



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

March 17, 2017

Weather Study

METEOROLOGY

WPR17FAMS2

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A. ACCIDENT

Location: Near Ilio Point, Hawaii
Date: December 30, 2016
Time: 1849 Hawaii standard time
0449 Coordinated Universal Time (UTC) on December 31, 2016
Aircraft: Cessna 172M, N174LL

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On December 30, 2016, about 1849 Hawaii standard time, a Cessna 172M, N174LL, departed Molokai Airport (MKK), Kaunakakai, Hawaii en route to the Honolulu Airport (HNL), Honolulu, Hawaii. Since that time, the private pilot and two passengers have not been located and the airplane is missing. The airplane disappeared from Air Traffic Control radar after takeoff and is presumed to have crashed in the Pacific Ocean. The airplane was registered to Yamataka Kumiko and operated by Lani Lea Sky Tours, LLC under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. Visual meteorological conditions prevailed and a flight plan was filed for the cross-country flight that departed MKK at 1843.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Hawaii standard time (HST) on December 30, 2016, and are based upon the 24-hour clock, where local time is -10 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The approximate location of the accident site was at latitude 21.2306° N, longitude 157.1856° W.

E. WEATHER INFORMATION

1.0 Synoptic Situation

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

1.1 Surface Analysis Chart

The NOAA Pacific Surface Analysis Chart for 1400 and 2000 HST are provided as figures 1 and 2, respectively, with the approximate location of the accident site marked with the red circle. The charts depicted a stationary frontal boundary stretched from west to east across the Hawaiian Islands. The frontal boundary then stretched northeastward becoming an occluded front with a storm to gale force low in the eastern Pacific Ocean. The storm force low at 1400 HST had a surface pressure of 1007-hectopascals (hPa), with the surface pressure rising to 1008-hPa by 2000 HST in the now gale force low. The surface low was nearly stationary between 1400 and 2000 HST in the eastern Pacific Ocean. Near the Hawaiian Islands along the stationary frontal boundary, general northeasterly to easterly winds existed speeds between 10 and 25 knots, which influenced local weather conditions. The stationary front acted as a lifting mechanism to aid cloud and precipitation formation.



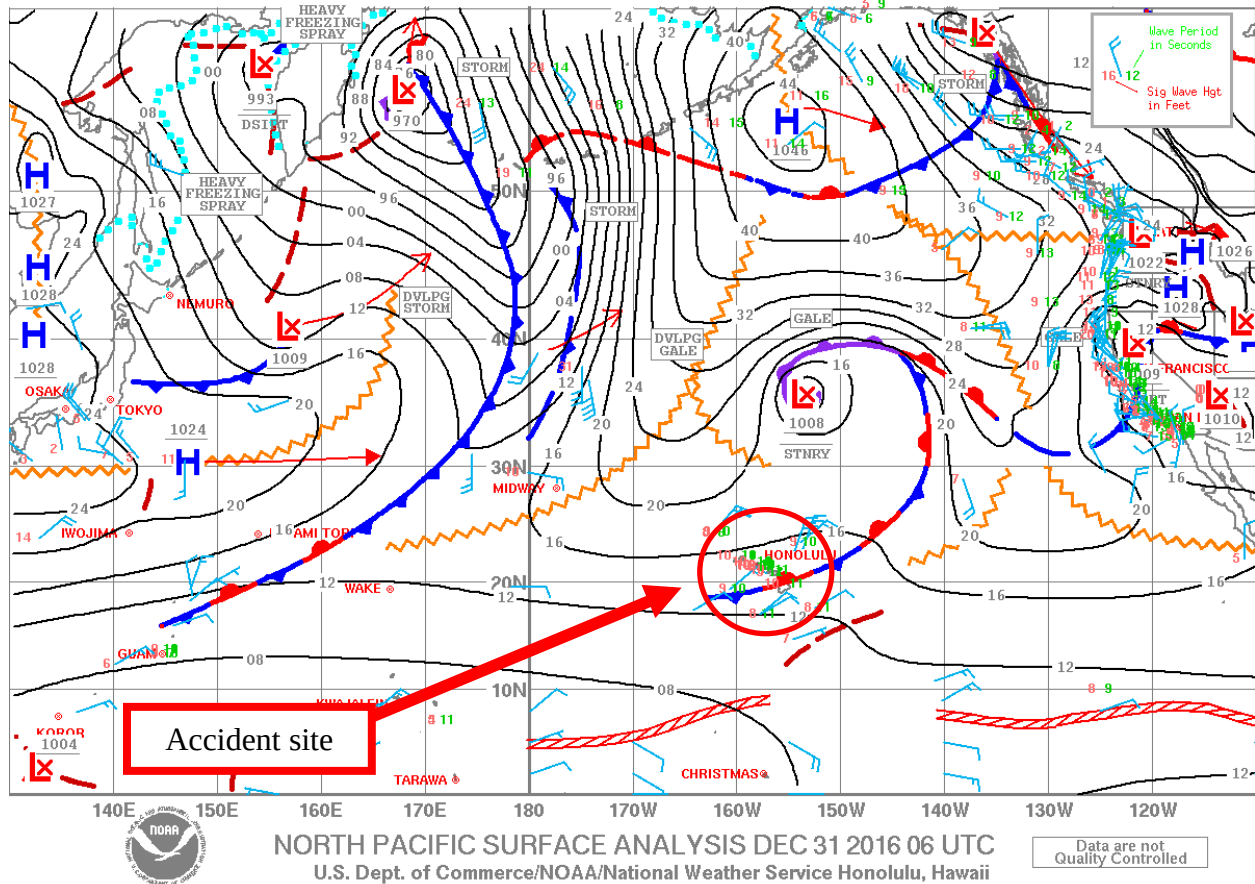


Figure 2 – NOAA Pacific Surface Analysis Chart for 2000 HST

1.2 Upper Air Charts

The NOAA 500-hPa Analysis Chart for 1400 HST is presented in figure 3. The 500-hPa chart depicted a mid-level trough¹ (associated with the surface frontal boundary, section 1.1) located over the Hawaiian Islands and the accident site. A mid-level low pressure center was located in the eastern Pacific Ocean associated with the storm to gale force surface low pressure center (section 1.1).

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

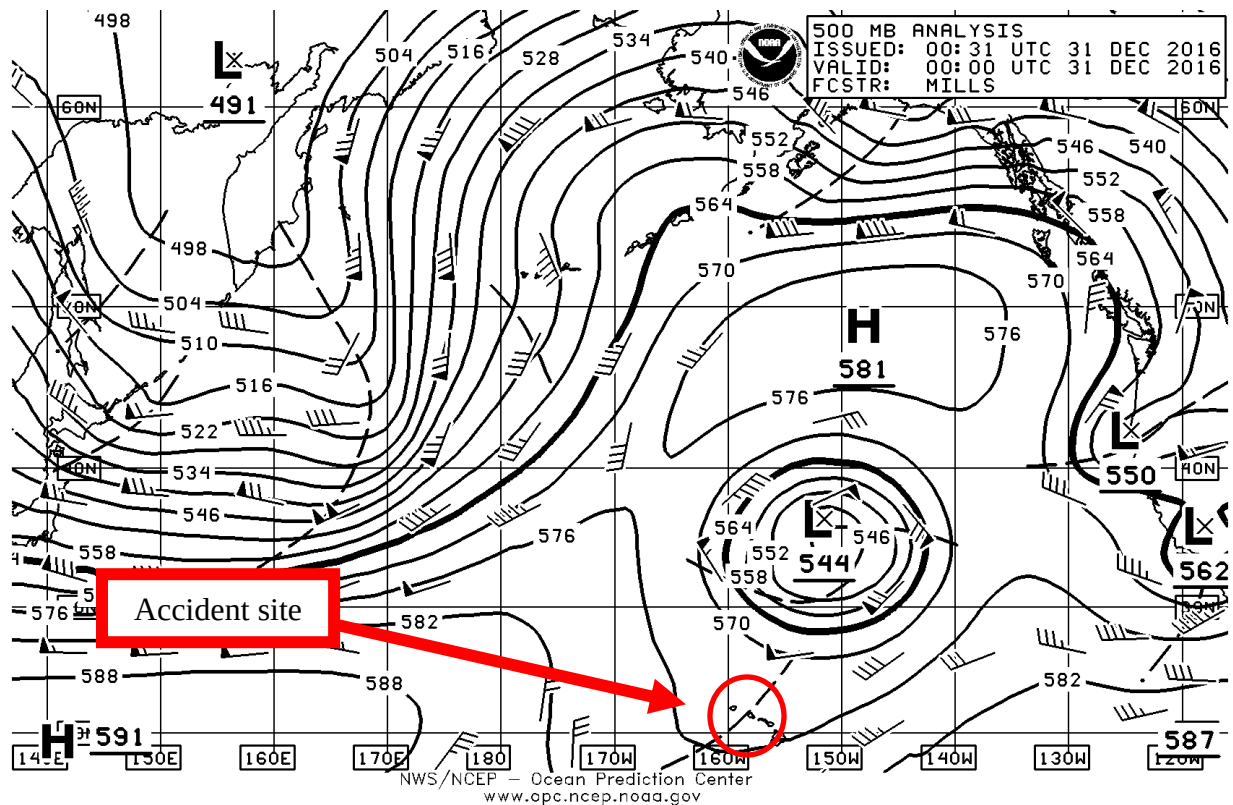


Figure 3 – NOAA 500-hPa Analysis Chart for 1400 HST

2.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language with visibility reported in statute miles for this section. Figure 4 is a local sectional chart with the accident site and the closest weather reporting location marked.

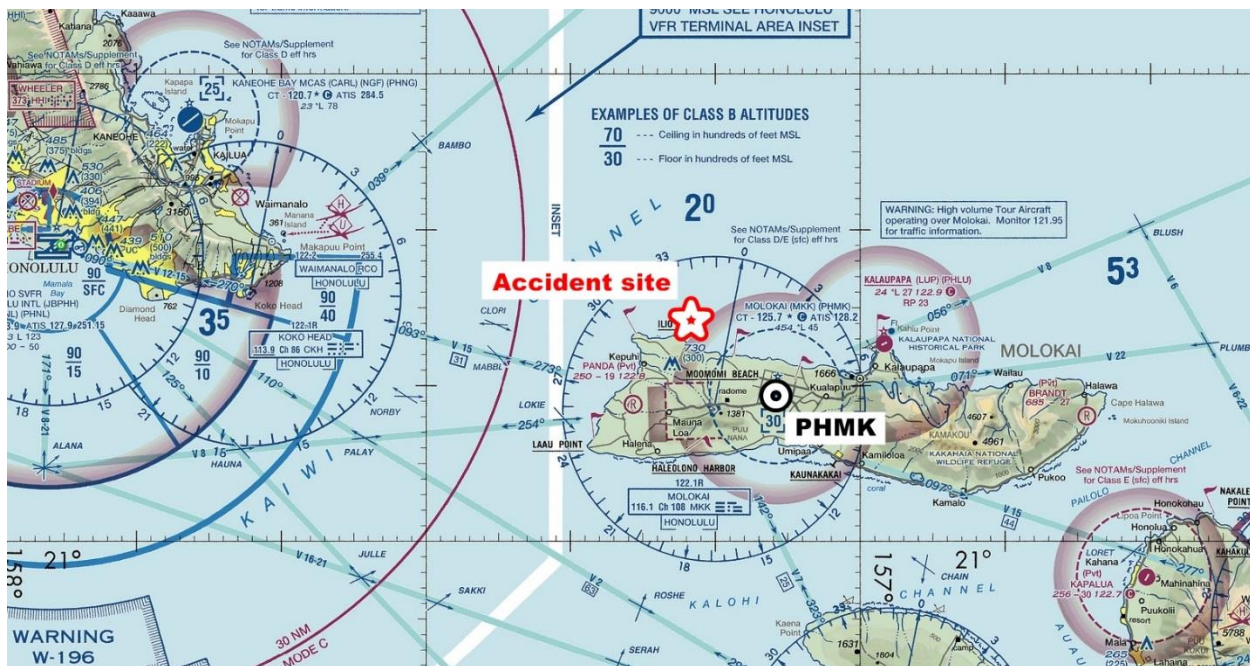


Figure 4 – Sectional map of the accident area with the location of the accident site and surface observation site

Molokai Airport (PHMK) had the closest official weather station to the accident site located on Molokai Island and was located 6 miles northwest of Kaunakakai, Hawaii. PHMK had an Automated Surface Observing System (ASOS₂) whose reports were supplemented by air traffic control. PHMK was located 7 miles east-southeast of the accident site, at an elevation of 454 feet, and had a 11° easterly magnetic variation₃ (figure 4). The following observations were taken and disseminated during the times surrounding the accident: ⁴

- [1254 HST] METAR PHMK 302329Z 02008G21KT 5SM -RA FEW007 BKN017 OVC025 22/18 A2994=
- [1354 HST] METAR PHMK 302354Z 02008G15KT 6SM BR FEW010 BKN020 OVC030 20/18 A2993 RMK AO2 RAE49 SLP140 P0004 60038 T02000183 10233 20200 58022=
- [1454 HST] METAR PHMK 310054Z 03010KT 6SM -RA BR FEW007 BKN019 OVC034 20/18 A2993 RMK AO2 RAB03 SLP137 P0004 T02000183=

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

³ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1980, latest measurement taken from <http://www.airnav.com/airport/PHMK>

⁴ The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that effected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1554 HST] METAR PHMK 310154Z 02013G20KT 6SM -RA BR SCT009 BKN023 OVC031
20/18 A2992 RMK AO2 SLP134 P0004 T02000183=

[1654 HST] METAR PHMK 310254Z 02007G17KT 5SM RA BR SCT006 BKN014 BKN024
19/18 A2995 RMK AO2 SLP145 P0010 60018 T01890178 53005=

[1754 HST] METAR PHMK 310354Z 01011G20KT 5SM BR SCT008 BKN014 OVC023
19/18 A2995 RMK AO2 RAE50 SLP147 P0007 T01890178=

**[1832 HST] SPECI PHMK 310432Z AUTO 01011G19KT 6SM -RA BR FEW009 BKN016
OVC055 19/18 A2995 RMK AO2 RAB07 P0002 T01890178 TSNO=**

**[1832 HST] METAR PHMK 310432Z AUTO 01011G19KT 6SM -RA BR FEW009 BKN016
OVC055 19/18 A2995=**

ACCIDENT TIME 1849 HST

**[1854 HST] METAR PHMK 310454Z AUTO 03012G18KT 6SM -RA BR SCT009 OVC016
19/18 A2995 RMK AO2 RAB07 SLP146 P0003 T01890178 TSNO=**

**[1904 HST] SPECI PHMK 310504Z AUTO 02008G17KT -RA FEW008 BKN014 OVC060
21/18 A2995 RMK AO2 P0000 T02110178 TSNO=**

[1904 HST] METAR PHMK 310504Z AUTO 02008G17KT -RA FEW008 BKN014 OVC060
21/18 A2995=

[1915 HST] SPECI PHMK 310515Z AUTO 03010G20KT -RA FEW008 OVC015 21/18
A2995 RMK AO2 P0000 T02110178 TSNO=

PHMK weather at 1832 HST, automated, wind from 010° at 11 knots with gusts to 19 knots, 6 miles visibility, light rain, mist, few clouds at 900 feet above ground level (agl), a broken ceiling at 1,600 feet agl, overcast skies at 5,500 feet agl, temperature of 19° Celsius (C), dew point temperature of 18° C, and an altimeter setting of 29.95 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1807 HST, one-hourly precipitation of 0.02 inches, temperature 18.9° C, dew point temperature 17.8° C, lightning detection system sensor is not operating.

PHMK weather at 1832 HST, automated, wind from 010° at 11 knots with gusts to 19 knots, 6 miles visibility, light rain, mist, few clouds at 900 feet agl, a broken ceiling at 1,600 feet agl, overcast skies at 5,500 feet agl, temperature of 19° C, dew point temperature of 18° C, and an altimeter setting of 29.95 inches of mercury.

PHMK weather at 1854 HST, automated, wind from 030° at 12 knots with gusts to 18 knots, 6 miles visibility, light rain, mist, scattered clouds at 900 feet agl, an overcast ceiling at 1,600 feet agl, temperature of 19° C, dew point temperature of 18° C, and an altimeter setting of 29.95 inches of mercury. Remarks: automated station with a precipitation discriminator, rain began at 1807 HST, sea level pressure 1014.6 hPa, one-hourly precipitation 0.03 inches, temperature 18.9° C, dew point temperature 17.8° C, lightning detection system sensor is not operating.

PHMK weather at 1904 HST, automated, wind from 020° at 8 knots with gusts to 17 knots, light rain, mist, few clouds at 800 feet agl, a broken ceiling at 1,400 feet agl, overcast skies at 6,000 feet agl, temperature of 21° C, dew point temperature of 18° C, and an altimeter setting of 29.95 inches of mercury. Remarks: automated station with a precipitation discriminator, one-hourly precipitation of a trace, temperature 21.1° C, dew point temperature 17.8° C, lightning detection system sensor is not operating. Neither the visibility sensor nor air traffic control supplementing the METARs reported a visibility conditions in the 1904 HST observation. That being said there is no observation of “missing” visibility, nor is there a mention of any equipment issues with the visibility sensor.

The observations from PHMK surrounding the accident time indicated MVFR⁵ conditions with periods of light rain and gusty surface winds from the north to northeast. The rain showers across Molokai will be further described in section 5.4 along with the movement and location of the accident flight.

3.0 Upper Air Data

A Global Data Assimilation System (GDAS) model sounding was created for the accident site for 2000 HST. The 2000 HST sounding was plotted on a standard Skew-T log P diagram⁶ with the derived stability parameters included in figure 5 (with data from the surface to 600-hPa, or 14,000 feet above msl.) This data was analyzed using the RAOB⁷ software package. The sounding depicted the lifted condensation level (LCL)⁸ at 1,995 feet, a convective condensation level (CCL)⁹ of 3,298 feet, and a level of free convection (LFC)¹⁰ at 2,663 feet. The freezing level was located at 12,326 feet. The precipitable water value was 1.36 inches.

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

⁶ 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.

⁷ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

⁸ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

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

¹⁰ Level of Free Convection (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.

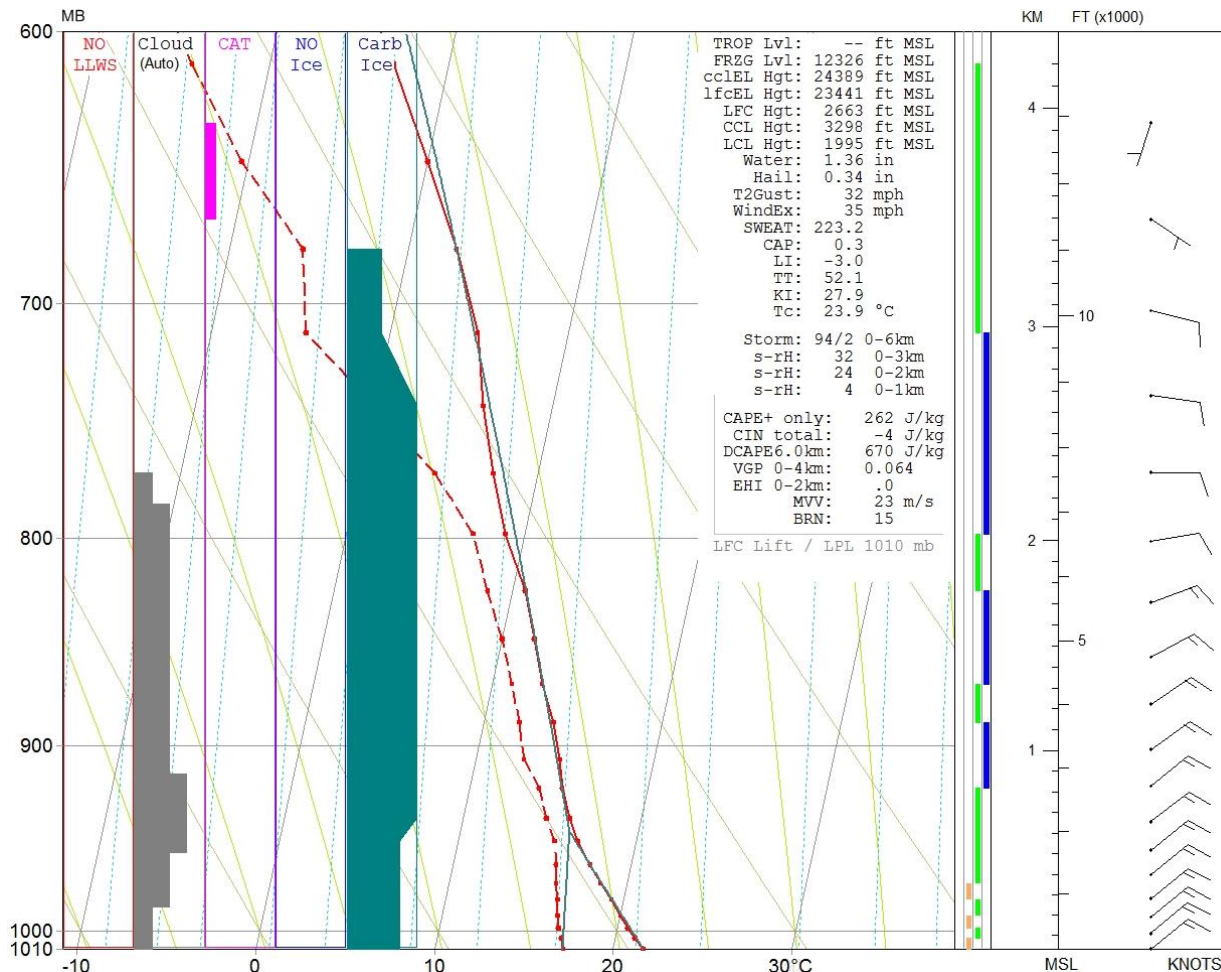


Figure 5 – 2000 HST GDAS sounding for the accident site

The 2000 HST GDAS sounding indicated a mix of unstable and conditionally unstable layers between the surface and 2,750 feet with a stable layer between 2,750 and 3,750 feet. Given the surface frontal boundary and mid-level trough around the accident time at the accident time, this environment would have been supportive of cloud formation and rain showers activity. 262 J/kg of CAPE₁₁ would have also supported the development of rain shower activity near lifting mechanisms with the maximum vertical velocity of the rain shower and/or thunderstorm updrafts to 23 m/s or 45 knots. RAOB identified the possibility of clouds from the surface through 8,000 feet and this would have likely led to instrument meteorological conditions (IMC) above 1,800 feet above msl (section 2.0, PHMK observations). No structural icing conditions were identified below 14,000 feet. RAOB identified the possibility of downdrafts coming out of the bottom of rain shower activity with wind gusts to 32 miles per hour (mph) (~ 28 knots) in the T2Gust parameter and wind gusts to 35 mph (~30 knots) in the WindEx parameter.

¹¹ Convective Available Potential Energy (CAPE) – CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

The 2000 HST GDAS sounding wind profile indicated a surface wind from 049° at 14 knots with the wind remaining primarily northeasterly to easterly through 14,000 feet. The wind speed remained between 10 to 15 knots between the surface and 10,000 feet. RAOB indicated no possibility of low-level wind shear outside of rain shower activity with a small layer of light clear-air turbulence between 12,000 and 13,000 feet.

4.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 band 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1600 HST through 2200 HST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 6, 7, and 8 present the GOES-15 infrared imagery from 1830, 1845, and 1900 HST at 6X magnification with the accident site highlighted with a red square. The infrared imagery indicated the cloud cover was moving from west to east across Molokai Island (attachment 1) with the colder brightness temperatures (green and blue colors) east and north of Molokai Island and the accident site. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 2000 HST GDAS sounding, the approximate cloud-top heights over the accident site were 11,000 feet at 1845 HST. It should be noted these figures have not been corrected for any parallax error.

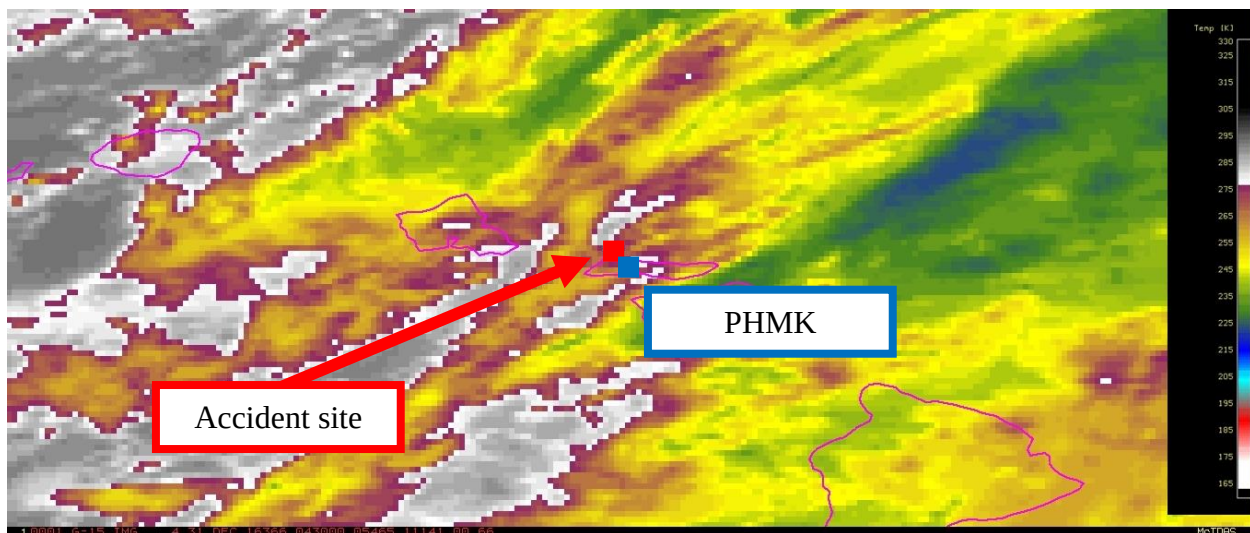


Figure 6 – GOES-15 infrared image at 1830 HST

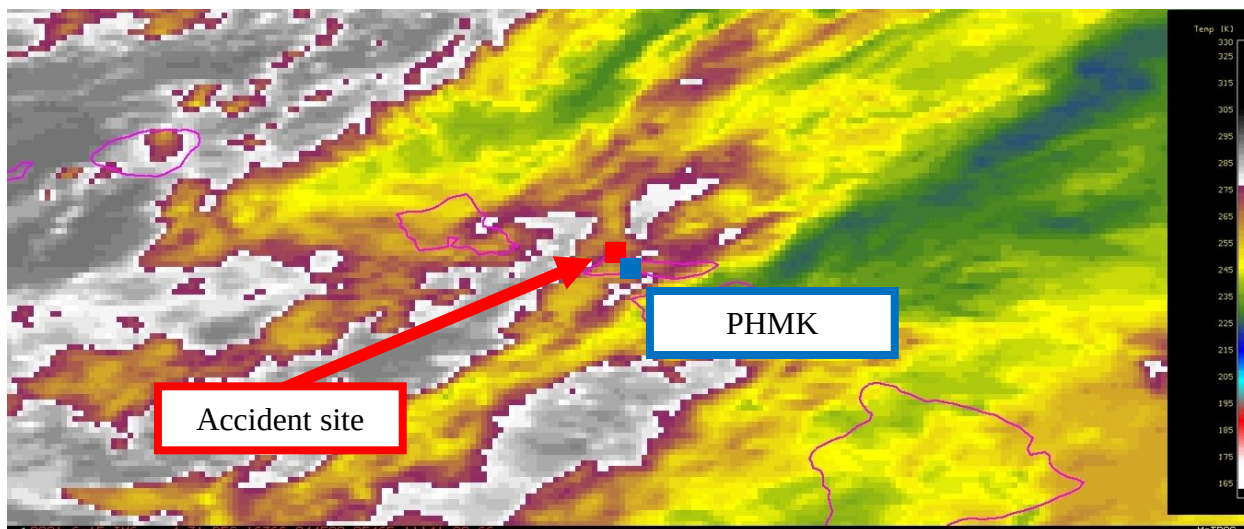


Figure 7 – GOES-15 infrared image at 1845 HST

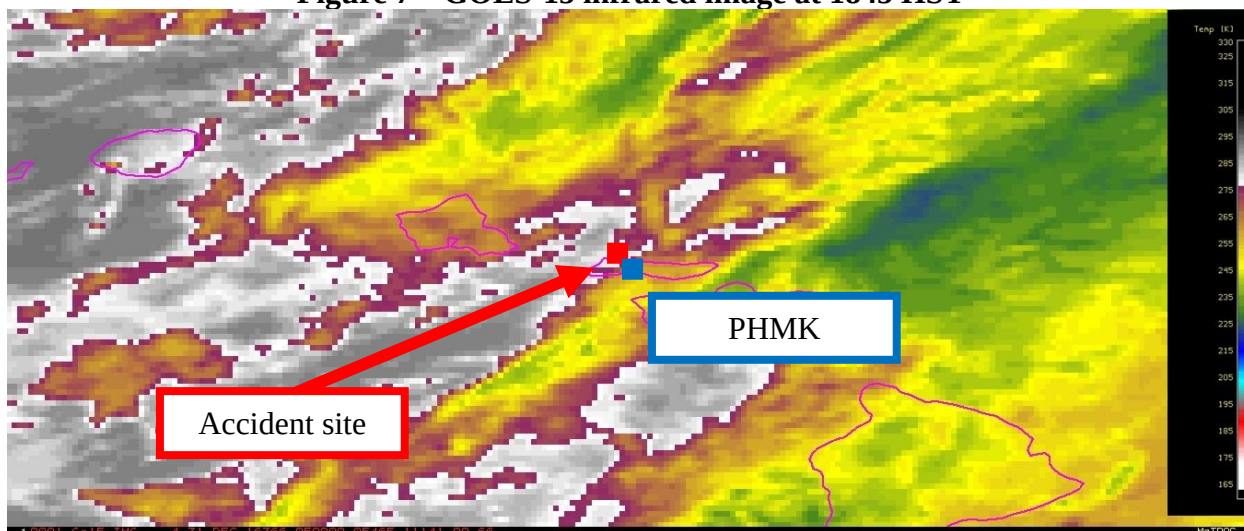


Figure 8 – GOES-15 infrared image at 1900 HST

5.0 Radar Imagery Information

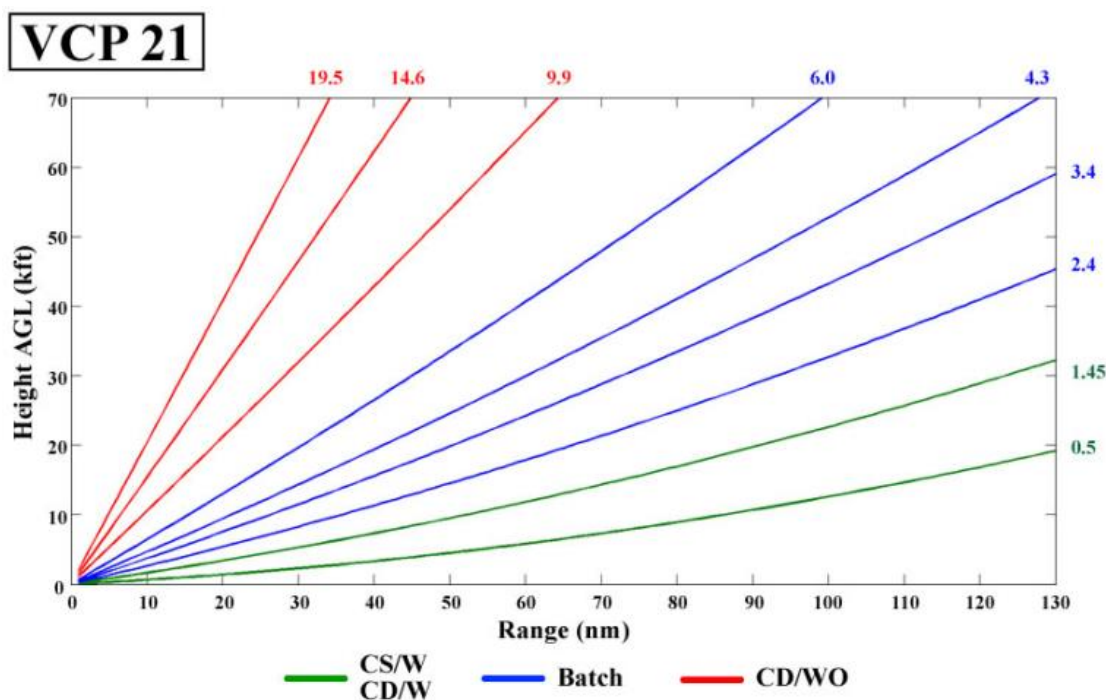
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹² to the accident site was the Molokai, Hawaii, radar (PHMO), which was located 6 miles south of the accident site at an elevation of 1,363 feet. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

¹² 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.

5.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the five to ten minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident, the PHMO WSR-88D radar was operating in the precipitation mode (Mode A, VCP-21). The following chart 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.



VCP-21 Precipitation Mode Scan Strategy¹³

¹³ 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)

5.2 Beam Height Calculation

Assuming standard refraction¹⁴ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width¹⁵ information¹⁶ of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	1,700 feet	1,410 feet	2,000 feet	590 feet
1.5°	2,340 feet	2,050 feet	2,640 feet	590 feet

Based on the radar height calculations, the 0.5° elevation scans depicted the conditions between 1,410 feet and 2,000 feet above msl over the accident site and the 1.5° elevation scans depicted the conditions between 2,050 feet and 2,640 feet above msl over the accident site. The 0.5° and 1.5° elevation scans are the closest altitudes to the accident flight level before the accident occurred.¹⁷

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁸ 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 (dBZ¹⁹), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “Thunderstorms,” dated February 19, 2013, 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 but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

¹⁴ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁵ Beam width – A measure of the angular width of a radar beam.

¹⁶ Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.

¹⁷ For more information, please see the air traffic control (ATC) data located in the docket for this accident.

¹⁸ 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.

¹⁹ 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.

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

5.4 Base Reflectivity and Lightning Data

Figures 9, 11, 13, and 15 present the PHMO WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1838, 1843, 1848, and 1853 HST, respectively, with a resolution of 0.5° X 250 m. Figures 10, 12, 14, and 16 present the PHMO WSR-88D base reflectivity images for the 1.5° elevation scans initiated at 1839, 1844, 1849, and 1854 HST, respectively, with a resolution of 0.5° X 250 m. Base reflectivity values between 5 to 15 dBZ were located above the accident site around the accident time. Stepping through the base reflectivity images (figures 9 through 16 and attachments 2 and 3), an outflow boundary is apparent, with the outer ring of the outflow boundary marked by the red/white arrows. The outflow boundary expands from 1839 (figure 10) through 1854 HST (figure 16) and likely occurred from a dissipating rain shower (attachments 2 and 3). An outflow boundary can create an environment favorable for unexpected changes in wind direction and speed (figure 17). With dissipating rain shower activity directly above the accident site at the accident time, the accident aircraft was in a favored region for downdrafts and outflow boundaries, while located in IMC above 1,800 feet msl (sections 2.0 and 3.0). There were no lightning strikes around the accident site at the accident time.²⁰ A review of the level II and III base velocity and storm relative velocity data was done, but the velocity data was inconclusive.

²⁰ A review of Earth Networks Total Lightning network was done.

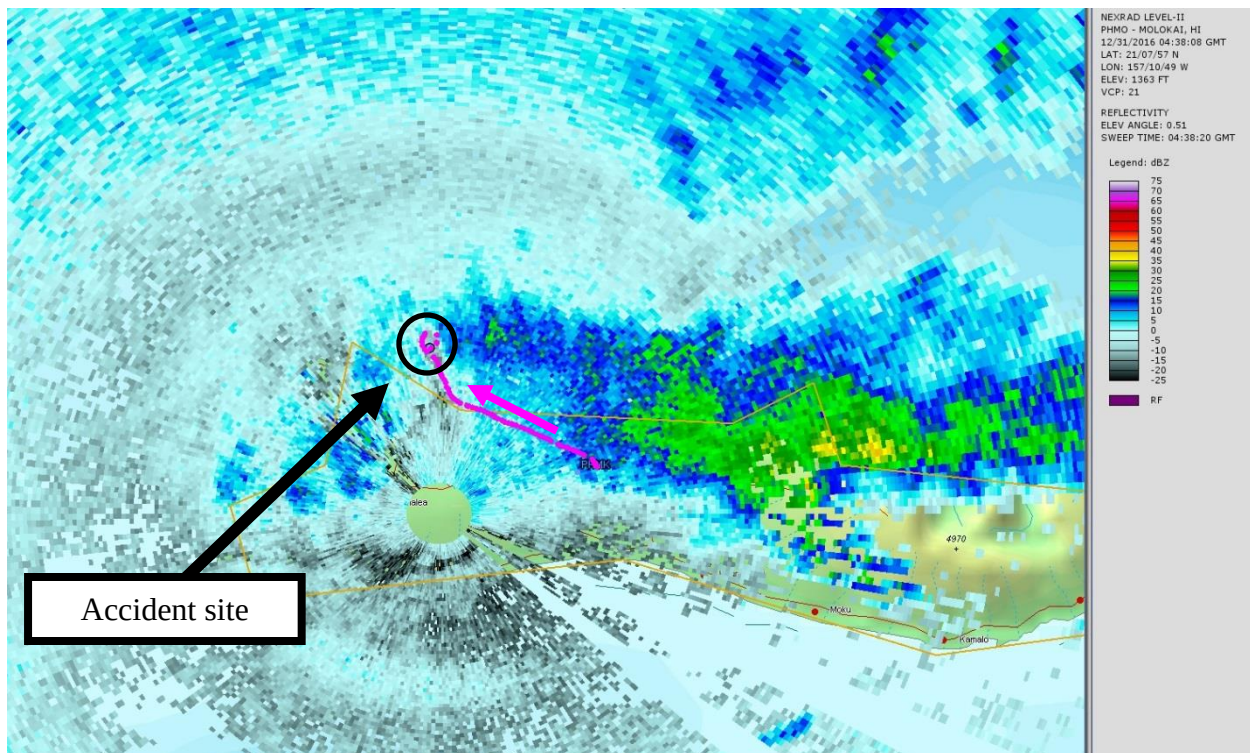


Figure 9 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1838 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

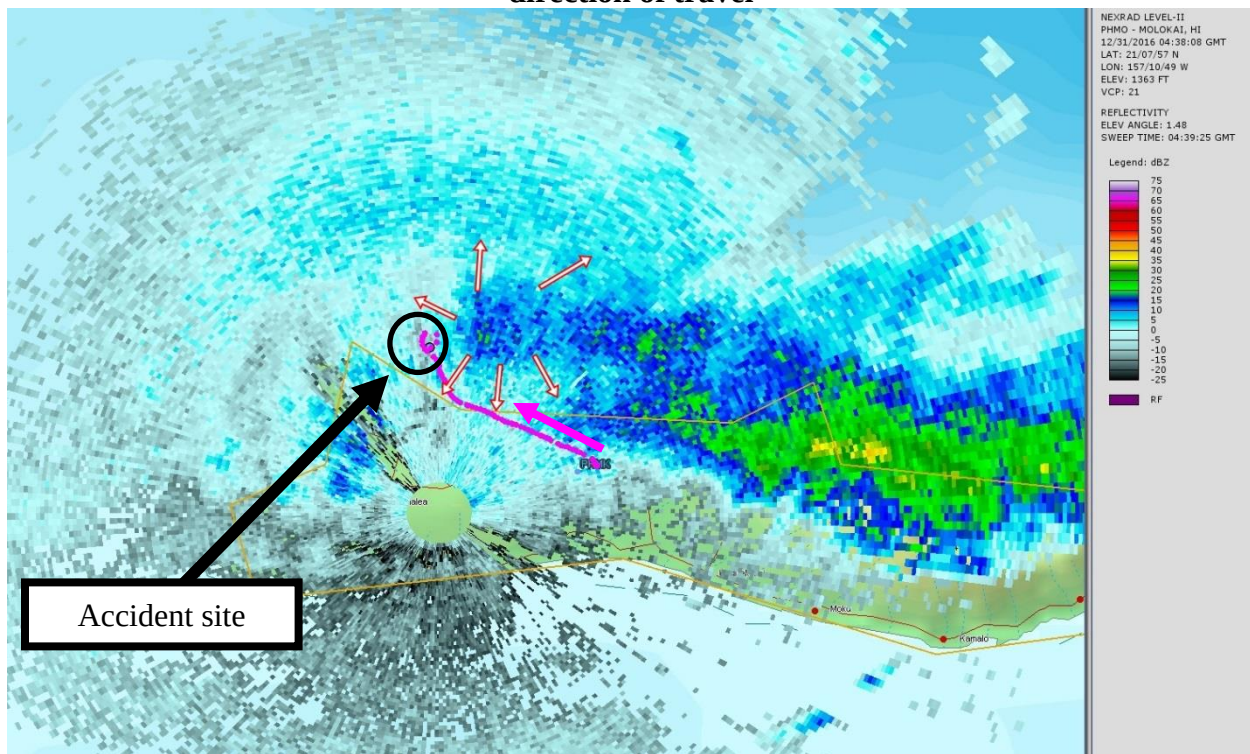


Figure 10 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1839 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

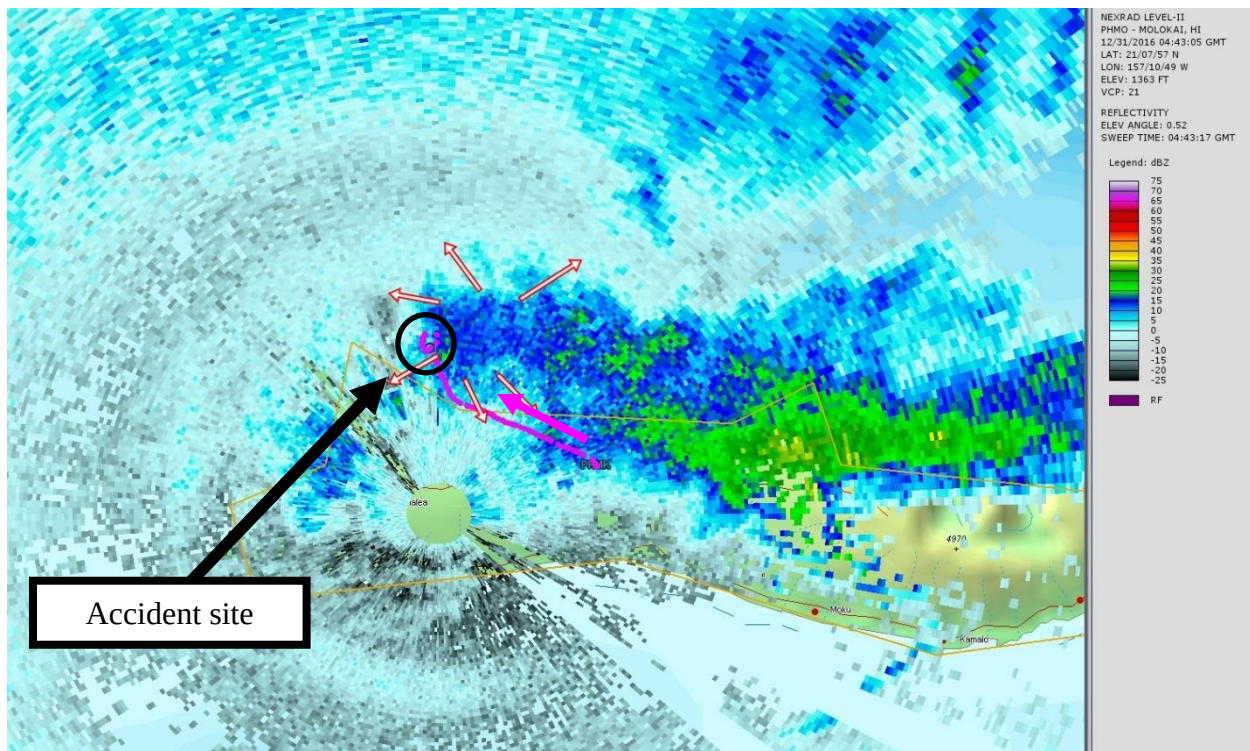


Figure 11 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1843 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

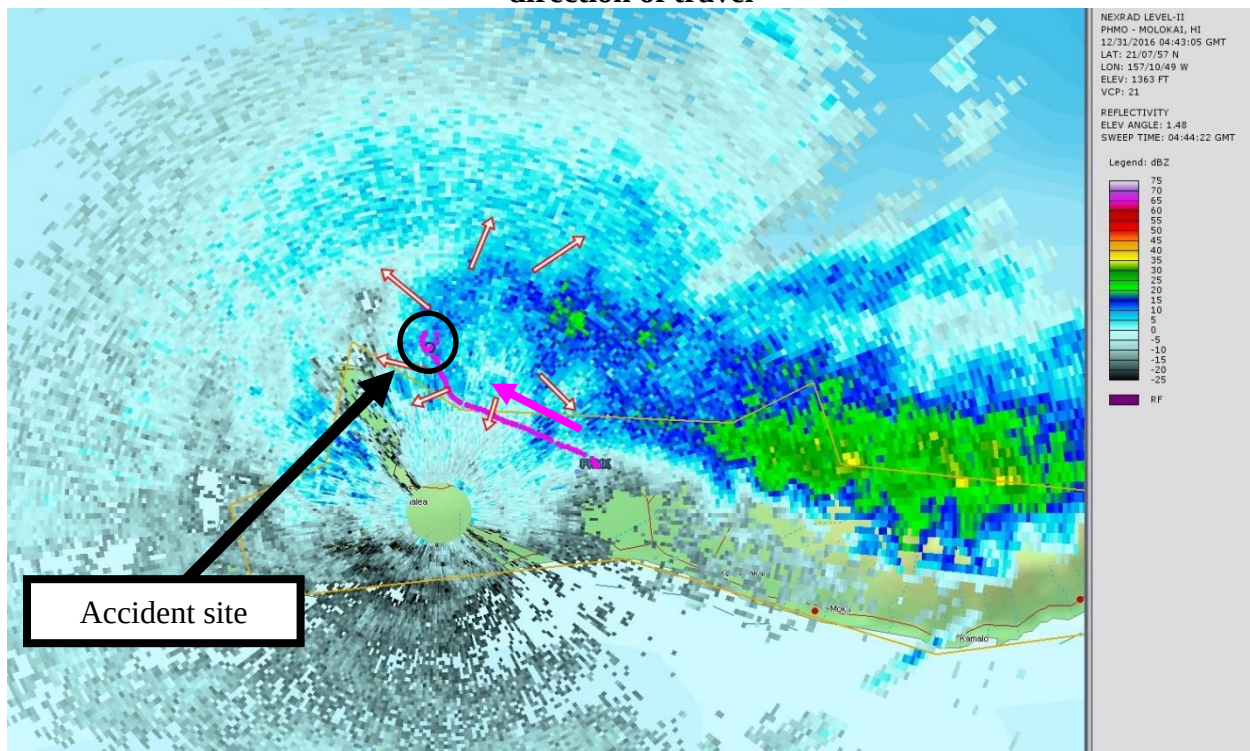


Figure 12 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1844 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

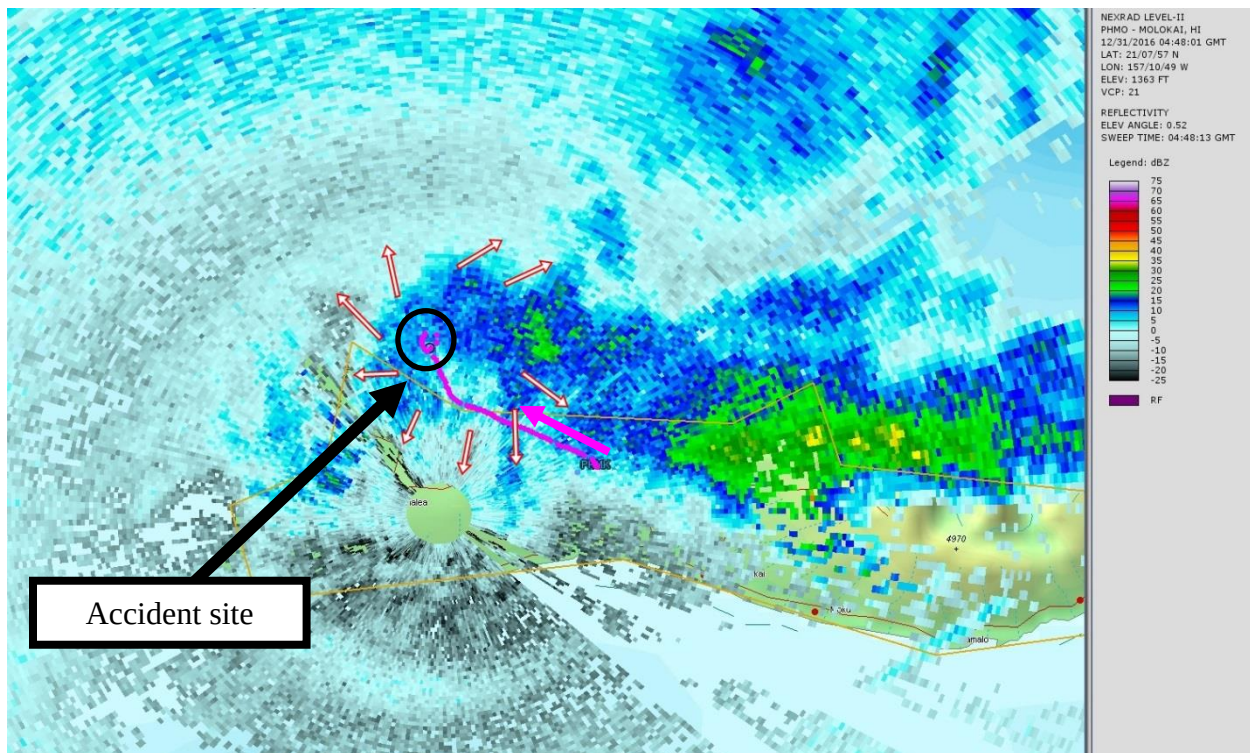


Figure 13 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1848 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

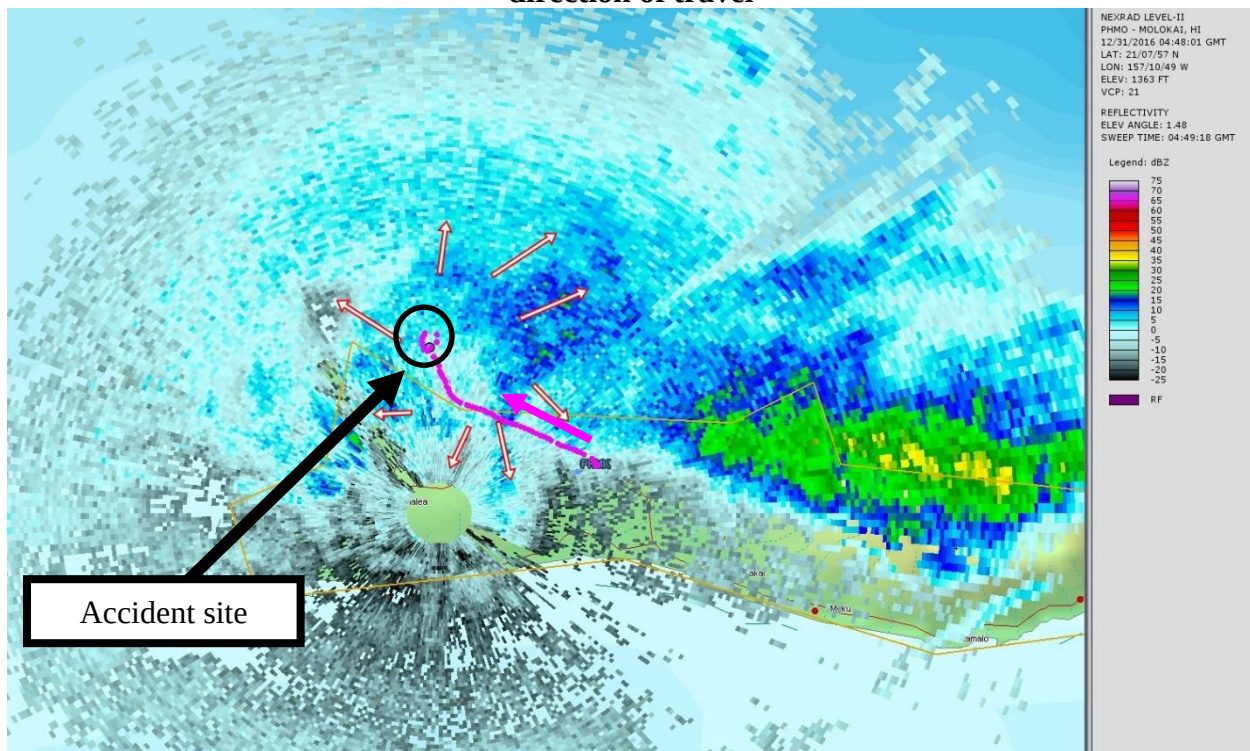


Figure 14 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1849 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

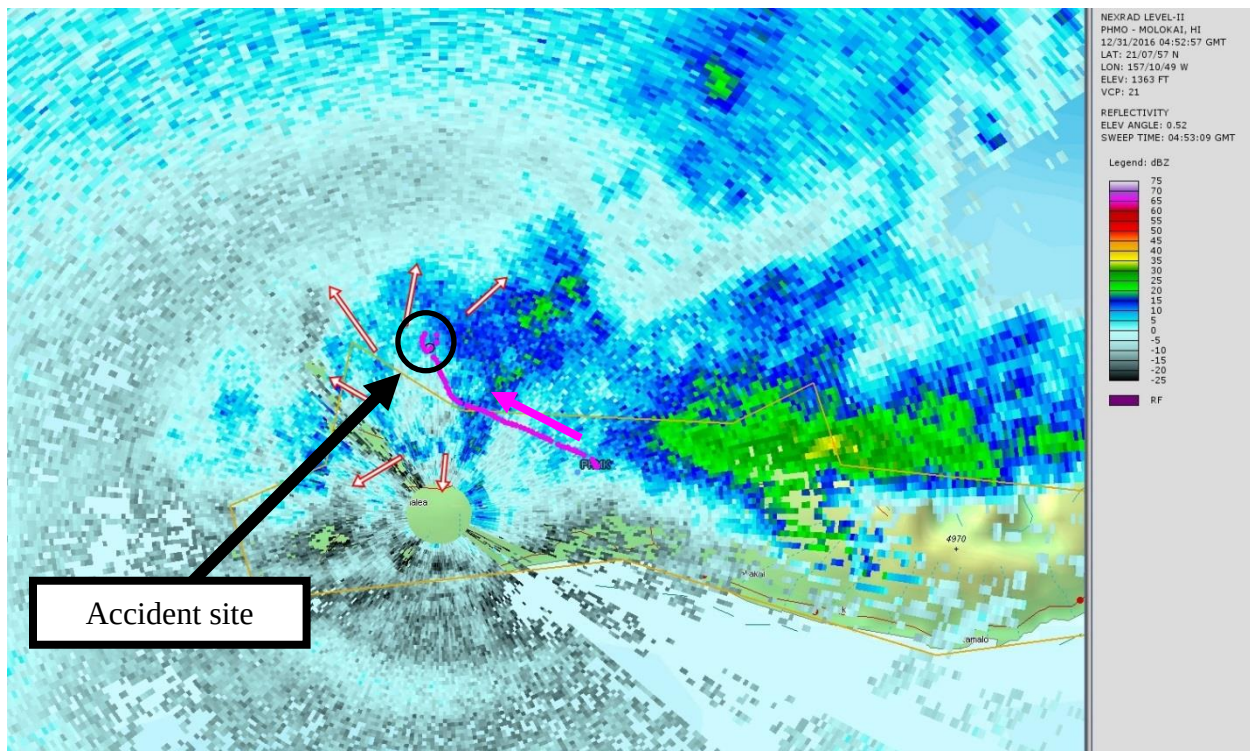


Figure 15 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1853 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

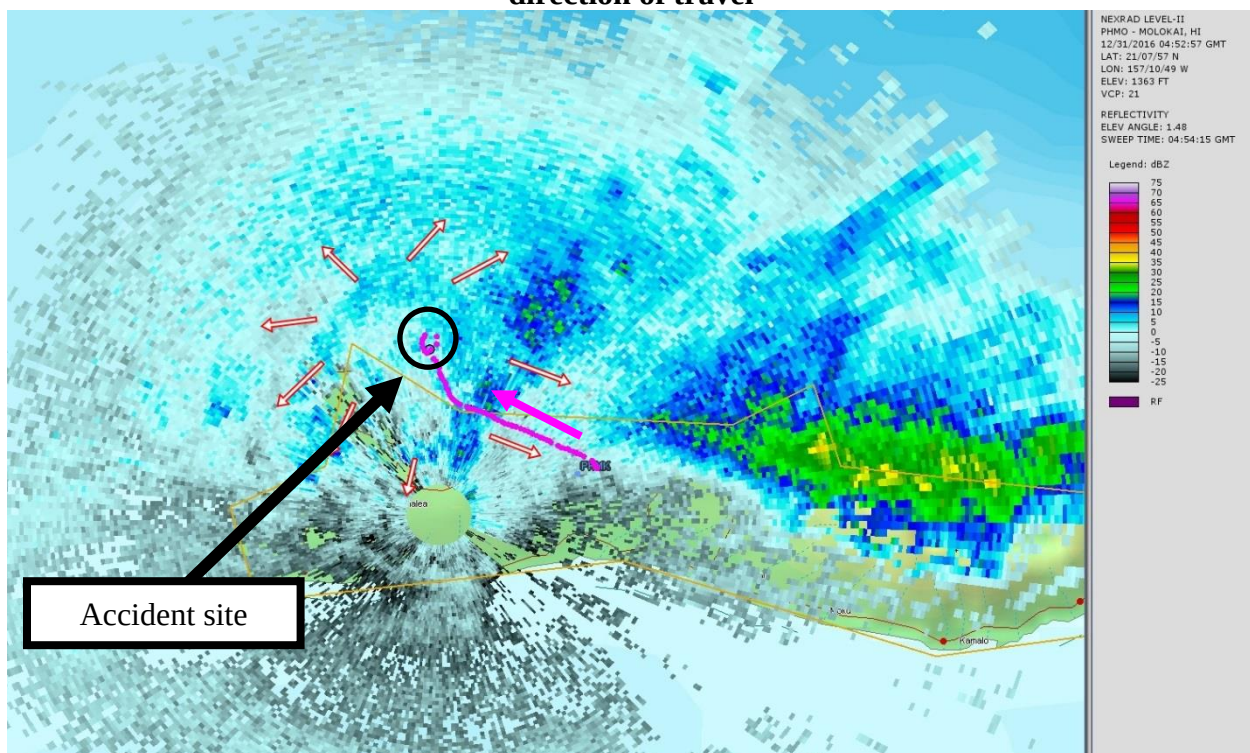


Figure 16 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1854 HST with the accident site marked with black circle and ATC track as pink dots with arrow in direction of travel

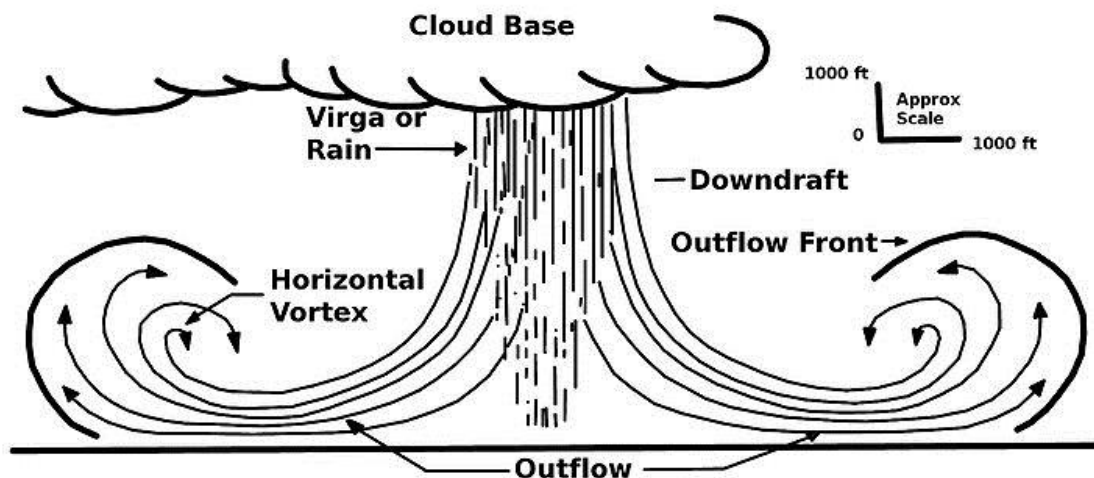


Figure 17 – Exemplar diagram of a downburst and outflow

6.0 Pilot Reports

All pilot reports (PIREPs) close to the accident site from about three hours prior to the accident time to about three hours after the accident time for below FL200²¹ are provided below:

OGG UA /OV OGG/TM 0153/FL001/TP TWR/WX 900 VIS/RM MOD RA

PHOG UA /OV OGG204002/TM 0213/FL006/TP B712/SK BKN006/WX +RA

LNK UA /OV LNK260018/TM 0220/FL035/TP C208/SK SCT035

PHOG UA /OV OGG200002/TM 0236/FL007/TP GLF4/SK BKN007

OGG UA /OV OGG200002/TM 0249/FL011/TP C208/SK BKN011/WX FV02SM

OGG UA /OV OGG200002/TM 0255/FL006/TP AT73/SK BKN006

OGG UA /OV OGG200002/TM 0351/FL008/TP A332/SK BKN008

OGG UA /OV OGG 204003/TM 0416/FL015/TP B752/SK BKN015

OGG UA /OV OGG204003/TM 0459/FL013/TP C208/SK SCT014

OGG UA /OV OGG204002/TM 0554/FL008/TP AT45/SK SCT008

Routine pilot report (UA); Over Kahului, Hawaii; Time – 1553 HST (0153Z on December 31); Altitude – 100 feet; Type aircraft – Tower; Weather – Visibility 900 feet; Remarks – Moderate rain.

²¹ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 204° radial; Time – 1613 HST (0213Z on December 31); Altitude – 600 feet; Type aircraft – Boeing B717-200; Sky – Broken ceiling at 600 feet; Weather – Heavy rain.

Routine pilot report (UA); 18 miles from Lanai City, Hawaii on the 260° radial; Time – 1620 HST (0220 on December 31); Altitude – 3,500 feet; Type aircraft – Cessna 208; Sky – Scattered clouds at 3,500 feet msl.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 200° radial; Time – 1636 HST (0236Z on December 31); Altitude – 700 feet; Type aircraft – Gulfstream Aerospace Gulfstream IV; Sky – Broken ceiling at 700 feet.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 200° radial; Time – 1649 HST (0249Z on December 31); Altitude – 1,100 feet; Type aircraft – Cessna 208; Sky – Broken ceiling at 1,100 feet; Weather – Forward visibility 2 miles.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 200° radial; Time – 1655 HST (0255Z on December 31); Altitude – 600 feet; Type aircraft – Aerospatiale ATR-73; Sky – Broken ceiling at 600 feet.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 200° radial; Time – 1751 HST (0351Z on December 31); Altitude – 800 feet; Type aircraft – Airbus A330-200; Sky – Broken ceiling at 800 feet.

Routine pilot report (UA); 3 miles from Kahului, Hawaii, on the 204° radial; Time – 1816 HST (0416Z on December 31); Altitude – 1,500 feet; Type aircraft – Boeing B757-200; Sky – Broken ceiling at 1,500 feet.

Routine pilot report (UA); 3 miles from Kahului, Hawaii, on the 204° radial; Time – 1859 HST (0459Z on December 31); Altitude – 1,300 feet; Type aircraft – Cessna 208; Sky – Scattered clouds at 1,400 feet.

Routine pilot report (UA); 2 miles from Kahului, Hawaii, on the 204° radial; Time – 1954 HST (0554Z on December 31); Altitude – 800 feet; Type aircraft – ATR-42-500; Sky – Scattered clouds at 800 feet.

7.0 SIGMET and CWSU Advisory

There were no SIGMETs valid for the accident site at the accident time.

There were no Center Weather Service Unit (CWSU) Meteorological Impact Statements (MIS)s that were valid for the accident site at the accident time. No CWSU Advisories (CWA)s were valid for the accident site at the accident time.

8.0 AIRMETs

An AIRMET Sierra was issued at 1845 HST and valid at the accident time for the accident site. The AIRMET Sierra warned of mountains temporarily obscured above 2,000 feet due to clouds and heavy rain showers on the north through east side of Molokai Island. The previous AIRMETs Sierra issued at 1713 HST (and valid for the accident time) and 1136 HST warned of the same mountain obscuration conditions on the north through east side of Molokai Island:

000

WAHW31 PHFO 310445 AAA
WA0HI

HNLS WA 310444 AMD
AIRMET SIERRA UPDATE 1 FOR IFR VALID UNTIL 311000

.
**AIRMET MTN OBSC...OAHU MOLOKAI LANAI...UPDATE
MTN AND N THRU E SECTIONS.
MTN TEMPO OBSC ABV 020 EXP DUE TO CLD AND +SHRA.
COND CONT BEYOND 1000Z.**

.
AIRMET MTN OBSC...BIG ISLAND MAUI...UPDATE
ENTIRE ISLAND.
MTN TEMPO OBSC ABV 020 EXP DUE TO CLD AND +SHRA/+TSRA.
COND CONT BEYOND 1000Z.

=HNLT WA 310400
AIRMET TANGO FOR TURB VALID UNTIL 311000

.
AIRMET TURB...HI
ENTIRE AREA.
TEMPO MOD TURB BTN FL300 AND FL400. COND CONT BEYOND 1000Z.

=HNLZ WA 310444 AMD
AIRMET ZULU UPDATE 1 FOR ICE AND FZLVL VALID UNTIL 311000

.
AIRMET ICE...MAUI AND BIG ISLAND AND ADJ WATERS.
MOD RIME ICE INC IN PRECIPITATION IN LVR 120-180.
COND CONT BEYOND 1000Z.

.
FZLVL...125.

000

WAHW31 PHFO 310313
WA0HI

HNLS WA 310400
AIRMET SIERRA FOR IFR VALID UNTIL 311000

.
**AIRMET MTN OBSC...OAHU MOLOKAI MAUI LANAI
MTN AND N THRU E SECTIONS.
MTN TEMPO OBSC ABV 020 EXP DUE TO CLD AND SHRA.
COND CONT BEYOND 1000Z.**

=HNLT WA 310400

AIRMET TANGO FOR TURB VALID UNTIL 311000

.
AIRMET TURB...HI
ENTIRE AREA.
TEMPO MOD TURB BTN FL300 AND FL400. COND CONT BEYOND 1000Z.

=HNLZ WA 310400
AIRMET ZULU FOR ICE AND FZLVL VALID UNTIL 311000
.
NO SIGNIFICANT ICE EXP.
.
FZLVL...125.

000
WAHW31 PHFO 302136
WA0HI

HNLS WA 302200
AIRMET SIERRA UPDATE 5 FOR IFR VALID UNTIL 310400
.
**AIRMET MTN OBSC...OAHU MOLOKAI MAUI LANAI
MTN AND N THRU E SECTIONS.
MTN TEMPO OBSC ABV 020 EXP DUE TO CLD AND SHRA.
COND CONT BEYOND 0400Z.**

=HNLT WA 302200
AIRMET TANGO UPDATE 5 FOR TURB VALID UNTIL 310400
.
AIRMET TURB...KAUAI OAHU
OVER AND IMT S THRU W OF MTN.
TEMPO MOD TURB BLW 070. COND CONT BEYOND 0400Z.
.
AIRMET TURB...HI
ENTIRE AREA.
TEMPO MOD TURB BTN FL300 AND FL400. COND CONT BEYOND 0400Z.

=HNLZ WA 302200
AIRMET ZULU UPDATE 3 FOR ICE AND FZLVL VALID UNTIL 310400
.
NO SIGNIFICANT ICE EXP.
.
FZLVL...109 PHLI SLOPING TO 124 PHTO.

9.0 Area Forecast

The Area Forecast issued at 1714 HST, valid at the accident time, forecasted few clouds at 1,000 feet above msl, scattered clouds at 2,000 feet, with a broken to overcast ceiling at 3,000 feet with tops at 10,000 feet, and light rain showers. Temporary conditions of broken ceilings at 2,000 feet with tops to 12,000 feet and visibilities between 3 and 5 miles with moderate rain showers were also forecast, with isolated conditions forecast to have broken ceilings at 1,500 feet with tops to 15,000 feet and visibilities below 3 miles in heavy rain showers:

FAHW31 PHFO 310314
FA0HI

HNLC FA 310335
SYNOPSIS AND VFR CLD/WX
SYNOPSIS VALID UNTIL 312200
CLD/WX VALID UNTIL 311600...OUTLOOK VALID 311600-312200

.
SEE AIRMET SIERRA FOR IFR CLD AND MT OBSC.
TS IMPLY SEV OR GREATER TURB SEV ICE LOW LEVEL WS AND IFR COND.
NON MSL HGT INDICATED BY AGL OR CEILING.

.
SYNOPSIS...MOISTURE ASSOCIATED WITH A STALLED FRONT WILL
AFFECT THE AREA FROM OAHU TO MAUI...PRIMARILY IMPACTING
WINDWARD AREAS. A TROUGH ALOFT APPROACHING FROM THE WEST MAY
ENHANCE THE MOISTURE TONIGHT...LEADING TO INCREASED COVERAGE
AND INTENSITY OF SHOWERS.

.
ENTIRE AREA.
BKN-OVC250-300. LOWER CLD AND WX FOLLOW.

.
BIG ISLAND INTERIOR ABV 090.
BKN-OVC120 TOPS 150 ISOL VIS 3SM SHRA/SHSN.
OUTLOOK...VFR.

.
BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM UPOLU
POINT TO CAPE KUMUKAHI TO APUA POINT.
SCT025 SCT-BKN050 TOPS 100 ISOL BKN025 TOPS 150 VIS 3-5SM SHRA.
OUTLOOK...VFR.

.
BIG ISLAND LOWER SLOPES AND COAST FROM APUA POINT TO SOUTH CAPE
TO PHKO TO UPOLU POINT.
SCT030 BKN-OVC060 TOPS 100 ISOL SHRA VIS 5SM. 06Z FEW-SCT025 FEW-SCT060.
OUTLOOK...VFR.

.
MTN...N THRU E SECTIONS AND ADJ WATERS OF KAUAI.
SCT020 BKN-OVC035 TOPS 100 TEMPO -SHRA ISOL BKN020 TOPS 100 VIS
3-5SM SHRA BR. OUTLOOK...VFR.

.
MTN...N THRU E SECTIONS AND ADJ WATERS OF OAHU MOLOKAI LANAI AND MAUI.
FEW010 SCT020 BKN-OVC030 TOPS 100 -SHRA TEMPO BKN020 TOPS 120 VIS
3-5SM SHRA BR ISOL BKN015 TOPS 150 VIS BLW 3SM +SHRA.
OUTLOOK...MVFR CIG/VIS SHRA.

.
REST OF AREA.
SCT020 SCT-BKN040 TOPS 080 TEMPO BKN035 TOPS 100 ISOL BKN025
TOPS 150 VIS 5SM -SHRA.
OUTLOOK...VFR.

10.0 Terminal Aerodrome Forecast

PHMK was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 1836 HST and was valid for a 19-hour period beginning at 1900 HST. The TAF for PHMK was as follows:

PHMK 310436Z 3105/3124 **02012G18KT 6SM -SHRA SCT008 BKN015 OVC035**
FM310900 02006KT P6SM VCSH SCT010 BKN020 OVC060
FM312000 01012G18KT P6SM VCSH SCT020 BKN035=

The forecast expected a wind from 020° at 12 knots with gusts to 18 knots, 6 miles visibility, light rain showers, scattered clouds at 800 feet agl, a broken ceiling at 1,500 feet agl, and overcast skies at 3,500 feet agl.

The PHMK TAF valid before the accident time was issued at 1320 HST and was valid for a 24-hour period beginning at 1400 HST. The 1320 HST TAF for PHMK was as follows:

TAF PHMK 302320Z 3100/3124 05012G18KT 6SM -SHRA FEW010 BKN020 OVC060
FM310400 02006KT P6SM VCSH SCT010 BKN020 OVC060
FM312000 01012G18KT P6SM VCSH SCT020 BKN035=

The forecast expected a wind from 020° at 6 knots, greater than 6 miles visibility, vicinity²² showers, scattered clouds at 1,000 feet agl, a broken ceiling at 2,000 feet agl, and overcast skies at 6,000 feet agl.

11.0 NWS Area Forecast Discussion

The NWS office in Honolulu, Hawaii, issued the following Area Forecast Discussion (AFD) at 1613 HST (closest AFD to the accident time). The aviation section of the AFD discussed that a stalled front was bringing MVFR conditions with moderate rain showers and IFR²³ conditions with heavy rain showers in the mountainous terrain from Oahu Island through Maui Island:

379
FXHW60 PHFO 310213
AFDHFO

Area Forecast Discussion
National Weather Service Honolulu HI
413 PM HST Fri Dec 30 2016

.SYNOPSIS...

A stationary front over Maui will linger through Saturday and then dissipate. Numerous showers will continue along the front, mainly across windward areas of Oahu, Molokai and Maui. Breezy trade winds will carry some showers over into leeward areas. An upper level trough will pass over the island chain tonight and Saturday, and could trigger some locally heavier showers along the front. Weak high pressure will build north of the islands behind the front, with trade winds gradually weakening during the weekend and into early next week.

&&

²² In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

²³ Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 feet agl and/or less than 3 miles visibility.

.DISCUSSION...

A weak stationary front is situated across Maui late this afternoon. Radar shows numerous showers across Maui and Molokai, with some of the showers occasionally moving onto windward Oahu and Lanai. Breezy trade winds are focusing the showers mostly over the windward sections of Maui and Molokai, but many are reaching leeward sides at times. Rainfall amounts have generally been moderate, but radar has shown a few heavier embedded showers this afternoon. Kauai and the Big Island are relatively dry.

Infrared satellite shows abundant high level clouds streaming across the state from Oahu eastward. These high clouds are due to a sharp upper level trough to the west and an associated jet stream coming up from the southwest. 00Z soundings from this afternoon showed little change in the profile of the atmosphere since this morning. The high cloud bases were shown at about 18 kft at Hilo. The high clouds are separated by a dry midlevel with shallow low level moisture associated with the front with tops at the 8 to 10 kft level. Precipitable water values were a dry 0.87 inches at Lihue and 1.27 inches at Hilo.

The upper trough to the west will slide eastward over the state tonight and Saturday, moving east of the Big Island by Saturday night. The trough will push the cirrus clouds east of the state by Saturday, however, it may act to enhance showers along the front tonight into Saturday morning with a few locally taller and heavier showers becoming possible. For now, locally heavy rainfall has been added to the forecast from windward Oahu to windward Maui. Because the front is expected to remain in place, we anticipate little change to the current weather through Saturday morning with models showing the front dissipating over Maui County Saturday night. Windward Maui and Molokai may still see some showers lingering into Saturday night, but the showers should be light.

We considered adding thunder to the forecast for tonight and Saturday morning as the upper trough passes by, but given the dry midlayers and low PW over Kauai expected to spread eastward, decided that there was not enough confidence to add to the forecast. The other issue we considered was a Winter Weather Advisory for the Big Island Summits tonight. While snow showers will be possible if the high clouds build down to the summits (which the models only briefly allude to tonight), the cloud bases would have to drop from 18 kft down to the summits at 14 kft. Again, not confident enough in the snow chances for an advisory.

By Saturday afternoon and evening, the cooler/drier airmass will spread across central parts of the state, as the upper trough moves east of the islands. Shower activity should decrease during this time as the upper support exits and moisture along the old frontal boundary becomes increasingly shallow. Trade winds will also be weakening during this time with only a weak high to our north, sandwiched in between a front far to the northwest and a meandering surface low far to the northeast.

Gentle trade winds with drier conditions are forecast to prevail

New Years Dat through the first half of next week as a weak surface ridge lingers just north of the state. Another weak front may drift southward into the islands toward the end of next week, but models have not been consistent with the timing or southward movement of this feature, so it is too soon to determine if it will affect us directly.

&&

.AVIATION...

Moisture associated with a stalled front remains over the area from Oahu through Maui County. The front is bringing areas of MVFR VIS/CIG in SHRA, and ISOL IFR VIS/CIG in +SHRA, primarily to windward waters, coasts and slopes, and briefly producing ISOL MVFR conditions as they spread leeward. AIRMET SIERRA for mountain obscuration is in place for the windward slopes from Oahu to Maui.

Breezy NE winds lie along and N of the front, and AIRMET SIERRA remains in place for low-level turbulence to the lee of the terrain of Oahu and Kauai. Moderate high-level turbulence continues over all islands due to an approaching trough aloft W of the area. The trough is bringing overcast high clouds over the islands in the WSW flow aloft.

&&

.MARINE...

Seas at the Hanalei/Waimea/Mokapu buoys have continued their gradual decline through the day, while Pauwela/Hilo have remained relatively steady around 11 feet. Between the lowering heights and recent surf reports, will drop the north shore advisories and lower the Kauai/Oahu east shore warnings to advisories. The swell was not only larger but seems to be slower to decline than expected, and will extend the east shore advisories through Saturday morning.

The morning ASCAT pass again only clipped the waters west of Kauai with winds 15-20 knots. The front continues to weaken, and has moved south across Kauai and Oahu to Maui County. High resolution guidance indicates pockets of 25 knot winds near the front, less than the 25-30 ASCAT picked up last night. The bulk of the small craft area is due to high seas, but there are some areas mainly near Maui County where the winds are also 25 knots. As the swell diminishes, seas will drop below 10 feet Saturday morning. Have kept the advisory for longer for Maalaea Bay and the Pailolo and Alenuihaha Channels due to winds. While the front will be dissipating, high resolution model guidance shows a surge of winds moving through and enhancing winds through these areas. From Sunday through the rest of the period, winds and seas remain below small craft levels.

&&

.HFO WATCHES/WARNINGS/ADVISORIES...

High Surf Advisory until noon HST Saturday for east facing shores of Kauai, Oahu, Molokai and Maui.

Small Craft Advisory until 7 PM HST Saturday for Maalaea Bay-Pailolo Channel-Alenuihaha Channel.

Small Craft Advisory until noon HST Saturday for Kauai Northwest Waters-Kauai Windward Waters-Kauai Leeward Waters-Kauai Channel-Oahu Windward Waters-Oahu Leeward Waters-Kaiwi Channel-Maui County Windward Waters-Big Island Windward Waters.

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\$\$

DISCUSSION...Foster

AVIATION...Morrison

MARINE...Bravender

12.0 Winds and Temperature Aloft Forecast

The NWS 1556 HST Winds and Temperature Aloft forecast valid for the accident flight is included below:

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000
FBHW31 KWNO 310156
FD1HW1
DATA BASED ON 310000Z
VALID 310600Z    FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT  1000 1500 2000 3000      6000      9000  12000  15000  18000  24000

LIH 0515 0517 0619 0622 9900+08 2410+05 2914+01 2913-05 3112-14 2526-24
HNL 0517 0518 0521 0624 0511+10 9900+04 2908+00 2709-05 2910-14 2529-24
LNH 0618 0716 9900+10 9900+04 2609+01 2712-05 2417-12 2435-23
OGG 0615 0616 0616 0716 1205+10 9900+04 2311+00 2616-05 2412-12 2438-23
KOA 9900 9900 2205 2408 2112+11 2112+05 2516+01 2712-06 2531-10 2457-21
ITO 9900 9900 9900 1506 1809+10 9900+06 2505+00 2511-05 2428-10 2449-21
```

The accident site was between the forecast point at HNL, and the forecast point at Lanai City, Hawaii, (LNY). The 1556 HST PHNL forecast indicated a wind from 050° at 17 knots at 1,000 feet, a wind from 050° at 18 knots at 1,500 feet, a wind from 050° at 21 knots at 2,000 feet, a wind from 060° at 24 knots at 3,000 feet, and a wind from 050° at 11 knots with a temperature of 10° C at 6,000 feet. The 1559 HST LNY forecast indicated a wind from 060° at 18 knots at 2,000 feet, a wind from 070° at 16 knots at 3,000 feet, and a calm wind at 6,000 feet with a temperature of 10° C.

13.0 Pilot Weather Briefing and Witness Information

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS) and Direct User Access Terminal Service, revealed that the accident pilot did request an official LMFS weather briefing. The accident pilot first called LMFS at 1617 HST before departing HNL for PHMK. During the 1617 HST LMFS call, the accident pilot declined to receive adverse weather conditions. The accident pilot contacted LMFS again at 1708 HST and the LMFS weather briefer mentioned an AIRMET Sierra that was valid along the route of flight. The accident pilot contacted LMFS again at 1820 HST after landing at PHMK and before departing on the accident flight. During the 1820 HST call, the accident pilot and LMFS briefer discussed an AIRMET Sierra. For more information please see attachments 4, 5, and 6.

In addition to the 1820 HST phone call, the accident pilot received text weather briefing information via LMFS at 1822 HST. The 1822 HST text weather briefing information contained an AIRMET Sierra that was valid along the route of flight, the METAR information for PHMK and HNL, the TAF information for both airports, the Area Forecast, and the Winds Aloft information. For more information please see attachment 7. It is unknown what if any other weather information the accident pilot checked before the accident flight.

14.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on December 30, 2016, indicated the following:

SUN

Begin civil twilight	0642 HST
Sunrise	0706 HST
Sun transit	1232 HST
Sunset	1758 HST
End civil twilight	1822 HST

MOON

Moonrise	0810 HST
Moon transit	1352 HST
Moonset	1936 HST

The phase of the Moon was Waxing Crescent with 3% of the Moon's visible disk illuminated. The Moon was likely not visible with the accident flight in IMC and the cloud tops at 11,000 feet.

F. LIST OF ATTACHMENTS

Attachment 1 – GOES-15 infrared satellite animation from 1745 to 1945 HST

Attachment 2 – PHMO WSR-88D reflectivity for the 0.5° elevation scan animation from 1828 to 1902 HST

Attachment 3 – PHMO WSR-88D reflectivity for the 1.5° elevation scan animation from 1828 to 1902 HST

Attachment 4 – LMFS call from 1617 HST

Attachment 5 – LMFS call from 1708 HST

Attachment 6 – LMFS call from 1820 HST

Attachment 7 – LMFS text weather briefing information from 1822 HST

Submitted by:

Paul Suffern
Senior Meteorologist

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