NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 14, 2019

Factual Report

METEOROLOGY

WPR19FA077

Table Of Contents

A. ACCIDENT

Location: Mt. Hood, Oregon
Date: January 25, 2019
Time: 1459 Pacific standard time
2259 Coordinated Universal Time (UTC)
Aircraft: Rockwell 112, Registration: N1332J

B. METEOROLOGIST

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

C. 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 official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Pacific standard time (PST) on January 25, 2019, and are based upon the 24-hour clock, where local time is -8 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 final wreckage location was estimated at latitude 45.3772° N, longitude 121.6928° W at an approximate elevation of 8,700 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the 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] https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

1.1 Surface Analysis Chart

The northwest United States section of the NWS Surface Analysis Chart for 1600 PST is provided as figure 1 with the approximate location of the accident site marked with the red circle. The chart indicated high pressure center was located in the eastern Pacific Ocean off the coast of Washington state with a pressure of 1035-hectopascals (hPa). There were no surface frontal boundaries depicted near the accident site.

The station models around the accident site depicted air temperatures in the upper 40's to low 50's degrees Fahrenheit (°F), dew point temperatures in the upper 30's °F with temperature-dew point spreads of 11° F or more, light and variable surface winds, and clear skies.

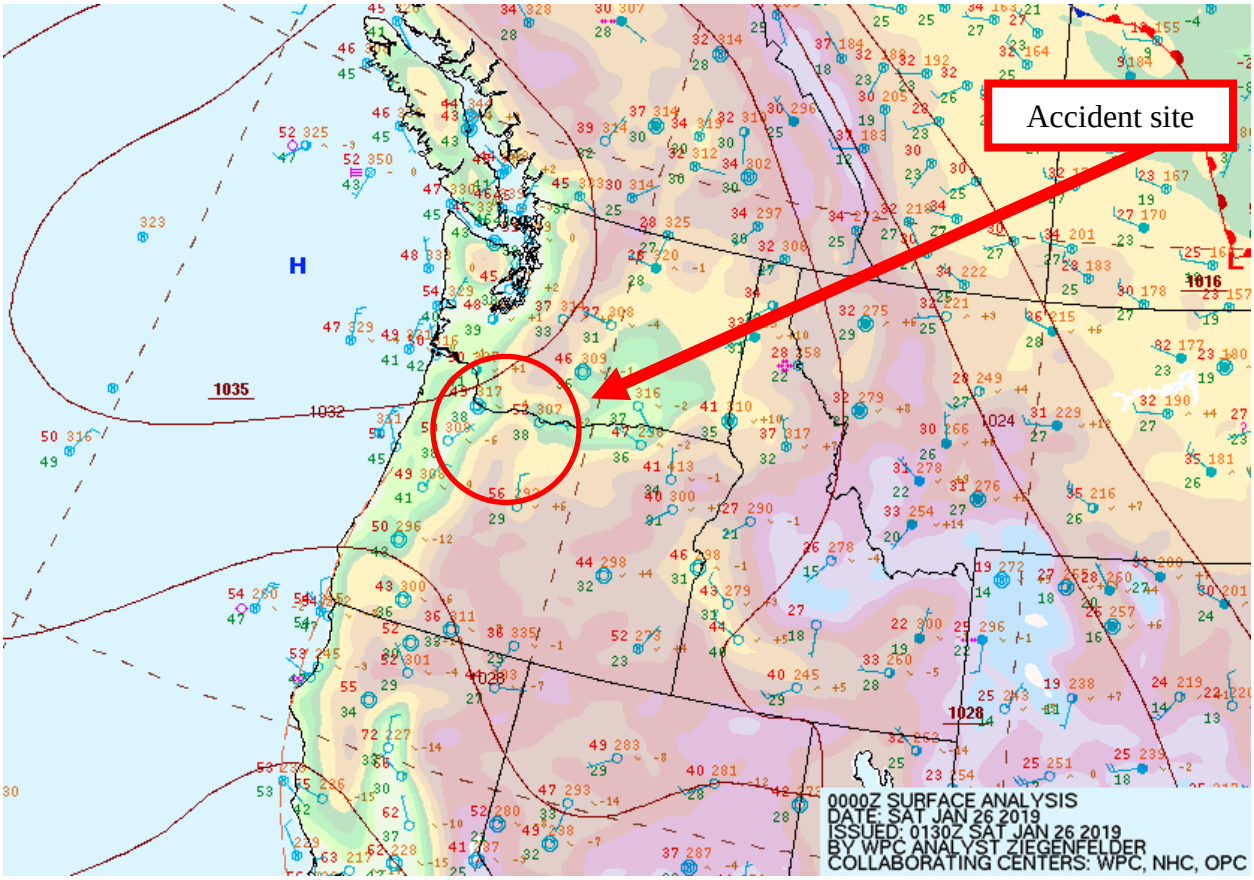

Figure 1 – NWS Surface Analysis Chart for 1600 PST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1600 PST at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There was a ridge[2] located west of the accident site above the surface high pressure system (figure 1) from 925- through 300-hPa. The wind was from the northeast at 20 knots at 925-hPa with the wind remaining northerly through 700-hPa and the wind speed increased to 35 knots by 700-hPa (figure 4). Through 300-hPa, the wind remained northerly at 35 knots (figure 6).

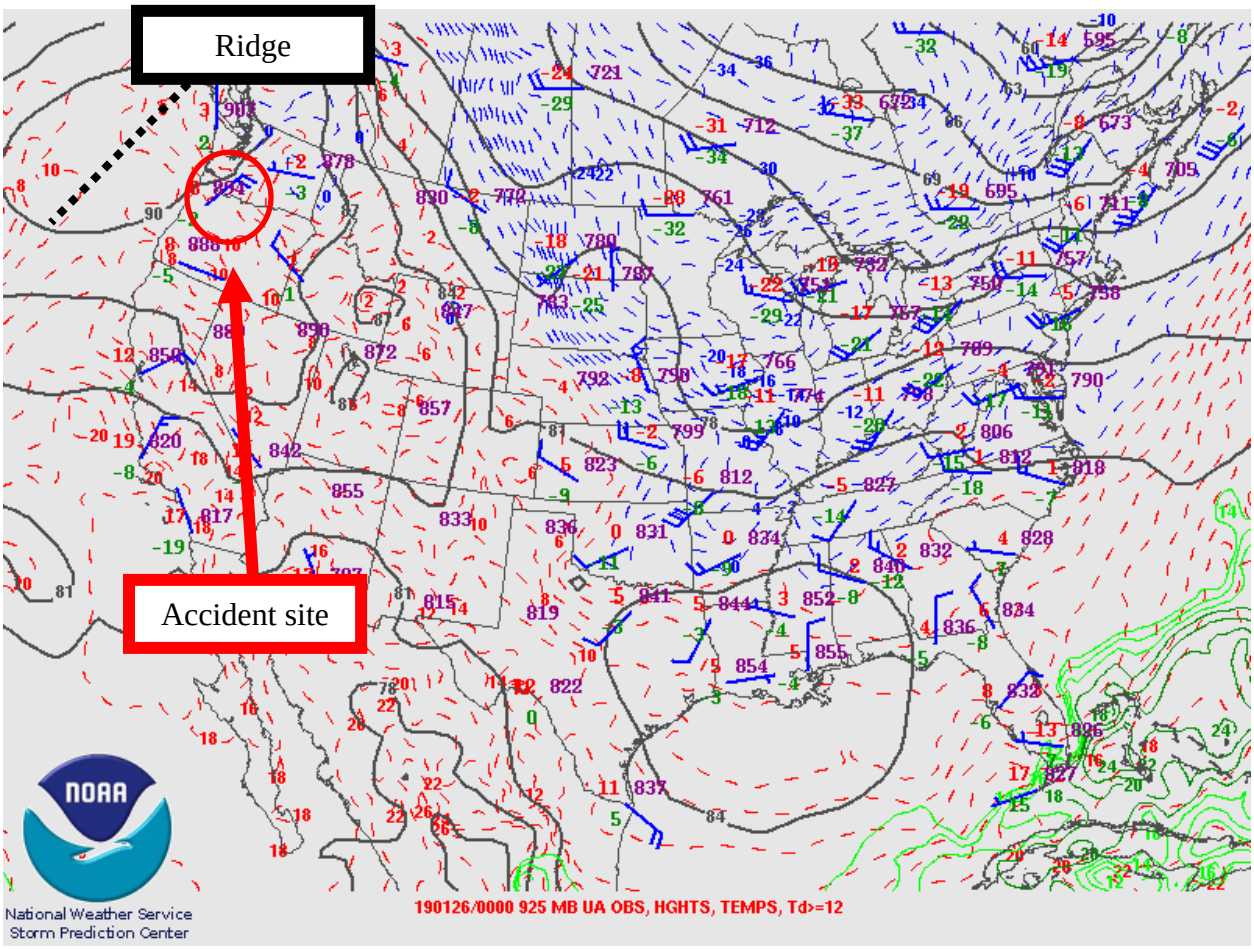

Figure 2 – 925-hPa Constant Pressure Chart for 1600 PST

[2] Ridge – An elongated area of relatively high atmospheric pressure or heights.

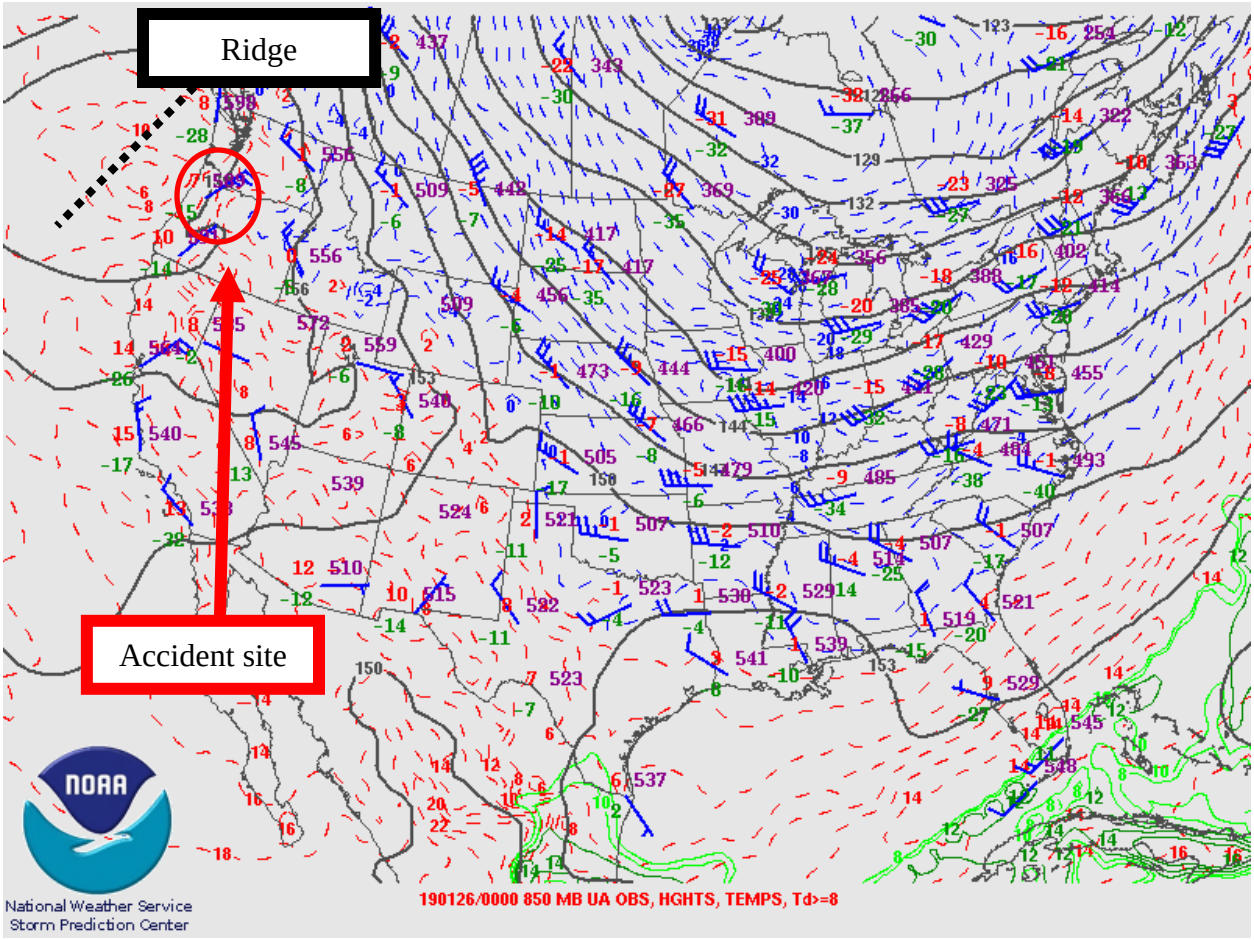

Figure 3 – 850-hPa Constant Pressure Chart for 1600 PST

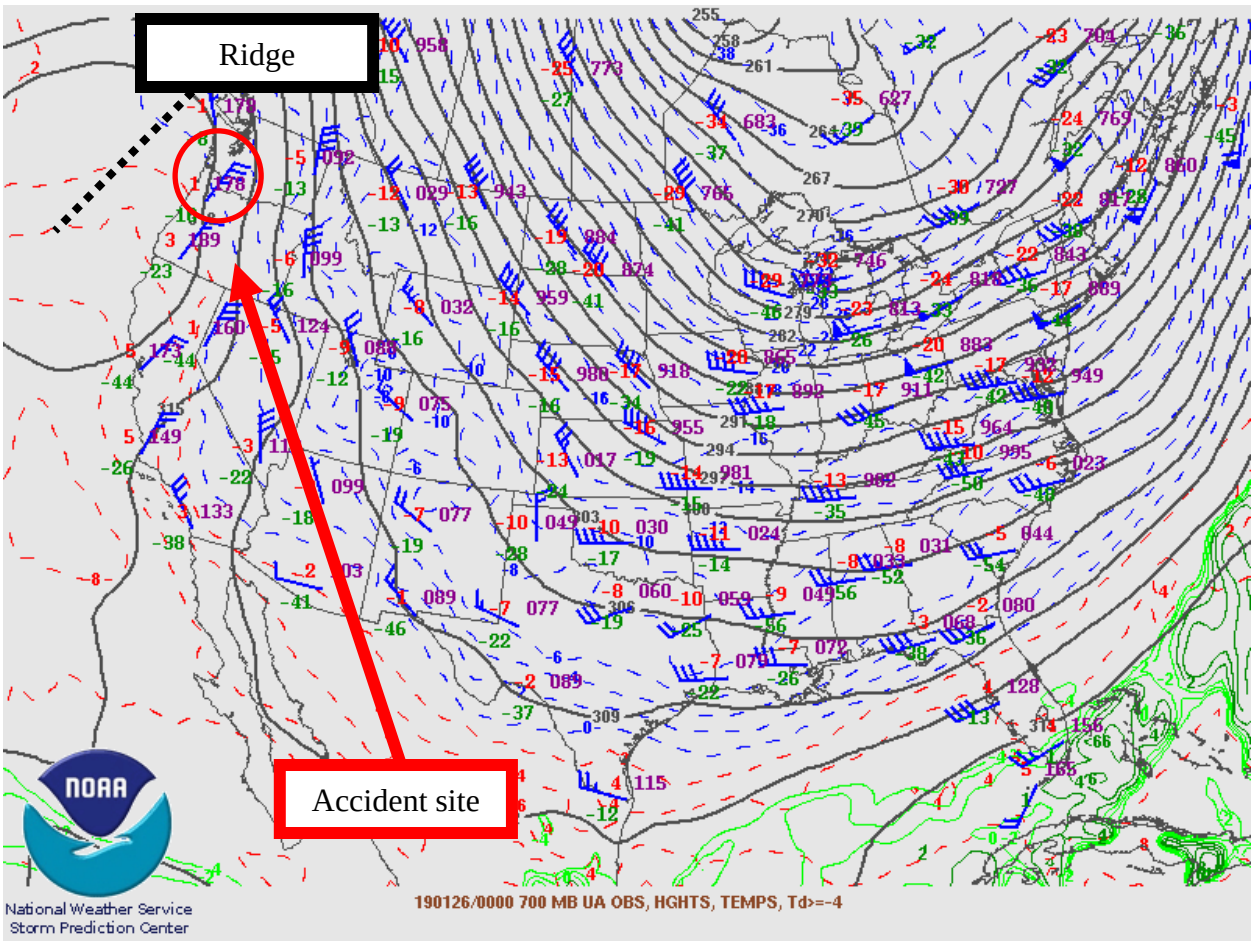

Figure 4 – 700-hPa Constant Pressure Chart for 1600 PST

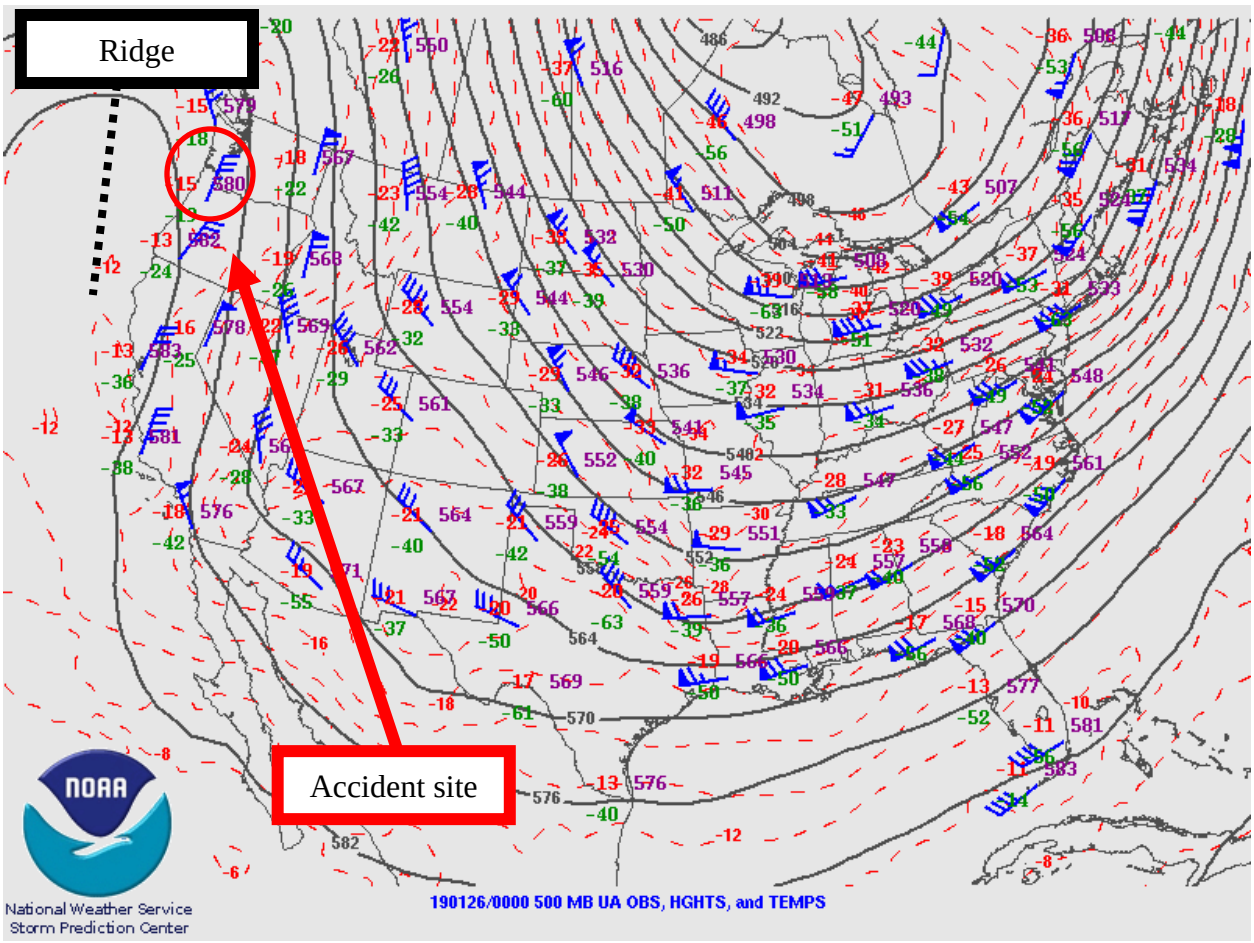

Figure 5 – 500-hPa Constant Pressure Chart for 1600 PST

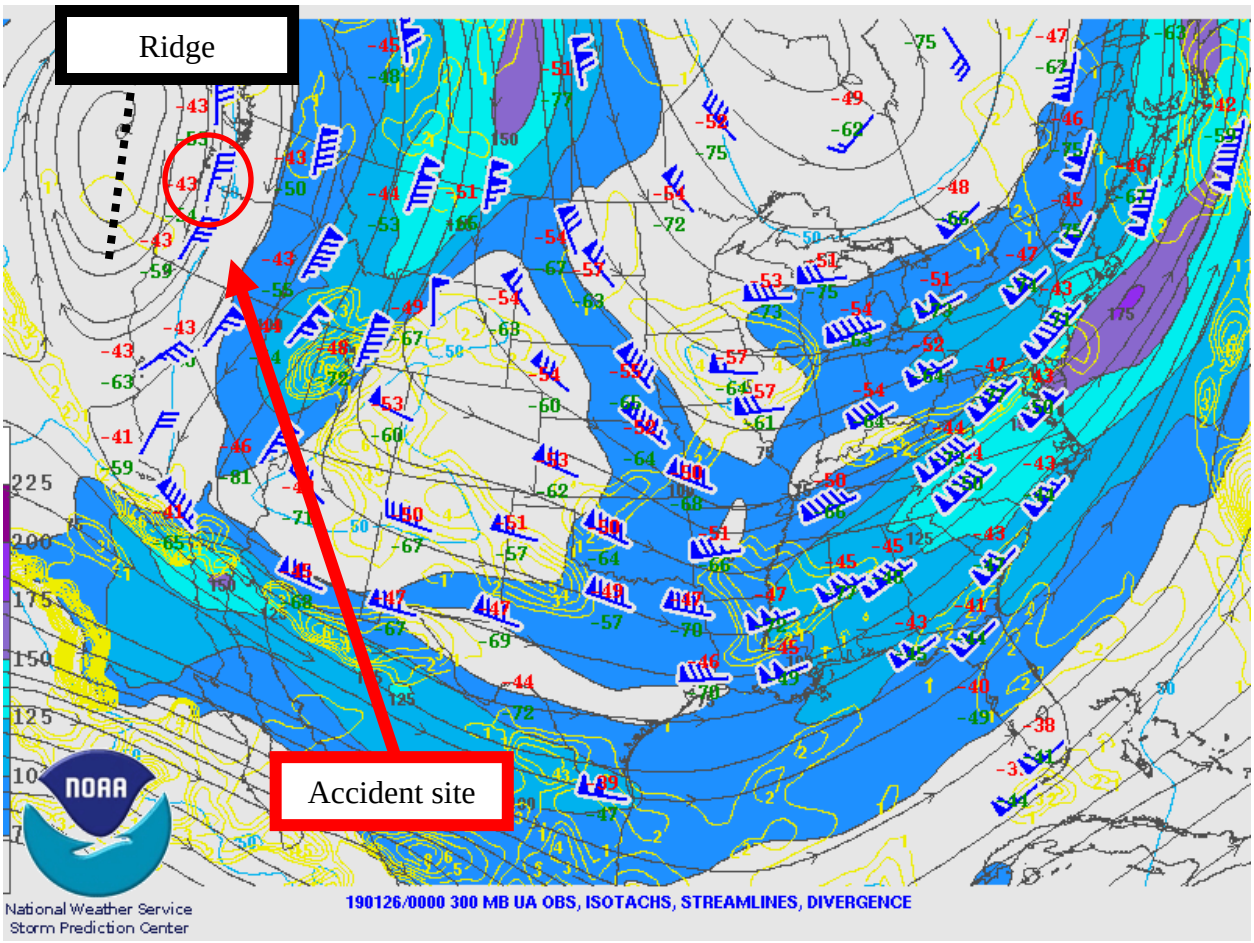

Figure 6 – 300-hPa Constant Pressure Chart for 1600 PST

2.0 SPC Products

SPC did not forecast any thunderstorms to impact the accident site at the accident time.

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 7 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked.

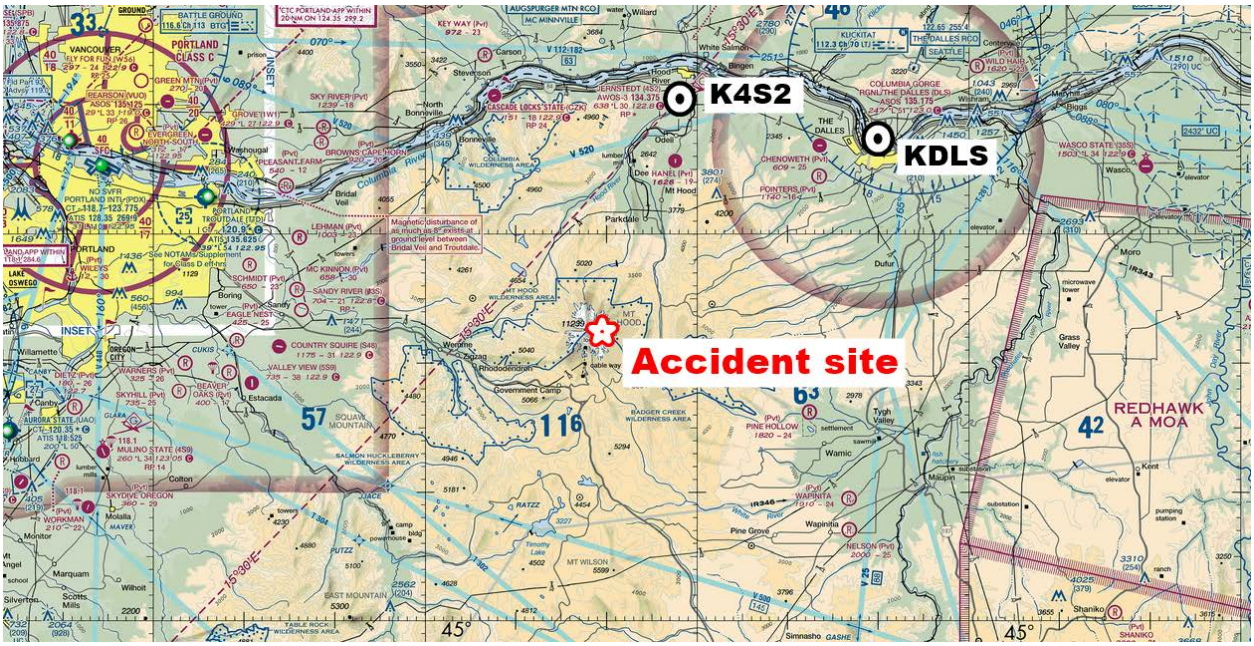

Figure 7 – Sectional chart of accident area with the location of the accident site and the closest surface observation sites

Ken Jernstedt Airfield (K4S2) had the closest official weather observations to the accident site. K4S2 had an Automated Weather Observing System (AWOS[3]) whose reports were not supplemented. K4S2 was located 19 miles north-northeast of the accident site, at an elevation of 638 ft, and had a 15° easterly magnetic variation[4] (figure 7). The following observations were taken and disseminated during the times surrounding the accident:[5]

[1315 PST] METAR K4S2 252115Z AUTO 30005KT 10SM CLR 08/03 A3042 RMK AO2 AWOS NOTAMED OSM=

[1335 PST] METAR K4S2 252135Z AUTO RMK TEMPORAIRILY INOPERATIVE=

[1355 PST] METAR K4S2 252155Z AUTO RMK TEMPORAIRILY INOPERATIVE=

[1415 PST] METAR K4S2 252215Z AUTO 33006KT 10SM CLR 11/03 A3042 RMK AO2 AWOS NOTAMED OSM=

[1435 PST] METAR K4S2 252235Z AUTO 34005KT 10SM CLR 10/03 A3042 RMK AO2=

[1455 PST] METAR K4S2 252255Z AUTO 35004KT 10SM CLR 10/03 A3043 RMK AO2=

[3] AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand feet, and altimeter setting.

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

[5] Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

ACCIDENT TIME 1459 PST

[1515 PST] METAR K4S2 252315Z AUTO 00000KT 10SM CLR 10/03 A3042 RMK AO2=

[1535 PST] METAR K4S2 252335Z AUTO 07003KT 10SM CLR 10/03 A3043 RMK AO2=

[1555 PST] METAR K4S2 252355Z AUTO 00000KT 10SM CLR 09/03 A3043 RMK AO2=

[1615 PST] METAR K4S2 260015Z AUTO 05004KT 10SM CLR 08/03 A3043 RMK AO2=

K4S2 weather at 1435 PST, automated, wind from 340° at 5 knots, 10 miles visibility or greater, clear skies below 12,000 ft above ground level (agl), temperature of 10 °Celsius (C), dew point temperature of 3° C, and an altimeter setting of 30.42 inches of mercury. Remarks: automated station with a precipitation discriminator.

K4S2 weather at 1455 PST, automated, wind from 350° at 4 knots, 10 miles visibility or greater, clear skies below 12,000 ft agl, temperature of 10 °C, dew point temperature of 3° C, and an altimeter setting of 30.43 inches of mercury. Remarks: automated station with a precipitation discriminator.

K4S2 weather at 1515 PST, automated, wind calm, 10 miles visibility or greater, clear skies below 12,000 ft agl, temperature of 10 °C, dew point temperature of 3° C, and an altimeter setting of 30.42 inches of mercury. Remarks: automated station with a precipitation discriminator.

K4S2 weather at 1535 PST, automated, wind from 070° at 3 knots, 10 miles visibility or greater, clear skies below 12,000 ft agl, temperature of 10 °C, dew point temperature of 3° C, and an altimeter setting of 30.43 inches of mercury. Remarks: automated station with a precipitation discriminator.

The observations from K4S2 surrounding the accident time supported visual flight rule (VFR)[6] conditions with northerly surface winds around 5 knots.

[6] Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 6 miles visibility.

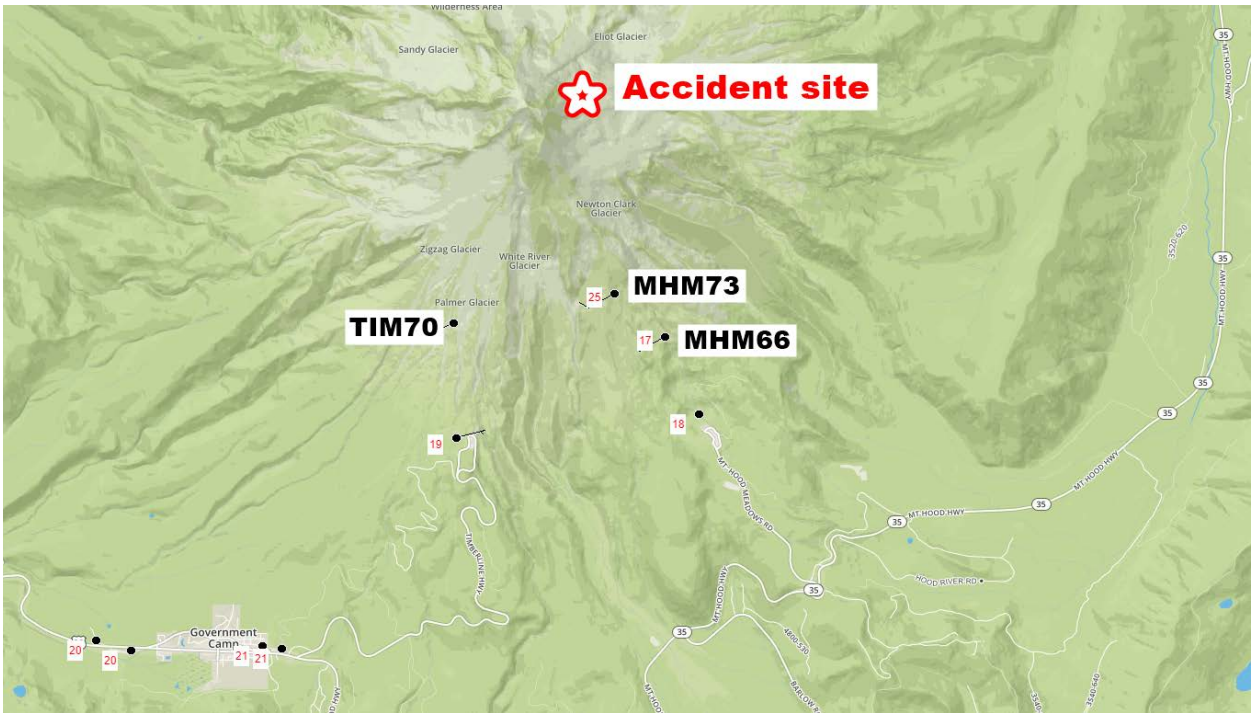

Figure 8 – Elevation map with the closest unofficial surface observation sites

Several unofficial surface observations sites were closer to the accident site than K4S2 and locations are documented in figure 8. Mt. Hood Meadows Cascade Express (MHM73) was the closest unofficial surface observation site to the accident site and was located 1 miles south of the accident site at an elevation of 7,300 ft (figure 8). MHM73 is owned and maintained by the Northwest Avalanche Center (NWAC). Figure 9 contains the observations from MHM73 surrounding the accident time:

STATION: MHM73
STATION NAME: Mt Hood Meadows Cascade Express
LATITUDE: 45.34927
LONGITUDE: -121.68163
ELEVATION [ft]: 7300
STATE: OR

Station_ID	Date_Time	air_temp_set_1	relative_humidity_set_1	wind_speed_set_1	volt_set_1	wind_gust_set_1	wind_direction_set_1	dew_point_temperature_set_1d	wind_chill_set_1d	wind_cardinal_direction_set_1d
		Fahrenheit	%	Miles/hour	volts	Miles/hour	Degrees	Fahrenheit	Fahrenheit	Code
MHM73	01/24/2019 21:00 PST	37.2	0.37	8.93	13.08	15.3	305.8	-66.64	32.75	NW
MHM73	01/24/2019 22:00 PST	35.98	0.37	4.18	13.08	12.17	305.5	-67.3		NW
MHM73	01/24/2019 23:00 PST	36.03	0.44	6.44	13.09	17.34	302.2	-65.05		WNW
MHM73	01/25/2019 00:00 PST	35.55	0.41	15.99	13.1	22.84	295.3	-66.23	28.16	WNW
MHM73	01/25/2019 01:00 PST	35.42	0.41	18.07	13.1	24.23	295.4	-66.3	27.41	WNW
MHM73	01/25/2019 02:00 PST	34.68	0.37	21.83	13.1	29.75	294.9	-68.02	25.54	WNW
MHM73	01/25/2019 03:00 PST	34.2	0.37	32.48	13.1	42.81	286.3	-68.28	22.82	WNW
MHM73	01/25/2019 04:00 PST	34.2	0.41	35.99	13.1	43.46	285.3	-66.97	22.26	WNW
MHM73	01/25/2019 05:00 PST	34.14	0.37	40.18	13.1	51.34	289.3	-68.31	21.56	WNW
MHM73	01/25/2019 06:00 PST	36.28	0.37	41.63	13.1	55.25	295.5	-67.14	24.23	WNW
MHM73	01/25/2019 07:00 PST	36.03	0.37	41.58	13.1	54.92	301.1	-67.28	23.9	WNW
MHM73	01/25/2019 08:00 PST	41.41	0.37	35.01	13.1	51	302	-64.33	31.94	WNW
MHM73	01/25/2019 09:00 PST	42.94	0.41	24.9	13.1	51.34	278.9	-62.14	35.47	W
MHM73	01/25/2019 10:00 PST	46.42	0.41	18.3	13.08	48	264.7	-60.22		W
MHM73	01/25/2019 11:00 PST	42.87	0.37	23.64	13.07	39.88	297.7	-63.54	35.6	WNW
MHM73	01/25/2019 12:00 PST	44.53	0.44	20.09	13.06	33.73	299	-60.31	38.39	WNW
MHM73	01/25/2019 13:00 PST	45.09	0.37	17.49	13.06	37.51	284.3	-62.32		WNW
MHM73	01/25/2019 14:00 PST	43.38	0.37	10.25	13.05	34.23	142	-63.26	39.57	SE
MHM73	01/25/2019 15:00 PST	41.16	0.41	12.86	13.05	37.78	126.7	-63.13	36.01	SE
MHM73	01/25/2019 16:00 PST	42.76	0.44	21.63	13.05	40.31	209.8	-61.3	35.84	SSW
MHM73	01/25/2019 17:00 PST	42.39	0.41	23	13.07	56.8	216.2	-62.45	35.11	SW
MHM73	01/25/2019 18:00 PST	41.85	0.44	19.22	13.08	47.51	264.4	-61.81	35.19	W
MHM73	01/25/2019 19:00 PST	41.85	0.37	21.16	13.08	38.36	286.8	-64.09	34.78	WNW
MHM73	01/25/2019 20:00 PST	43.12	0.44	17.36	13.1	29.68	297.3	-61.1	37.21	WNW
MHM73	01/25/2019 21:00 PST	43.5	0.41	17.76	13.1	43.89	291.1	-61.83	37.59	WNW

Figure 9 – List of observations from MHM73 surrounding the accident time

MHM73 weather at 1400 PST was reported as, wind from 142° at 10.25 miles-per-hour (mph) with gusts to 34.23 mph, and a temperature of 43.38 °F.

MHM73 weather at 1500 PST was reported as, wind from 126.7° at 12.86 mph with gusts to 37.78 mph, and a temperature of 41.16 °F.

MHM73 weather at 1600 PST was reported as, wind from 209.8° at 21.63 mph with gusts to 40.31 mph, and a temperature of 42.76 °F.

Timberline Magic Mile (TIM70) was the next closest unofficial surface observation site to the accident site and was located 2 miles southwest of the accident site at an elevation of 6,990 ft (figure 8). TIM70 was owned and maintained by the NWAC. Figure 10 contains the observations from TIM70 surrounding the accident time:

STATION: TIM70
STATION NAME: Timberline Magic Mile
LATITUDE: 45.34537
LONGITUDE: -121.71175
ELEVATION [ft]: 6990
STATE: OR

Station_ID	Date_Time	air_temp_	relative_h	wind_speed_set_1	volt_set_1	wind_gust_set_1	wind_direction_set_1	dew_point_temperature_set_1d	wind_chill_set_1d	wind_cardinal_direction_set_1d
		Fahrenhei	%	Miles/hour	volts	Miles/hour	Degrees	Fahrenheit	Fahrenheit	Code
TIM70	01/24/2019 21:00 PST	38.08	41.75	10.85	13.27	17.83	316.9	16.66	32.99	NW
TIM70	01/24/2019 22:00 PST	36.25	45.54	10.42	13.27	14.76	322	17.01	30.96	NW
TIM70	01/24/2019 23:00 PST	35.17	55.5	10.96	13.27	14.12	321.5	20.66	29.44	NW
TIM70	01/25/2019 00:00 PST	34.92	51.64	14.03	13.27	17.52	320.7	18.73	28	NW
TIM70	01/25/2019 01:00 PST	34.56	59.62	18.52	13.27	24.43	322.5	21.8	26.21	NW
TIM70	01/25/2019 02:00 PST	32.74	46.09	23.69	13.27	29.1	318.9	14.07	22.64	NW
TIM70	01/25/2019 03:00 PST	31.41	37.84	26.82	13.27	34.43	322	8.41	20.25	NW
TIM70	01/25/2019 04:00 PST	31.51	41.63	28.45	13.27	39.57	318.5	10.64	20.05	NW
TIM70	01/25/2019 05:00 PST	31.15	38.92	32.3	13.27	42.81	314.8	8.8	18.85	NW
TIM70	01/25/2019 06:00 PST	33.35	38.72	36.8	13.27	47.98	315.6	10.67	21.01	NW
TIM70	01/25/2019 07:00 PST	33.73	81.9	36.44	13.27	47.98	317.4	28.72	21.57	NW
TIM70	01/25/2019 08:00 PST	34.32	51.11	34.94	13.27	48.56	317.1	17.93	22.58	NW
TIM70	01/25/2019 09:00 PST	40.66	17.26	27.2	13.27	41.76	314.8	-0.62	32.14	NW
TIM70	01/25/2019 10:00 PST	45.14	10.76	23.38	13.27	49.26	323.1	-6.77		NW
TIM70	01/25/2019 11:00 PST	44.74	12.72	29.37	13.27	47.36	329.3	-3.67	37.09	NNW
TIM70	01/25/2019 12:00 PST	45.72	11.5	22.64	13.28	48.03	318.3	-4.96		NW
TIM70	01/25/2019 13:00 PST	47.07	19.69	21.25	13.28	46.17	328.5	7.52		NNW
TIM70	01/25/2019 14:00 PST	47.91	19.28	19.06	13.28	37.65	329.7	7.75		NNW
TIM70	01/25/2019 15:00 PST	46.45	24.89	11.97	13.28	41.03	327.5	12.21		NNW
TIM70	01/25/2019 16:00 PST	46.71	23.88	17.47	13.27	49.59	332.8	11.5		NNW
TIM70	01/25/2019 17:00 PST	46.33	26.18	17.45	13.27	37.27	328.5	13.25		NNW
TIM70	01/25/2019 18:00 PST	45.72	28.75	18.23	13.27	38.83	334	14.85		NNW
TIM70	01/25/2019 19:00 PST	45.36	21.71	16.13	13.27	33.93	334.1	8.23		NNW
TIM70	01/25/2019 20:00 PST	45.97	24.89	10.54	13.27	26.11	329.8	11.8		NNW
TIM70	01/25/2019 21:00 PST	44.02	34.09	7.81	13.26	22.01	325.7	17.28		NW

Figure 10 – List of observations from TIM70 surrounding the accident time

TIM70 weather at 1400 PST was reported as, wind from 329.7° at 19.06 mph with gusts to 37.65 mph, and a temperature of 47.91 °F.

TIM70 weather at 1500 PST was reported as, wind from 327.5° at 11.97 mph with gusts to 41.03 mph, and a temperature of 46.45 °F.

TIM70 weather at 1600 PST was reported as, wind from 332.8° at 17.47 mph with gusts to 49.59 mph, and a temperature of 46.71 °F.

Mt Hood Meadows Blue (MHM66) was the third closest unofficial surface observation site to the accident site and was located 2 miles south-southeast of the accident site at an elevation of 6,540 ft (figure 8). MHM66 was owned and maintained by the NWAC. Figure 11 contains the observations from MHM66 surrounding the accident time:

# STATION: MHM66										
# STATION NAME: Mt Hood Meadows Blue										
# LATITUDE: 45.34357										
# LONGITUDE: -121.67227										
# ELEVATION [ft]: 6540										
# STATE: OR										
Station_ID	Date_Time	air_temp_set_1	relative_humidity_set_1	wind_speed_set_1	volt_set_1	wind_gust_set_1	wind_direction_set_1	dew_point_temperature_set_1d	wind_chill_set_1d	wind_cardinal_direction_set_1d
		Fahrenheit	%	Miles/hour	volts	Miles/hour	Degrees	Fahrenheit	Fahrenheit	Code
MHM66	01/24/2019 21:00 PST	37.02	35.26	6.4	13.52	10.29	244.9	11.84		WSW
MHM66	01/24/2019 22:00 PST	37.33	34.1	0.69	13.52	4.92	25.41	11.36		NNE
MHM66	01/24/2019 23:00 PST	39.16	30.42	6.26	13.53	12.8	274.7	10.4		W
MHM66	01/25/2019 00:00 PST	40.14	26.88	13.33	13.54	19.44	276.7	8.5	34.62	W
MHM66	01/25/2019 01:00 PST	39.9	29.13	14.88	13.54	19.37	313.1	10.08	33.86	NW
MHM66	01/25/2019 02:00 PST	39.34	27.29	16.55	13.55	21.39	297.1	8.14	32.7	WNW
MHM66	01/25/2019 03:00 PST	37.94	20	22.64	13.56	31	267.5	0.23	29.51	W
MHM66	01/25/2019 04:00 PST	37.27	17.17	27.09	13.56	33.91	276.5	-3.52	27.77	W
MHM66	01/25/2019 05:00 PST	38.55	25.35	29.1	13.57	38.59	271.9	5.84	29.08	W
MHM66	01/25/2019 06:00 PST	40.84	22.56	26.8	13.57	37.09	291.8	5.25	32.44	WNW
MHM66	01/25/2019 07:00 PST	41.25	21.36	28.61	13.57	38.52	327.2	4.41	32.67	NNW
MHM66	01/25/2019 08:00 PST	47.59	9.23	22.17	13.57	30.89	267	-7.95		W
MHM66	01/25/2019 09:00 PST	46.83	9.44	14.67	13.56	31.12	315.2	-8.09		NW
MHM66	01/25/2019 10:00 PST	45.18	5.76	16.26	13.56	37.65	334.2	-18.87		NNW
MHM66	01/25/2019 11:00 PST	44.2	7.73	24.85	13.56	33.02	337.3	-14.02	37.1	NNW
MHM66	01/25/2019 12:00 PST	45.55	9.85	17.9	13.56	29.55	14.52	-8.22		NNE
MHM66	01/25/2019 13:00 PST	46.29	10.56	15.05	13.56	26.49	352.4	-6.25		N
MHM66	01/25/2019 14:00 PST	44.49	22.62	8.81	13.55	25.52	57.11	8.4	41.43	ENE
MHM66	01/25/2019 15:00 PST	44.13	14.95	11.52	13.54	21.5	13.05	-0.81	40.03	NNE
MHM66	01/25/2019 16:00 PST	44.08	21.02	9.26	13.53	17.74	38.56	6.44	40.77	NE
MHM66	01/25/2019 17:00 PST	43.93	24.8	9.84	13.53	22.15	24.23	9.97	40.37	NNE
MHM66	01/25/2019 18:00 PST	45.18	20.54	18.5	13.53	28.97	358.1	6.86		N
MHM66	01/25/2019 19:00 PST	45.1	19.83	14.41	13.53	22.55	327.6	6.03		NNW
MHM66	01/25/2019 20:00 PST	46.58	11.28	18.34	13.52	25.12	324	-4.68		NW
MHM66	01/25/2019 21:00 PST	47.07	28.79	15.55	13.53	23.91	310.7	16.06		NW

Figure 11 – List of observations from MHM66 surrounding the accident time

MHM66 weather at 1400 PST was reported as, wind from 57.11° at 8.81 mph with gusts to 25.52 mph, and a temperature of 44.49 °F.

MHM66 weather at 1500 PST was reported as, wind from 13.05° at 11.52 mph with gusts to 21.5 mph, and a temperature of 44.13 °F.

MHM66 weather at 1600 PST was reported as, wind from 38.56° at 9.26 mph with gusts to 17.74 mph, and a temperature of 44.08 °F.

The unofficial observations from MHM73, TIM70, and MHM66 surrounding the accident time indicated very gusty wind conditions with gusts close to 50 mph and variable wind directions with the gusting winds.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Salem, Oregon, KSLE, located 62 miles west-southwest of the accident site, with a site number 72694 and an elevation of 200 ft. The 1600 PST KSLE sounding was plotted on a standard Skew-T Log P diagram,[7] and is included in figure 12 (with data from the surface to 500-hPa (or approximately 19,000 ft msl). This data was analyzed using the RAOB[8] software package. The sounding depicted the lifted condensation level (LCL)[9] at 2,053 ft agl (2,253 ft msl) and the convective condensation level (CCL)[10] at 12,726 ft agl (12,926 ft msl). The sounding had a less than 60 percent relative humidity from the surface through 15,000 ft. The freezing level was located at 10,821 ft msl. The precipitable water value was 0.53 inches.

[7] 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.

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

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

[10] CCL – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

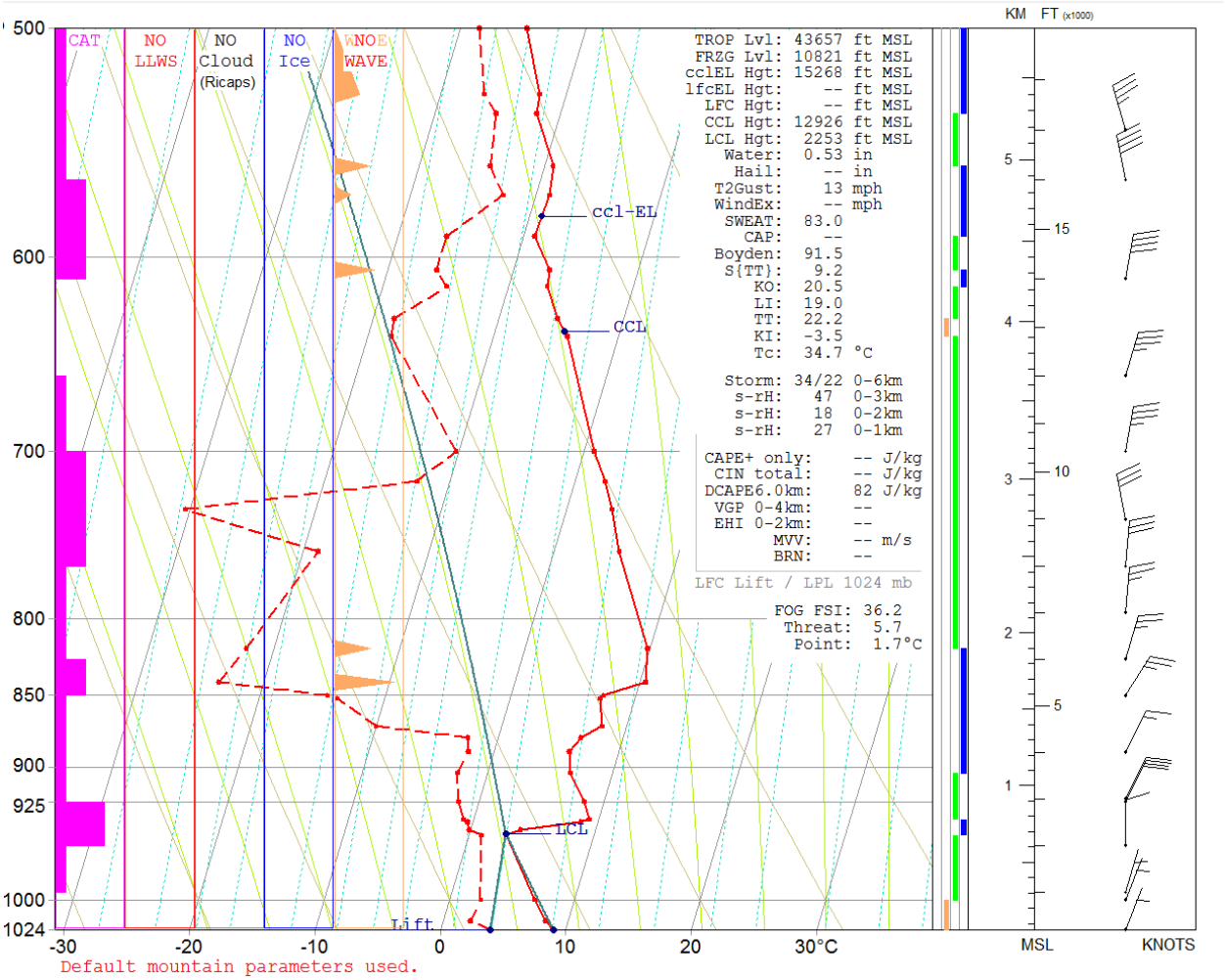

Figure 12 – 1600 PST KSLE sounding

The 1600 PST KSLE sounding indicated alternating conditionally unstable and stable environments from the surface through 19,000 ft msl, with a conditionally unstable environment from 6,000 ft msl through 13,000 ft msl. RAOB did not identify the possibility of clouds for below 19,000 ft msl. No icing was indicated by RAOB below 19,000 ft msl.

The 1600 PST KSLE sounding wind profile indicated a surface wind from 020° at 6 knots with the wind increasing in speed to 20 knots from the north by 2,000 ft. RAOB did not identify low-level wind shear (LLWS) potential between the surface and 2,000 ft. RAOB indicated the possibility of light to moderate clear-air turbulence in several layers above 2,000 ft msl. RAOB also indicated the possibility of moderate to severe mountain wave conditions[11] between 5,500 and 7,000 ft with updraft and downdraft speeds as high as 2,037 ft per minute (fpm) (figure 13). ROAB also identified moderate to severe mountain wave conditions at 14,000 ft msl with updraft and downdraft speeds as high as 1,315 fpm. Mountain wave conditions are further discussed in sections 16.0 and 17.0.

[11] Default RAOB mountain range parameters were used.

Level	Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x---W---Turb nm fpm max
12	4007	889	6.0	-2.0	56	25 / 16				
13	4311	879	6.6	-2.4	53					
14	4558	871	8.0	-10.0	27					
15	5154	852	7.2	-13.8	21		LGT			
16	5217	850	7.4	-14.6	19	30 / 23				
17	5506	841	10.4	-23.6	7		MDT			2.57 2037 SEVERE
18	6000	826				15 / 26				
19	6228	819	9.8	-22.2	9		LGT			4.45 1029 MD-SV
20	7000	796				5 / 24	LGT			
21	8000	767				5 / 29				
22	8317	758	5.2	-18.8	16		MDT			
23	9000	739				350 / 31				
24	9212	733	3.6	-30.4	6					
25	9798	717	2.4	-12.6	32		MDT			
26	10432	700	0.8	-10.2	44	10 / 33	LGT			
27	12000	659				15 / 37				
28	12814	639	-4.1	-18.1	33					
29	13180	630	-5.3	-18.3	35					
30	13841	614	-6.9	-14.9	53					
31	14000	610				10 / 41				
32	14177	606	-7.1	-16.1	49					5.67 1315 MD-SV
33	14859	590	-9.1	-16.1	57					
34	15691	571	-8.9	-12.6	75		MDT			4.03 521 LIGHT
35	16000	564				350 / 40				
36	16276	558	-9.3	-14.3	67		LGT			4.93 995 MD-SV
37	17000	542				345 / 37				
38	17339	535	-11.9	-15.1	77					
39	17718	527	-12.1	-16.5	70		LGT			4.28 726 LT-MD
40	19032	500	-14.7	-18.5	73	355 / 37				
41	19382	493	-15.3	-19.3	71					5.84 140 LIGHT
42	19992	481	-16.5	-23.5	55	355 / 38				
43	22124	441	-19.1	-33.1	28					4.93 522 LIGHT
44	23424	418	-22.1	-36.1	27					9.76 849 LT-MD

Figure 13 – 1600 PST KSLE sounding text data

5.0 Satellite Data

The Geostationary Operational Environmental Satellite number 17 (GOES-17) imagery was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible (band 2) and infrared (bands 13) imagery at a wavelength of 0.64 microns (μm) and 10.3 μm, respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1100 PST through 1700 PST at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figure 14 presents the GOES-17 visible imagery from 1500 PST at 3X magnification with the accident site highlighted with a red square. The GOES-17 imagery indicated a small amount of cloud cover directly above Mt. Hood with the cloud cover above the highest terrain moving from north to south (attachment 1). A stationary, wave-like cloud pattern can be seen in the clouds near Mt. Rainier in Washington north of the accident site (attachment 1). Figure 15 presents the GOES-17 infrared imagery from 1500 PST 3X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated a small amount of cloud cover directly above Mt. Hood and the highest terrain with the cooler brightness temperatures (green colors, higher cloud tops) north and east of the accident site over eastern Washington and Idaho. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1600 PST SLE sounding, the approximate cloud-top heights over the accident site were 13,000 ft at 1500 PST (269º Kelvin). It should be noted these figures have not been corrected for any parallax error.

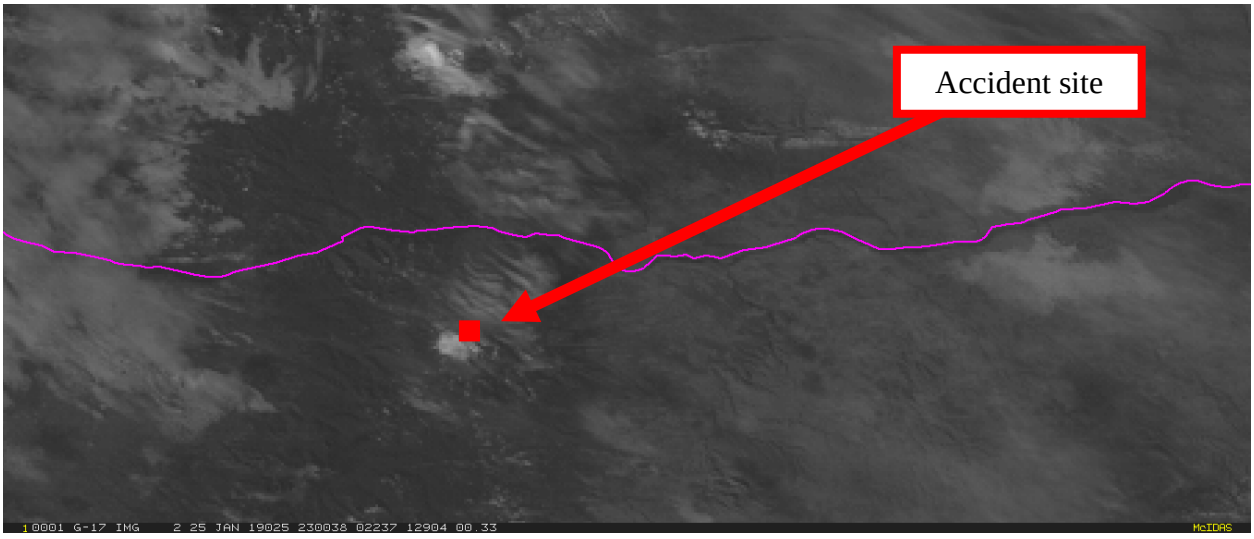

Figure 14 – GOES-17 visible image at 1500 PST

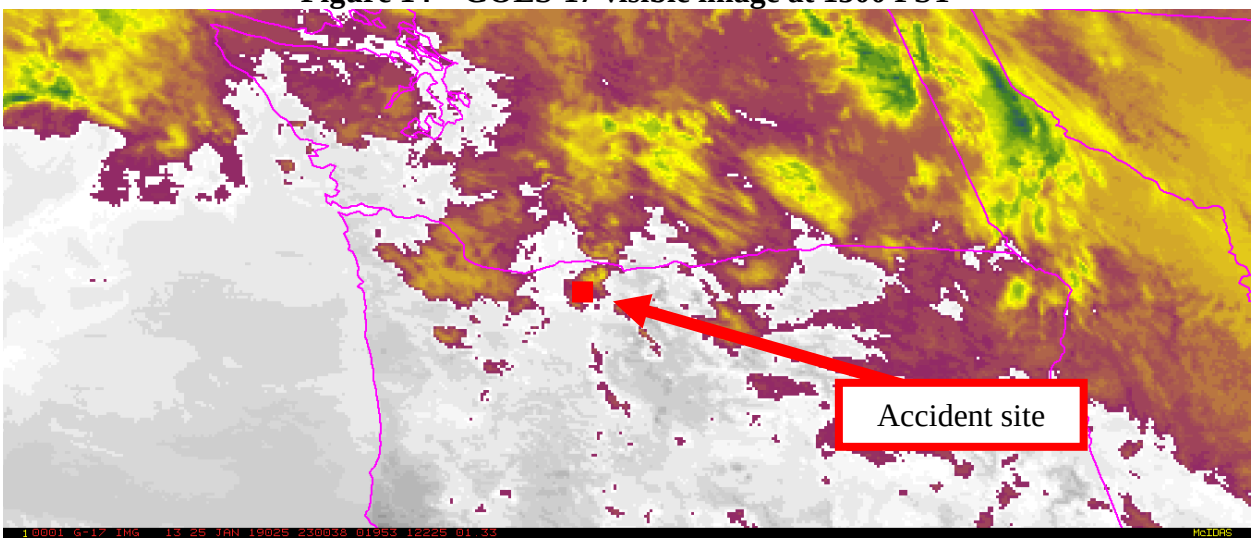

Figure 15 – GOES-17 infrared image at 1500 PST

6.0 Weather Radar Imagery

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[12] to the accident site was Portland, Oregon, (KRTX), located 57 miles west of the accident site. Level II archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. No meteorological precipitation targets were noted above the accident site around the accident time.

A regional view of the NWS national composite radar mosaic is included as figure 16 for 1500 PST with the approximate accident site marked by a red circle. The image depicted no meteorological precipitation echoes above the accident site.

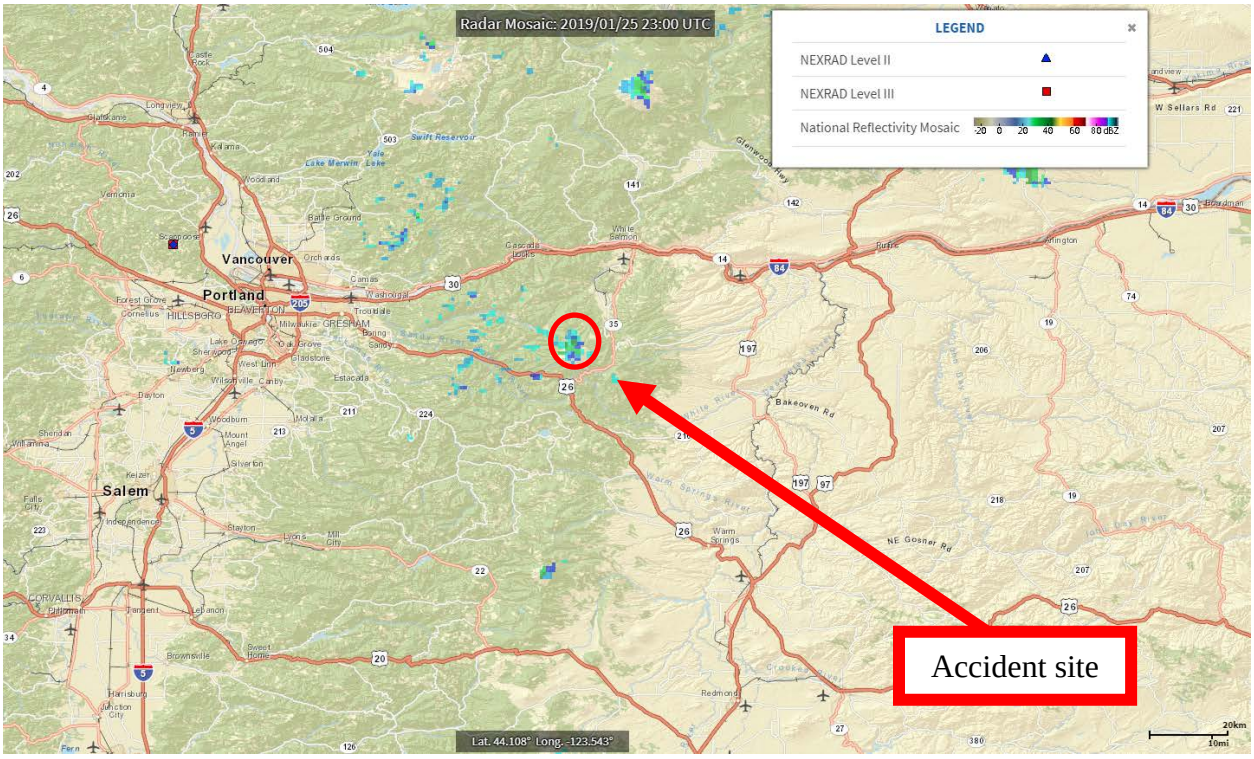

Figure 16 – Regional Composite Reflectivity image for 1500 PST

7.0 Pilot Reports[13]

There were no pilot reports (PIREPs) submitted into the national airspace system (NAS) within 150 miles of the accident site from about four hours prior to the accident time to about four hours after the accident time.

[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.

[13] Only pilot reports distributed into the NAS with the World Meteorological Organization (WMO) headers UBWA**, and UBORWY**.

8.0 SIGMET

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

9.0 CWSU Advisories

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

10.0 AIRMETs

There were no Airmen's Meteorological Information (AIRMET) advisories valid for the accident site at the accident time.

11.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident flight are shown in attachment 2. The GFA surface forecast products indicated VFR conditions with a surface wind from the northwest at 5 knots. The GFA cloud forecast products indicated high cirrus clouds to clear sky conditions were forecast for the accident site at 1600 PST.

12.0 Terminal Aerodrome Forecast

Columbia Gorge Regional/The Dalles Municipal Airport, Oregon, (KDLS) was the closest site with a NWS Terminal Aerodrome Forecast (TAF) located 27 miles northeast of the accident site at 247 ft (figure 7). The KDLS TAF valid at the accident time was the TAF issued at 0925 PST and was valid for a 24-hour period beginning at 1000 PST. The 0925 PST TAF for KDLS was as follows:

TAF KDLS 251725Z 2518/2618 **31005KT P6SM BKN200**
FM260700 VRB04KT 6SM BR FEW250
FM261200 10002KT 2SM BR SCT005 SCT250
FM261700 VRB02KT 6SM BR FEW005 FEW250=

Between 1000 and 2300 PST, the TAF expected a wind from 310° at 5 knots, greater than 6 miles visibility, and a broken ceiling at 20,000 ft agl.

13.0 NWS Area Forecast Discussion

The NWS Office in Portland, Oregon, issued the following Area Forecast Discussion (AFD) at 1006 PST (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed VFR conditions for the afternoon from the Portland area eastward with fog and low stratus likely to return during the overnight hours:

FXUS66 KPQR 251806
AFDPQR

Area Forecast Discussion
National Weather Service Portland OR
1004 AM PST Fri Jan 25 2019

.SYNOPSIS...High pressure will support dry and mild weather through Tuesday, though Monday through early Tuesday will likely see breezy offshore flow across much of the forecast area. An upper trough will bring a chance for rain starting Wednesday.

&&

.SHORT TERM...Today through Monday night...There will be little change in the weather the next several days as an upper level ridge will support dry weather with light winds, and have leaned towards persistence for the short term forecast. Stratus in the interior valley early this morning is preventing widespread fog from forming. Satellite imagery is showing signs of the stratus thinning with localized clearing though, continuing a chance for fog to form later this morning (closer to sunrise). Offshore flow will be slightly stronger tonight and there will be a better chance for of clearing in the interior and expect more widespread fog early Saturday morning. Temperatures will peak in the low to mid 50s for the interior Saturday afternoon with little change in the high temperatures Sunday and Monday afternoons. It will likely be sunnier and warmer for the coast and higher terrain where the afternoon temperatures should peak in the upper 50s. ~TJ

.LONG TERM...No Changes. Previous discussion follows...Tuesday through Thursday...Dry conditions remain through at least Tuesday. Models vary on when the upper ridge will break down, but generally agree that an upper level shortwave trough may produce light rain across NW Oregon and SW Washington Wednesday. Models then diverge regarding the extent to which the upper ridge rebuilds over the area and therefore whether we end up in a more stagnant or progressive pattern. Bowen

&&

.AVIATION...Mainly MVFR stratus this morning across the inland valleys across SW Washington and NW Oregon, though cigs had fallen into the IFR category for KEUG as of 17z. With weak flow and poor mixing, the low clouds will be stubborn and will likely last into the early afternoon hours for most of the inland valleys. Areas that remained out of the stratus have some patches of IFR/LIFR stratus, mainly in the Coast Range valleys and lower portions of the Columbia River...these areas should see gradual improvement and break into VFR conditions by 21z. High pressure and light winds will set up another fog/low stratus situation tonight; the impact on flying conditions will depend on whether or not cigs clear out by this evening. Clearing skies by this evening will make most valley locations prone to fog, though easterly winds are likely to develop near the Columbia Gorge and along much of the coast by Sat morning...resulting in a better chance for those areas to remain VFR tonight and Sat morning.

KPDX AND APPROACHES...MVFR cigs likely to persist through the

morning, but should lift to VFR this afternoon. Think that cigs will begin to scatter this evening, opening the door for fog or low stratus development overnight. Weagle/Pyle

&&

.MARINE...High pressure will remain over the NE Pac through the weekend. Meanwhile, thermal low pressure will continue to build along the northern California and southern Oregon coast. This will result in persistent N-NE winds. The winds may reach close to small craft advisory speeds over PZZ275 this afternoon and evening, but think the stronger winds will remain south and west of our waters. Winds will become offshore over the waters early next week. They will likely become strong enough to require a small craft advisory, with the strongest winds over the outer waters and near the coastal gaps.

Seas are expected to remain around 6 to 8 feet through the weekend. They may become rather choppy as the winds pick up early next week. Pyle/Weagle

&&

.PQR WATCHES/WARNINGS/ADVISORIES...
OR...None.
WA...None.
PZ...None.

&&

$$

14.0 Winds and Temperature Aloft Forecast

The NWS 1157 PST Winds and Temperature Aloft forecast valid for the closest point to the accident site is included below:

```
FBUS31 KWNO 251957
FD1US1
DATA BASED ON 251800Z
VALID 260000Z   FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT  3000    6000    9000   12000   18000   24000  30000  34000  390008
PDX 0411 0223+09 3631+02 3634-04 3545-15 3549-26 344243 344253 344265
```

The accident site was closest to the Portland, Oregon, (PDX) forecast point. The PDX forecast valid for 1600 PST and for use between 1200 and 1900 PST indicated a wind at 6,000 ft from 020° at 23 knots with a temperature of 9 °C, a wind at 9,000 ft from 360° at 31 knots with a temperature of 2 °C, a wind at 12,000 ft from 360° at 34 knots with a temperature of -4 °C, and a wind at 18,000 ft from 350° at 45 knots with a temperature of -15 °C.

15.0 Pilot Weather Briefing

The accident pilot did not request a weather briefing through Leidos.

A search of archived ForeFlight information indicated that the accident pilot did not review or request any weather information from ForeFlight. It is unknown if the accident pilot checked or received additional weather information before or during the accident flight.

16.0 Mountain Waves and Hazardous Mountain Winds

In FAA Advisory Circular (AC) 00-6B[14] published on August 23, 2016, section 17.2.2.1 describes mountain wave conditions and the associated aviation hazards therein (figure 17). Additional information on the hazardous weather and wind conditions in mountainous terrain is published in the FAA's Advisory Circular 00-57 (AC-00-57)[15] published on September 10, 1997.

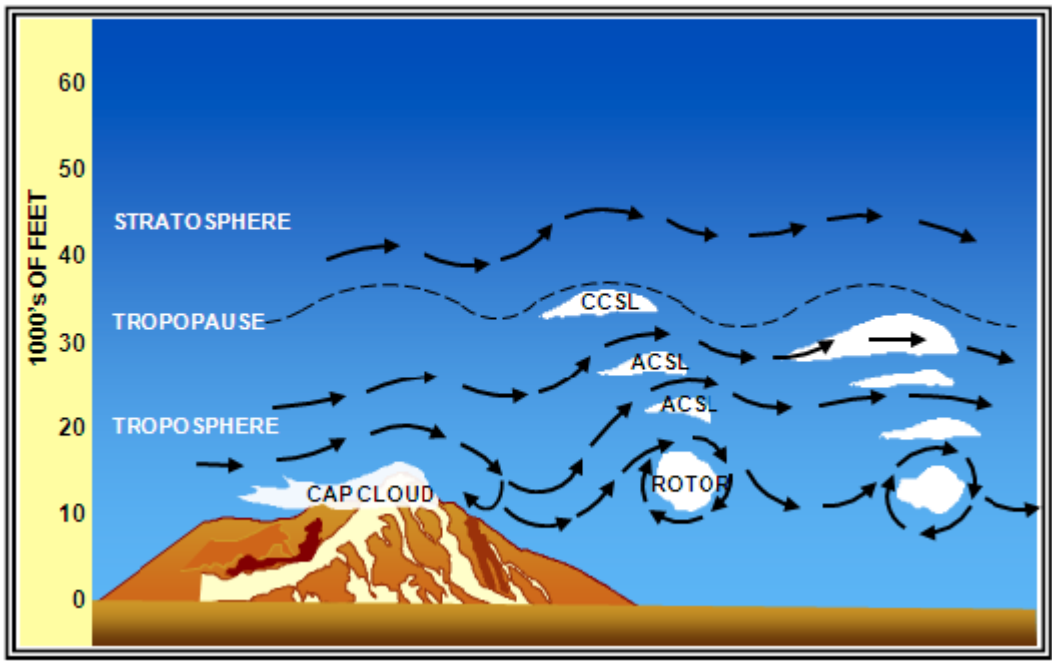

Figure 17 – AC 00-06B mountain wave conditions

14 https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_00-6B.pdf

15 https://www.faa.gov/documentLibrary/media/Advisory_Circular/00-57.pdf

17.0 Weather Research and Forecasting Model Simulation

A Weather Research and Forecasting Model (WRF) simulation was run to simulate the weather conditions surrounding the time of the accident using initialization data from the NAM 218.[16] WRF ARW (Advanced Research WRF core) version 3.2.1.5 was run with 3 domains with horizontal grid spacing of 8 km, 1.6 km, and 320 m over the accident site. Other WRF simulation parameters included: 55 vertical levels, the 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, and the Dudhia scheme used for the long and short wave radiation. The terrain (in ft) used in domain 2 and domain 3 are shown in figures 18 and 19 along with the location of the cross sections used figures 22 through 25 (along with attachments 3 and 4) with the location of the accident site marked.

Figures 20 and 21 depicted the winds[17] at 680 and 670 hPa (approximately 11,000 ft and 11,500 ft msl, respectively) in knots at 1450 and 1500 PST for domain 3. The WRF model indicated a rapid change in wind speed near Mt. Hood and the accident site with wind speeds ranging from 48 knots down to 20 knots over the course of a kilometer.

Figures 22 and 23 depicted the potential temperature[18] in degrees Kelvin (solid lines) and the vertical velocity (color fill) in fpm at 1450 and 1500 PST along a north-to-south cross-section with each marker a distance of 320 meters with the x-axis approximately 23 kilometers long. The vertical velocity data indicated that when the accident flight was making its first pass south of Mt. Hood around 1454 PST that the accident flight was in a location of updrafts with speeds between 100 and 300 fpm (figure 22). By 1459 PST when the accident flight made its second pass south of Mt. Hood the accident flight was in a location of downdrafts with speeds greater than 2000 fpm. Directly above and within 2 kilometers (horizontally) of Mt. Hood there were rapidly changing updraft and downdraft conditions (attachment 3) between 8,500 and 14,500 ft around the accident time.[19]

Figures 24 and 25 depicted the potential temperature (solid lines) and the horizontal wind speed in knots (color fill) at 1450 and 1500 PST along a north-to-south cross-section with each marker a distance of 320 meters with the x-axis approximately 23 kilometers long. The horizontal wind data indicated that when the accident flight was making its first pass south of Mt. Hood around 1454 PST that the accident flight was in a location of horizontal speeds between 30 and 34 knots (figure 24). By 1459 PST when the accident flight made its second pass south of Mt. Hood the accident flight was in a location of horizontal wind speeds of 36 knots with wind speeds varying between 14 knots and 40 knots over the distance of 1 kilometer. Directly above and within 2 kilometers (horizontally) of Mt. Hood there were rapidly changing horizontal wind speed conditions (attachment 4) between 8,500 and 14,500 ft around the accident time.

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[16] https://www.nco.ncep.noaa.gov/pmb/products/nam/

[17] All wind magnitudes are in knots and are sustained wind speeds.

[18] Potential temperature of a parcel of fluid at pressure P is the temperature that the parcel would acquire if adiabatically brought to a standard reference pressure P_0, usually 1000 hPa.

[19] See Air Traffic Control data in the docket for this accident for accident flight track locations.

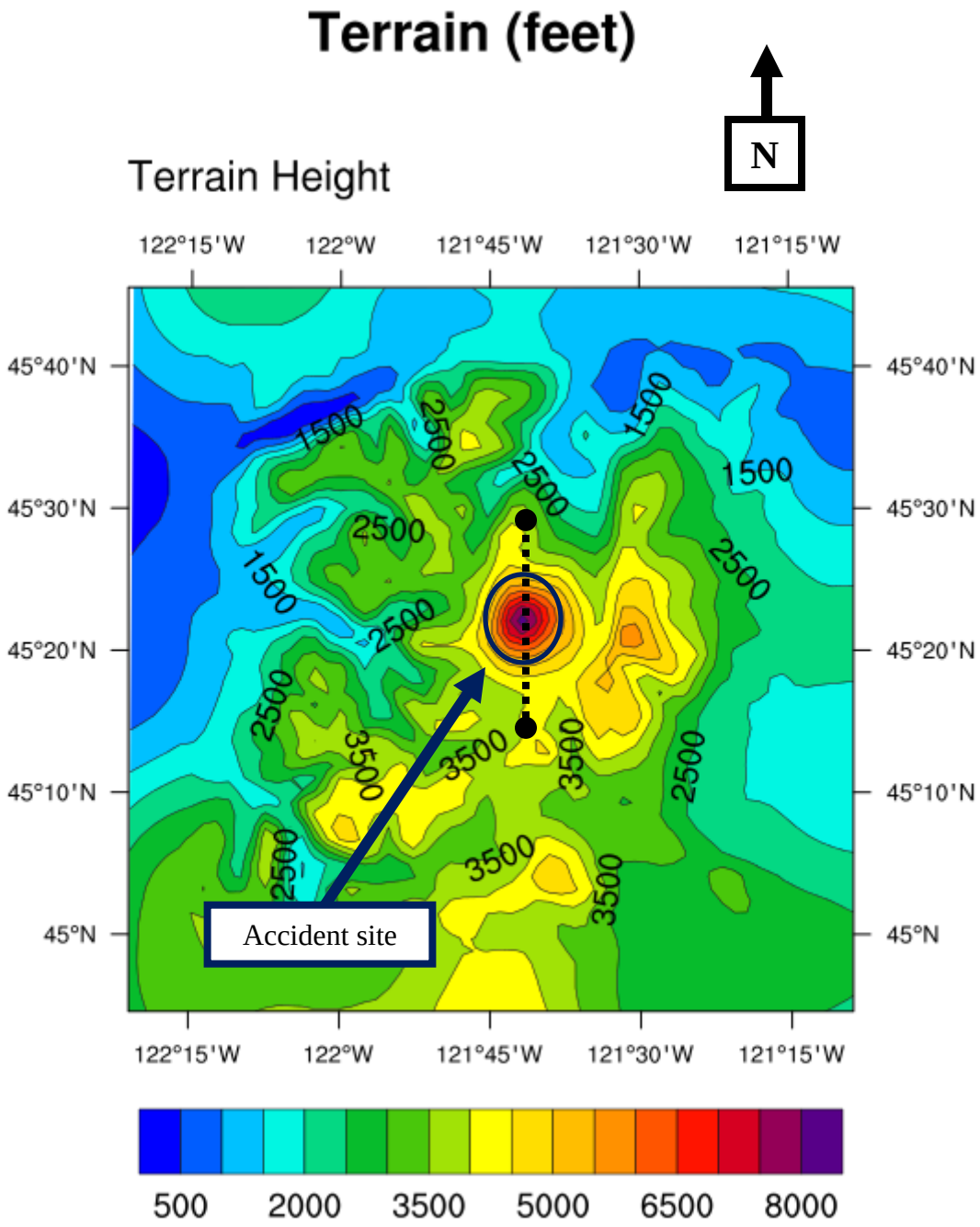

Figure 18 – WRF simulation terrain for domain 2 in ft with the accident site marked and the locations of the cross sections (black dashed lines)

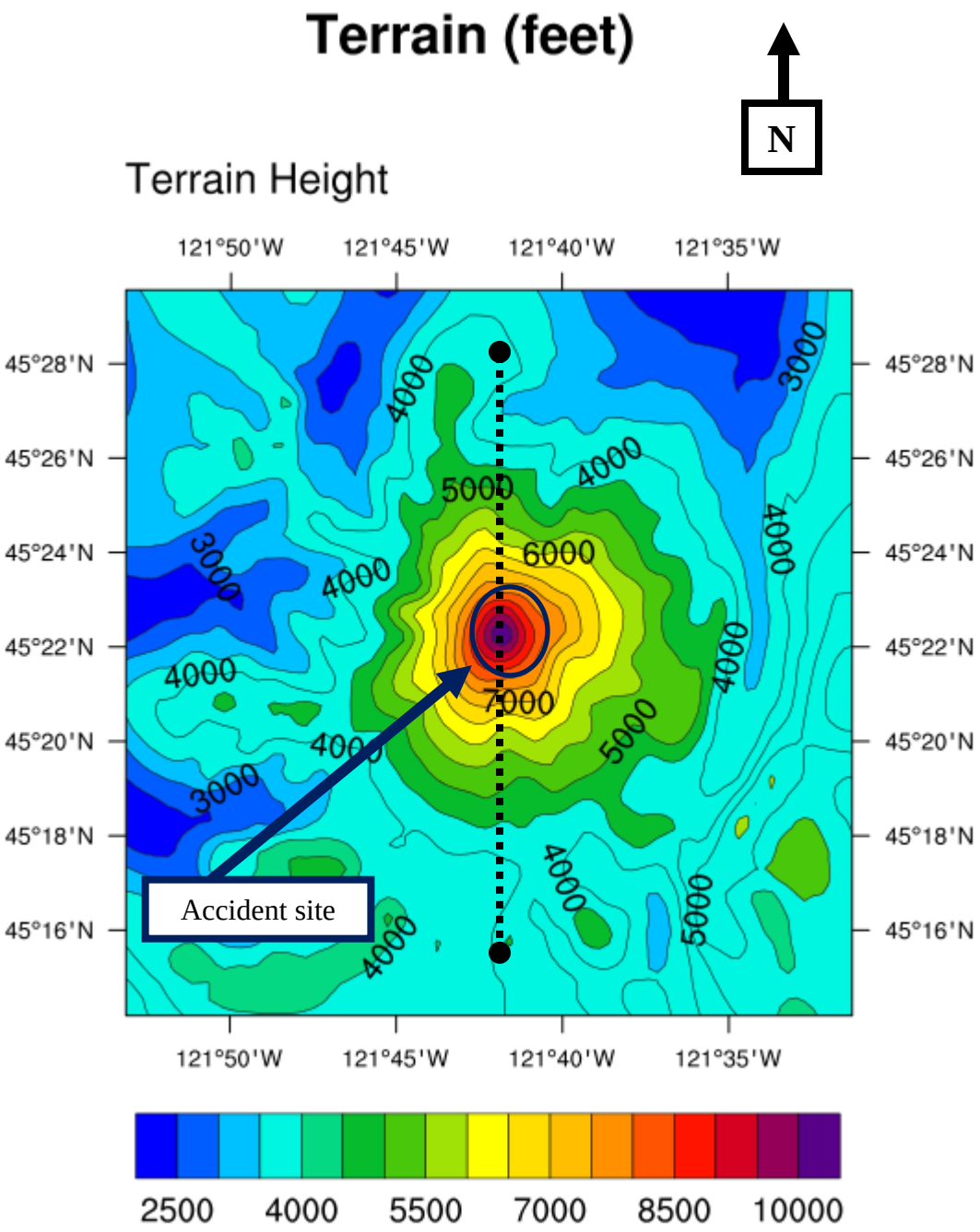

Figure 19 – WRF simulation terrain for domain 3 in ft with the accident site marked and the locations of the cross sections (black dashed lines)

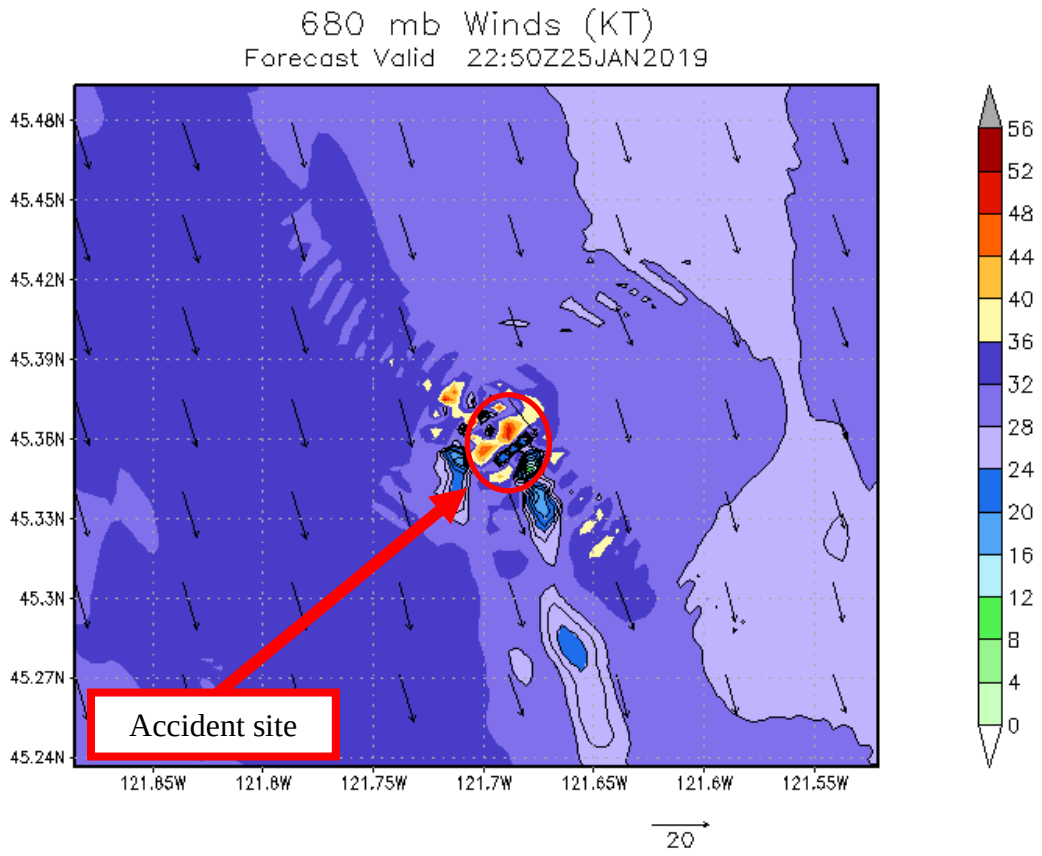

Figure 20 – WRF domain 3 wind in knots at 680 hPa (~11,000 ft msl) from 1450 PST with the approximate accident site marked

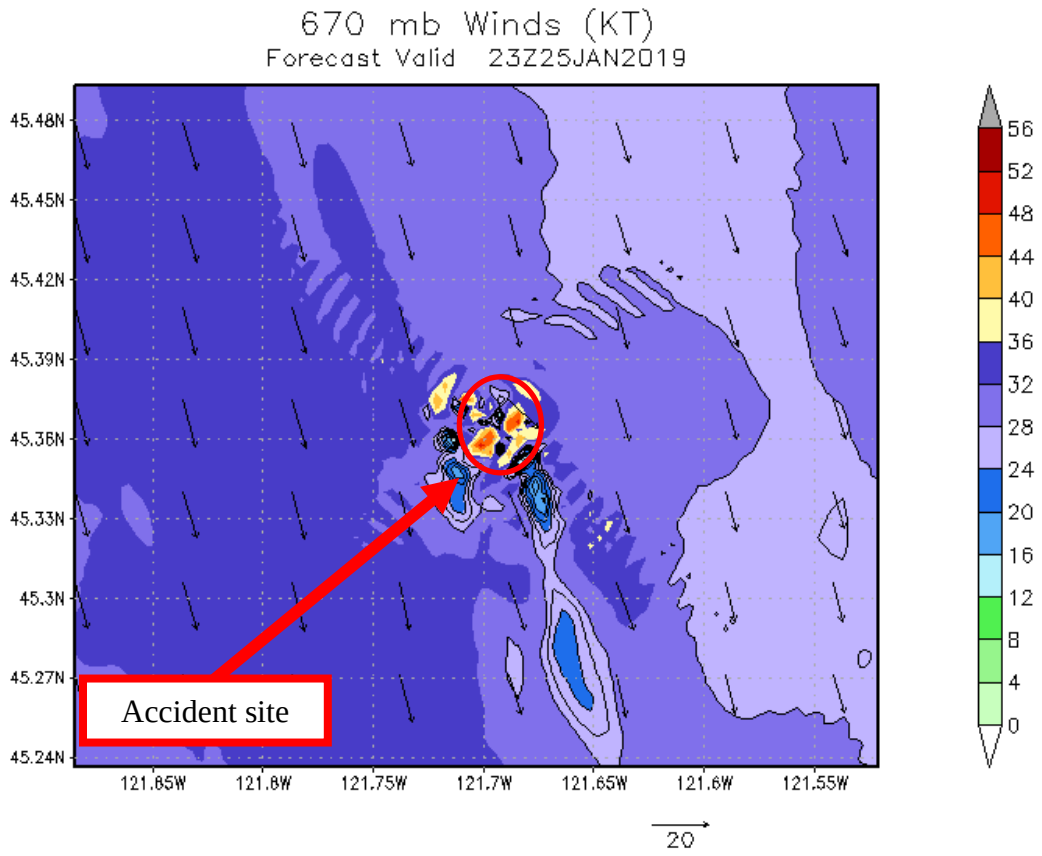

Figure 21 – WRF domain 3 wind in knots at 670 hPa (~11,500 ft msl) from 1500 PST with the approximate accident site marked

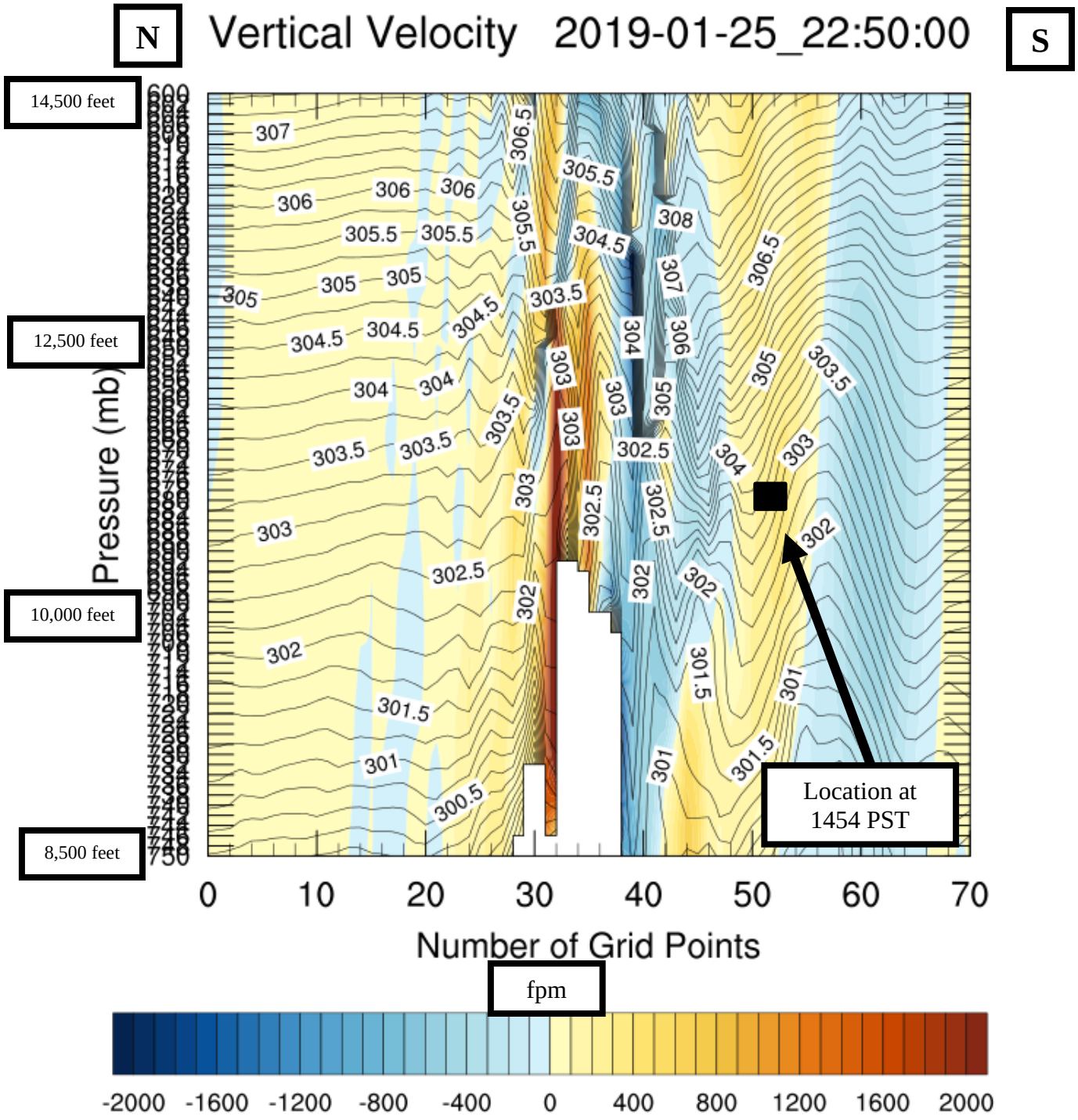

Figure 22 – WRF cross section from 1450 PST of vertical velocity in fpm (color fill) and potential temperature in degrees Kelvin (black lines) from north to south across the terrain

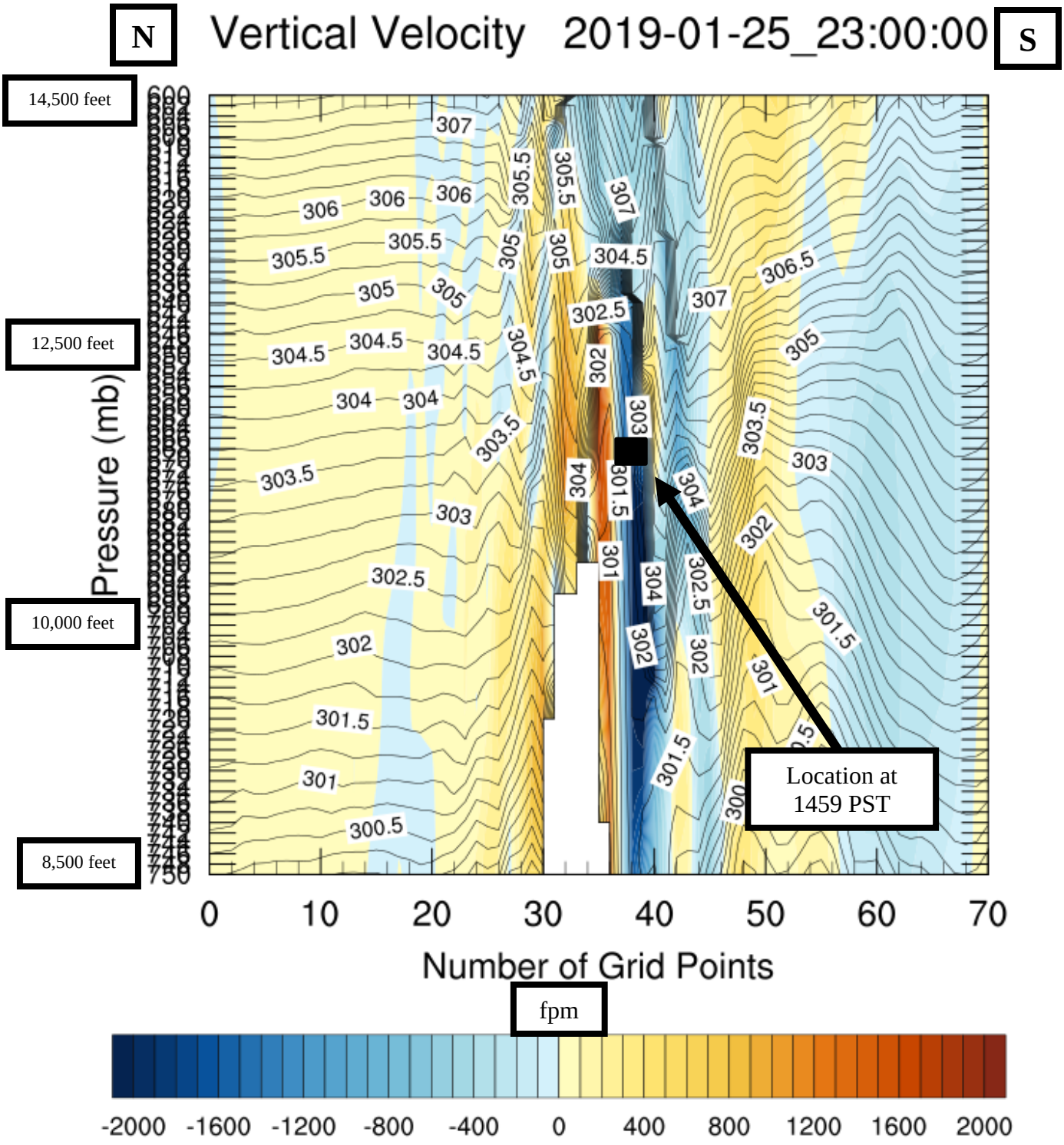

Figure 23 – WRF cross section from 1500 PST of vertical velocity in fpm (color fill) and potential temperature in degrees Kelvin (black lines) from north to south across the terrain

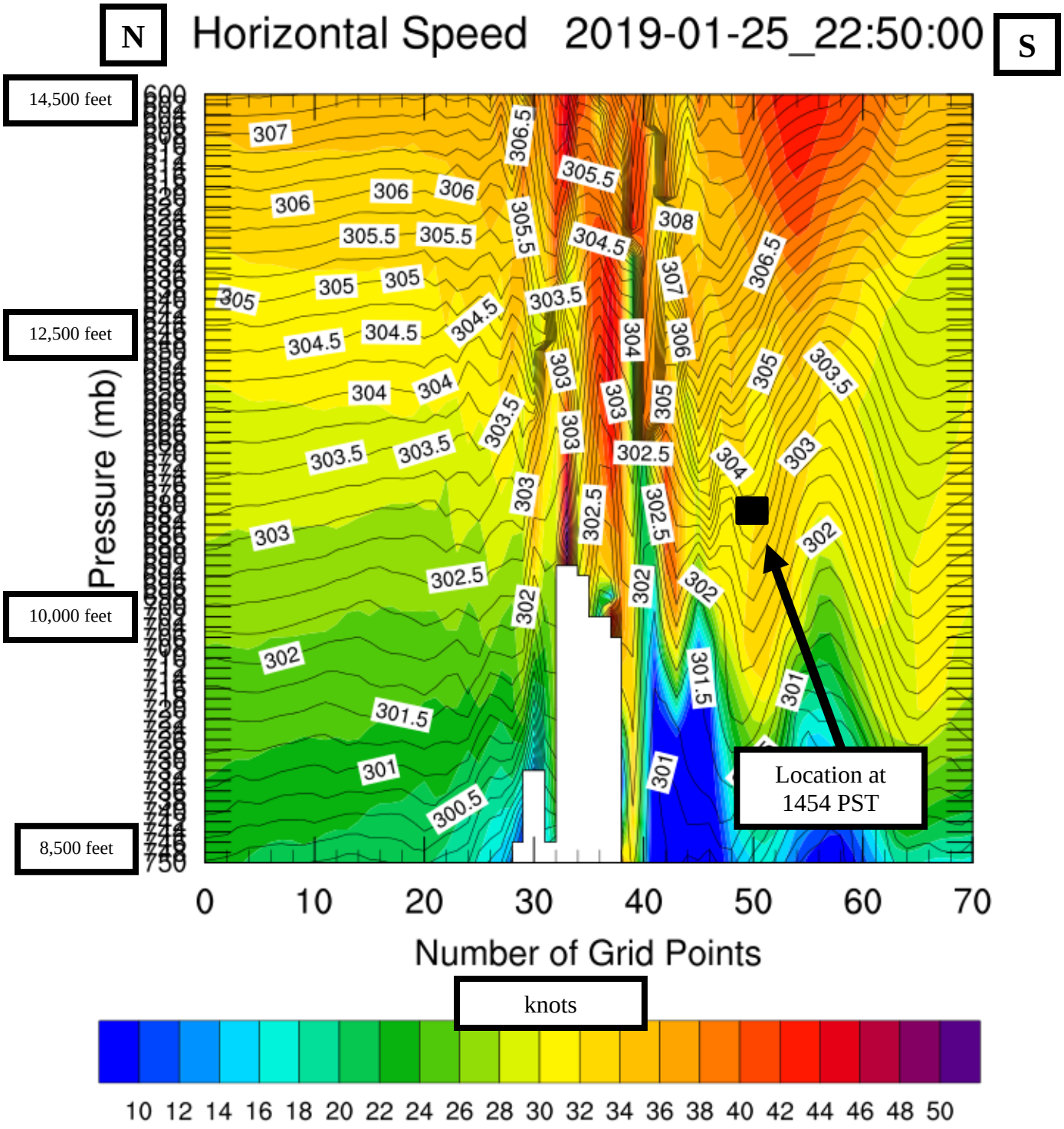

Figure 24 – WRF cross section from 1450 PST of horizontal wind speed in knots (color fill) and potential temperature in degrees Kelvin (black lines) from north to south across the terrain

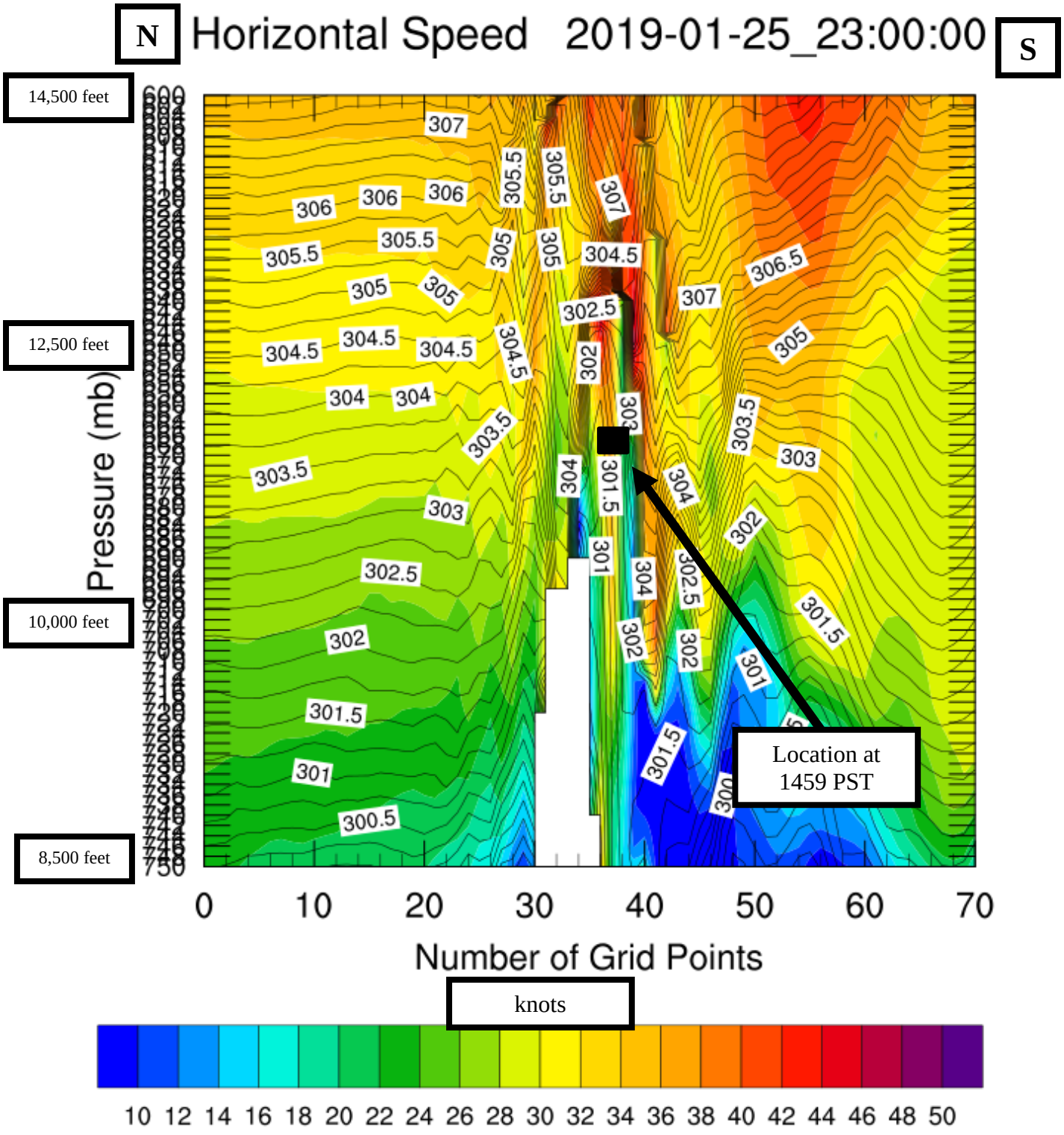

Figure 25 – WRF cross section from 1450 PST of horizontal wind speed in knots (color fill) and potential temperature in degrees Kelvin (black lines) from north to south across the terrain

18.0 Graphic Turbulence Guidance

The NWS Aviation Weather Center (AWC) provided the Graphical Turbulence Guidance (GTG)[20] products that were available before the accident flight departed. It is unknown if the accident pilot reviewed the GTG products. The GTG products are provided in attachment 5.

19.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on January 25, 2019, indicated the following:

SUN	
Begin civil twilight	0703 PST
Sunrise	0735 PST
Sun transit	1219 PST
Accident	**1459 PST**[21]
Sunset	1704 PST
End civil twilight	1736 PST

E. LIST OF ATTACHMENTS

Attachment 1 – GOES-17 visible imagery animation from 1445 to 1515 PST

Attachment 2 – GFA products available before the accident flight for around the accident time

Attachment 3 – WRF cross section from 1330 PST to 1510 PST of vertical velocity in fpm (color fill) and potential temperature in degrees Kelvin (black lines)

Attachment 4 – WRF cross section from 1330 PST to 1510 PST of horizontal wind speed in knots (color fill) and potential temperature in degrees Kelvin (black lines)

Attachment 5 – NWS AWC GTG forecast and images for the accident time for the surface through 35,000 ft

Submitted by:

_____

Paul Suffern
Senior Meteorologist

[20] https://aviationweather.gov/turbulence/gtg
[21] Inserted accident time for reference and context.

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