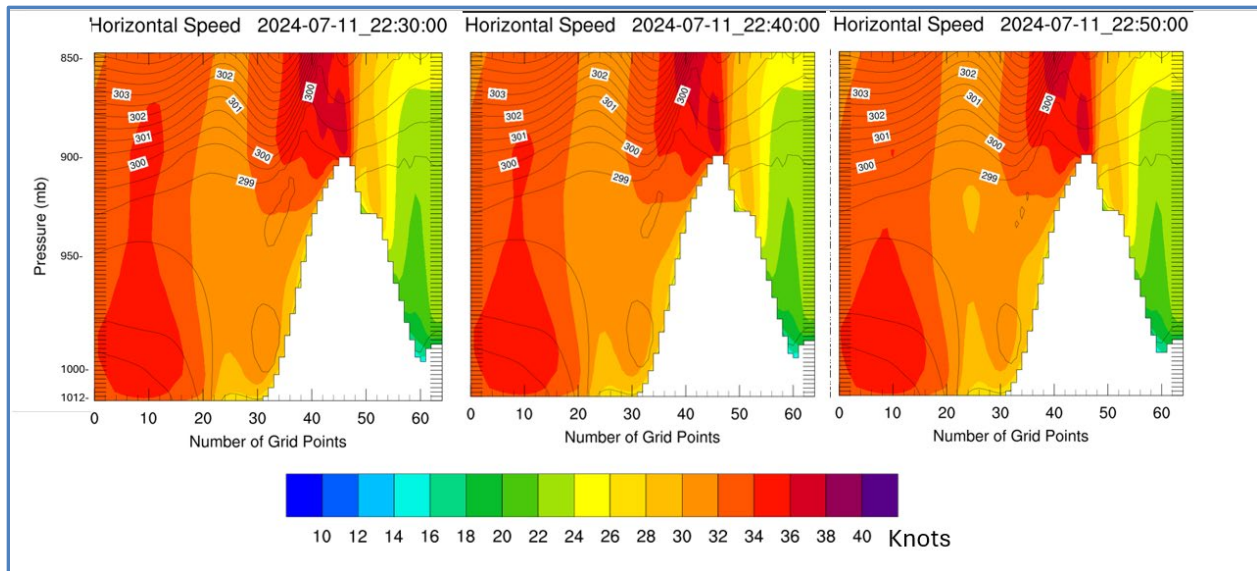


Figure 15 - WRF model cross-section of isentropes and horizontal winds at 1220 HST (left), 1230 HST (center), and 1240 HST (right), with accident site at grid point 30.

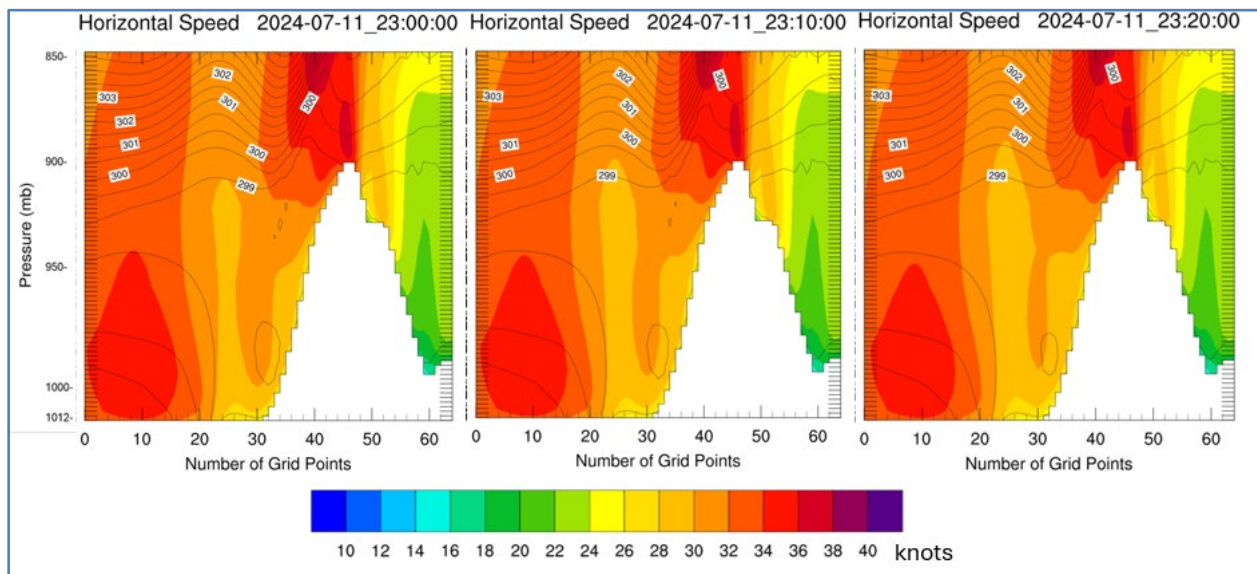


Figure 16 - WRF model cross-section of isentropes and horizontal winds at 1300 HST (left), 1310 HST (center), and for 1320 HST (right) with accident site at grid point 30.

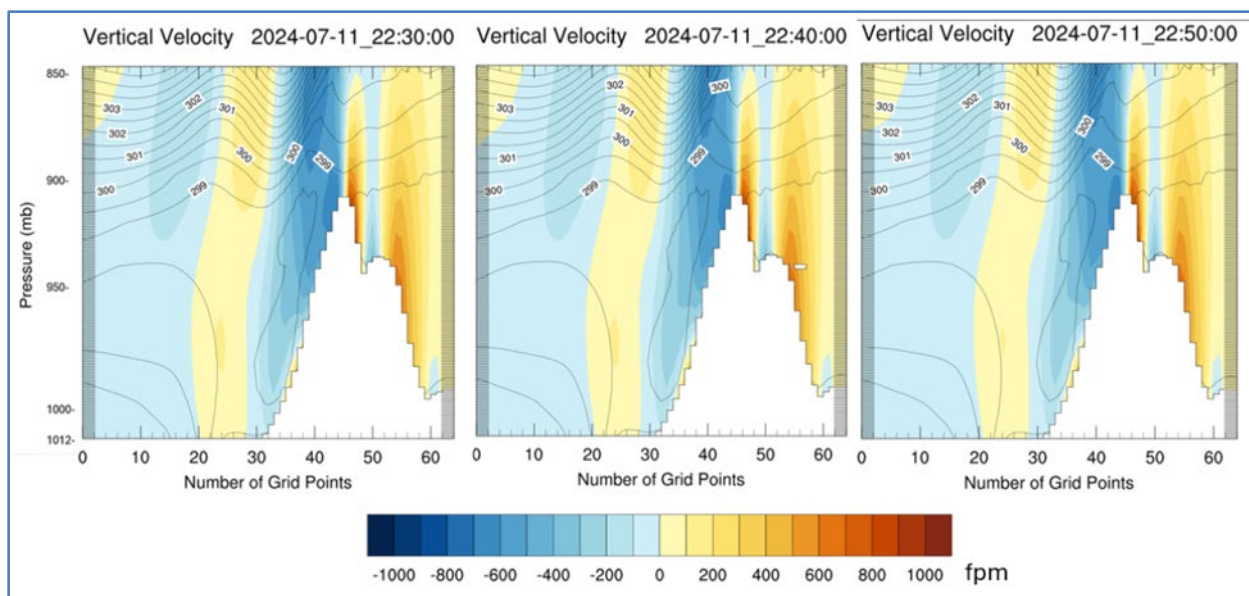


Figure 17 - WRF model cross-section of isentropes and vertical velocity for 1230 HST (left), 1240 HST (center), and 1250 HST (right) with the accident site at grid point 30.

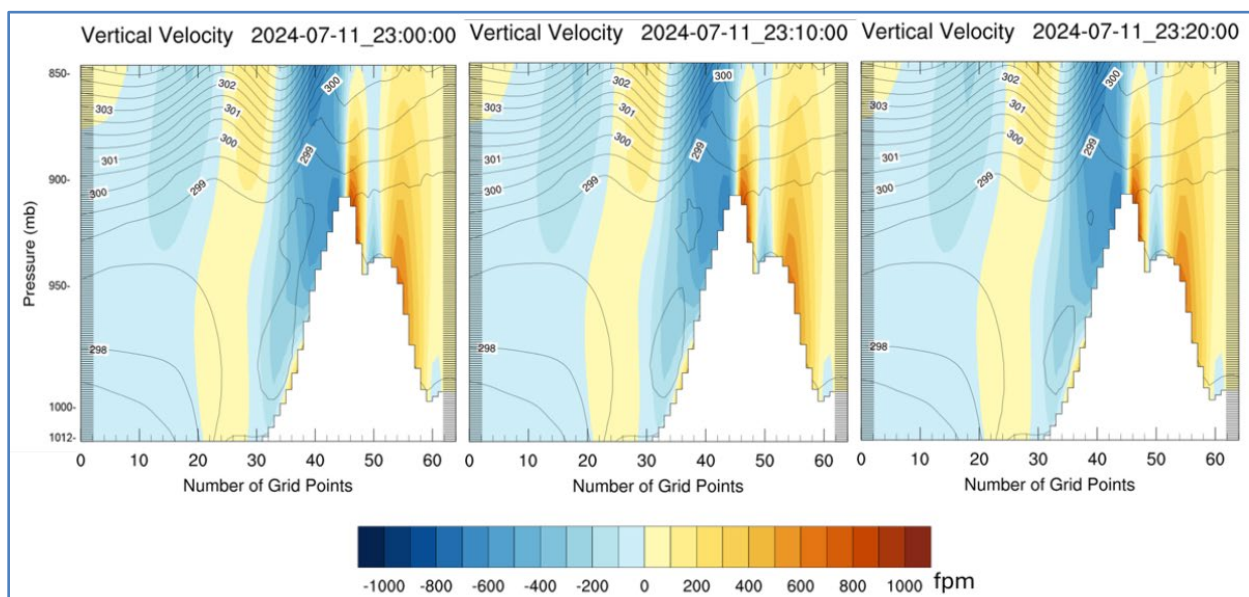


Figure 18 - WRF model cross-section of isentropes and vertical velocity for 1300 HST (left), 1310 HST (center), and 1320 HST (right) with the accident site at grid point 30.

10.0 NWS Forecast Products

The NWS Honolulu (PHNO) Weather Forecast Office (WFO) is responsible for issuing Terminal Aerodrome Forecasts (TAF) across Hawaii and other weather advisories and warnings. The following products were issued surrounding the period.

10.1 Terminal Aerodrome Forecast

The closest TAF to the accident site was for the departure PHLI. While a TAF is only current for a 5 statute mile radius of the specific airport's center point, pilot's, weather briefers, and flight planning systems will often provide the closest TAF for a more time and specific weather breakdown in preflight weather briefings. The forecast current for PHLI during the period was issued at 0734 HST and was as follows:

TAF PHLI 111734Z 1118/1218 05017KT P6SM VCSH SCT020 BKN045=

The TAF for PHLI expected for the 24 hour period beginning at 0800 HST, winds from 050° at 17 knots, visibility 6 miles or more, with rain showers in the vicinity³³ of the airport, scattered clouds at 2,000 ft agl, and with a ceiling broken at 4,500 ft.

10.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short-term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF and provide some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The AFD current was issued at 1000 HST and was as follows:

*FXHW60 PHFO 112001 CCA
AFDHFO*

*Area Forecast Discussion
National Weather Service Honolulu HI
1000 AM HST Thu Jul 11 2024*

.SYNOPSIS...

Strong trade winds will persist, delivering abundant patches of low clouds to most areas, while associated brief showers will mainly fall over windward areas. The Kona slopes will receive their typical summertime afternoon and evening clouds and showers.

.DISCUSSION...

Breezy to windy trades will prevail into next week, supported by a persistent surface ridge far N of the islands. The ENE trade winds will deliver abundant patches of low clouds to windward areas (and occasionally leeward on the smaller islands), while associated brief showers will mainly fall over windward areas. The Kona slopes will receive their typical summertime afternoon and evening clouds and showers.

A westward-moving mid-level trough just E of the area will weaken as it moves over the islands through Friday. Weak instability associated with this feature is the likely culprit behind the

³³ Vicinity is defined as within 5 to 10 statute miles of the airport center point.

increased mixed-depth layer noted on the 12Z PHTO sounding and recent radar VAD wind profiles - up to 10 kft. This is allowing primarily stable low clouds to spread leeward, leading to conditions that are little more cloudy than expected.

The trough will dissipate Friday night and Saturday, and the inversion base should lower enough to allow for more leeward sunshine over the weekend and into next week. Otherwise, randomly distributed clusters of stable and showery low clouds will periodically move through, modulating sky and shower coverage as they do so, mainly windward.

.AVIATION...

Breezy to windy trades will continue for the next couple of days, with passing showers favoring windward and mauka areas. Expect mainly VFR, with brief MVFR in showers/low clouds.

AIRMET Sierra for tempo mountain obscuration remains in effect for windward areas of Oahu, Molokai, and Maui. Conditions are expected to improve for these areas by this afternoon.

AIRMET Tango for low-level turbulence in the lee of island terrain will remain in effect for the next several days due to the strong trades. Surface winds may briefly surpass 30kt, but these conditions are not likely to last long enough to need an AIRMET.

.HFO WATCHES/WARNINGS/ADVISORIES...

Small Craft Advisory until 6 PM HST Friday for all Hawaiian waters.

10.3 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). A review of the NWS AWC GFA ceiling and visibility, clouds, and wind products indicated that the closest grid point to the accident site indicated that VFR conditions were expected to prevail with visibility greater than 5 miles, isolated rain showers, with scattered clouds at 2,500 ft, and winds from 080° at 23 knots gusting to 30 knots.

10.4 Zone Forecast

The NWS Zone Forecast issued by PHFO at about 1500 HST was as follows for Kauai.

*FPHW50 PHFO 111305
ZFPHFO*

*Zone Forecast Product for Hawaii
National Weather Service Honolulu HI
305 AM HST Thu Jul 11 2024*

HIZ029-120730-

Kauai North-
Including Princeville, Hanalei, Na Pali State Park
305 AM HST Thu Jul 11 2024

.TODAY...Partly sunny. Breezy. Scattered showers in the morning, then isolated showers in the afternoon. Highs 76 to 86. East winds up to 20 mph. Chance of rain 50 percent.

.TONIGHT...Mostly cloudy. Breezy. Scattered showers in the evening, then numerous showers after midnight. Lows 64 to 74. East winds up to 20 mph. Chance of rain 70 percent.

.FRIDAY...Breezy. Partly sunny with scattered showers. Highs 76 to 86. East winds up to 20 mph. Chance of rain 50 percent.

10.5 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 over the Hawaiian Islands are issued by the NWS Honolulu (PHFO) WFO. 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.

While the NWS PHFO office had several SIGMETs current for the area for thunderstorms, none were current in the immediate vicinity of the accident site. The only other advisory was for occasional mountain obscuration conditions over high terrain in clouds and precipitation. No advisories were current over the region for turbulence, high gusting surface winds, LLWS, or icing.

WAHW31 PHFO 111526
WA0HI

HNLS WA 111600
AIRMET SIERRA UPDATE 3 FOR IFR VALID UNTIL 112200

.
AIRMET MTN OBSC...MAUI MOLOKAI OAHU
N THRU E SECTIONS.
MTN TEMPO OBSC ABV 020 EXP DUE TO CLD AND SHRA.
COND IMPROVING AFT 2000Z.

**AIRMET MTN OBSC...KAUAI
N THRU E SECTIONS.
CANCEL AIRMET. COND HAVE IMPROVED.**

=HNLT WA 111600
AIRMET TANGO UPDATE 2 FOR TURB VALID UNTIL 112200

.
AIRMET TURB...HI

OVR AND IMT W THRU SW OF MTN.
TEMPO MOD TURB BLW 080.
COND CONT BEYOND 2200Z.

=HNLZ WA 111600
AIRMET ZULU UPDATE 2 FOR ICE AND FZLVL VALID UNTIL 112200

.
NO SIGNIFICANT ICE EXP.

.
FZLVL...166 PHLI SLOPING TO 173 PHTO.

11.0 Witness Statements

Witnesses hiking on the Kalalua Trail, which is situated along the Na Pali Coast on the northern shores of Kauai, reported that during a brief rest stop that overlooked the coast, they described encountering strong gusty wind conditions. They reported that as they rested, a “huge” sudden gust of wind blew over them, which was followed by a very loud “bang”. As their attention was drawn to the source of the loud noise, they saw the helicopter wreckage freefalling into the ocean in two sections, a main fuselage and the tail boom section. The witnesses said that the helicopter wreckage sank moments after striking the water, about 1/4 mile offshore.

Another witness was operating a charter boat and was located about 3 miles northeast of the accident and responded to the U.S. Coast Guard request for assistance. The ship’s captain reported east-northeast trade winds at a constant 20 to 25 mph (17 to 22 kts) with gusts to 40 mph (35 kts) and greater. In addition, he also observed several waterspouts about ½ mile offshore, with a diameter of 50 yards and extended to about 1,000 ft.

F. ATTACHMENTS

Attachment 1 - FAA PHBK north weather camera imagery from 1100-1345 HST.
Attachment 2 - FAA QOK west weather camera view from 1100-1345 HST.
Attachment 3 - GOES-18 infrared satellite imagery animation from 1100-1320 HST.
Attachment 4 - GOES-18 GeoColor satellite imagery animation from 1100-1320 HST.
Attachment 5 - GOES-18 water vapor satellite imagery animation from 1100-1320 HST.
Attachment 6 - PHKI WSR-88D base reflectivity animation surrounding the period.

Submitted by:

Donald Eick
NTSB Senior Meteorologist