



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

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Weather Factual

METEOROLOGY

ANC20FA007

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A. ACCIDENT

Location: Cooper Landing, Alaska
Date: November 29, 2019
Time: 1911 Alaska standard time
0411 Coordinated Universal Time (UTC) November 30, 2019
Aircraft: Piper PA-31-350; Registration: N4087G

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 Alaska standard time (AKST) based upon the 24-hour clock, where local time is -9 hours from UTC, and UTC=Z. 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 miles. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports and "P" for OCONUS airports.

The accident site location used was at latitude 60.5042° N, longitude 150.1514° W at an approximate elevation of 1,450 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 (AC) "Aviation Weather Services", AC 00-45H change 2¹.

¹

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030

1.1 Surface Analysis Chart

The Alaska section of the NWS Surface Analysis Chart for 1800 AKST is provided as figure 1 with the location of the accident site marked within the red circle. The chart depicted a low pressure system at 992-hectopascals (hPa) over the Gulf of Alaska with an occluded front stretched northward over the southern Kenai Peninsula. A cold front stretched southward from the Kenai Peninsula over the eastern Gulf of Alaska. A developing stationary boundary was located across central Alaska. The accident site was located north of the occluded and cold frontal boundaries on the cold air side of the fronts.

The station models around the accident site depicted air temperatures in the low-30's to 40 degrees Fahrenheit (°F), dew point temperatures in the mid 30's °F with a temperature-dew point spread of 4°F or less, a variable wind under 10 knots, overcast skies, and light rain along the southern and eastern portions of the Kenai Peninsula.

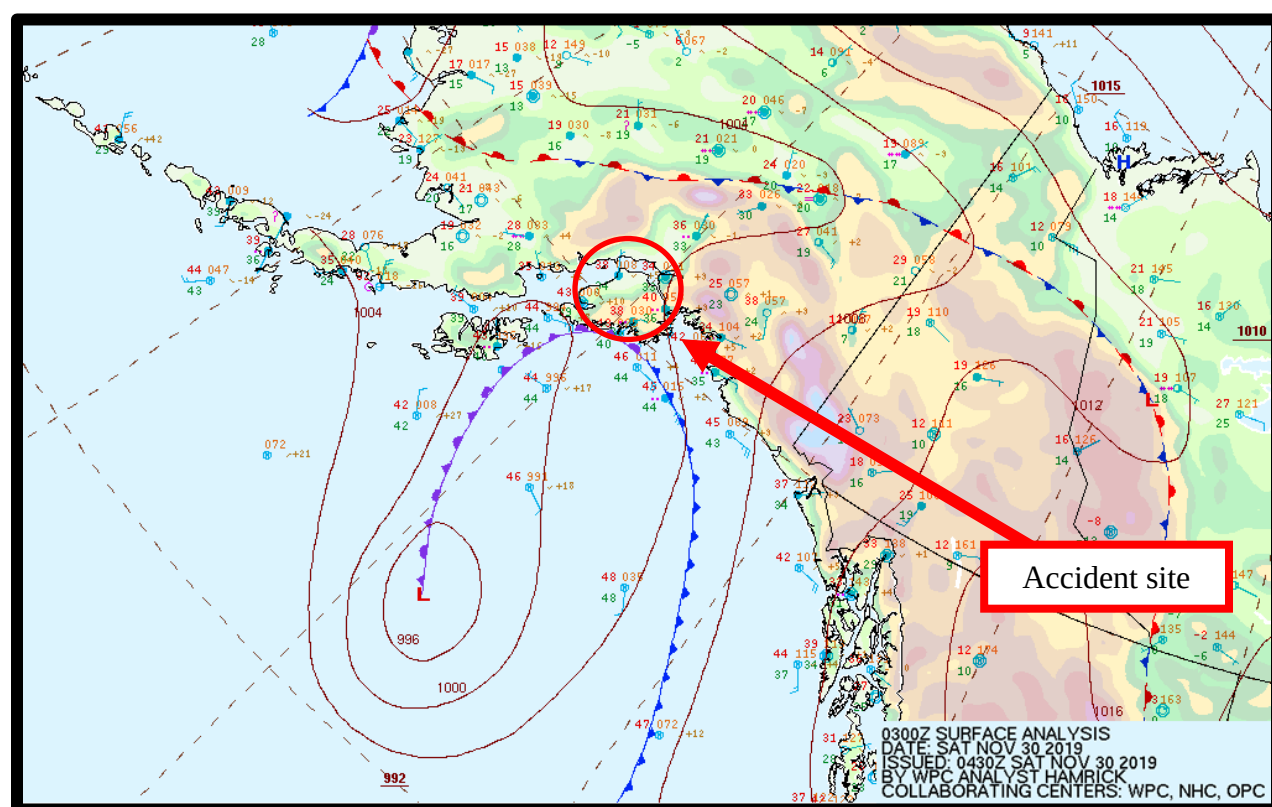


Figure 1 – NWS Surface Analysis Chart for 1900 AKST

2.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 2 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked.



Figure 2 – Sectional chart of accident area with the location of the accident site and the closest surface observation sites

The closest official weather reporting facility to the accident site was from Soldotna Airport (PASX), Soldotna, Alaska, at an elevation of 113 ft, located 26 miles west of the accident site (figure 2). PASX had an Automated Weather Observing System (AWOS²) whose reports were not supplemented. PASX had an 17° easterly magnetic variation³. The following observations were taken and disseminated during the times surrounding the accident:⁴

[1356 AKST] METAR PASX 292256Z AUTO 28004KT 10SM OVC075 03/02 A2955 RMK AO2 SLP017 T00330022=

[1456 AKST] METAR PASX 292356Z AUTO 25006KT 10SM FEW070 03/02 A2955 RMK AO2 SLP015 60000 T00330022 10044 20017 58003=

[1556 AKST] METAR PASX 300056Z AUTO 00000KT 10SM FEW075 02/01 A2955 RMK AO2 SLP016 T00220011 FZRANO=

² 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 12,000 feet, and altimeter setting.

³ Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

⁴ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[1656 AKST] METAR PASX 300156Z AUTO 00000KT 10SM BKN070 02/01 A2955 RMK
AO2 SLP016 T00220011 FZRANO=

[1756 AKST] METAR PASX 300256Z AUTO 25003KT 10SM OVC075 02/01 A2956 RMK
AO2 SLP021 T00170011 53006 FZRANO=

**[1856 AKST] METAR PASX 300356Z AUTO 25003KT 10SM BKN080 BKN095 02/02
A2956 RMK AO2 SLP019 T00220017 FZRANO=**

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**[1956 AKST] METAR PASX 300456Z AUTO 00000KT 10SM BKN080 01/01 A2956 RMK
AO2 SLP018 T00110011 FZRANO=**

[2056 AKST] METAR PASX 300556Z AUTO 00000KT 10SM OVC090 01/01 A2955 RMK
AO2 SLP018 T00110006 10033 20011 56003 FZRANO=

[2156 AKST] METAR PASX 300656Z AUTO 00000KT 10SM BKN060 BKN100 01/01
A2954 RMK AO2 SLP012 T00110006 FZRANO=

PASX weather at 1856 AKST, automated, wind from 250° at 3 knots, 10 miles visibility or greater, a broken ceiling at 8,000 ft above ground level (agl), broken skies at 9,500 ft agl, temperature of 2°Celsius (C), dew point temperature of 2°C, and an altimeter setting of 29.56 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, sea level pressure 1001.9 hPa, temperature 2.2°C, dew point temperature 1.7°C, freezing rain information not available.

PASX weather at 1956 AKST, automated, wind calm, 10 miles visibility or greater, a broken ceiling at 8,000 ft agl, temperature of 1°C, dew point temperature of 1°C, and an altimeter setting of 29.56 inHg. Remarks: automated station with a precipitation discriminator, sea level pressure 1001.8 hPa, temperature 1.1°C, dew point temperature 1.1°C, freezing rain information not available.

The intended destination airport was Seward Airport (PAWD), Seward, Alaska, at an elevation of 22 ft, located 31 miles southeast of the accident site (figure 2). PAWD had an Automated Surface Observing System (ASOS⁵) whose reports were not supplemented. The following observations were taken and disseminated during the times surrounding the accident:

[1553 AKST] METAR PAWD 300053Z AUTO 00000KT 8SM BKN055 OVC085 04/03 A2961
RMK AO2 RAE29 SLP025 P0001 T00390028 TSNO=

[1606 AKST] SPECI PAWD 300106Z AUTO 00000KT 1 3/4SM BR BKN050 OVC070
04/03 A2961 RMK AO2 T00390033 TSNO=

⁵ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, weather, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

[1623 AKST] SPECI PAWD 300123Z AUTO 00000KT 3SM -RA BR BKN048 BKN055
OVC070 03/03 A2961 RMK AO2 RAB13 P0000 T00330028 TSNO=

[1653 AKST] METAR PAWD 300153Z AUTO 02003KT 8SM -RA OVC042 03/03 A2961
RMK AO2 RAB13 SLP028 P0001 T00330033 TSNO=

[1753 AKST] METAR PAWD 300253Z AUTO 12003KT 5SM -RA BR FEW002 OVC046
03/02 A2962 RMK AO2 SLP030 P0001 60003 T00330022 53002 TSNO=

**[1853 AKST] METAR PAWD 300353Z AUTO 00000KT 10SM -RA OVC046 03/03 A2961
RMK AO2 SLP027 P0001 T00330028 TSNO=**

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**[1953 AKST] METAR PAWD 300453Z AUTO 17003KT 10SM OVC055 03/03 A2961 RMK
AO2 RAE20 SLP026 P0000 T00280028 TSNO=**

[2053 AKST] METAR PAWD 300553Z AUTO 27003KT 10SM -RA OVC050 03/02 A2959
RMK AO2 RAB43 SLP021 P0000 60004 T00280022 10044 20028 58009 TSNO=

[2153 AKST] METAR PAWD 300653Z AUTO 00000KT 8SM BKN055 OVC070 03/03 A2958
RMK AO2 RAE14 SLP015 P0001 T00280028 TSNO=

PAWD weather at 1853 AKST, automated, wind calm, 10 miles visibility or greater, light rain, an overcast ceiling at 4,600 ft agl, temperature of 3°C, dew point temperature of 3°C, and an altimeter setting of 29.61 inHg. Remarks: automated station with a precipitation discriminator, sea level pressure 1002.7 hPa, 0.01 inches of precipitation since 1753 AKST, temperature 3.3°C, dew point temperature 2.8°C, thunderstorm information not available.

PAWD weather at 1953 AKST, automated, wind from 170° at 3 knots, 10 miles visibility or greater, an overcast ceiling at 5,500 ft agl, temperature of 3°C, dew point temperature of 3°C, and an altimeter setting of 29.61 inHg. Remarks: automated station with a precipitation discriminator, rain ended at 1920 AKST, sea level pressure 1002.6 hPa, a trace of precipitation since 1853 AKST, temperature 2.8°C, dew point temperature 2.8°C, thunderstorm information not available.

The observations for PASX and PAWD surrounding the period indicated VFR⁶ conditions with ceilings between 4,600 ft msl and 8,100 ft msl and precipitation reported at PAWD. MVFR and IFR conditions with light rain prevailed at PAWD before 1753 AKST.

⁶ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category

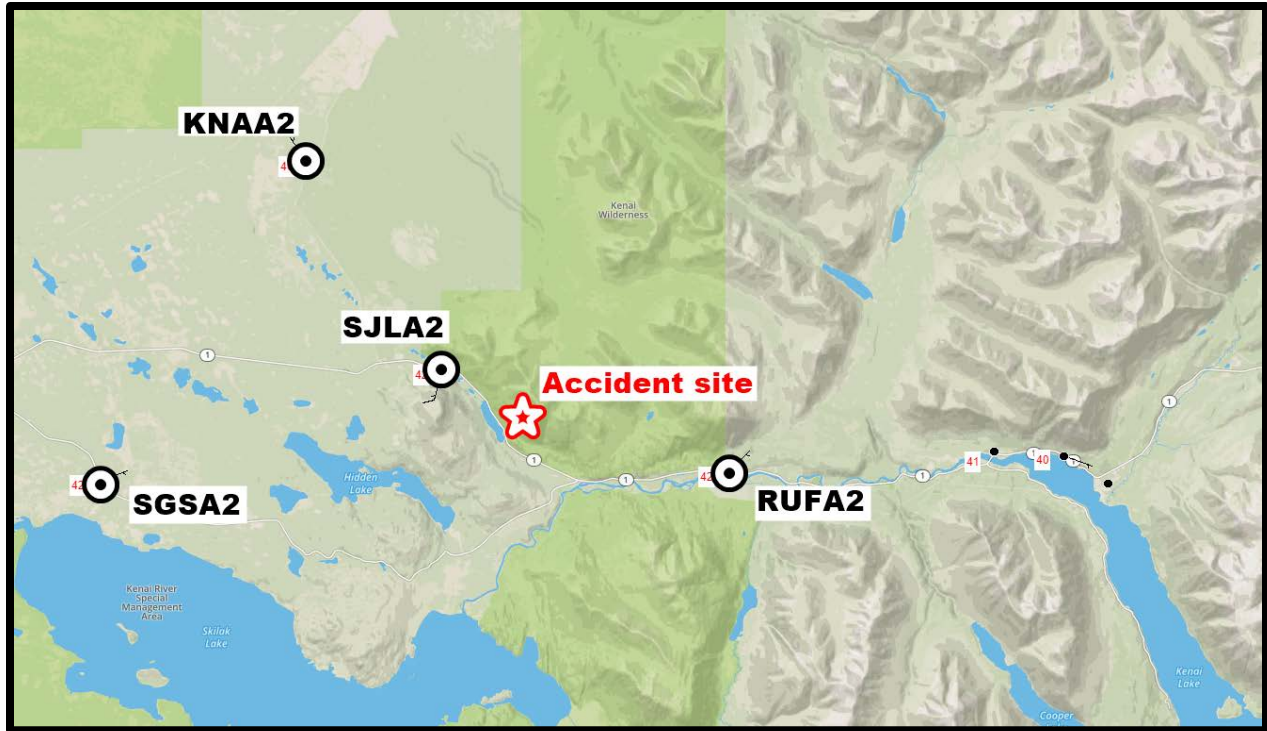


Figure 3 – Elevation map with the closest unofficial surface observation sites

Several unofficial surface observations sites were closer to the accident site than PASX and locations are documented in figure 3. Sterling Highway at Jean Lake Hill (SJLA2) was the closest unofficial surface observation site to the accident site and was located 2 miles west-northwest of the accident site at an elevation of 620 ft (figure 3). SJLA2 is owned and maintained by the Alaska Department of Transportation (AKDOT). Figure 4 contains the observations from SJLA2 surrounding the accident time:

of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

# STATION: SJLA2										
# STATION NAME: Sterling Highway @ Joan Lake Hill MP 62										
# LATITUDE: 60.52376										
# LONGITUDE: -150.21016										
# ELEVATION [ft]: 620										
# STATE: AK										
Station_ID	Date_Time	air_temp_set_1 Fahrenheit	relative_humidity_set_1 %	wind_speed_set_1 Miles/hour	wind_direction_set_1 Degrees	wind_gust_set_1 Miles/hour	dew_point_temperature_set_1d Fahrenheit	wind_chill_set_1d Fahrenheit	wind_cardinal_direction_set_1d Code	
SJLA2	11/29/2019 23:20 UTC	44.08	63	21.72	160	31.68	32.16	37.5	SSE	
SJLA2	11/29/2019 23:40 UTC	44.08	63	22.97	160	31.05	32.16	37.27	SSE	
SJLA2	11/29/2019 23:50 UTC	43.72	64	19.26	160	31.05	32.21	37.54	SSE	
SJLA2	11/30/2019 00:10 UTC	44.08	62	22.35	160	36.62	31.76	37.38	SSE	
SJLA2	11/30/2019 00:20 UTC	43.9	62	23.6	155	42.84	31.59	36.93	SSE	
SJLA2	11/30/2019 00:50 UTC	44.62	59	25.46	160	37.87	31.03	37.53	SSE	
SJLA2	11/30/2019 01:10 UTC	44.44	59	21.72	150	33.53	30.86	37.96	SSE	
SJLA2	11/30/2019 01:20 UTC	44.44	59	17.38	150	34.78	30.86	38.85	SSE	
SJLA2	11/30/2019 01:30 UTC	44.08	60	18.63	155	35.39	30.94	38.12	SSE	
SJLA2	11/30/2019 01:50 UTC	43.9	61	16.78	155	27.31	31.18	38.31	SSE	
SJLA2	11/30/2019 02:10 UTC	44.62	58	18.01	150	30.42	30.6	38.93	SSE	
SJLA2	11/30/2019 02:20 UTC	44.62	57	19.26	130	33.53	30.17	38.67	SE	
SJLA2	11/30/2019 02:30 UTC	44.8	57	21.09	145	33.53	30.34	38.53	SE	
SJLA2	11/30/2019 02:40 UTC	44.62	58	17.38	145	39.12	30.6	39.07	SE	
SJLA2	11/30/2019 03:00 UTC	44.62	57	12.41	130	28.57	30.17	40.35	SE	
SJLA2	11/30/2019 03:10 UTC	45.16	56	16.78	150	32.91	30.34		SSE	
SJLA2	11/30/2019 03:20 UTC	44.62	57	16.15	160	28.57	30.17	39.36	SSE	
SJLA2	11/30/2019 03:30 UTC	44.44	57	18.63	130	31.05	30	38.57	SE	
SJLA2	11/30/2019 04:30 UTC	44.62	57	17.38	135	31.05	30.17	39.07	SE	
SJLA2	11/30/2019 04:40 UTC	44.44	57	17.38	145	29.19	30	38.85	SE	
SJLA2	11/30/2019 04:50 UTC	44.44	56	17.38	140	33.53	29.56	38.85	SE	
SJLA2	11/30/2019 05:20 UTC	44.44	57	15.52	140	33.53	30	39.29	SE	
SJLA2	11/30/2019 05:30 UTC	44.44	57	15.52	145	26.71	30	39.29	SE	
SJLA2	11/30/2019 06:10 UTC	44.08	57	14.27	140	27.94	29.66	39.17	SE	
SJLA2	11/30/2019 06:30 UTC	44.08	56	17.38	150	27.94	29.23	38.4	SSE	
SJLA2	11/30/2019 06:40 UTC	44.26	55	18.63	155	27.31	28.95	38.35	SSE	
SJLA2	11/30/2019 07:10 UTC	43.9	56	18.01	165	27.31	29.06	38.03	SSE	

Figure 4 – List of observations from SJLA2 surrounding the accident time

SJLA2 weather at 1830 AKST was reported as, wind from 130° at 18.63 miles-per-hour (mph) with gusts to 31.05 mph, and a temperature of 44.44°F.

SJLA2 weather at 1930 AKST was reported as, wind from 135° at 17.38 mph with gusts to 31.05 mph, and a temperature of 44.62°F.

Sterling Highway at Russian River Ferry (RUFA2) was the next closest unofficial surface observation site to the accident site and was located 5 miles east of the accident site at an elevation of 377 ft (figure 3). RUFA2 was owned and maintained by the AKDOT. Figure 5 contains the observations from RUFA2 surrounding the accident time:

# STATION: RUFA2										
# STATION NAME: Sterling Highway @ Russian River Ferry										
# LATITUDE: 60.48734										
# LONGITUDE: -150.00211										
# ELEVATION [ft]: 377										
# STATE: AK										
Station_ID	Date_Time	air_temp_set_1 Fahrenheit	relative_humidity_set_1 %	wind_speed_set_1 Miles/hour	wind_direction_set_1 Degrees	wind_gust_set_1 Miles/hour	visibility_set_1 Statute miles	precip_accum_24_hour_set_1 Inches	dew_point_temperature_set_1d Fahrenheit	
RUFA2	11/30/2019 01:10 UTC	44.08	66	4.34	105	12.41	1.24	0.1	33.33	
RUFA2	11/30/2019 01:20 UTC	43.72	67	7.45	75	14.27	1.24	0.1	33.36	
RUFA2	11/30/2019 01:30 UTC	43.54	68	5.59	115	14.27	1.24	0.09	33.56	
RUFA2	11/30/2019 01:40 UTC	43.36	67	4.34	90	10.56	1.24	0.09	33.02	
RUFA2	11/30/2019 01:50 UTC	43.18	68	6.22	90	9.93	1.24	0.09	33.22	
RUFA2	11/30/2019 02:00 UTC	42.82	69	4.34	115	10.56	1.24	0.09	33.24	
RUFA2	11/30/2019 02:10 UTC	42.82	69	4.97	115	8.68	1.24	0.09	33.24	
RUFA2	11/30/2019 02:20 UTC	42.64	69	3.11	115	6.85	1.24	0.08	33.07	
RUFA2	11/30/2019 02:30 UTC	43.36	67	4.34	110	11.18	1.24	0.08	33.02	
RUFA2	11/30/2019 02:40 UTC	43.18	68	3.74	120	13.04	1.24	0.08	33.22	
RUFA2	11/30/2019 02:50 UTC	43.18	67	3.74	115	11.79	1.24	0.08	32.85	
RUFA2	11/30/2019 03:00 UTC	43.18	66	4.97	110	9.31	1.24	0.07	32.47	
RUFA2	11/30/2019 03:10 UTC	43.36	66	3.11	95	8.08	1.24	0.07	32.64	
RUFA2	11/30/2019 03:20 UTC	43.72	64	3.74	125	9.31	1.24	0.07	32.21	
RUFA2	11/30/2019 03:30 UTC	43.18	68	4.34	130	9.31	1.24	0.07	33.22	
RUFA2	11/30/2019 03:40 UTC	43.9	65	5.59	115	11.18	1.24	0.07	32.77	
RUFA2	11/30/2019 03:50 UTC	43.54	63	3.74	90	9.93	1.24	0.06	31.64	
RUFA2	11/30/2019 04:00 UTC	44.98	59	6.22	85	12.41	1.24	0.06	31.37	
RUFA2	11/30/2019 04:10 UTC	44.98	58	5.59	95	11.18	1.24	0.06	30.94	
RUFA2	11/30/2019 04:20 UTC	45.34	57	5.59	105	15.52	1.24	0.06	30.85	
RUFA2	11/30/2019 04:30 UTC	45.16	58	6.22	85	11.79	1.24	0.06	31.11	
RUFA2	11/30/2019 04:40 UTC	44.98	57	5.59	80	15.52	1.24	0.06	30.51	
RUFA2	11/30/2019 04:50 UTC	44.8	58	3.74	110	11.79	1.24	0.05	30.77	
RUFA2	11/30/2019 05:00 UTC	44.8	58	3.11	125	13.67	1.24	0.05	30.77	
RUFA2	11/30/2019 05:10 UTC	44.98	57	7.45	75	18.01	1.24	0.05	30.51	
RUFA2	11/30/2019 05:20 UTC	44.98	57	7.45	95	15.52	1.24	0.05	30.51	
RUFA2	11/30/2019 05:30 UTC	44.44	59	4.34	90	13.67	1.24	0.05	30.86	
RUFA2	11/30/2019 05:40 UTC	44.44	60	6.85	100	13.67	1.24	0.04	31.28	

Figure 5 – List of observations from RUFA2 surrounding the accident time

RUFA2 weather at 1910 AKST was reported as, wind from 095° at 5.59 mph with gusts to 11.18 mph, and a temperature of 44.98°F.

RUFA2 weather at 1920 AKST was reported as, wind from 105° at 5.59 mph with gusts to 15.52 mph, and a temperature of 45.34°F.

Kenai National Wildlife Refuge equipment (KNAA2) was a Remote Automated Weather Station (RAWS) and was the third closest unofficial surface observation site to the accident site and was located 7 miles northwest of the accident site at an elevation of 462 ft (figure 3). KNAA2 was owned and maintained by the Alaska Bureau of Land Management (AK BLM). Figure 6 contains the observations from KNAA2 surrounding the accident time:

# STATION: KNAA2									
# STATION NAME: KENAI NWR									
# LATITUDE: 60.598500									
# LONGITUDE: -150.3081									
# ELEVATION [ft]: 462									
# STATE: AK									
Station_ID	Date_Time	air_temp_set_1 Fahrenheit	relative_humidity_set_1 %	wind_speed_set_1 Miles/hour	wind_direction_set_1 Degrees	wind_gust_set_1 Miles/hour	peak_wind_speed_set_1 Miles/hour	dew_point_temperature_set_1d Fahrenheit	
KNAA2	11/29/2019 15:56 UTC	42.01	67	2.01	85	7	7	31.73	
KNAA2	11/29/2019 16:56 UTC	43	62	4	93	8.99	8.99	30.73	
KNAA2	11/29/2019 17:56 UTC	44.01	61	4.99	94	14.99	14.99	31.28	
KNAA2	11/29/2019 18:56 UTC	43	62	1.01	209	13	13	30.73	
KNAA2	11/29/2019 19:56 UTC	42.01	68	1.01	182	4.99	4.99	32.1	
KNAA2	11/29/2019 20:56 UTC	45	59	3	106	8.99	8.99	31.39	
KNAA2	11/29/2019 21:56 UTC	45	59	0		11.01	11.01	31.39	
KNAA2	11/29/2019 22:56 UTC	46	58	3	114	8.99	8.99	31.9	
KNAA2	11/29/2019 23:56 UTC	45	59	5.99	134	14	14	31.39	
KNAA2	11/30/2019 00:56 UTC	45	58	5.99	116	18.01	18.01	30.96	
KNAA2	11/30/2019 01:56 UTC	44.01	60	4	77	14.99	14.99	30.87	
KNAA2	11/30/2019 02:56 UTC	45	57	4.99	143	14.99	14.99	30.53	
KNAA2	11/30/2019 03:56 UTC	45	58	7	133	17	17	30.96	
KNAA2	11/30/2019 04:56 UTC	45	57	7	115	17	17	30.53	
KNAA2	11/30/2019 05:56 UTC	45	58	4	121	18.99	18.99	30.96	
KNAA2	11/30/2019 06:56 UTC	45	57	4	148	15.99	15.99	30.53	
KNAA2	11/30/2019 07:56 UTC	44.01	57	3	136	18.01	18.01	29.6	
KNAA2	11/30/2019 08:56 UTC	44.01	57	4	123	13	13	29.6	
KNAA2	11/30/2019 09:56 UTC	45	54	3	216	21	21	29.19	
KNAA2	11/30/2019 10:56 UTC	44.01	62	4.99	165	14	14	31.69	
KNAA2	11/30/2019 11:56 UTC	44.01	61	8.01	133	18.01	18.01	31.28	
KNAA2	11/30/2019 12:56 UTC	44.01	64	2.01	138	14	14	32.49	
KNAA2	11/30/2019 13:56 UTC	42.01	70	4.99	156	15.99	15.99	32.83	
KNAA2	11/30/2019 14:56 UTC	39.99	71	1.01	327	12.01	12.01	31.24	

Figure 6 – List of observations from KNAA2 surrounding the accident time

KNAA2 weather at 1856 AKST was reported as, wind from 133° at 7 mph with gusts to 17 mph, and a temperature of 45°F.

KNAA2 weather at 1956 AKST was reported as, wind from 115° at 7 mph with gusts to 17 mph, and a temperature of 45°F.

Skilak Guard Station RAWS (SGSA2) was the furthest unofficial surface observation site located within 10 miles of the accident site and SGSA2 was located 9 miles west of the accident site at an elevation of 307 ft (figure 3). SGSA2 was owned and maintained by the AK BLM. Figure 7 contains the observations from SGSA2 surrounding the accident time:

# STATION: SGSA2								
# STATION NAME: SKILAK GUARD STATION								
# LATITUDE: 60.484133								
# LONGITUDE: -150.460567								
# ELEVATION [ft]: 307								
# STATE: AK								
Station_ID	Date_Time	air_temp_set_1 Fahrenheit	relative_humidity_set_1 %	wind_speed_set_1 Miles/hour	wind_direction_set_1 Degrees	wind_gust_set_1 Miles/hour	precip_accum_set_1 Inches	peak_wind_speed_set_1 Miles/hour
SGSA2	11/29/2019 15:54 UTC	43	68	4	49	11.01	8.12	11.01
SGSA2	11/29/2019 16:54 UTC	43	65	4	47	10	8.12	10
SGSA2	11/29/2019 17:54 UTC	44.01	63	4.99	63	12.01	8.12	12.01
SGSA2	11/29/2019 18:54 UTC	45	61	5.99	66	15.99	8.12	15.99
SGSA2	11/29/2019 19:54 UTC	45	61	4.99	56	14.99	8.12	14.99
SGSA2	11/29/2019 20:54 UTC	45	62	4	51	14.99	8.12	14.99
SGSA2	11/29/2019 21:54 UTC	45	61	4	66	15.99	8.12	15.99
SGSA2	11/29/2019 22:54 UTC	46	60	4.99	64	14	8.12	14
SGSA2	11/29/2019 23:54 UTC	45	61	4.99	67	18.01	8.12	18.01
SGSA2	11/30/2019 00:54 UTC	45	60	4.99	74	20	8.12	20
SGSA2	11/30/2019 01:54 UTC	45	59	4.99	79	14	8.12	14
SGSA2	11/30/2019 02:54 UTC	45	60	4	68	15.99	8.12	15.99
SGSA2	11/30/2019 03:54 UTC	45	60	4.99	67	17	8.12	17
SGSA2	11/30/2019 04:54 UTC	44.01	63	5.99	76	14.99	8.12	14.99
SGSA2	11/30/2019 05:54 UTC	44.01	66	4.99	65	27	8.13	27
SGSA2	11/30/2019 06:54 UTC	45	58	4.99	67	14.99	8.13	14.99
SGSA2	11/30/2019 07:54 UTC	45	58	4.99	67	13	8.13	13
SGSA2	11/30/2019 08:54 UTC	44.01	59	4	60	15.99	8.13	15.99
SGSA2	11/30/2019 09:54 UTC	45	58	5.99	79	15.99	8.13	15.99
SGSA2	11/30/2019 10:54 UTC	44.01	60	4	78	14	8.13	14
SGSA2	11/30/2019 11:54 UTC	44.01	62	2.01	70	11.01	8.13	11.01
SGSA2	11/30/2019 12:54 UTC	44.01	64	4	84	12.01	8.13	12.01
SGSA2	11/30/2019 13:54 UTC	43	67	1.01	84	13	8.13	13
SGSA2	11/30/2019 14:54 UTC	42.01	72	2.01	71	8.01	8.13	8.01

Figure 7 – List of observations from SGSA2 surrounding the accident time

SGSA2 weather at 1856 AKST was reported as, wind from 67° at 4.99 mph with gusts to 17 mph, and a temperature of 45°F.

SGSA2 weather at 1956 AKST was reported as, wind from 76° at 5.99 mph with gusts to 14.99 mph, and a temperature of 44.01°F. SGSA2 also reported 0.01 inches of precipitation between 1956 and 2056 AKST.

The unofficial observations from SJLA2, RUFA2, KNA2, and SGSA2 surrounding the accident time indicated gusty surface wind conditions with wind gusts between 15 and 31 mph (13 and 27 knots) and an east to southeast wind direction. In addition, SGSA2 reported precipitation accumulation of 0.01 inches between 1956 and 2056 AKST.

3.0 Upper Air Data

A Global Data Assimilation System (GDAS) model sounding was created for near the accident site for 1800 AKST with a surface elevation of 1,739 ft.⁷ The 1800 AKST GDAS sounding was plotted on a standard Skew-T Log P diagram⁸ with the derived stability parameters included in figure 8 with data from the surface to 600-hPa (or approximately 13,000 ft msl). This data was analyzed using the RAOB⁹ software package. The sounding depicted the lifted condensation level (LCL)¹⁰ at 619 ft agl (2,358 ft msl) and the convective condensation level (CCL)¹¹ at 3,830 ft agl (5,569 ft msl). The sounding had a greater than 80% relative humidity from the surface through 15,000 ft msl. The freezing level was located at 1,964 ft agl (3,703 ft msl). The precipitable water value was 0.44 inches.

⁷ GDAS sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

⁸ 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.

⁹ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹⁰ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹¹ 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.

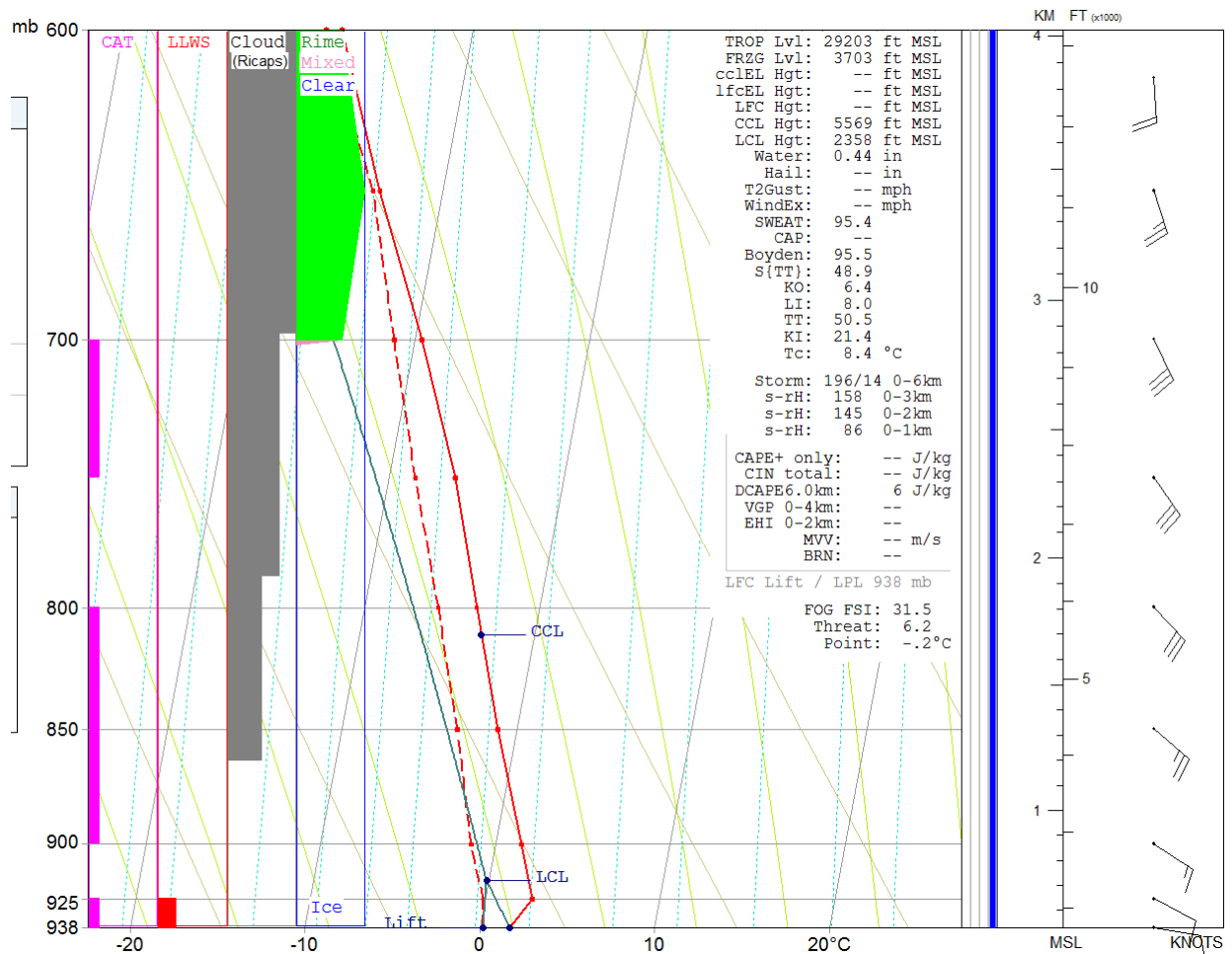


Figure 8 – 1800 AKST GDAS sounding

The 1800 AKST GDAS sounding indicated a conditionally stable environment from the surface through 13,000 ft msl. RAOB identified the possibility of clouds above ~2,300 ft agl (~4,000 ft msl). Moderate or greater rime icing was indicated by RAOB above ~10,000 ft msl.

The 1800 AKST GDAS sounding wind profile indicated a surface wind from 100° at 9 knots with the wind increasing in speed to 23 knots by ~2,300 ft agl (~4,000 ft msl). RAOB identified low-level wind shear (LLWS) potential between the surface and ~500 ft agl (~2,200 ft msl). RAOB indicated the possibility of light clear-air turbulence in several layers between the surface and 10,000 ft msl.

4.0 Satellite Data

Data from the Geostationary Operational Environmental Satellite number 17 (GOES-17) data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible (band 2) and infrared (band 13) imagery at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1400 AKST through 2200 AKST at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here. Given the sun angle and time of day the visible imagery did not provide useful information.

Figure 9 is the GOES-17 infrared imagery from 1910 AKST at 5X magnification with a temperature enhancement curve applied and the accident site highlighted by a red square. Inspection of the infrared imagery indicated cloud cover above the accident site at the accident time. The cloud cover was moving from south to north across the accident site (attachment 1). Wave-like patterns¹² can be seen in the low-level water vapor imagery moving northward across the accident site and the Kenai Peninsula at the accident time (attachment 2). It should be noted these figures have not been corrected for any parallax error. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the GDAS sounding, the approximate cloud-top heights over the accident site were 20,000 ft msl at 1910 AKST (temperature of about 243 Kelvin).

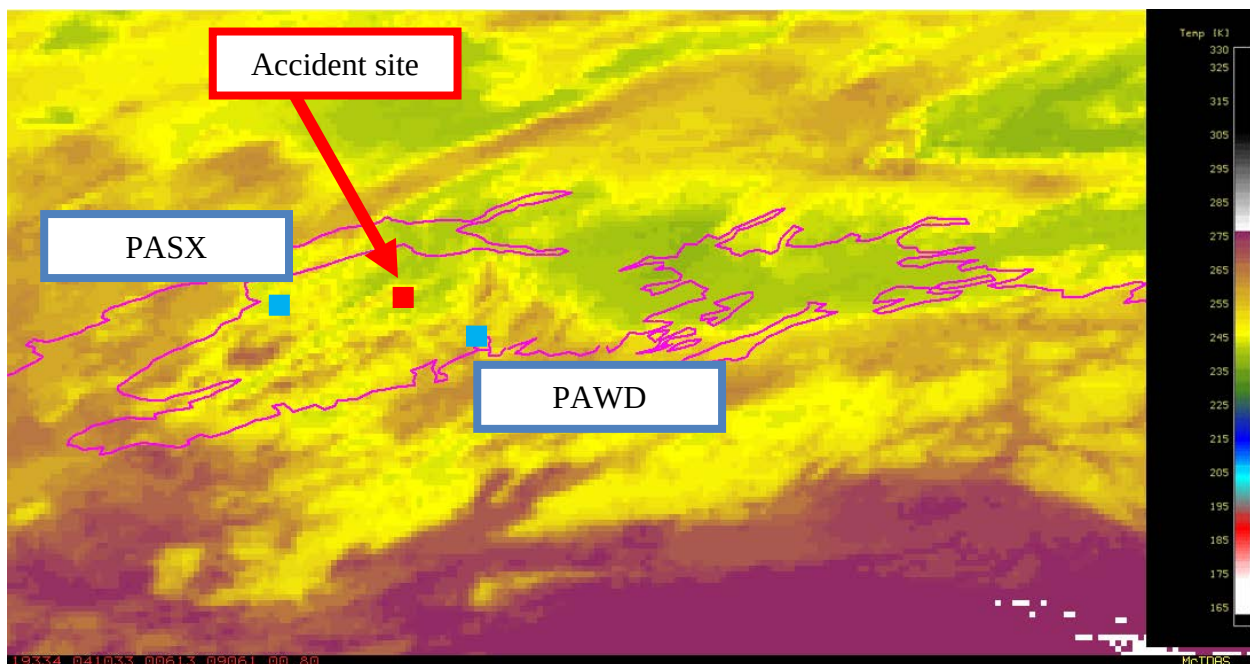


Figure 9 – GOES-17 infrared image at 1910 AKST

¹² http://rammb.cira.colostate.edu/wmovl/VRL/Texts/SATELLITE_METEOROLOGY/CHAPTER-3.PDF

5.0 Radar Imagery Information

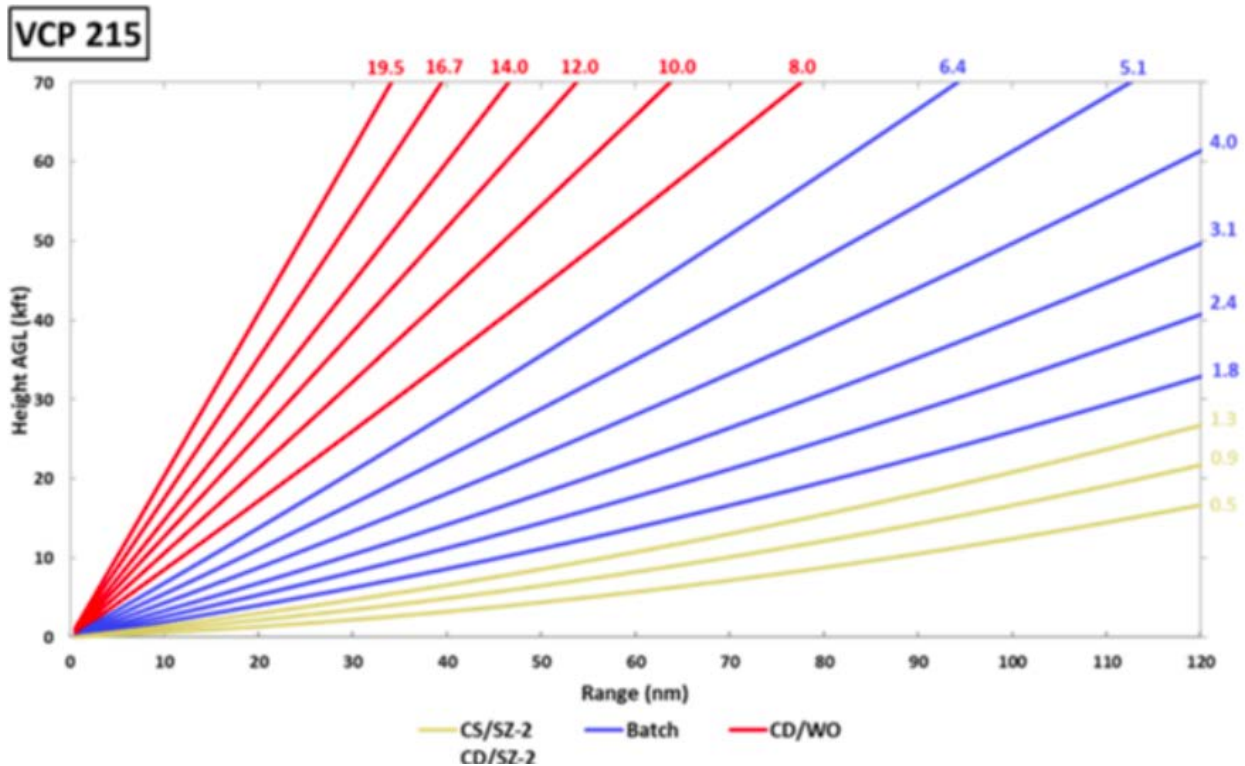
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹³ to the accident site was from Kenai/Anchorage, Alaska, (PAHG) located 38 miles west of the accident site. Level II archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

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. 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 14 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 215 (VCP-215). 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 PAHG WSR-88D radar was operating in the precipitation mode VCP-215. 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.

¹³ 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.



VCP-215 Precipitation Mode Scan Strategy¹⁴

5.2 Beam Height Calculation

Assuming standard refraction¹⁵ of the WSR-88D radar beam with the antenna elevation at 356 ft, a distance of 38 miles, and considering a beam width¹⁶ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
PAHG 0.5°	3,420 ft	1,550 ft	5,290 ft
PAHG 0.9°	5,030 ft	3,160 ft	6,900 ft
PAHG 1.3°	6,630 ft	4,760 ft	8,500 ft

¹⁴ 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)

¹⁵ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁶ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

Based on the radar height calculations for the elevation scans listed in the above table, the PAHG base reflectivity images from the 0.5° elevation scans depicted the conditions between 1,550 ft and 5,290 ft msl over the accident site and this elevation scan of the ones available from PAHG “saw” the closest altitudes to the surface. Attachments 3, 4, and 5 contain animations of the 0.5°, 0.9°, and 1.3° elevation scans, respectively.

5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors¹⁷ 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 decibel (dBZ¹⁸), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C¹⁹, “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:

- 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

¹⁷ 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.

¹⁸ 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.

¹⁹

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

5.4 Base Reflectivity and Lightning Data

Figure 10 presents the PAHG WSR-88D base reflectivity images for the 0.5° elevation scan initiated at 1908:17 AKST, with a resolution of 0.5° X 250 m. The image depicted echoes of 10 to 20 dBZ above the accident site at the accident time. The echoes above the accident did not move and are consistent with the location of higher terrain targets. However, between 1902 and 1932 AKST (attachment 3), echoes of 15 to 25 dBZ were growing in areal coverage just west and southwest of the accident site and moving northwestward with time. In the 0.9° and 1.3° elevation scans, the 10 to 20 dBZ values are consistently moving northwestward from near PAWD (at 1831 AKST) and over the accident site at the accident time (attachments 4 and 5).

There were no lightning strikes around the accident site at the accident time.²⁰

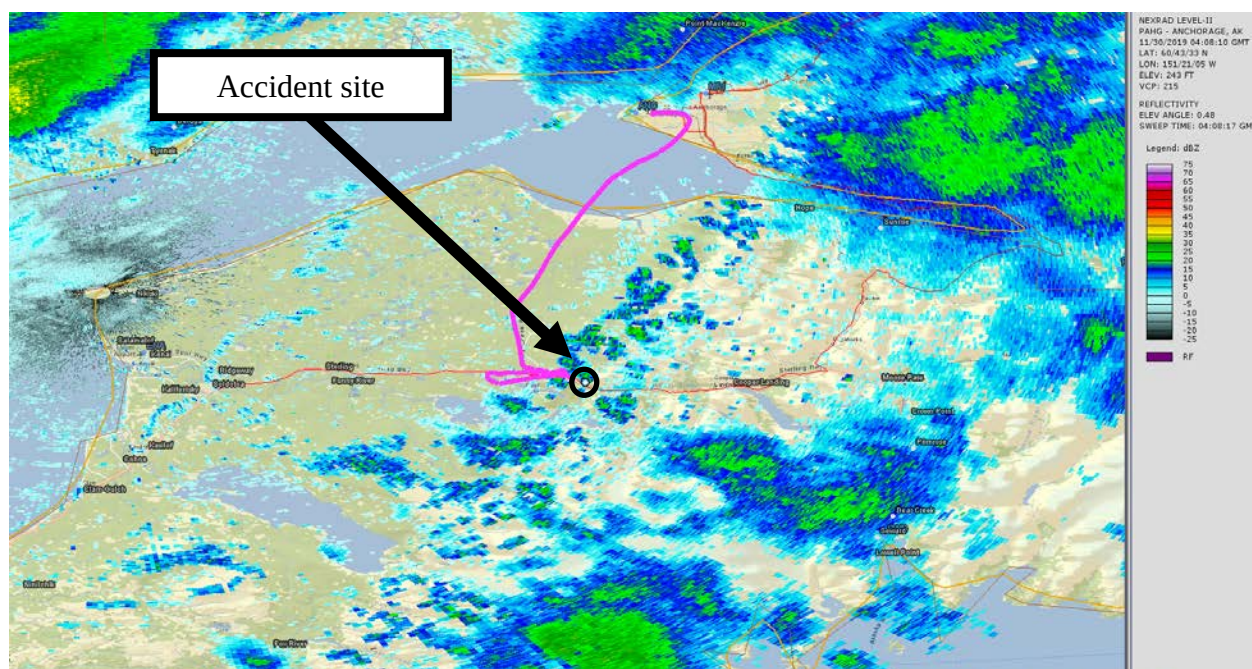


Figure 10 – PAHG WSR-88D reflectivity for the 0.5° elevation scan initiated at 1908:17 AKST with the accident site marked with a black circle and the accident flight track marked as a pink line

6.0 Pilot Reports

All pilot reports²¹ (PIREPs) within 100 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time for below 18,000 ft are provided below:

HOM UA /OV 6005N 15131W /TM 0240 /FL031 /TP PA32 /TB NEG /IC NEG /RM VMC

ANC UA /OV TED 210030/TM 0455/FL070/TP DH8A/TA M9/IC LIGHT CLEAR ICE 085-075/RM DURD

ANC UA /OV TED245025/TM 0534/FLDURD/TP B747/TA M1/IC LGT RIME ICE 060-036

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

²¹ Only pilot reports with the World Meteorological Organization (WMO) header UBAK** identifier were considered.

ANC UA /OV TED160005/TM 0612/FLDURD/TP B737/TB LGT TURB 170-110 MOD CHOP 110-070/RM DURD
ON WITTI4 ARRIVAL

Two PIREPs after the accident time mentioned light clear and rime icing around 3,600 to 8,500 ft msl and one PIREP from a Boeing 737 reported light turbulence and moderate chop during descent into Anchorage, Alaska.

7.0 SIGMET

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

8.0 CWSU Advisories

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

9.0 Area Forecast

The Alaska Aviation Weather Unit (AAWU) issued the following Area Forecast for a region that included the accident location and the route of flight to PAWD. This Area Forecast warned of occasional broken ceilings at 2,500 ft msl with light rain showers, visibilities between 3 and 5 miles in light snow showers and mist, otherwise occasional broken ceilings at 4,500 ft msl with isolated light rain showers. In the vicinity of Turnagain Arm and Anchorage a surface wind from the southeast at 25 knots with gusts to 45 knots were forecast. There was an Airmen's Meteorological Information (AIRMET) out for mountain obscuration due to clouds and precipitation, an AIRMET warning of LLWS, and an AIRMET warning of occasional moderate icing between 6,000 ft and 15,000 ft msl with the freezing level at 3,000 ft msl:

FAAK48 PAWU 292110

FA8H

ANCH FA 292115

AK SRN HLF EXCP SE AK...

.

AIRMETS VALID UNTIL 300515

CB IMPLY POSSIBLE SEV OR GREATER TURB SEV ICE LLWS AND IFR CONDS.

NON MSL HEIGHTS NOTED BY AGL OR CIG.

.

SYNOPSIS VALID UNTIL 301500

WK QSTNRY FNT PAIN-PADQ WILL DSIPT IN PLACE DUR PD. TROF FM PADQ SE
WILL MOV INTO CNTRL GULF AK DUR PD. OCFNT IN ARC ACROSS CNTRL-ERN BERING
SEA THENCE S ACROSS ERN ALEUTIANS WILL SWEEP NE INTO SW AK-BRISTOL
BAY AS IT WKNS. NW-SE RIDGE VCY KISKA IS WILL MOVE QUICKLY NE TO VCY
PACD BY END OF PD AS DVLPG 986 MB LOW MOVES TO JUST S PADK.

.

COOK INLET AND SUSITNA VLY AB...VALID UNTIL 300900

...CLOUDS/WX...

AIRMET IFRALG/VCY AK RANGE OCNL CIG BLW 010/VIS BLW 3SM SN BR. NC...

AIRMET MT OBSCMTS OBSC IN CLDS/PCPN. NC...

ALG/VCY AK RANGE SCT005 OVC015 TOP 150 LYRS ABV TO FL270 VIS 3-5SM -SN.
 OCNL CIG BLW 010/VIS BLW 3SM -SN BR.
 ELSW FEW025 SCT045 BKN-OVC070 TOP 150 SEPD LYRS ABV TO FL270.
ALG/VCY ERN MTS OCNL BKN025 -SHRA/VIS 3-5SM -SHSN BR.
ELSW OCNL BKN045. ISOL -SHRA.
VCY TURNAGAIN ARM AND HILL SIDE ABV ANCHORAGE SFC WND SE 25G45KT.
 OTLK VALID 300900-301500...VCY AK RANGE IFR CIG SN. ELSW VFR SHRA.
 PASSES...
 LAKE CLARK...MERRILL...RAINY...WINDY...IFR CIG SN BR TURB.
 PORTAGE...IFR CIG RA BR TURB.
...TURB...
*****AIRMET LLWS***VCY PANC LLWS CONDS. NC...**
 N PANC ISOL MOD TURB BLW 040.
 VCY MTS AND WITHIN 40NM OF MTS FM PAAQ-PAEN ISOL MOD TURB BLW 080.
 ...ICE AND FZLVL...
*****AIRMET ICE***PANC S OCNL MOD ICEIC 060-150. FZLVL 030. NC...**
ELSW ISOL MOD ICEIC 060-150.

10.0 AIRMETs

Airmen's Meteorological Information (AIRMET) advisories Sierra, Tango, and Zulu were valid for the accident site at the accident time and the wording is contained below:

WAAK48 PAWU 292110
 WA80
 ANCS WA 292115
 AIRMET SIERRA FOR IFR AND MT OBSC VALID UNTIL 300515
 .
COOK INLET AND SUSITNA VLY AB
ALG/VCY AK RANGE OCNL CIG BLW 010/VIS BLW 3SM SN BR. NC.
 .
COOK INLET AND SUSITNA VLY AB
MTS OBSC IN CLDS/PCPN. NC.
 .
 =ANCT WA 292115
 AIRMET TANGO FOR TURB/STG SFC WINDS VALID UNTIL 300515
 .
COOK INLET AND SUSITNA VLY AB
VCY PANC LLWS CONDS. NC.
 .
 =ANCZ WA 292115
 AIRMET ZULU FOR ICING VALID UNTIL 300515
 .
COOK INLET AND SUSITNA VLY AB
PANC S OCNL MOD ICEIC 060-150. FZLVL 030. NC.
 .

11.0 AAWU Graphics

The AAWU graphical forecasts valid for the accident time are contained in figures 11 to 14. The graphics warned of MVFR to IFR conditions, a surface wind greater than 30 knots, LLWS, and moderate icing above 6,000 ft msl at the accident site or along the route of flight.

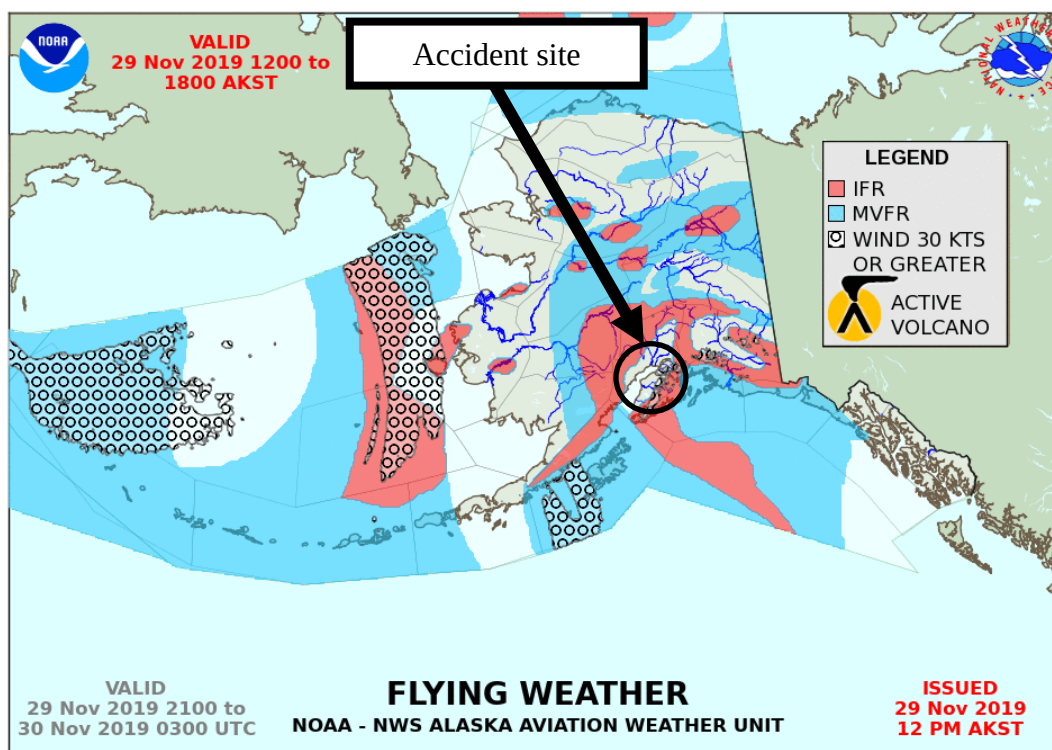
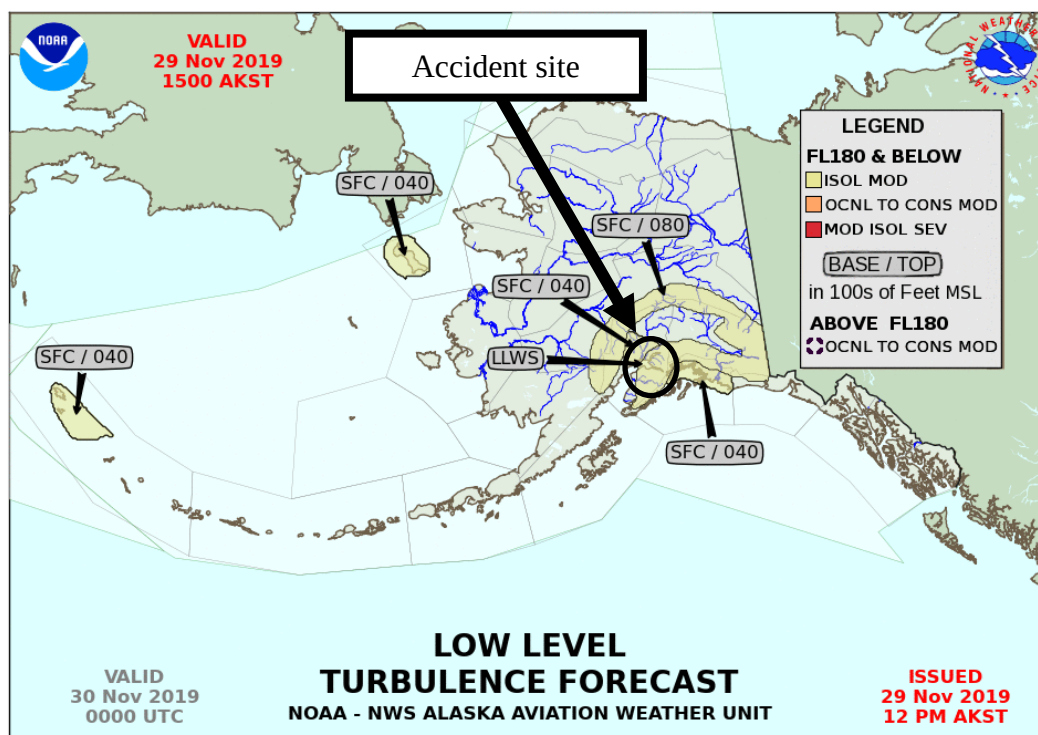


Figure 11 – AAWU Flying Weather forecast issued at 1200 AKST and valid 1200 to 1800 AKST



12.0 Terminal Aerodrome Forecast

There were no NWS Terminal Aerodrome Forecast (TAF) sites located within 30 miles of the accident site or the destination airport of PAWD.

13.0 NWS Area Forecast Discussion

The NWS Office in Anchorage, Alaska, issued the following Area Forecast Discussion (AFD) at 1658 AKST (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed precipitation moving northward along the Kenai Peninsula with temperatures near freezing around Anchorage:

FXAK68 PAFC 300158
AFDAFC

Southcentral and Southwest Alaska Forecast Discussion
National Weather Service Anchorage AK
458 PM AKST Fri Nov 29 2019

.ANALYSIS AND UPPER LEVELS...

A deep low a few hundred miles south of Kodiak Island is weakening as it exits eastward. This is allowing the upper trough which has been nearly stationary over the eastern Bering Sea to begin to progress eastward. While the upper level deformation that had set up between the two systems has ended, there is still decent vertical motion ahead of the upper trough. This is bringing light snow to portions of interior Bristol Bay (mainly Iliamna northward) as well as the west side of the Alaska Range and across the middle Kuskokwim Valley (near Sleetmute). An occluded front which extends from the low south of Kodiak up and around the northwest Gulf is lifting northward toward Prince William Sound leading to persistent rain near sea level and some mountain snow. A barrier jet is beginning to form ahead of the front along the north Gulf coast, with winds strengthening from Cape Suckling to Hinchinbrook Entrance. Upslope flow continues to produce precipitation along the west side of Cook Inlet on up to the Susitna Valley, though it is much lighter than the past couple days. Low level southerly flow has pushed all the way up the valley changing precipitation to all rain as far north as Chulitna.

Out west, an elongating and weakening front extending from a low over the northwest Bering Sea is approaching the Alaska Peninsula and Southwest Alaska coast. Expect a narrow band of light precipitation with this front. Cold air advection showers prevail behind this front across the Bering Sea and Aleutians.

Lastly, a strong upper jet and atmospheric river are crossing the north central Pacific. The flow is fairly zonal right now, but expect some amplification tonight as a short-wave digs southward out of Russia tonight. This will lead to cyclogenesis and

development of the next storm to affect the southern mainland later this weekend into early next week.

&&

.MODEL DISCUSSION...

There are some minor timing and precipitation type differences among the models with precipitation event over Southcentral on Saturday. In particular, most of the forecast soundings from the western Kenai to Anchorage show a quick transition from rain to snow as an upper trough approaches during the day Saturday. However, with southerly winds moving up the Inlet into Anchorage, this usually maintains warmer surface temperatures. Thus, tend to prefer the warmer guidance and a slower transition from rain to snow.

Models have mostly converged on a common solution with deepening low tracking from the eastern Aleutians to Bristol Bay Saturday night and into the Gulf on Sunday. The NAM is the one big outlier with a weaker low and farther south track. Forecast changes will be based off of the GFS/ECMWF which show a very similar storm track.

&&

.AVIATION...

PANC...The tail end of the short-wave trough crossing Southwest Alaska will move up Cook Inlet this evening while a weak wave from the Gulf is pulled northward across the Kenai Peninsula. This could bring some light precipitation to the terminal as early as 09Z, but with above freezing temperatures in place and persistent southeast flow across the Kenai and Chugach Mountains, any precipitation that does fall will be in the form of rain. Thus, expect VFR conditions to prevail.

A second stronger trough arrives in Cook Inlet tomorrow morning. This will intensify precipitation, perhaps enough to cool the column (via melting) and change precipitation to snow. However, a south wind off of the warm waters of Cook Inlet should keep surface temperatures above freezing. Thus, if it does change to snow, it will be wet snow with little or no accumulation. For now, have indicated a mix of rain and snow in the TAF with a trend toward lowering ceilings. If it does snow, expect the ceiling and visibility to both decrease markedly.

&&

.SHORT TERM FORECAST SOUTHCENTRAL ALASKA (Days 1 and 2)...

Remnants of a weakening trough continue to bring light precipitation to the Susitna Valley. Temperatures have been warm enough for a change to rain across the southern Susitna Valley this afternoon, and warm air is expected to linger longer than previously thought. Southeasterly cross-barrier flow has allowed for drier conditions over the western Kenai Peninsula and Anchorage Bowl, however as the next upper level wave approaches

Saturday, these midlevel winds will weaken and become more southerly. This will allow for an increase in precipitation throughout the day on Saturday. While the northern Susitna Valley will see snow, most other locations will start as rain with a possible rain/snow mix by midday. By the end of the weekend, another upper level low moves into the Gulf and brings another chance of snowfall for Southcentral, though there are still many uncertainties regarding the placement of the low center as well as the timing of the colder air.

&&

.SHORT TERM FORECAST SOUTHWEST ALASKA (Days 1 through 3)...

An active pattern continues for the area as a pair of systems affects the region. The first of which will be an Arctic front pushing into the coast from the Kuskokwim Delta to the Western Capes. A narrow band of snow will accompany this feature with some light accumulations possible. This front will continue to weaken some through the next 24 hours, as it continues to outrun the better upper level support associated with a eastern Siberia low (the better jet dynamics and ascent/ventilation remains over the northern Bering).

However, the southern portion of the front will begin to stall on Saturday, as a wave of low pressure develops along it. This low is expected to bisect Bristol Bay as it heads towards King Salmon by Sunday afternoon. Snow will develop near both the front and the low, with the heaviest snow developing just north of the storm track. Given the model differences in strength and track, and considering this is still 36 to 48 hours out, decided to hold off on an Winter Weather Advisory. However, this may need to be issued with the next forecast package for any combination of snowfall exceeding advisory criteria (6 inches in 12 hours/12 inches in 24 hours) snowfall, or for a combination of accumulation snowfall with reduced visibilities due to winds of 25 mph or more.

&&

.SHORT TERM FORECAST BERING SEA/ALEUTIANS (Days 1 through 3)...

A gale force front extends from the eastern Bering Sea through the tip of the AKPEN this afternoon. Winds are subsiding while becoming westerly behind the front. This feature will be a key player in the weather over the next few days, as rapid cyclogenesis (low pressure development) commences across the west central Aleutians. A disturbance from Siberia will dive into the base of a Bering trough, aided by a fairly strong upper-level jet streak. The models continue to hold their ground, with the majority of them strengthening and showing a track from near Atka to King Salmon.

However, there are still differences in the forecast strength, with the European model dropping the low to 969mb on the stronger side, to 980 mb on the GFS, with the Canadian in between but

closer to the European.

The NAM is an outlier as it's weaker, faster, and further south/east. As such, it was discounted. Overall, it's looking more and more likely that sustained winds will be either high-end gale or low-end storm force system, with gusts into the storm force range either way. Snow will change to rain for much of the Aleutians and Alaska Peninsula (AKPEN), as warmer air moves into the region.

&&

.MARINE (Days 3 through 5)...

On Monday, low pressure will move into the central Aleutians, although there is some uncertainty if this low will track north or south of the Aleutians as it continues eastward. If this low deepens enough, there is a chance that storm force winds may develop around the core. For now, it looks to produce westerly small craft winds with embedded gales from the western Aleutians Monday towards the AKPEN Tuesday. A small craft to possibly gale force low in the northern Bering looks to drop towards the southeast Monday then gradually weaken Tuesday with uncertainty as to when it will dissipate or where exactly its remnants will end up.

A front associated with a low over Prince William Sound will produce small crafts and gales Monday into Tuesday. While the front then weakens and moves out of the area, offshore flow will continue to produce locally strong winds near terrain gaps along the Gulf coast.

&&

.LONG TERM FORECAST (Days 3 through 7)...

By Monday, a cold upper level trough over Southwest Alaska will be shifting east into Southcentral with the accompanying strong cold air advection supporting snow showers and strengthening offshore north to northwesterly winds. Once the trough reaches the northern Gulf coast, a cutoff upper low will vertically stack over the surface low near Prince William Sound. Both features will then track slowly to the east southeast Monday night and Tuesday with snow showers gradually tapering off and skies clearing. The resulting cold, dry pattern will persist through midweek with another upper level trough swinging in from the northwest around Wednesday and prolonging the offshore flow.

To the west, a more active storm track will persist near the Aleutians supported by cold air over the Bering and a strong westerly jet. A developing surface low near the central Aleutians on Monday will continue east through the southern Bering Monday night with upper level ridging out ahead of it building in over the Southwest Alaska coast. The surface low will then turn southeastward, crossing the western Alaska Peninsula Tuesday morning and digging south of the central Gulf Wednesday. As this low phases with the cold upper trough over southern Alaska, an

upstream high amplitude upper level ridge will build in over the western Bering Monday night and Tuesday, moving east to be centered over the central and eastern Bering Tuesday night and Wednesday.

A warm front pushing up the west side of the ridge will reach the eastern Bering Wednesday night and southwest Alaska coast Thursday morning. The associated cold front will follow more slowly due to several waves developing along it and lifting north through the Aleutians Wednesday and Thursday. A cold upper level trough swinging off of the Kamchatka Peninsula Wednesday night and over the western Aleutians Thursday will spin up a deep vertically stacked low over the Bering Thursday night and Friday. As this larger and more consolidated low develops it will strengthen the frontal system along the Southwest Alaska coast and push it inland Thursday night and Friday.

&&

.AFC WATCHES/WARNINGS/ADVISORIES...

PUBLIC...NONE.

MARINE...Storm Warning 172 174 176

Gale Warning 119 132 414 150-170 173 180 181.

Heavy Freezing Spray Warning 181.

FIRE WEATHER...NONE.

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14.0 Winds and Temperature Aloft Forecast

The NWS 1655 AKST Winds and Temperature Aloft forecast valid for 2100 AKST for the closest point to the accident site is included below:

FBAK31 KWN0 300155

FD1AK1

DATA BASED ON 300000Z

VALID 300600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

ANC 1427 1723-02 1920-09 1820-15 1838-28 2114-35 202847 203848 213847

The accident site was closest to the Anchorage, Alaska (ANC) forecast point. The ANC forecast for use between 1700 and 0000 AKST indicated a wind at 3,000 ft from 140° at 27 knots, at 6,000 ft a wind from 170° at 23 knots with a temperature of -2°C, and at 9,000 ft a wind from 190° at 20 knots with a temperature of -9°C.

15.0 Pilot Weather Briefing

The accident pilot did not request nor receive a weather briefing through FAA Alaska Flight Services or Leidos. A check of ForeFlight was done and revealed that the accident pilot did not request weather information through ForeFlight. The accident pilot did review weather before departure according to witness information, but it is unknown exactly what weather information was reviewed outside of the AAWU METAR page. For more information please see the Operations section and interview information contained in the docket for this accident.

16.0 Witness Information

Several witnesses in the vicinity of the accident site provided weather information. One of the witnesses noted there was some wind, it was dry at their location, and the temperature was 42°F near Jean Lake along the Sterling Highway at the accident time. Another witness traveling east bound from the Sterling Flats region at the accident time recalled the wind was variable with strong intermittent gusts, light rain, and temperature of 43°F. A third witness near Jean Lake stated it was very dark, he could not see the mountain tops or any clouds, and there was no wind or precipitation. A witness near mile marker 63 on Sterling Highway stated it was very windy with winds about 25 knots gusting to 40 knots, and the witness saw the trees swaying back and forth, but reported no precipitation at his location. For more witness information please see the docket for this accident.

17.0 Web Camera Images

Images from the FAA's Aviation Weather Cameras were retrieved and are contained in attachments 6 and 7. Given the sun angle and time of day the imagery did not provide useful information at the accident time.

18.0 NWS Alaska Weather Model Information

At NOAA's Earth System Research Laboratory (ESRL)²² a High Resolution Rapid Refresh (HRRR) weather model is run over Alaska called the HRRR_AK with 3-kilometer (km) grid spacing. Data from the HRRR_AK was retrieved for the accident timeframe and is contained in figures 15 and 16 and in attachment 8. Figures 15 and 16 show the wind speed and direction at 80 meters above ground at 1900 and 2000 AKST with the accident site located in an area of wind speed between 25 to 35 knots with directions from the east and southeast. Directly north of the accident site and west of the higher terrain were wind speeds between 5 to 10 knots (figures 15 and 16). For more information please see attachment 8.

²² <https://rapidrefresh.noaa.gov/hrrr/>

HRRR_AK 11/30/2019 (00:00) 4h fcst - Experimental

Valid 11/30/2019 04:00 UTC
80m Wind (kt)

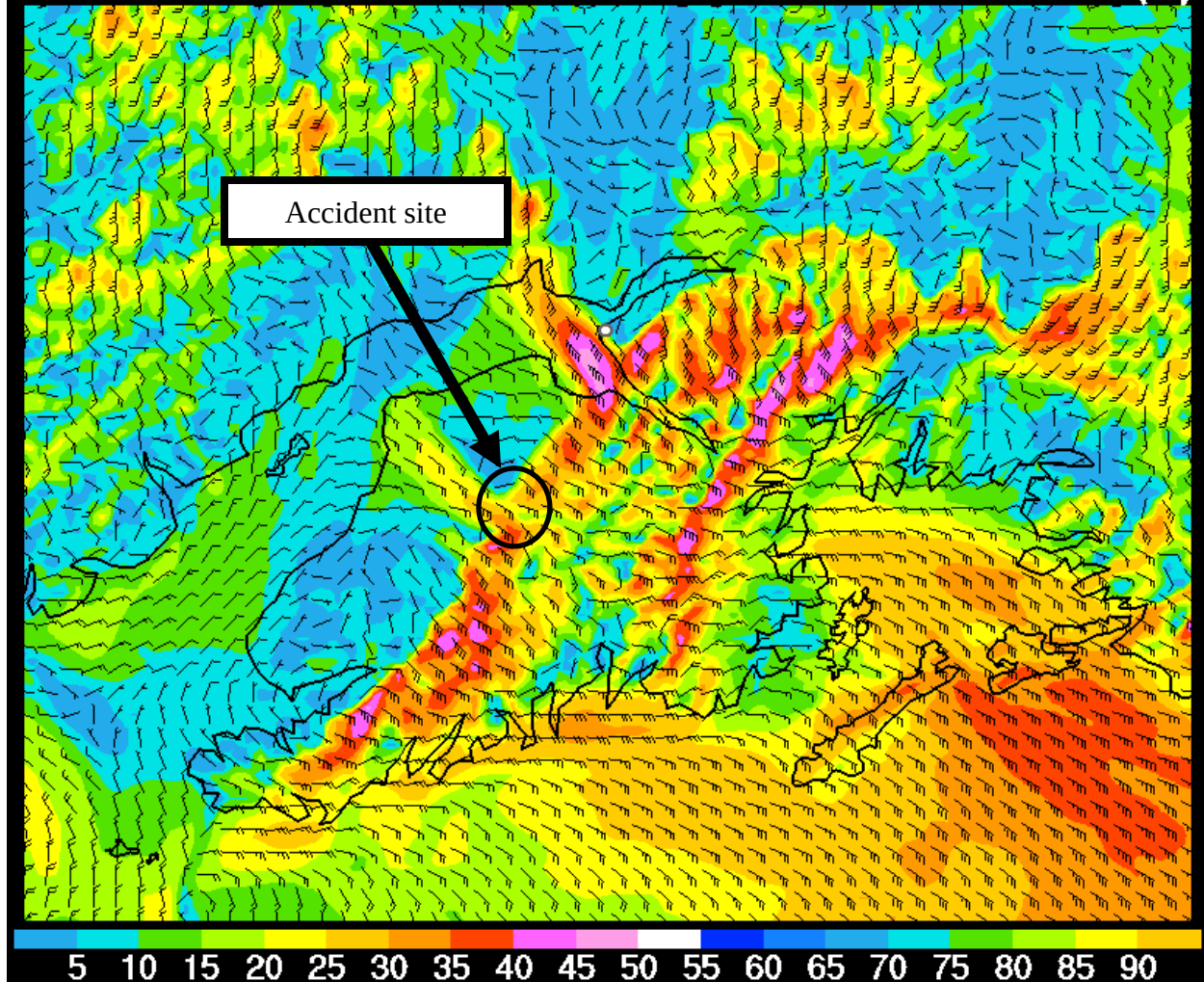


Figure 15 – HRRR_AK 1900 AKST 80 meter wind (knots)

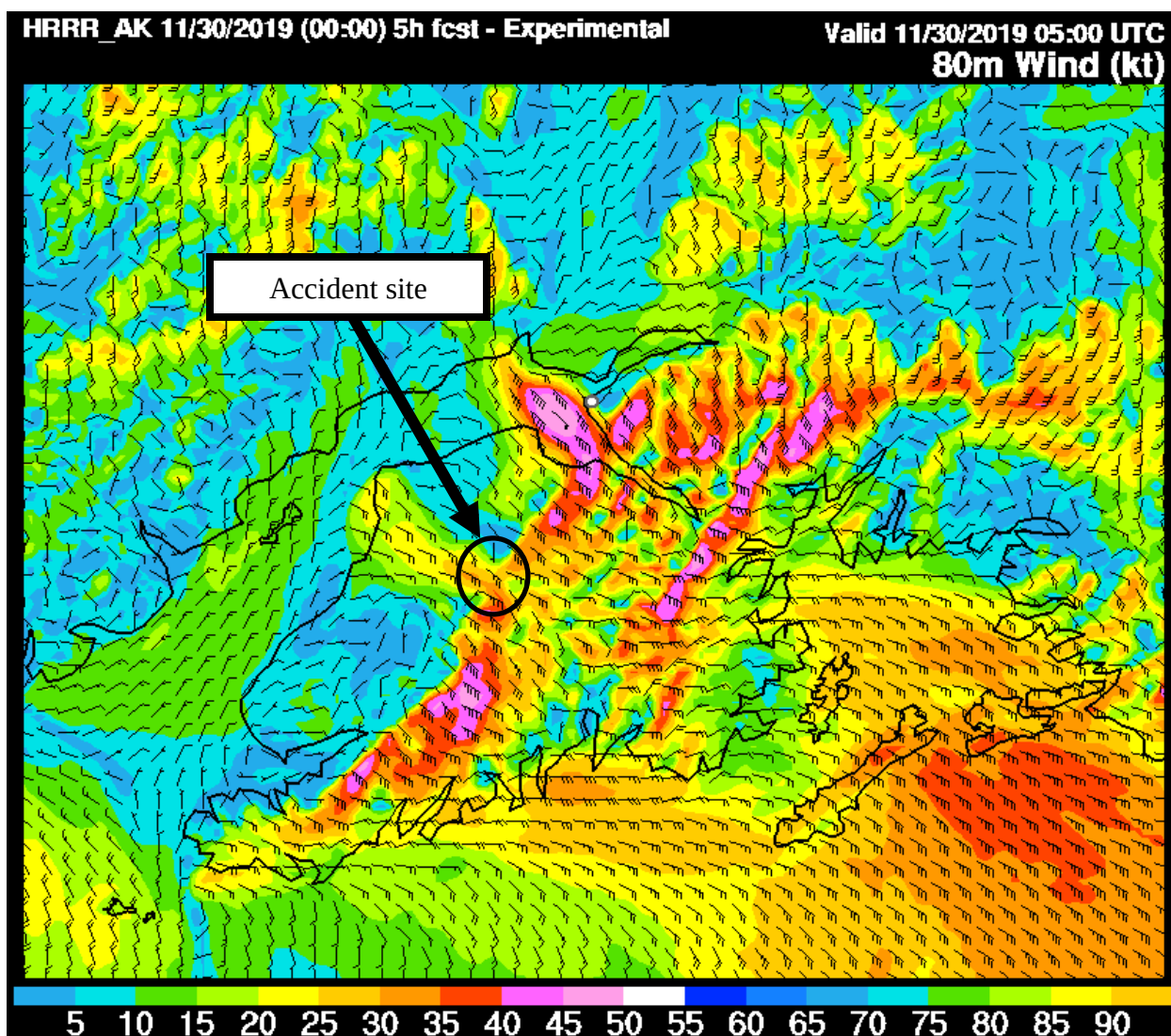


Figure 16 – HRRR_AK 2000 AKST 80 meter wind (knots)

19.0 Mountain Waves and Hazardous Mountain Winds

In FAA Advisory Circular (AC) 00-6B²³ 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)²⁴ published on September 10, 1997.

²³

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

²⁴

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

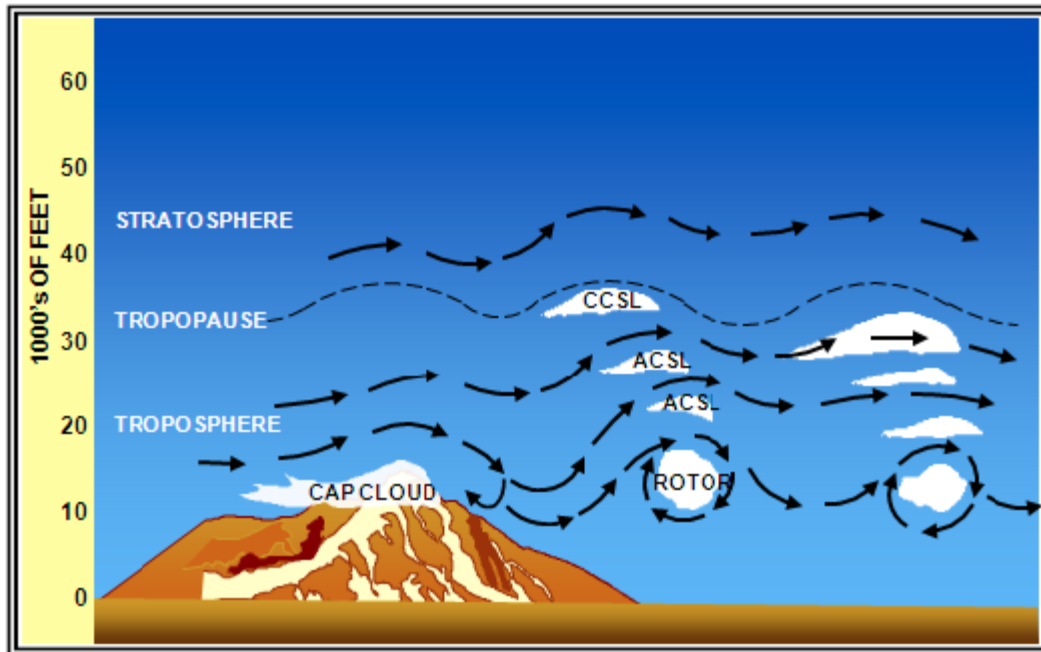


Figure 17 – AC 00-06B mountain wave conditions

20.0 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 GFS4.²⁵ WRF ARW (Advanced Research WRF core) version 4.1.2 was run with 3 domains with horizontal grid spacing of 8 km, 1.6 km, and 320 m over the accident site. Other WRF simulation parameters included: 60 vertical levels, the multi-scale Kain-Fritsch cumulus parameterization scheme used on the outer domain, a Lin et al. microphysics scheme, a Yonsei University boundary layer scheme, Noah land surface physics, the Dudhia scheme used for short wave radiation, and the RRTM scheme for the long wave radiation. 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 26 (along with attachment 9) with the location of the accident site marked.

Figures 20 and 21 depicted the winds²⁶ at 910 and 930 hPa (approximately 2,500 ft and 2,000 ft msl, respectively) in knots at 1900 and 1910 AKST. The WRF model indicated stronger winds northwest of the higher terrain between 1,500 and 3,000 ft (attachment 9) with horizontal wind speeds of 40 to 50 knots in the area of the accident site at the accident time (figure 21).

Figures 22 and 23 depicted the vertical velocity (color fill) in fpm at 1900 and 1910 AKST along a west-to-east cross-section with each marker a distance of 320 meters with the x-axis approximately 37 kilometers long. The vertical velocity data indicated that the accident flight near the accident time was in an area of rapidly transitioning updraft and downdrafts with magnitudes of 1,500 feet per minute (fpm). A downdraft with speeds of 1,500 fpm was directly above the accident site (figures 22 and 23) with an updraft with speeds between 1,000 and 1,500 fpm were directly west of the accident site by a kilometer or less.

Figures 24 and 25 depicted the potential temperature²⁷ (solid lines) in Kelvin and the horizontal wind speed in knots (color fill) at 1900 and 1910 AKST along a west-to-east cross-section with similar cross section characteristics as figures 22 and 23. The horizontal wind data indicated that the accident site was in an area of 30 to 40 knot wind speeds with wind speeds above 50 knots near the mountain top level (between 2,500 and 3,500 ft msl).

Figure 26 depicted the potential temperature (solid lines) in Kelvin and the relative humidity in percent (color fill) at 1910 AKST along a west-to-east cross-section with similar cross section characteristics as figures 22 and 23. The relative humidities were above 90 percent near the mountain top level (between 2,500 and 3,500 ft msl) in the vicinity of the accident site. In addition the WRF model soundings created the accident site and for points at 1909 and 1902 AKST within the flight track (attachment 9) indicated a highly dynamic low-level environment with similar environments described in section 19.0 that are favorable for mountain wave hazard conditions.²⁸ For more information and imagery for the WRF simulation please see attachment 9.

²⁵ <https://nomads.ncdc.noaa.gov/data/gfs4/>

²⁶ All wind magnitudes are in knots and are sustained wind speeds.

²⁷ 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.

²⁸ See the docket for this accident for accident flight track locations.

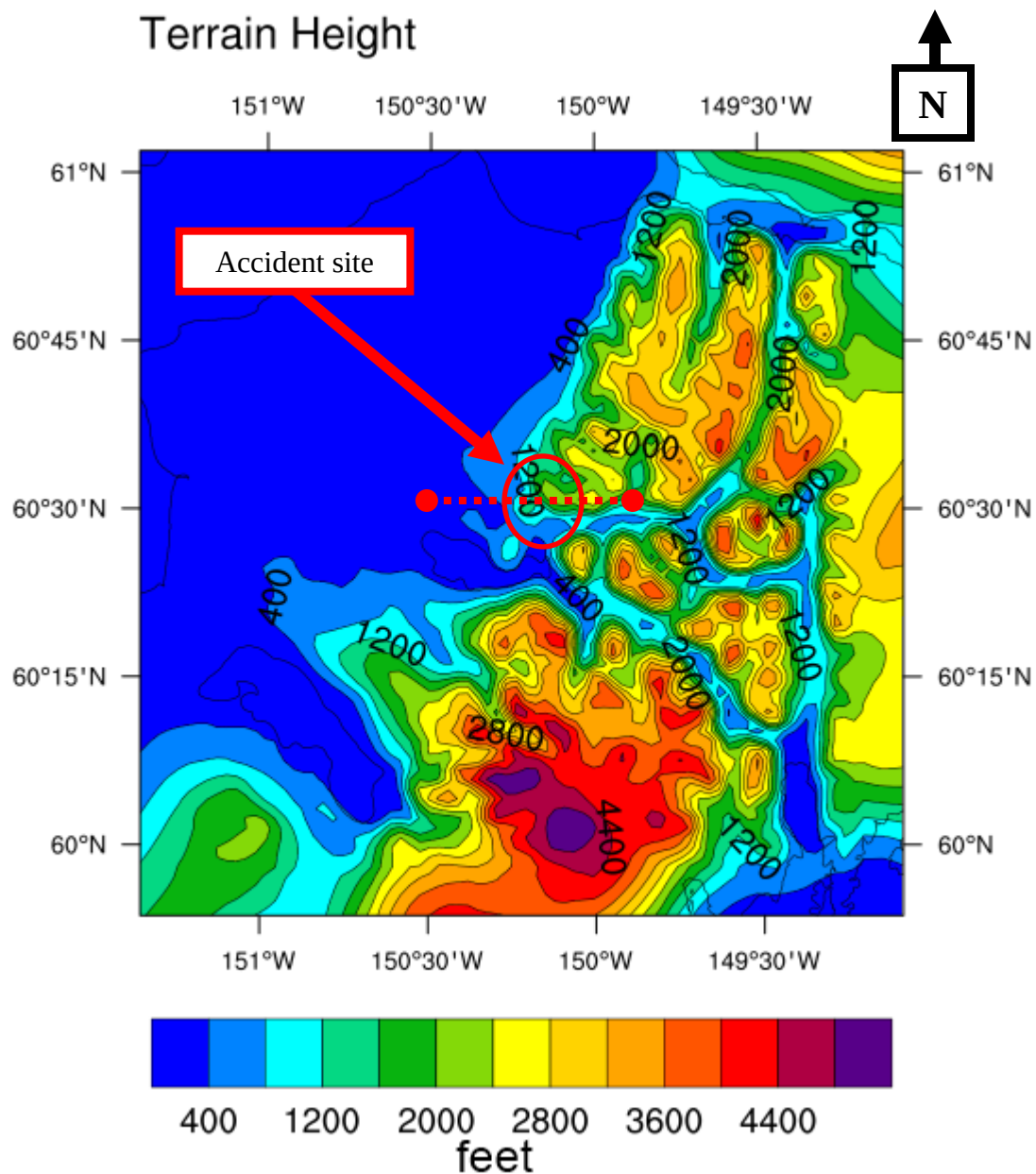


Figure 18 – WRF simulation terrain for domain 2 in ft with the accident site marked and the location of the cross section (red dashed lines)

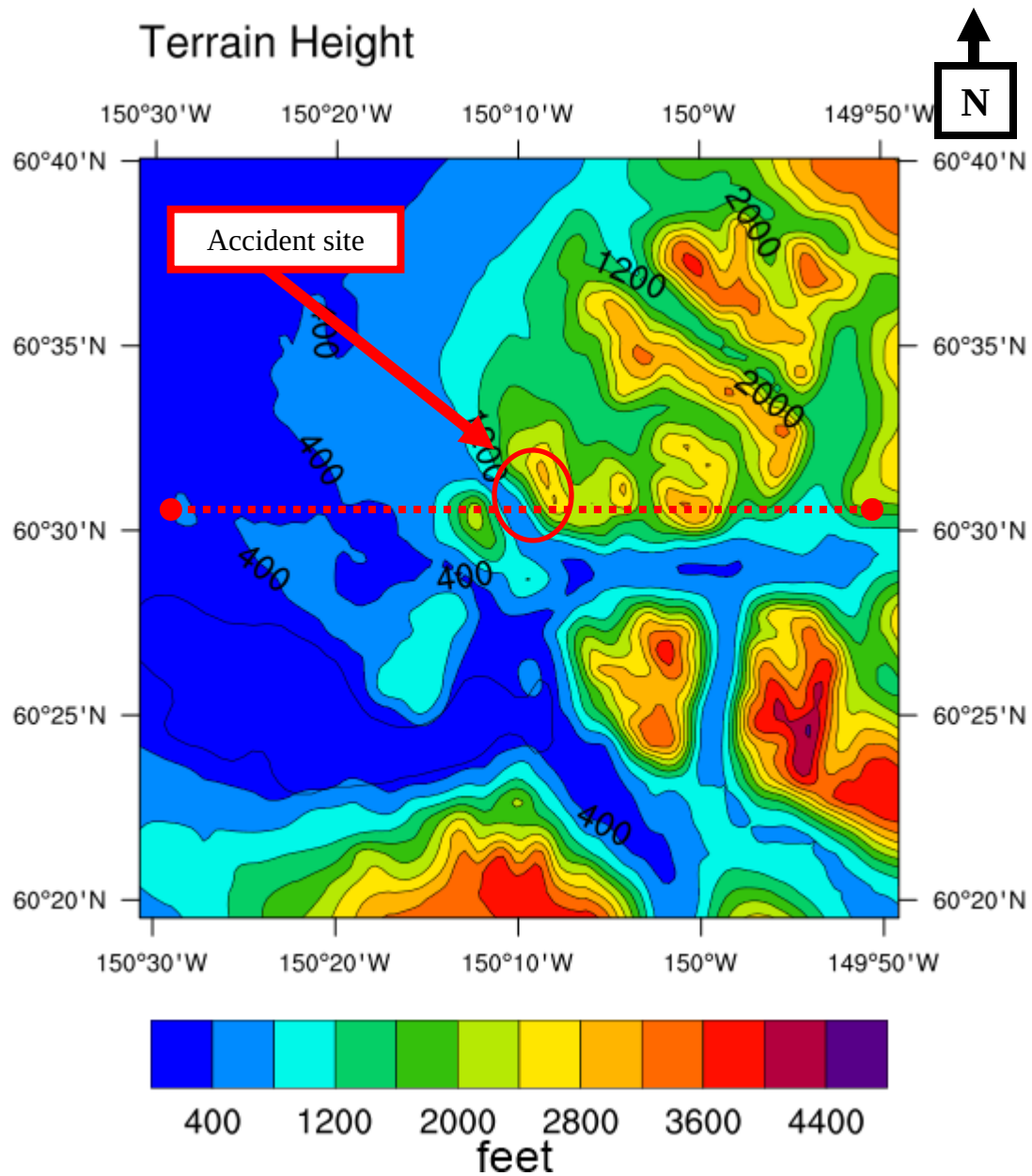


Figure 19 – WRF simulation terrain for domain 3 in ft with the accident site marked and the location of the cross section (red dashed lines)

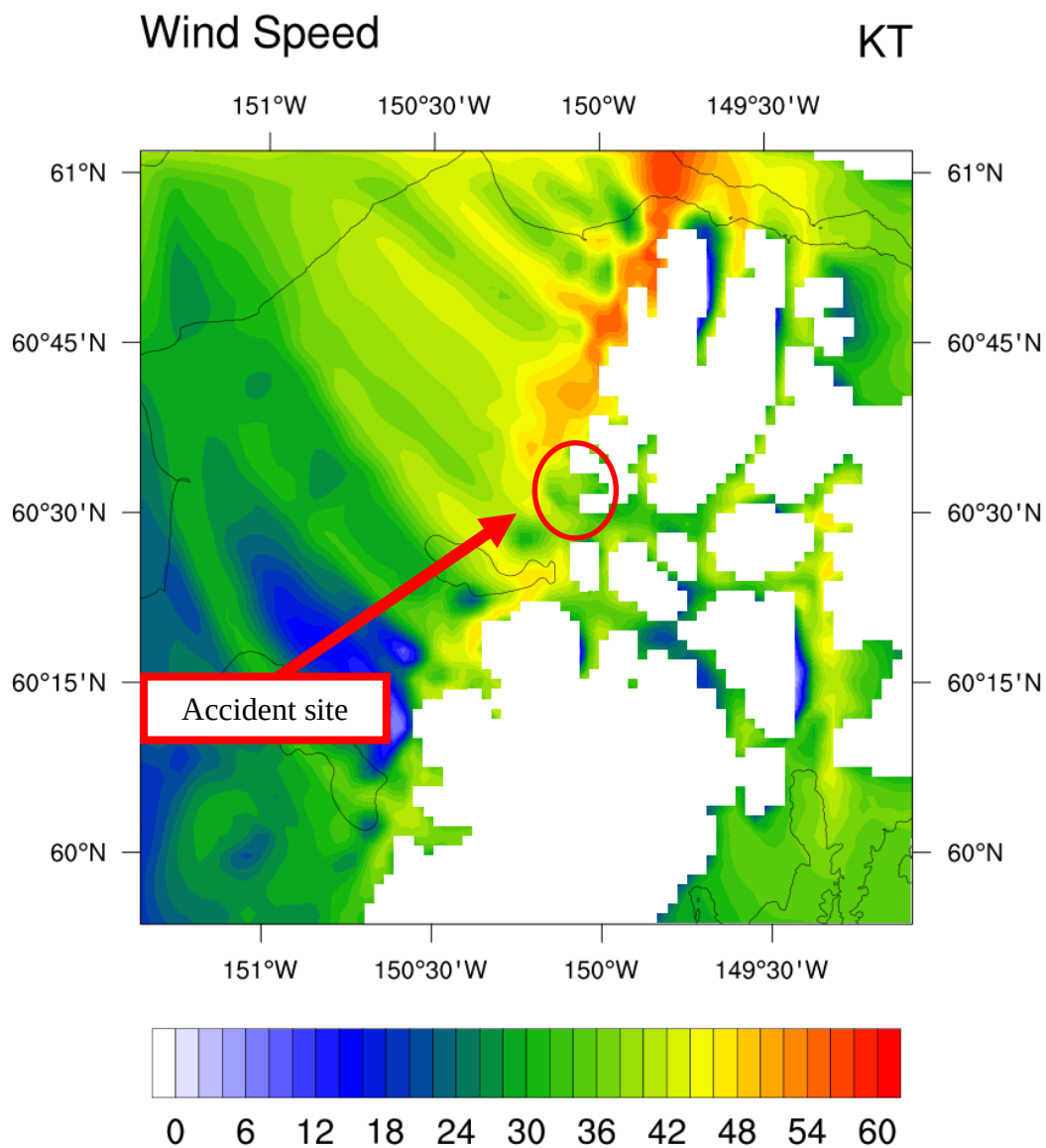


Figure 20 – WRF domain 2 wind in knots at 910 hPa (~2,500 ft msl) from 1900 AKST with the approximate accident site marked

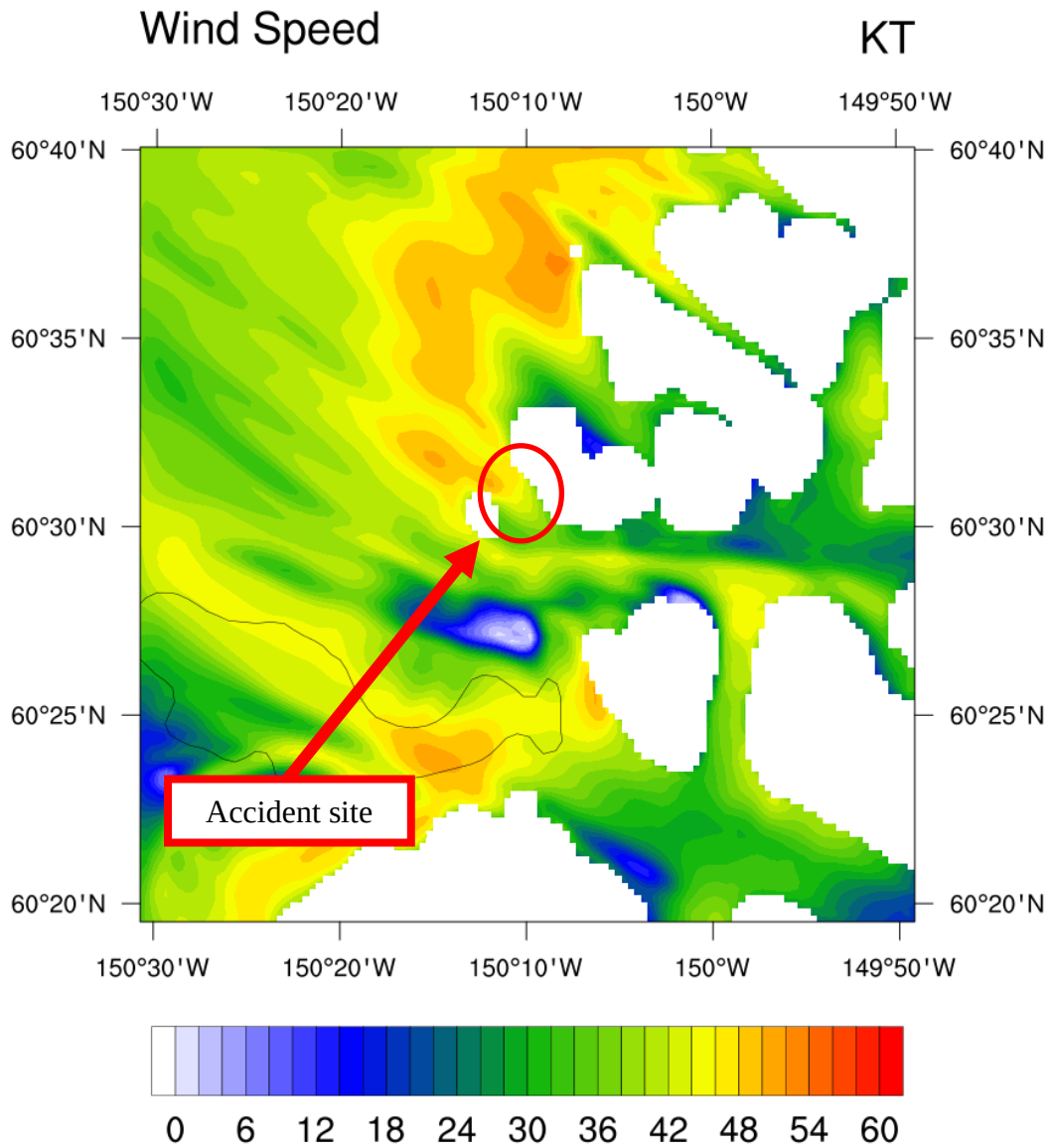


Figure 21 – WRF domain 3 wind in knots at 930 hPa (~2,000 ft msl) from 1910 AKST with the approximate accident site marked

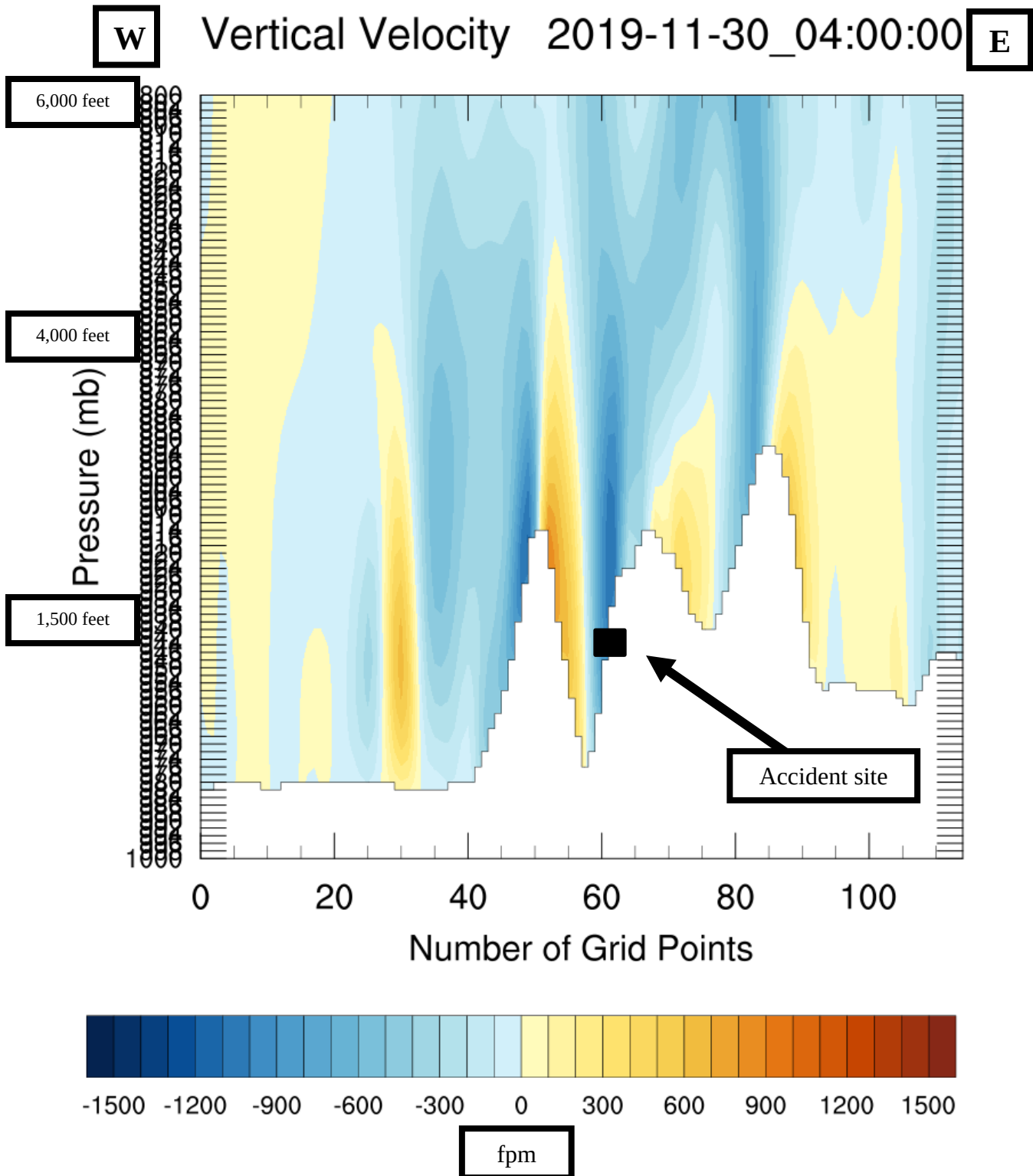


Figure 22 – WRF cross section from 1900 AKST of vertical velocity in fpm (color fill) from west to east across the terrain

W Vertical Velocity 2019-11-30_04:10:00 **E**

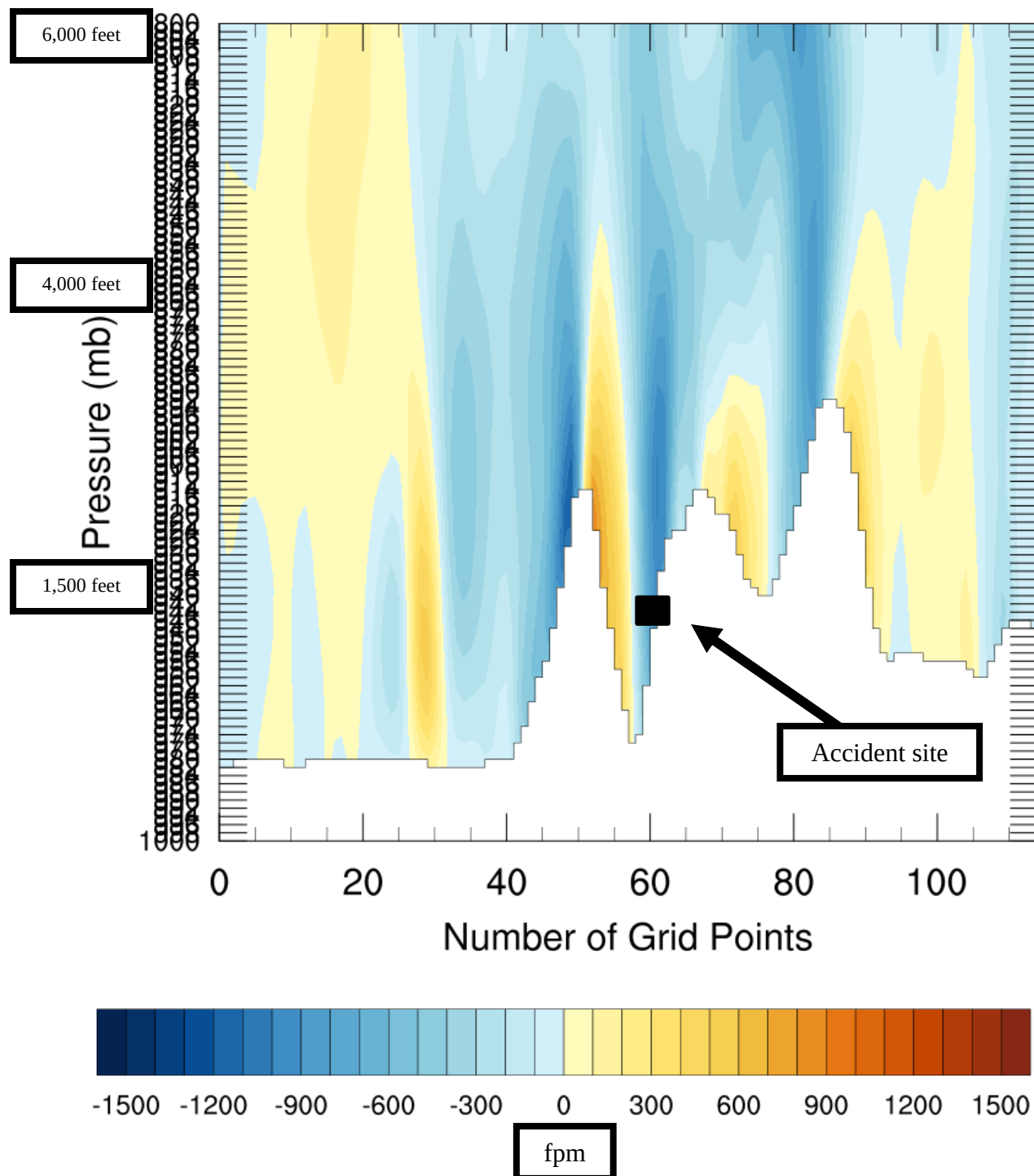


Figure 23 – WRF cross section from 1910 AKST of vertical velocity in fpm (color fill) from west to east across the terrain

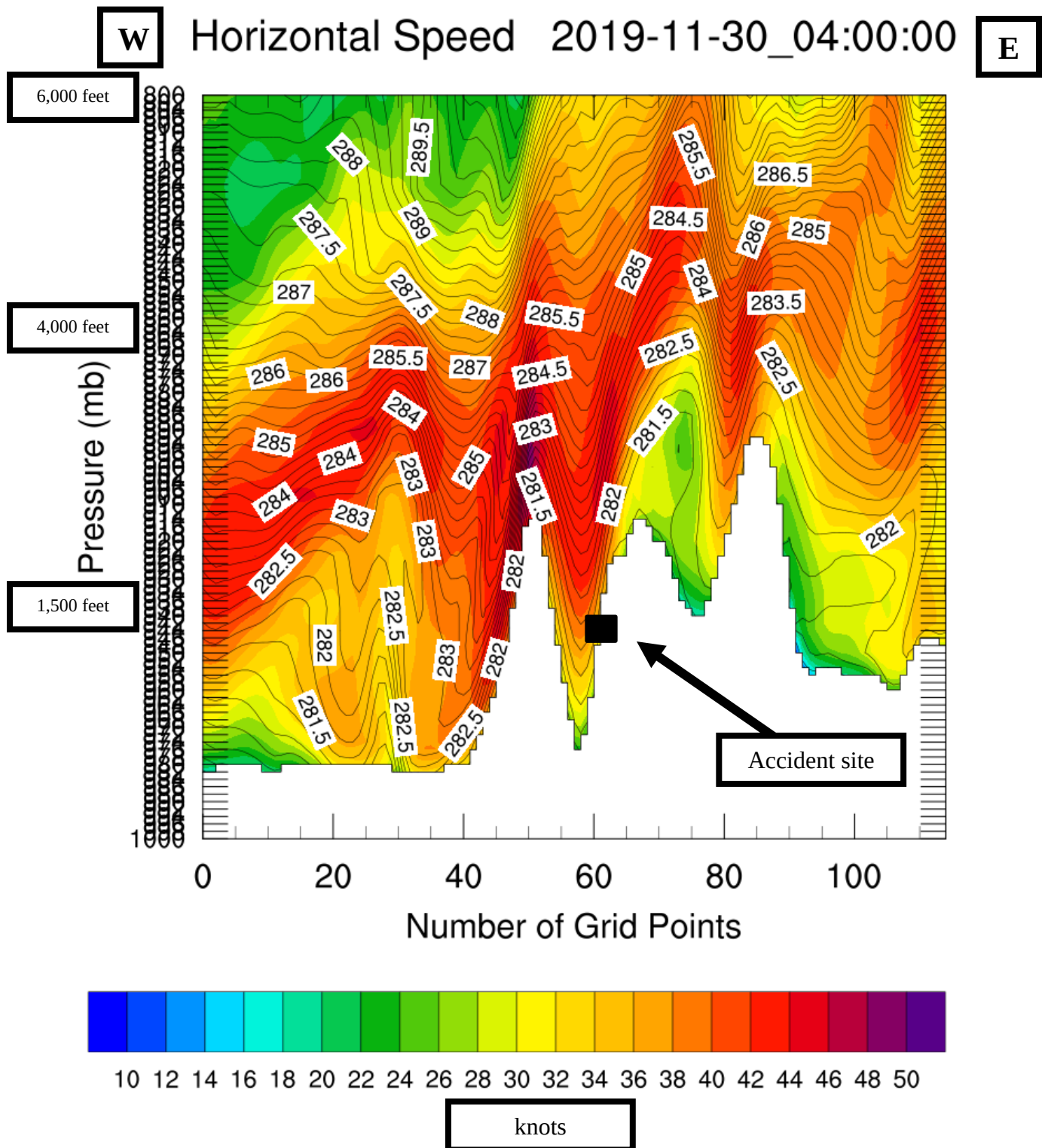


Figure 24 – WRF cross section from 1900 AKST of horizontal wind speed in knots (color fill) and potential temperature in Kelvin (black lines) from west to east across the terrain

W

Horizontal Speed 2019-11-30_04:10:00

E

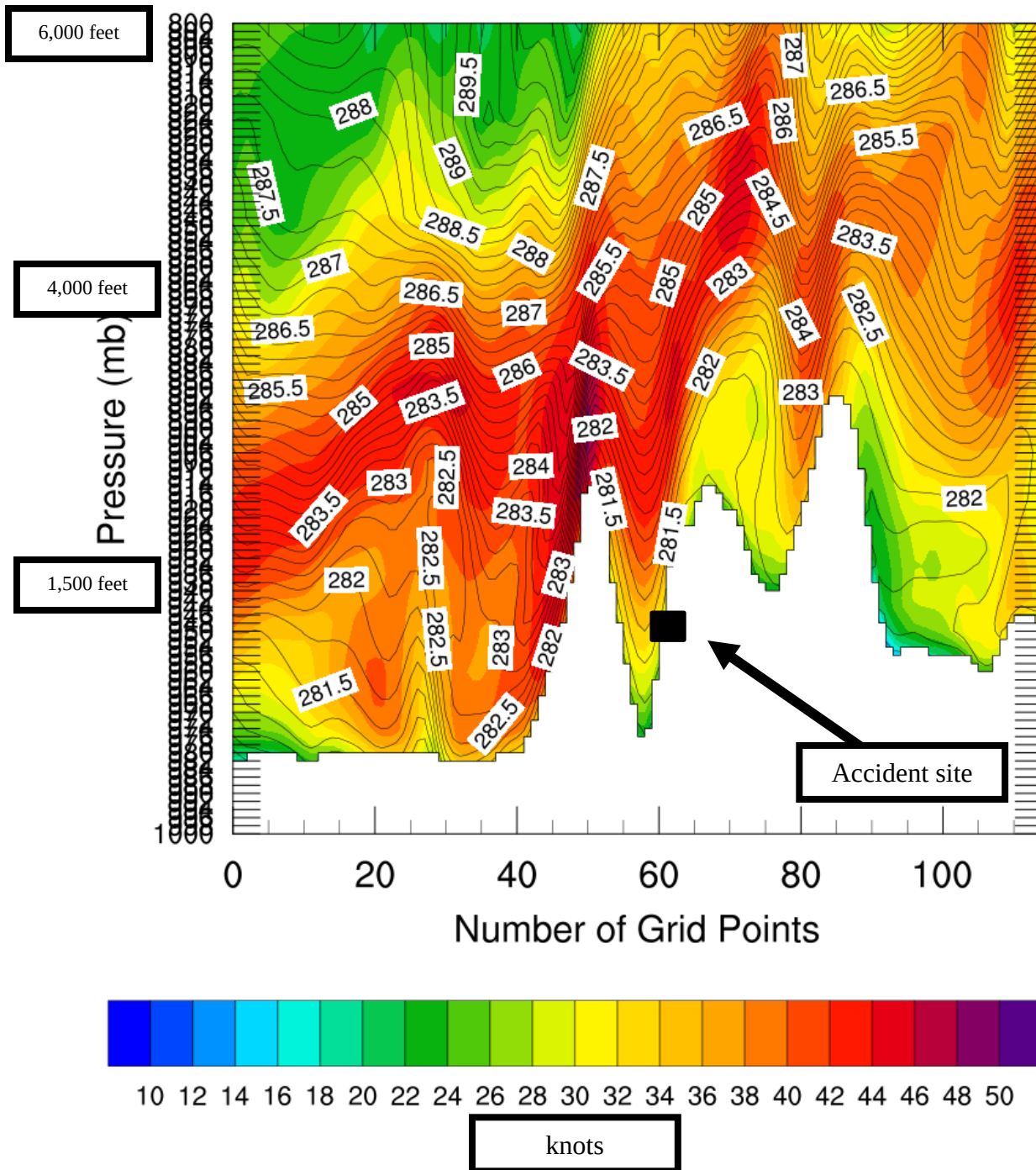


Figure 25 – WRF cross section from 1910 AKST of horizontal wind speed in knots (color fill) and potential temperature in Kelvin (black lines) from west to east across the terrain

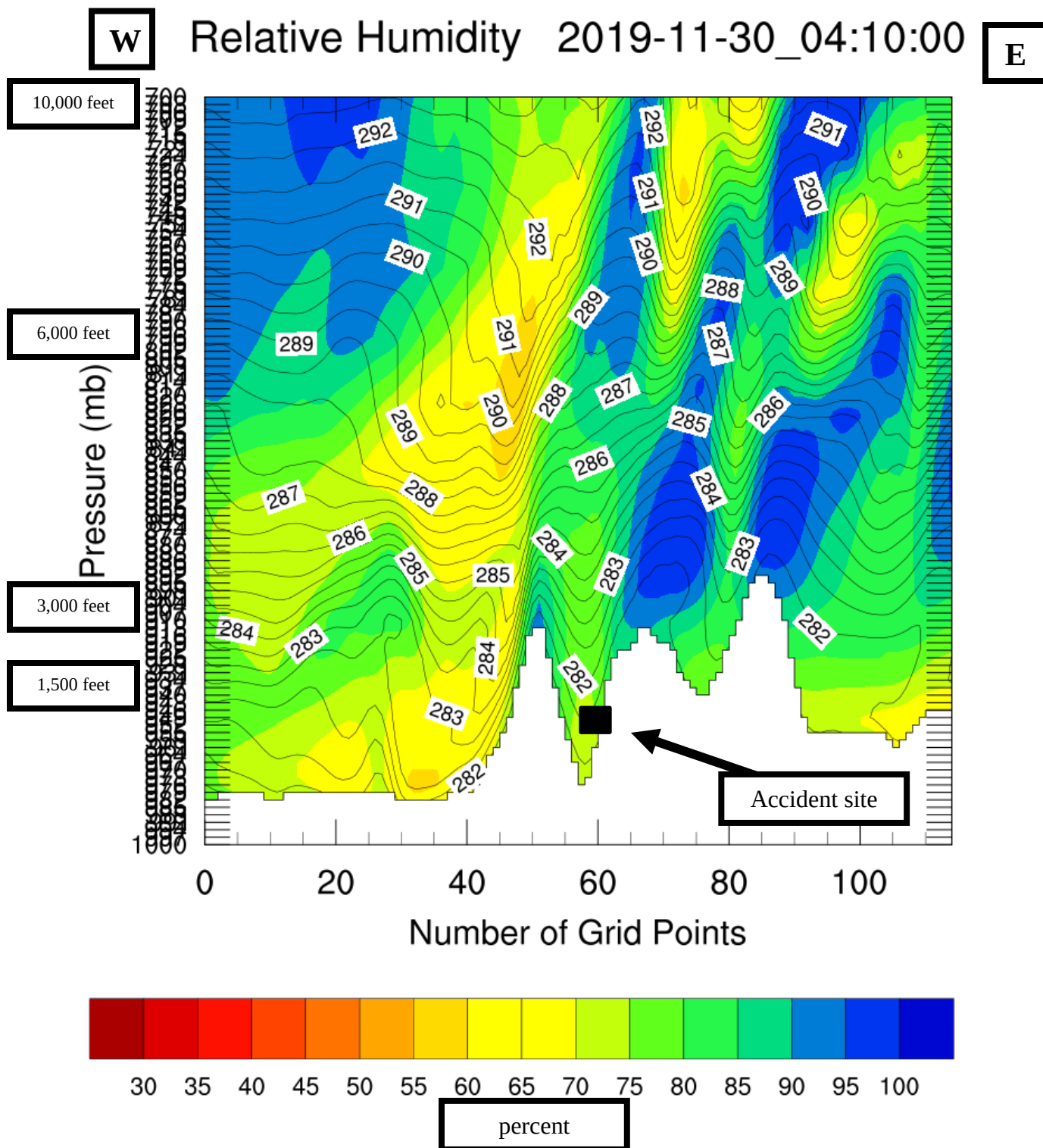


Figure 26 – WRF cross section from 1910 AKST of relative humidity in percent (color fill) and potential temperature in Kelvin (black lines) from west to east across the terrain

21.0 Astronomical Data

The astronomical data obtained for the accident site on November 29, 2019, indicated the following conditions:

SUN

Begin civil twilight	0841 AKST
Sunrise	0935 AKST
Sun transit	1249 AKST
Sunset	1602 AKST
End civil twilight	1657 AKST
<i>Accident</i>	<i>1911 AKST²⁹</i>

MOON

Moonrise	1302 AKST
Moon transit	1552 AKST
Moonset	1845 AKST
<i>Accident</i>	<i>1911 AKST³⁰</i>

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

E. LIST OF ATTACHMENTS

Attachment 1 – GOES-17 Infrared satellite animation from 1800 to 2000 AKST

Attachment 2 – GOES-17 Low-level water vapor satellite animation from 1800 to 2000 AKST

Attachment 3 – PAHG WSR-88D base reflectivity 0.5° elevation scan animation between 1831 and 1932 AKST

Attachment 4 – PAHG WSR-88D base reflectivity 0.9° elevation scan animation between 1831 and 1932 AKST

Attachment 5 – PAHG WSR-88D base reflectivity 1.3° elevation scan animation between 1831 and 1932 AKST

Attachment 6 – FAA web camera imagery from Soldotna

Attachment 7 – FAA web camera imagery from Cooper Landing

Attachment 8 – Alaska HRRR weather computer model imagery surrounding accident time

Attachment 9 – Additional WRF simulation imagery and animations surrounding accident time

²⁹ Inserted accident time for reference and context.

³⁰ Inserted accident time for reference and context.

Submitted by:

Paul Suffern
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