



## **NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Aviation Safety  
Washington, D.C. 20594

November 28, 2017

### **Group Chairman's Factual Report**

# **METEOROLOGY**

WPR17FA008

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## **A. ACCIDENT**

Location: South Lake Tahoe, California  
Date: October 15, 2016  
Time: 1552 Pacific daylight time  
2252 Coordinated Universal Time (UTC)  
Airplane: Cessna 182D, N8718X

## **B. METEOROLOGIST**

Paul Suffern  
Group Chairman  
Operational Factors Division (AS-30)  
National Transportation Safety Board

## **C. SUMMARY**

On October 15, 2016, at 1552 Pacific daylight time a Cessna 182D, N8718X, struck the eastern face of Red Peak Mountain, in the Desolation Wilderness near South Lake Tahoe, California. The airplane was registered to and operated by the pilot under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The private pilot sustained fatal injuries, and the airplane was destroyed. The cross-country flight departed Winnemucca Municipal Airport, Winnemucca, Nevada about 1320 with a planned destination of Westover Field / Amador County Airport, Jackson, California. Marginal visual meteorological conditions with moderate rain prevailed at Lake Tahoe Airport, 10 miles east of the accident site, and no flight plan had been filed.

## **D. DETAILS OF THE INVESTIGATION**

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Pacific daylight time (PDT) on October 15, 2016, and are based upon the 24-hour clock, where local time is -7 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 accident site was located at latitude 38.92° N, longitude 120.21° W, at an approximate elevation of 7,915 feet.

## **E. FACTUAL INFORMATION**

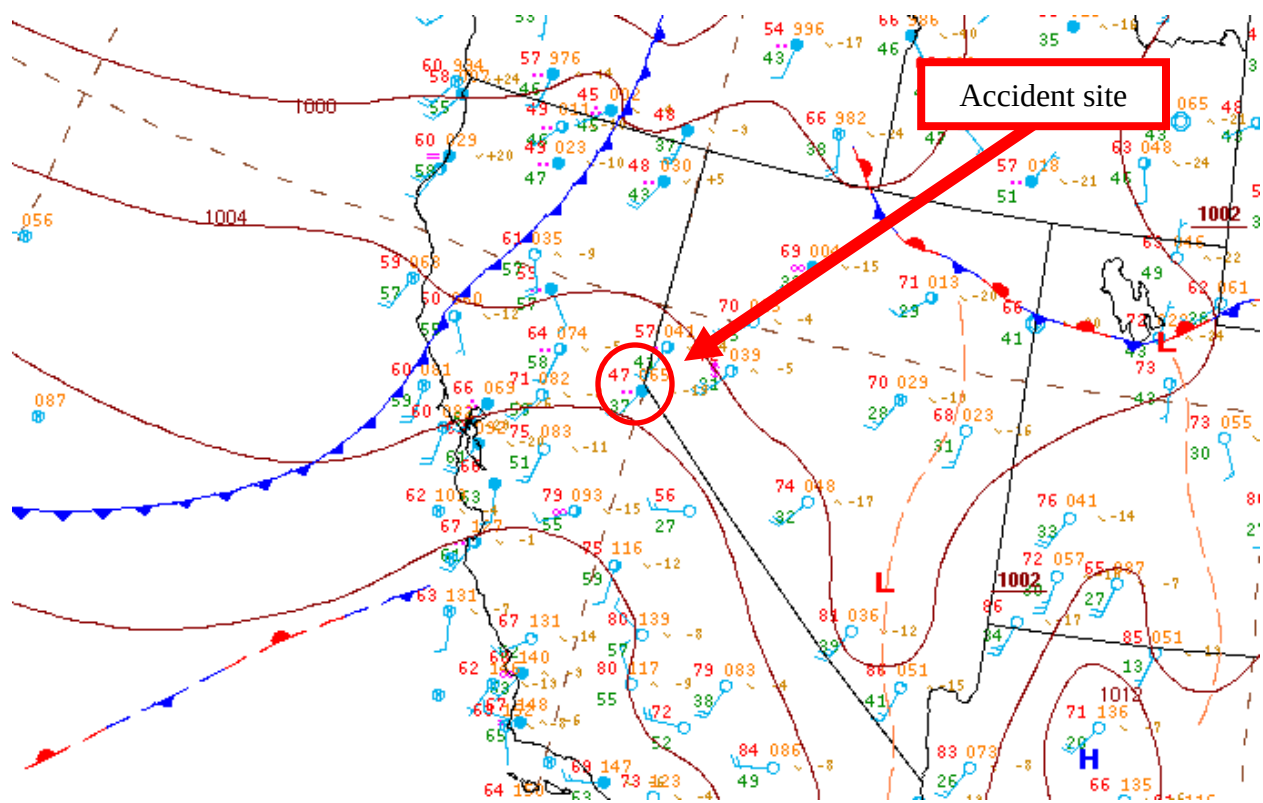
### **1.0 Synoptic Situation**

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-0045H.

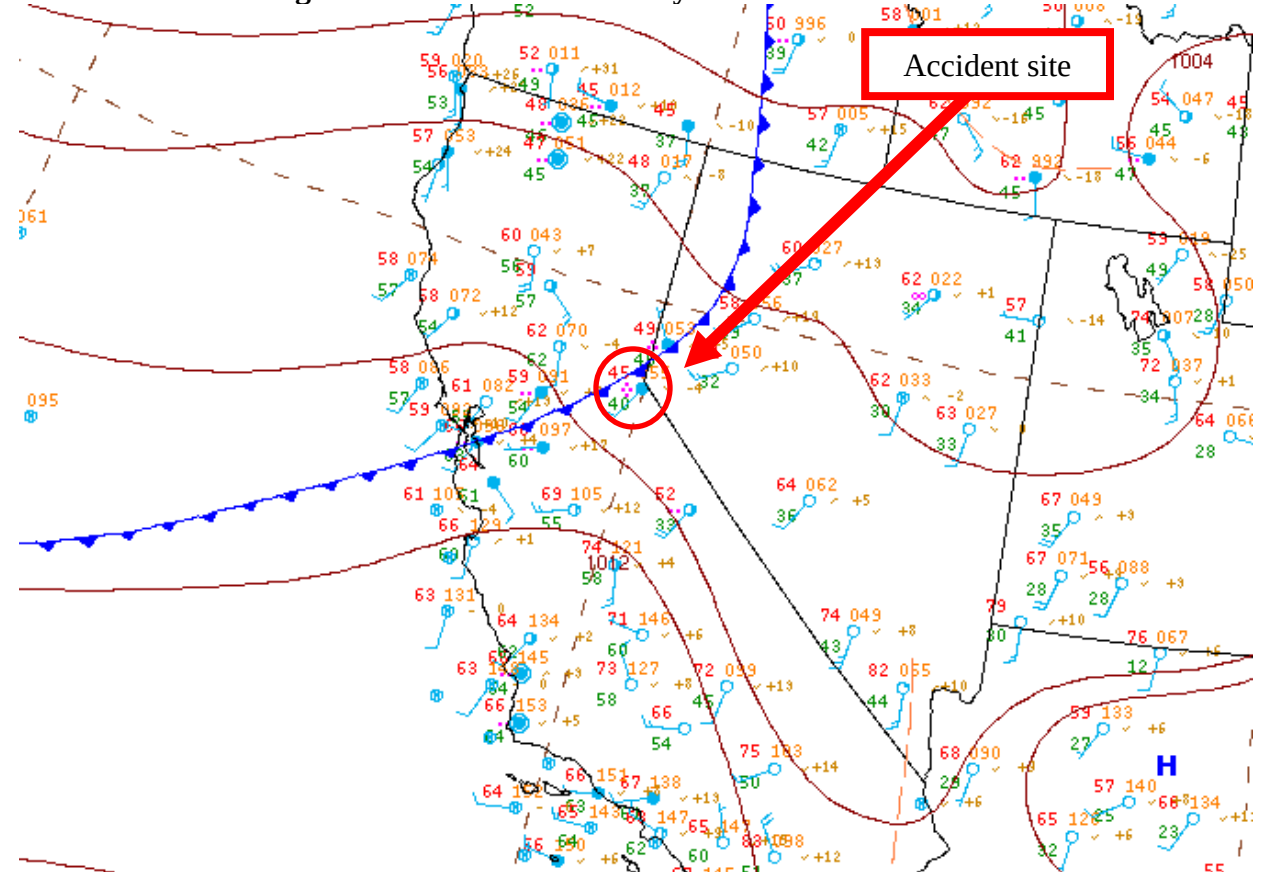
#### **1.1 Surface Analysis Chart**

The NWS Surface Analysis Chart for 1700 PDT is provided as figure 1 with the approximate location of the accident site marked. The chart indicated a surface low pressure center southeast of the accident site just north of Las Vegas, Nevada, with a surface pressure of 1002-hectopascals (hPa). A cold front was located in northwestern California at 1700 PDT. The cold front moved southeastward over the accident site by 2000 PDT (figure 2).

The station models around the accident site at 1700 PDT depicted air temperatures in the mid 40’s to high 50’s degrees Fahrenheit (°F), with temperature-dew point spreads of 10° F or more, a south to southwest wind between 5 and 15 knots, mostly cloudy skies, and light rain. With the cold front boundary moving over the accident site by 2000 PDT (figure 2), the station models around the accident site depicted air temperatures in mid to high 40’s °F, temperature-dew point spreads under 10° F, a south to southwest wind between 10 and 20 knots south of the cold front and a northwest wind to 10 knots north of the cold front, cloudy skies, and moderate to heavy rain.



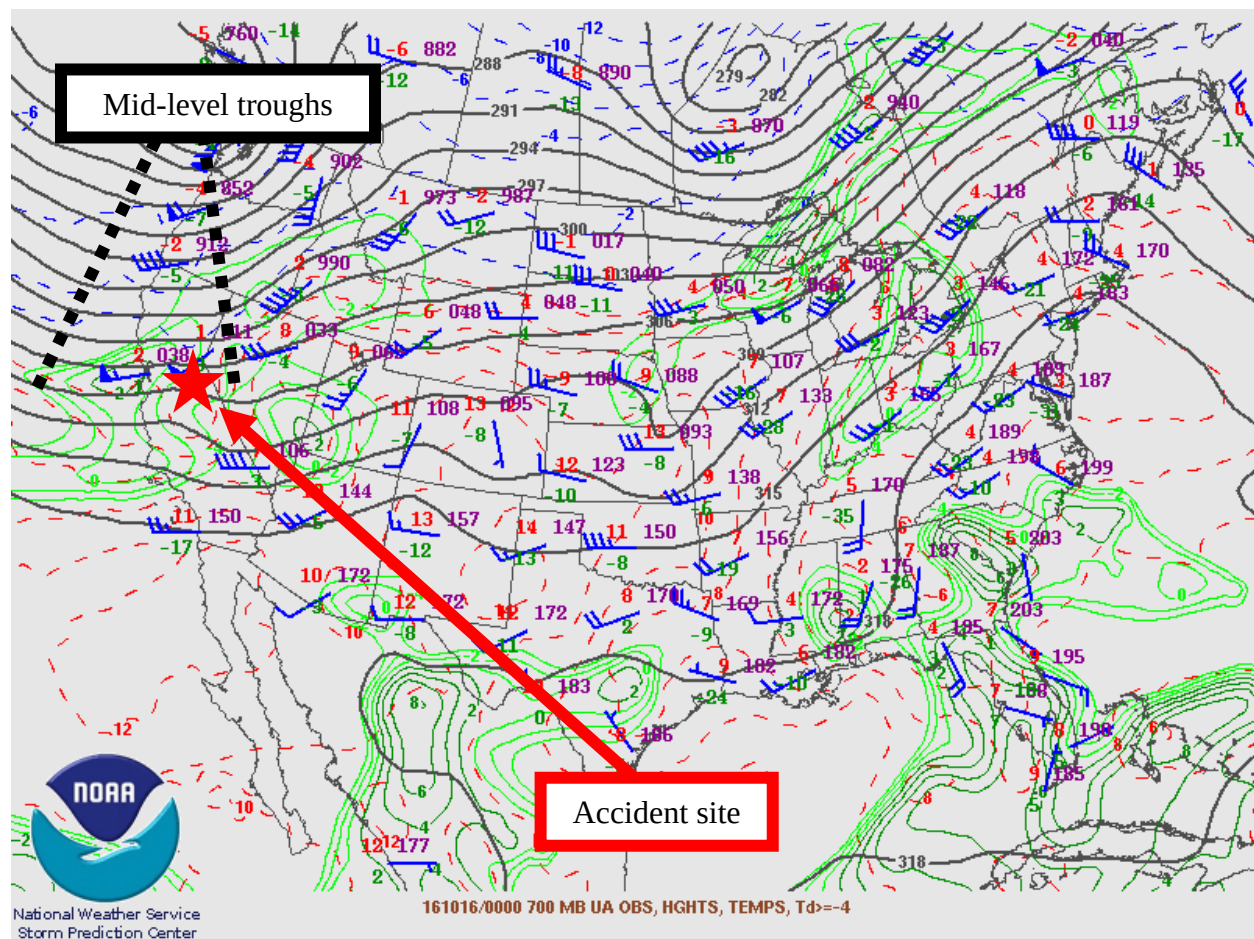
**Figure 1 – NWS Surface Analysis Chart for 1700 PDT**



**Figure 2 – NWS Surface Analysis Chart for 2000 PDT**

## 1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1700 PDT at 700-, 500-, and 300-hPa are presented in figures 3 through 5. The 700-hPa chart depicted mid-level troughs<sup>1</sup> just east and west of the accident site. Troughs typically act as lifting mechanisms where enhanced lift, gusty winds, fronts, clouds, and precipitation can occur. Troughs and frontal boundaries (figures 1 and 2) near mountainous terrain also act to aid in the mixing of low-level air, allowing for the possibility of low-level wind shear (LLWS), mountain waves, and turbulence. In addition, at 500-hPa, there was a mid-level trough west of the accident site, while at 300-hPa the accident site was located in the exit region of the jet streak<sup>2</sup>, where enhanced lift, clouds, and precipitation can occur. There was a southwest wind around 50 knots at 700-hPa with the wind becoming westerly by 300-hPa. The wind increased to 80 knots by 500-hPa with a wind speed of 70 knots at 300-hPa above the accident site at 1700 PDT (figures 4 and 5).



**Figure 3 – 700-hPa Constant Pressure Chart for 1700 PDT**

<sup>1</sup> Trough – An elongated area of relatively low atmospheric pressure or heights.

<sup>2</sup> Jet Streak – Localized area of the strongest winds located within the jet stream.

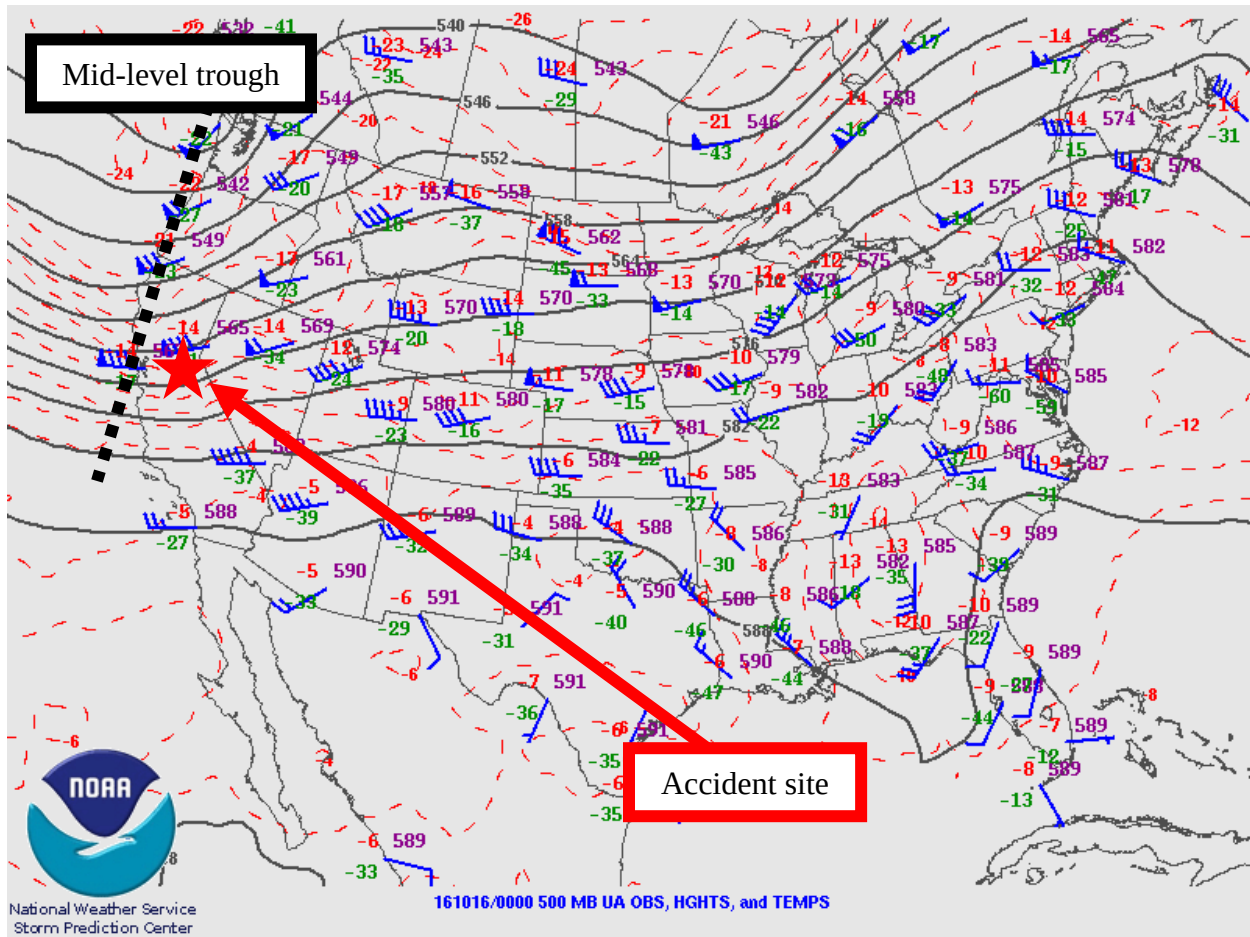
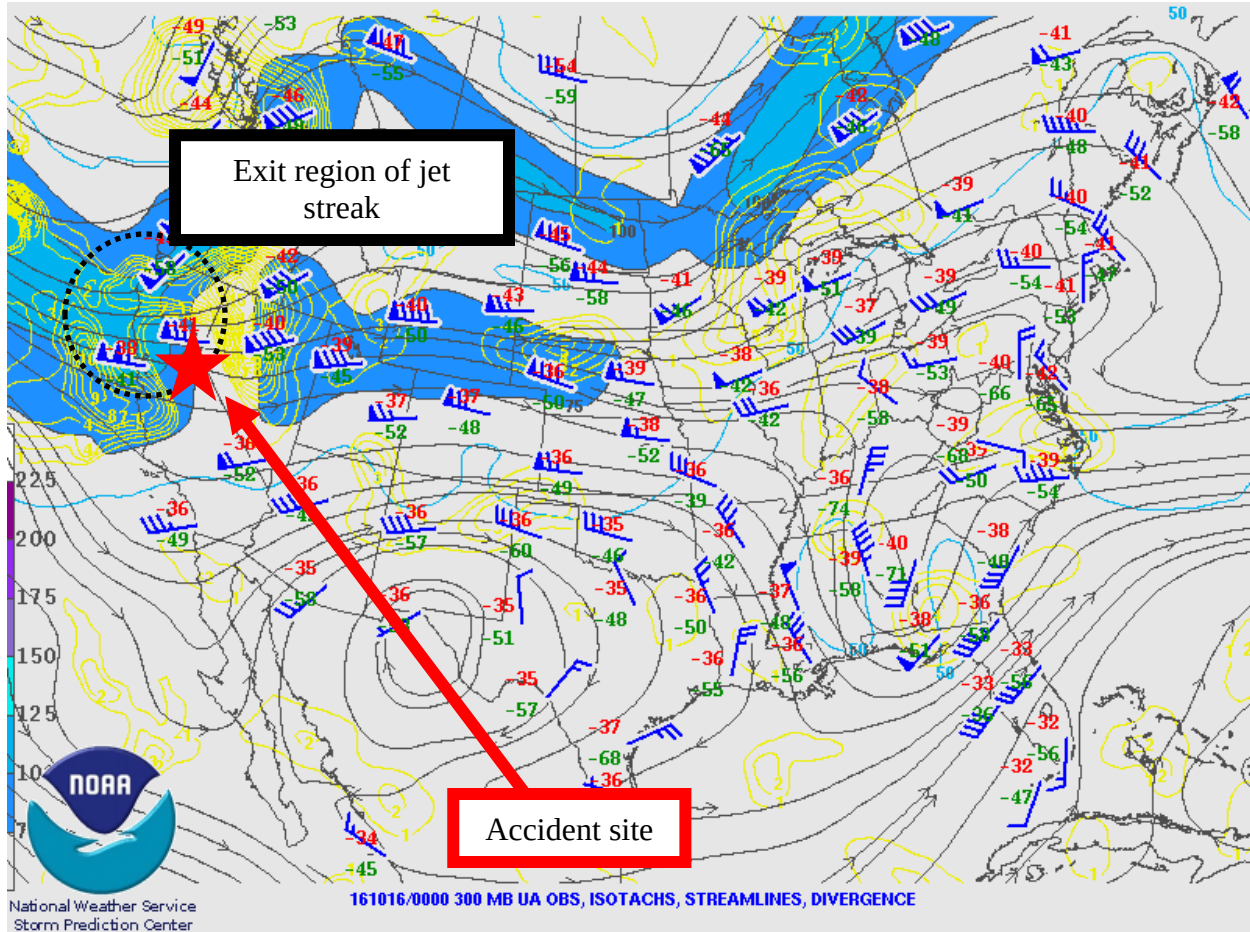


Figure 4 – 500-hPa Constant Pressure Chart for 1700 PDT



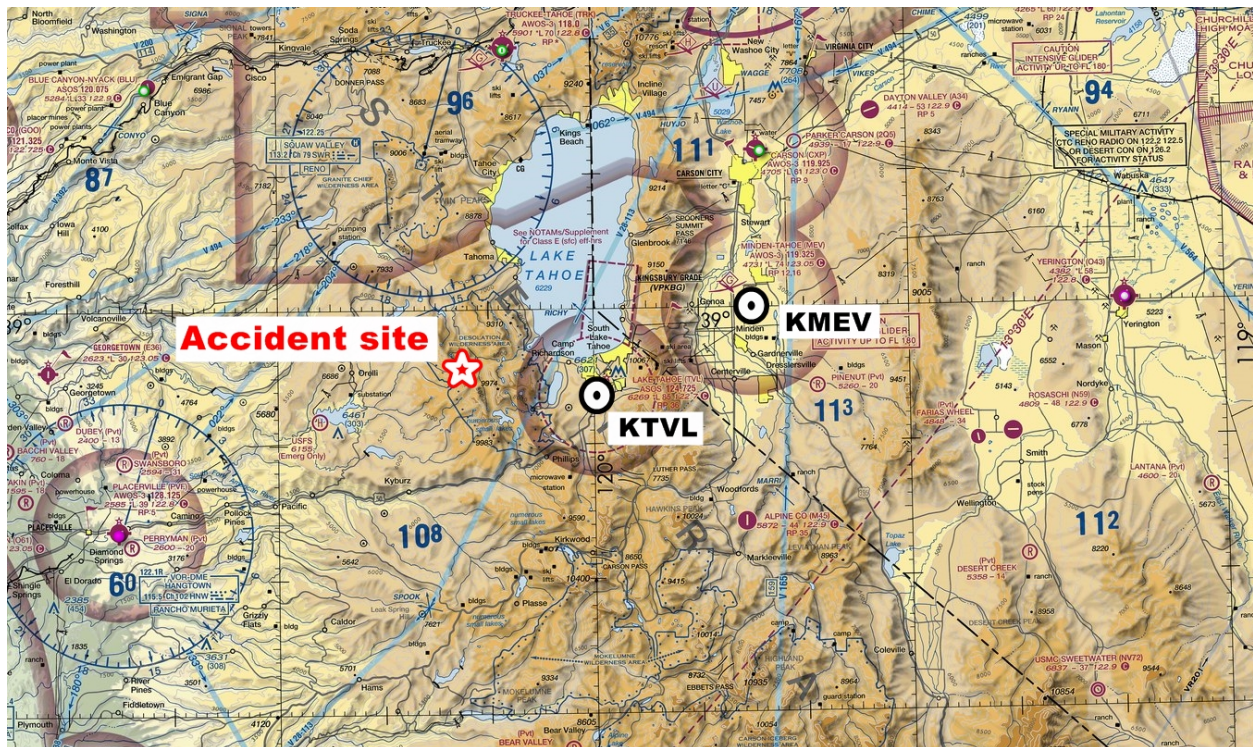
**Figure 5 – 300-hPa Constant Pressure Chart for 1700 PDT**

## 2.0 SPC Products

SPC did not forecast any storms for the accident site around the accident time.

## 3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 6 is a view of the regional sectional map with the nearest official weather reporting sites and the accident site.



Lake Tahoe Airport (KTVL) had the closest official weather station to the accident site and was located 3 miles southwest of South Lake Tahoe, California. KTVL had an Automated Surface Observing System (ASOS<sup>3</sup>) whose reports were not supplemented. KTVL was located 10 miles east-southeast of the accident site, at an elevation of 6,269 feet, and had a 16° easterly magnetic variation<sup>4</sup> (figure 6). The following observations were taken and disseminated during the times surrounding the accident: <sup>5</sup>

[0853 PDT] METAR KTVL 151553Z AUTO 19021G31KT 10SM CLR 11/02 A2994 RMK  
AO2 PK WND 19031/1553 SLP101 T01110017=

[0953 PDT] METAR KTVL 151653Z AUTO 20018G34KT 10SM CLR 12/02 A2995 RMK  
AO2 PK WND 21035/1643 SLP103 T01170022=

[1053 PDT] METAR KTVL 151753Z AUTO 19028G42KT 10SM CLR 13/02 A2995 RMK  
AO2 PK WND 20042/1744 SLP102 T01280017 10128 20083 53004=

<sup>3</sup> ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

<sup>4</sup> Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from <http://www.airnav.com/airport/KTVL>

<sup>5</sup> The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that effected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1153 PDT] METAR KTVL 151853Z AUTO 19020G32KT 10SM SCT042 BKN085 12/03  
A2996 RMK AO2 PK WND 19038/1825 SLP105 T01220028=

[1253 PDT] METAR KTVL 151953Z AUTO 19021G28KT 10SM SCT042 BKN055  
BKN090 12/03 A2993 RMK AO2 PK WND 19033/1912 SLP094 T01220028=

[1353 PDT] METAR KTVL 152053Z AUTO 18020G28KT 10SM OVC038 11/03 A2990  
RMK AO2 PK WND 17030/2006 SLP085 T01110028 58016=

**[1453 PDT] METAR KTVL 152153Z AUTO 20017G29KT 10SM BKN044 OVC075 12/02  
A2986 RMK AO2 PK WND 19029/2149 SLP071 T01170022=**

**[1545 PDT] SPECI KTVL 152245Z AUTO 20016G23KT 4SM RA SCT027 OVC033 09/05  
A2986 RMK AO2 PK WND 18027/2156 RAB2156 P0002 T00890050=**

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**[1553 PDT] METAR KTVL 152253Z AUTO 19017G29KT 4SM RA SCT024 BKN029  
OVC034 08/05 A2987 RMK AO2 PK WND 19029/2253 RAB2156  
SLP079 P0004 T00830050=**

**[1602 PDT] SPECI KTVL 152302Z AUTO 19015G29KT 8SM -RA FEW023 BKN030  
OVC037 08/04 A2987 RMK AO2 PK WND 21026/2258 P0000 T00830039=**

[1653 PDT] METAR KTVL 152353Z AUTO 21014G30KT 8SM -RA SCT033 BKN040  
OVC050 08/03 A2983 RMK AO2 PK WND 22032/2339 SLP065 P0001  
60005 T00830028 10133 20083 57019=

[1723 PDT] SPECI KTVL 160023Z AUTO 20017G28KT 3SM RA FEW014 OVC035 08/03  
A2982 RMK AO2 PK WND 18041/0005 LTG DSNT SW AND W  
P0003 T00780033=

KTVL weather at 1453 PDT, wind from 200° at 17 knots with gusts to 29 knots, 10 miles visibility, broken ceiling at 4,400 feet above ground level (agl), overcast skies at 7,500 feet agl, temperature of 12° Celsius (C), dew point temperature of 2° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station without a precipitation discriminator, peak wind at 1449 PDT from 190° at 29 knots, sea level pressure 1007.1 hPa, temperature 11.7° C, dew point temperature 2.2° C.

KTVL weather at 1545 PDT, wind from 200° at 16 knots with gusts to 23 knots, 4 miles visibility, moderate rain, scattered clouds at 2,700 feet agl, overcast ceiling at 3,300 feet agl, temperature of 9° C, dew point temperature of 5° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station without a precipitation discriminator, peak wind at 1456 PDT from 180° at 27 knots, rain began at 1456 PDT, one-hourly precipitation of 0.02 inches, temperature 8.9° C, dew point temperature 5.0° C.

KTVL weather at 1553 PDT, wind from 190° at 17 knots with gusts to 29 knots, 4 miles visibility, moderate rain, scattered clouds at 2,400 feet agl, broken ceiling at 2,900 feet agl, overcast skies at 3,400 feet agl, temperature of 8° C, dew point temperature of 5° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station without a precipitation discriminator, peak wind at 1553 PDT from 190° at 29 knots, rain began at 1456 PDT, sea-level pressure 1007.9 hPa, one-hourly precipitation of 0.04 inches, temperature 8.3° C, dew point temperature 5.0° C.

KTVL weather at 1602 PDT, wind from 190° at 15 knots with gusts to 29 knots, 8 miles visibility, light rain, few clouds at 2,300 feet agl, broken ceiling at 3,000 feet agl, overcast skies at 3,700 feet agl, temperature of 8° C, dew point temperature of 4° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station without a precipitation discriminator, peak wind at 1558 PDT from 210° at 26 knots, one-hourly precipitation of a trace, temperature 8.3° C, dew point temperature 3.9° C.

Minden-Tahoe Airport (KMEV) was the second closest official weather station to the accident site and was located 4 miles north of Minden, Nevada. KMEV had an Automated Weather Observing System (AWOS<sup>6</sup>) whose reports were not supplemented. KMEV was located 22 miles east-northeast of the accident site, at an elevation of 4,731 feet, and had an 15° easterly magnetic variation<sup>7</sup> (figure 6). The following observations were taken and disseminated during the times surrounding the accident:

[1315 PDT] METAR KMEV 142015Z AUTO 16020G29KT 10SM FEW032 SCT046  
SCT070 12/05 A2996 RMK AO2=  
[1335 PDT] METAR KMEV 142035Z AUTO 15021G32KT 10SM CLR 13/04 A2996 RMK  
AO2=  
[1355 PDT] METAR KMEV 142055Z AUTO 16023G33KT 7SM FEW032 SCT044 SCT055  
12/05 A2997 RMK AO2=  
[1415 PDT] METAR KMEV 142115Z AUTO 15021G32KT 3SM -RA FEW024 SCT034  
OVC046 10/05 A2997 RMK AO2=  
[1435 PDT] METAR KMEV 142135Z AUTO 15020G33KT 10SM FEW025 SCT037  
BKN046 12/05 A2995 RMK AO2=  
[1455 PDT] METAR KMEV 142155Z AUTO 14022G29KT 7SM FEW025 SCT038 BKN049  
12/04 A2996 RMK AO2=

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<sup>6</sup> 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.

<sup>7</sup> Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2020, latest measurement taken from <http://www.airnav.com/airport/KMEV>

***[1515 PDT] METAR KMEV 142215Z AUTO 15011G26KT 8SM SCT031 BKN047 OVC060  
10/07 A2998 RMK AO2=***

***[1535 PDT] METAR KMEV 142235Z AUTO 16020G26KT 8SM FEW033 BKN046  
OVC060 10/05 A2999 RMK AO2=***

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***[1555 PDT] METAR KMEV 142255Z AUTO 17018G25KT 8SM FEW033 BKN048  
OVC055 09/06 A3000 RMK AO2 P0001=***

***[1615 PDT] METAR KMEV 142315Z AUTO 16015G25KT 7SM FEW025 SCT038 BKN048  
09/05 A2999 RMK AO2=***

***[1635 PDT] METAR KMEV 142335Z AUTO 16018G26KT 8SM FEW026 SCT038 SCT050  
09/06 A2998 RMK AO2=***

***[1655 PDT] METAR KMEV 142355Z AUTO 16021G27KT 10SM FEW033 FEW042  
SCT048 09/05 A2998 RMK AO2=***

KMEV weather at 1515 PDT, wind from 150° at 11 knots with gusts to 26 knots, 8 miles visibility, scattered clouds at 3,100 feet agl, broken ceiling at 4,700 feet agl, overcast skies at 6,000 feet agl, temperature of 10° C, dew point temperature of 7° C, and an altimeter setting of 29.98 inches of mercury. Remarks: automated station with a precipitation discriminator.

KMEV weather at 1535 PDT, wind from 160° at 20 knots with gusts to 26 knots, 8 miles visibility, few clouds at 3,300 feet agl, broken ceiling at 4,600 feet agl, overcast skies at 6,000 feet agl, temperature of 10° C, dew point temperature of 5° C, and an altimeter setting of 29.99 inches of mercury. Remarks: automated station with a precipitation discriminator.

KMEV weather at 1555 PDT, wind from 170° at 18 knots with gusts to 25 knots, 8 miles visibility, few clouds at 3,300 feet agl, broken ceiling at 4,800 feet agl, overcast skies at 5,500 feet agl, temperature of 9° C, dew point temperature of 6° C, and an altimeter setting of 30.00 inches of mercury. Remarks: automated station with a precipitation discriminator, one-hourly precipitation of 0.01 inches.

KMEV weather at 1615 PDT, wind from 160° at 15 knots with gusts to 25 knots, 7 miles visibility, few clouds at 2,500 feet agl, scattered clouds at 3,800 feet agl, broken ceiling at 4,800 feet agl, temperature of 9° C, dew point temperature of 5° C, and an altimeter setting of 29.99 inches of mercury. Remarks: automated station with a precipitation discriminator.

#### 4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Reno, Nevada, (KREV), located 43 miles northeast of the accident site, with a site number 72489, and an elevation of 4,970 feet. The 1700 PDT sounding was plotted on a standard Skew-T log P diagram<sup>8</sup> with the derived stability parameters included in figure 7 (with data from the surface to 600-hPa, or about 14,000 feet msl.) This data was analyzed utilizing the RAOB<sup>9</sup> software package. The sounding depicted the Lifted Condensation Level (LCL)<sup>10</sup> at 8,254 feet, a Convective Condensation Level (CCL)<sup>11</sup> of 11,740 feet, and a Level of Free Convection (LFC)<sup>12</sup> at 10,058 feet. The freezing level was located at 10,734 feet. The precipitable water value was 0.54 inches.

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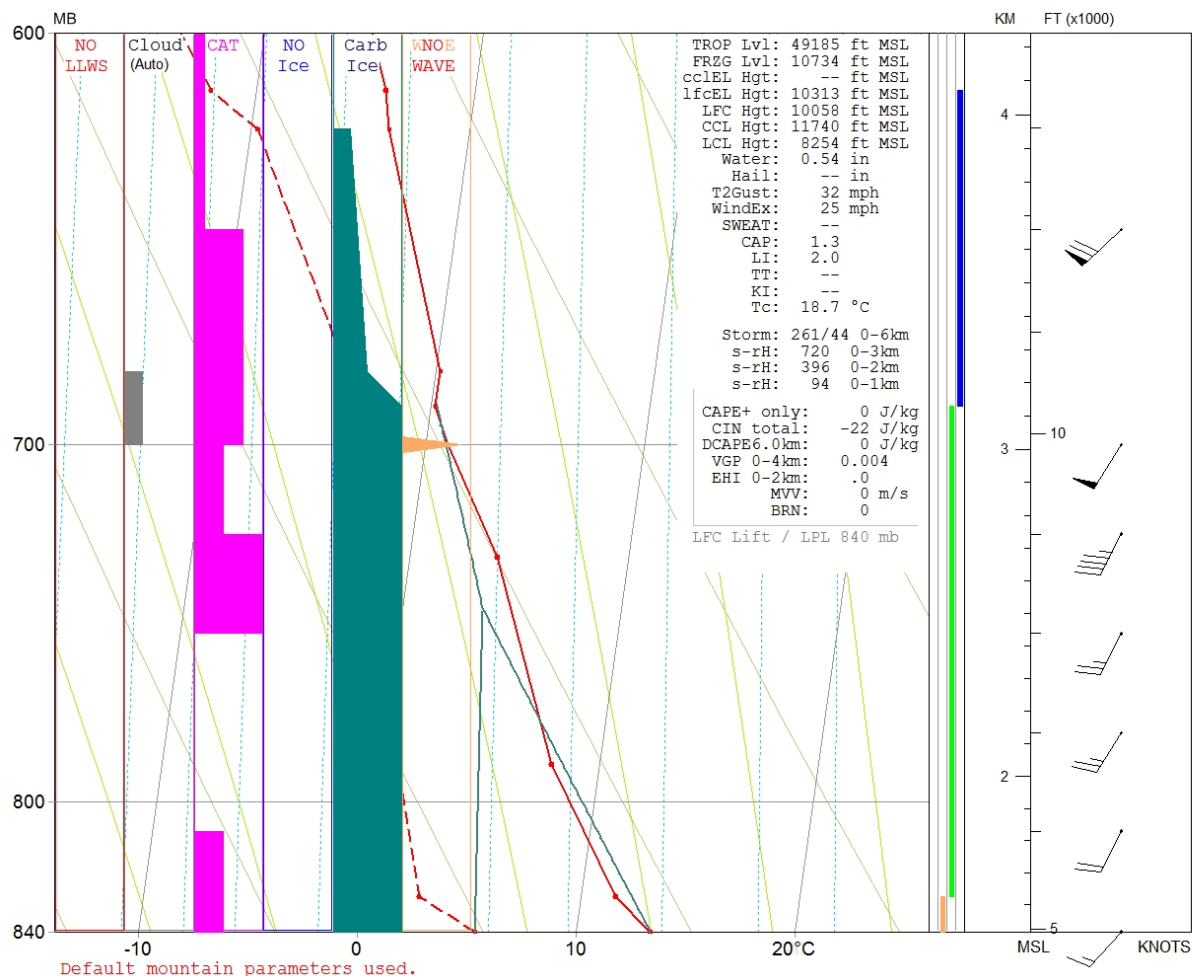
<sup>8</sup> Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

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

<sup>10</sup> Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

<sup>11</sup> Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

<sup>12</sup> Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.



**Figure 7 – 1700 PDT KREV sounding**

The 1700 PDT KREV sounding indicated a conditionally unstable environment from the surface through 10,000 feet with a stable layer from 10,000 feet through 14,000 feet. KREV sounding indicated relatively dry conditions east of the mountains with a cloud layer only likely near 10,000 feet, but the surface observations (section 3.0) and weather radar data (sections 6.4 and 6.5) indicated additional moisture at the accident site around the accident time. RAOB did not indicate any structural icing conditions.

The sounding wind profile indicated a surface wind at KREV from 220° at 14 knots with an increase in wind speed to 45 knots by 9,000 feet. No LLWS was identified by RAOB near KREV, but several layers of clear air turbulence were indicated by RAOB between the surface and 14,000 feet.

The 1700 PDT KREV sounding provided the following table information with RAOB indicating that mountain wave conditions were likely near 10,000 feet msl with updraft and downdrafts around 2,645 feet per minute. Default mountain parameters were used to calculate mountain wave conditions to indicate the greatest mountain wave conditions possible given the environment. Mountain wave conditions were also indicated as likely around 14,000 feet and 20,000 feet (table 1):

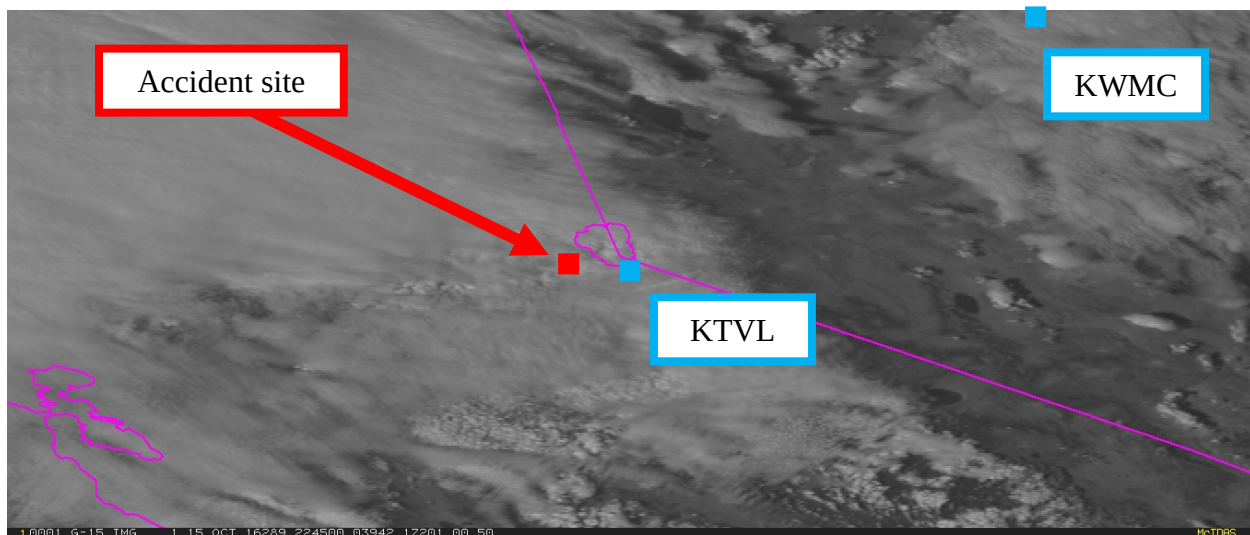
| Level | Height<br>(ft-MSL) | Pres<br>(mb) | T<br>(C) | Td<br>(C) | RH<br>(%) | DD / FF<br>(deg / kts) | CAT<br>(FAA) | LLWS | Icing - Type<br>(AFGWC method) | Wave/x---W---Turb<br>nm fpm max |
|-------|--------------------|--------------|----------|-----------|-----------|------------------------|--------------|------|--------------------------------|---------------------------------|
| 1     | 4970               | 840          | 13.4     | 5.4       | 58        | 220 / 14               |              |      |                                |                                 |
| 2     | 5333               | 829          | 11.6     | 2.6       | 54        |                        | MDT          |      |                                |                                 |
| 3     | 6000               | 809          |          |           |           | 205 / 21               |              |      |                                |                                 |
| 4     | 6682               | 789          | 7.8      | 0.8       | 61        |                        |              |      |                                |                                 |
| 5     | 7000               | 780          |          |           |           | 210 / 23               |              |      |                                |                                 |
| 6     | 8000               | 751          |          |           |           | 205 / 23               |              |      |                                |                                 |
| 7     | 8772               | 730          | 4.0      | -2.0      | 65        |                        | XTR          |      |                                |                                 |
| 8     | 9000               | 724          |          |           |           | 205 / 45               | MDT          |      |                                |                                 |
| 9     | 9887               | 700          | 1.0      | -3.0      | 75        | 210 / 52               |              |      |                                | 5.24 2645 SEVERE                |
| 10    | 10267              | 690          | 0.2      | -3.3      | 77        |                        |              |      |                                |                                 |
| 11    | 10613              | 681          | 0.2      | -4.1      | 73        |                        | SVR          |      |                                |                                 |
| 12    | 12000              | 646          |          |           |           | 225 / 68               |              |      |                                |                                 |
| 13    | 12982              | 622          | -3.7     | -9.7      | 63        |                        |              |      |                                |                                 |
| 14    | 13360              | 613          | -4.1     | -12.1     | 54        |                        | LGT          |      |                                |                                 |
| 15    | 14000              | 598          |          |           |           | 230 / 73               |              |      |                                | 7.06 1248 MD-SV                 |
| 16    | 14130              | 595          | -5.5     | -14.5     | 49        |                        |              |      |                                |                                 |
| 17    | 14435              | 588          | -5.5     | -18.5     | 35        |                        |              |      |                                |                                 |
| 18    | 15010              | 575          | -6.3     | -17.3     | 41        |                        |              |      |                                |                                 |
| 19    | 16000              | 553          |          |           |           | 230 / 70               |              |      |                                |                                 |
| 20    | 17131              | 529          | -11.1    | -20.1     | 47        |                        |              |      |                                |                                 |
| 21    | 17708              | 517          | -12.1    | -22.1     | 43        |                        | LGT          |      |                                |                                 |
| 22    | 18545              | 500          | -13.7    | -20.7     | 55        | 235 / 81               |              |      |                                |                                 |
| 23    | 18947              | 492          | -14.7    | -20.7     | 60        | 235 / 83               |              |      |                                |                                 |
| 24    | 19507              | 481          | -16.1    | -24.1     | 50        |                        |              |      |                                |                                 |
| 25    | 19662              | 478          | -16.1    | -25.1     | 46        |                        | XTR          |      |                                |                                 |
| 26    | 19922              | 473          | -16.3    | -20.1     | 72        | 245 / 73               |              |      | LGT Rime                       |                                 |
| 27    | 20079              | 470          | -16.1    | -20.9     | 66        |                        |              |      |                                | 8.85 2261 SEVERE                |

**Table 1 – 1700 PDT KREV sounding table information**

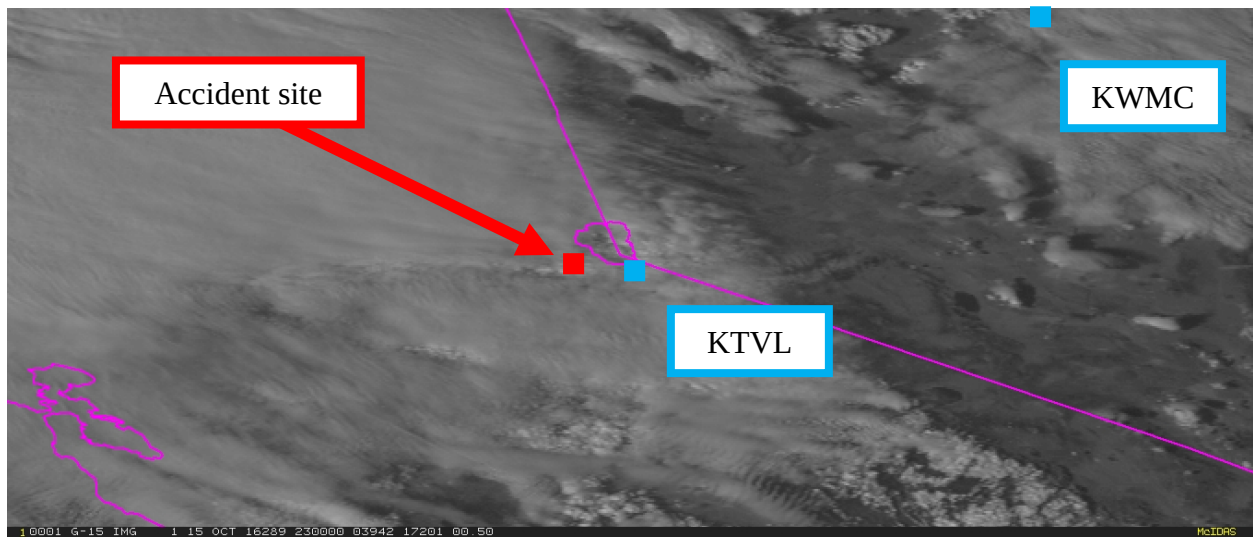
## 5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 band 1 and 4) at wavelengths of 0.65 microns ( $\mu\text{m}$ ) and 10.7  $\mu\text{m}$ , respectively, were retrieved for the scene. Satellite imagery surrounding the time of the accident, from 1300 PDT through 1700 PDT at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

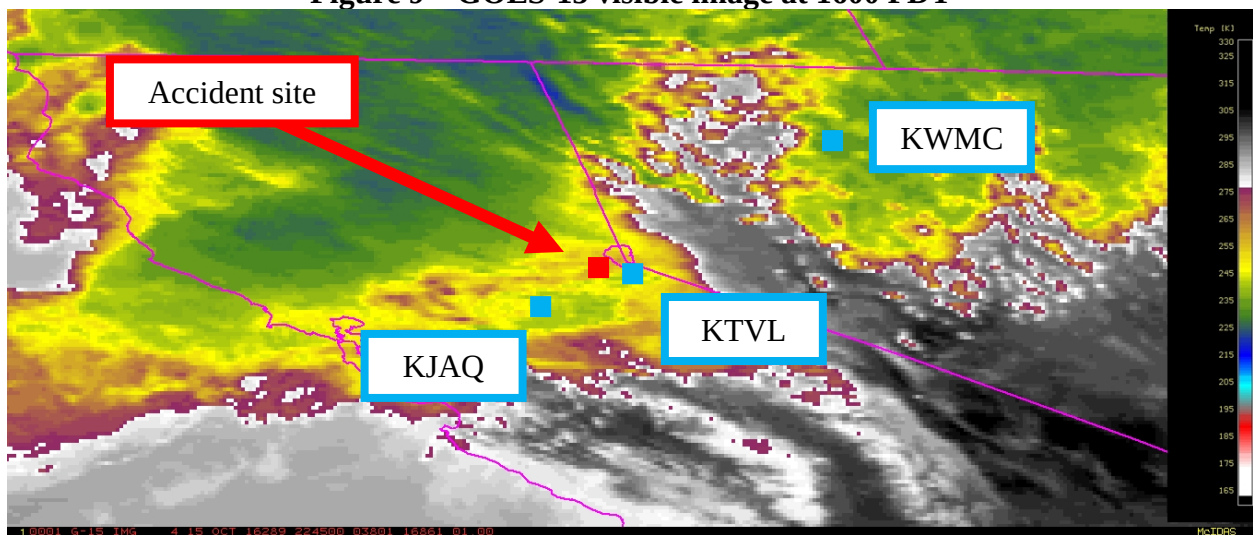
Figures 8 and 9 present the GOES-15 visible imagery from 1545 and 1600 PDT at 2X magnification. Inspection of the visible imagery indicated cloud cover rapidly increasing in coverage from the Nevada/California border westward. Between the departure airport of KWMC and KTVL there were lenticular clouds indicated in Nevada (figures 8 and 9 and attachment 1). Data in attachment 1 indicated that the cloud cover continued to move eastward into western Nevada after the accident time, but the cloud cover was present over the Lake Tahoe region as early as 1153 PDT (section 3.0) and continued to increase in coverage (attachment 1) through the accident time. Figure 10 presents the GOES-15 infrared imagery from 1545 PDT at 4X magnification with the accident site highlighted with a red square. The infrared imagery indicated cooler brightness temperatures (green and blue colors) located northwest of the accident site located over northern California. There were similar brightness temperatures between the departure airport of KWMC (figure 10) and the destination airport, KJAQ, (figure 10), with warmer brightness temperatures located across western Nevada in areas with less cloud cover as indicated by the visible imagery (figures 8 and 9, attachment 1). Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1700 PDT KREV sounding, the approximate cloud-top heights over the accident site were 18,500 feet at 1545 PDT. It should be noted these figures have not been corrected for any parallax error.



**Figure 8 – GOES-15 visible image at 1545 PDT**



**Figure 9 – GOES-15 visible image at 1600 PDT**



**Figure 10 – GOES-15 infrared image at 1545 PDT**

## 6.0 Radar Imagery Information

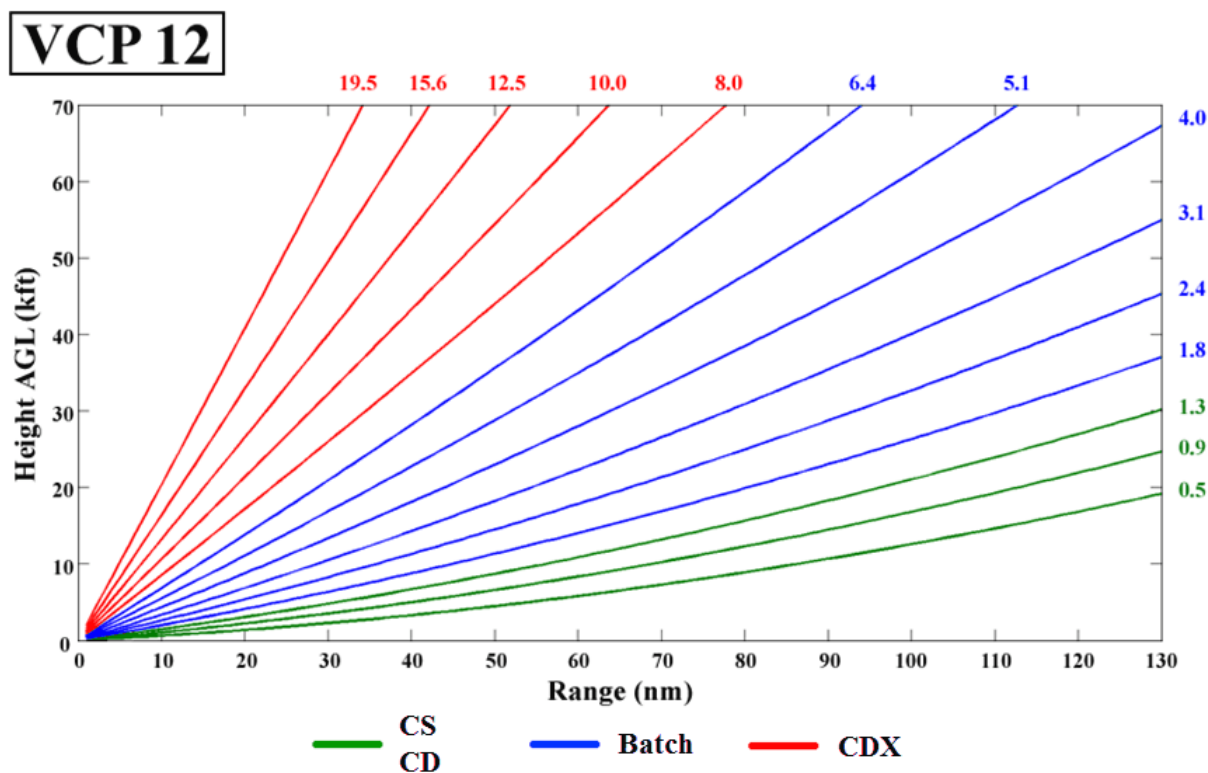
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)<sup>13</sup> was from Reno, Nevada, (KRGX) located 61 miles northeast of the accident site with an elevation of 8,299 feet. Level II and III archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

<sup>13</sup> 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.

## 6.1 Volume Scan Strategy

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

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 12 (VCP-12, figure 11). 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 KRGX WSR-88D radar was operating in the precipitation mode (Mode A, VCP-12). 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.



**Figure 11 – VCP-12 Precipitation Mode Scan Strategy<sup>14</sup>**

<sup>14</sup> Contiguous Surveillance (CS)--The low 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.

## 6.2 Beam Height Calculation

Assuming standard refraction<sup>15</sup> of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width<sup>16</sup> information<sup>17</sup> of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

| ANTENNA ELEVATION | BEAM CENTER | BEAM BASE   | BEAM TOP    | BEAM WIDTH |
|-------------------|-------------|-------------|-------------|------------|
| 0.5°              | 14,230 feet | 11,220 feet | 17,240 feet | 6,020 feet |

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 11,220 feet and 17,240 feet msl over the accident site and these are the closest altitudes to the accident flight level before the accident occurred.<sup>18</sup>

## 6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors<sup>19</sup> it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ<sup>20</sup>), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

---

W – With range unfolding (W)

WO – Without range unfolding (WO)

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

<sup>16</sup> Beam width – A measure of the angular width of a radar beam.

<sup>17</sup> Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.

<sup>18</sup> For more information please see the air traffic control (ATC) data contained in the docket of this accident.

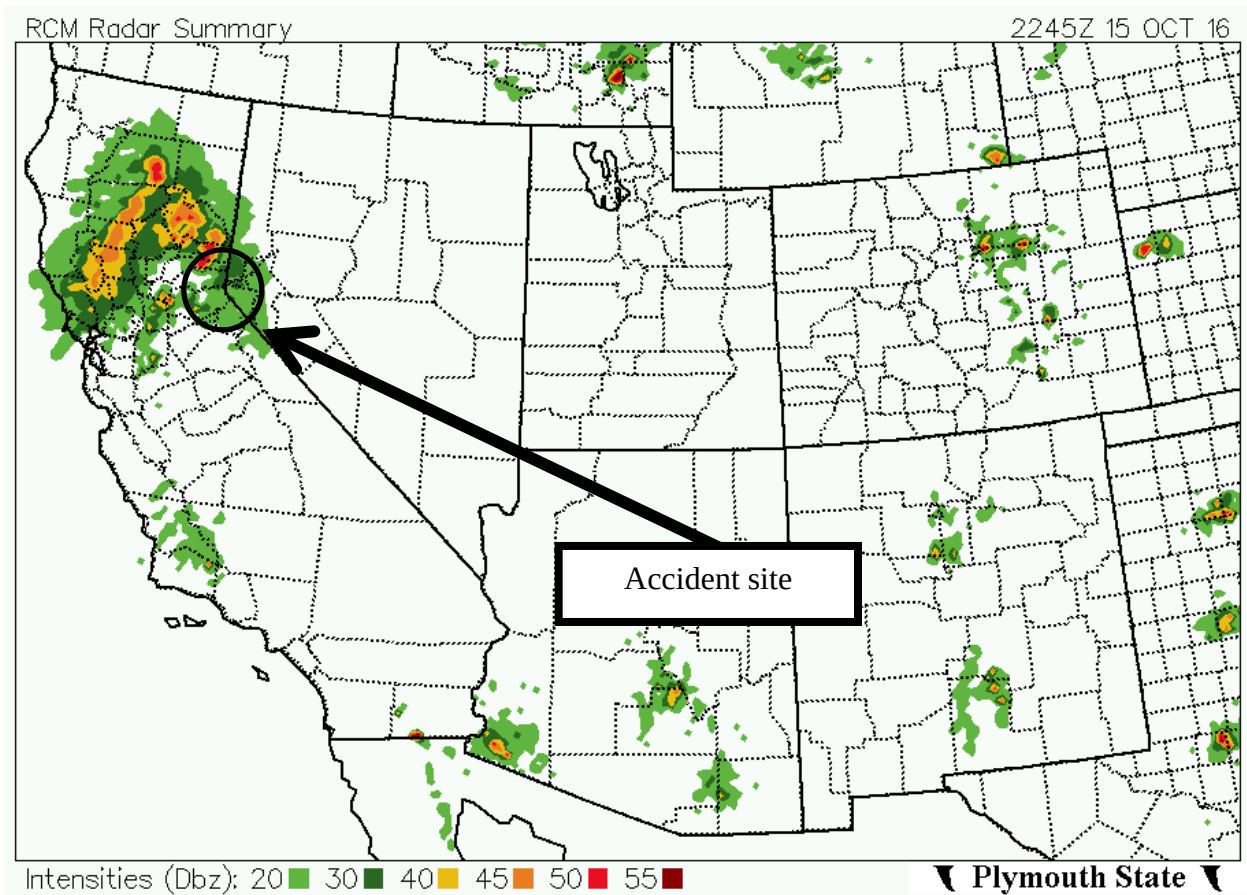
<sup>19</sup> Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth’s surface; also, any water particles blown by the wind from the earth’s surface. Hydrometeors are classified as; (a) Liquid or solid water particles 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.

<sup>20</sup> dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

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

#### 6.4 Regional Weather Radar Summary

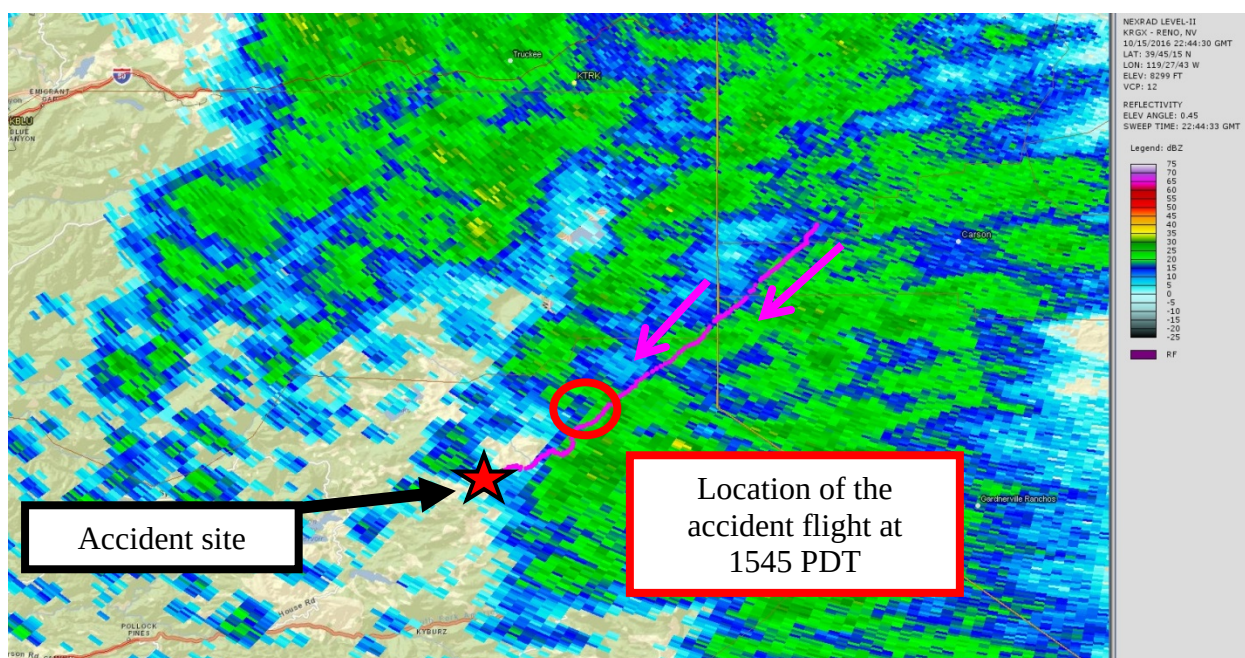
Figure 12 provides a radar summary image from 1545 PDT with reflectivity values over the southwestern United States. The accident site was located in an area of 20 to 30 dBZ values at 1545 PDT. These reflectivity values indicated light to moderate echoes at the accident site around the accident time.



**Figure 12 – Radar summary image for 1545 PDT with the accident site**

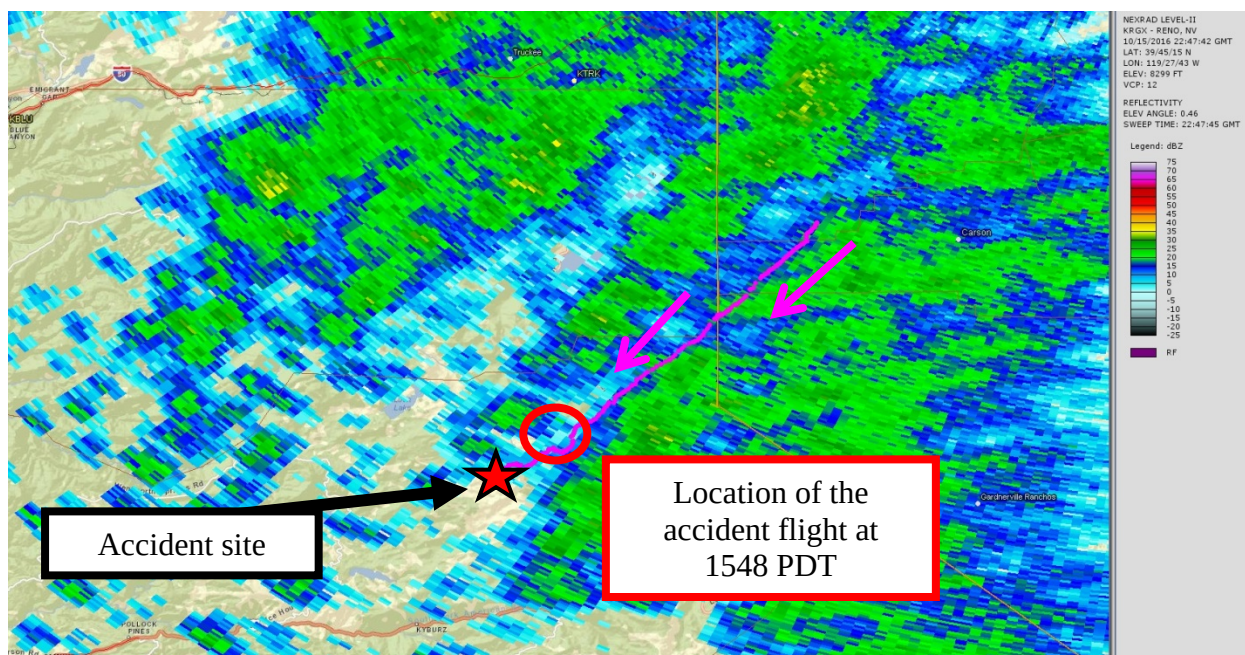
## 6.5 Base Reflectivity and Lightning Data

Figures 13 through 15 present the KRGX WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 1545, 1548, and 1551 PDT with a resolution of 0.5° X 250 m. The ATC flight track is also included with the arrows pointing in the direction of travel (to the southwest) with the ATC track from 1530 to 1552 PDT (pink line). The accident flight track indicated that the accident aircraft flew through 5 to 30 dBZ reflectivity values located along the route of flight before 1551 PDT with the precipitation targets moving from southwest to northeast (attachment 2). The reflectivity values match the observed surface conditions (section 3.0) of precipitation around the accident site at the accident time. There were no lightning strikes near the accident site at the accident time.<sup>21</sup>

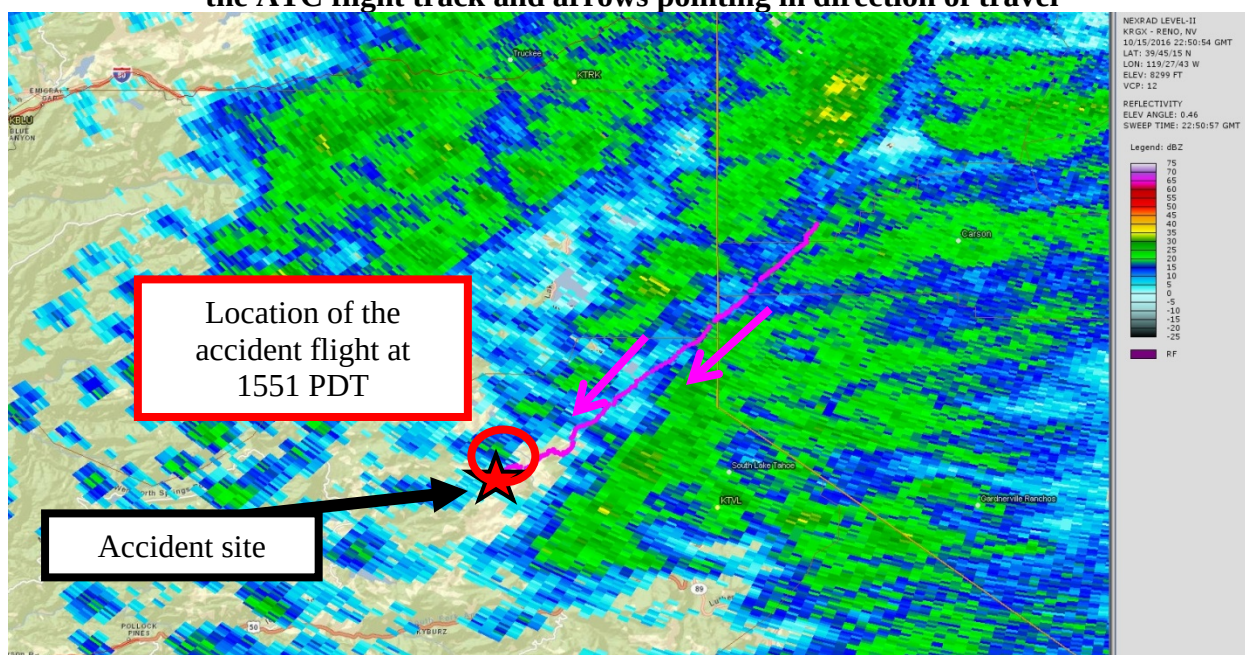


**Figure 13 – KRGX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1545 PDT with the ATC flight track and arrows pointing in direction of travel**

<sup>21</sup> A review of Earth Networks Total Lightning network was done.



**Figure 14 – KRGX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1548 PDT with the ATC flight track and arrows pointing in direction of travel**



**Figure 15 – KRGX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1551 PDT with the ATC flight track and arrows pointing in direction of travel**

## 7.0 Pilot Reports

All pilot reports (PIREPs) close to the accident site from around four hours prior to the accident time to around two hours after the accident time for below FL250<sup>22</sup> are provided below:

<sup>22</sup> Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. This altitude is

RNO UA /OV FINAL RWY 16R/TM 1945/FLDURD/TP A320/RM +/- 15 DURD=  
 SAC UA /OV SAC/TM 2005/FL120/TP A320/TB MOD CHOP 120-155/RM ZOA CWSU=  
 RNO UA /OV FMG270005/TM 2010/FL050/TP B737/RM +/- 20KTS 050 DURD=  
 KRNO UUA /OV FINAL TO RWY 16R/TM 2105/FL500/TP B737/RM +/- 20KTS BLO 500=  
 BAB UA /OV BAB270013/TM 2123/FL170/TP B737/TB LGT-MOD CHOP 135-170/RM ZOA CWSU=  
 KRNO UA /OV FINAL RWY 16R/TM 2144/FL1000/TP B737/RM +15 KTS BLO 1000=  
 BIH UUA /OV BIH250020/TM 2201/FL160/TP SR22/TB SEV/RM ZOA CWSU=  
 MOD UA /OV MOD100001/TM 2206/FL220/TP A320/TB MOD=  
 MOD UA /OV MOD090010/TM 2207/FL250/TP A320/TB MOD/RM ZOA CWSU=  
 STS UA /OV STS/TM 2306/FL145/TP C560/IC LGT RIME/RM ZOA CWSU=  
 APC UA /OV SGD/TM 2308/FL160/TP B747/IC MOD RIME/RM ZOA CWSU=  
 TRK UA /OV SWR/TM 2325/FL200/TP A319/TA M20/IC LGT RIME/RM ZOA CWSU=  
 SMF UA /OV BAB085040/TM 2325/FL180/TP B737/TA 04/TB LGT-MOD CHOP 180-110/IC LGT RIME 175-145/RM DURD=  
 MOD UA /OV MOD070029/TM 2330/FL120/TP MD83/TB MOD/RM DURD 120-100=  
 TRK UA /OV SWR/TM 2345/FL220/TP B737/TA M22/IC LGT RIME/RM ZOA CWSU=  
 KRNO UA /OV FINAL RWY 16R/TM 2345/FL006/TP E75L/RM +15 AT 600=  
 RBL UA /OV RBL013006/TM 2359/FL240/TP DH8D/IC LGT MX/RM ZOA CWSU=  
 SFO UA /OV KSFO50008 /TM 0001 /FL110 /TP B739 /TB MOD /RM TRUKN SID / MOD CHOP FL100-300 / MOSTLY SMOOTH 320-340 AWC-WEB:=  
 SMF UA /OV ILA006021/TM 0002/FL220/TP DH8D/TA M05/IC LGT MX/RM ZOA CWSU=  
 TRK UA /OV SWR180020/TM 0014/FL230/TP CRJ7/TB LGT-MOD CHOP /IC LGT RIME/RM ZOA CWSU=  
 RNO UA /OV FMG120010/TM 0016/FL120/TP B737/TB MOD=  
 MOD UA /OV MOD210025/TM 0033/FL050/TP C560/TB MOD=  
 KRNO UA /OV 2 MILES SOUTH OF RNO/TM 0035/FL065/TP B737/SK BASES BKN065, NO TOPS REPORT=

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calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

Routine pilot report (UA); Over Reno, Nevada, on final to runway 16R; Time – 1245 PDT (1945Z); Altitude – During descent; Type aircraft – Airbus A320; Remarks – +/- 15 knots during descent.

Routine pilot report (UA); Over Sacramento, California; Time – 1305 PDT (2005Z); Altitude – 12,000 feet msl; Type aircraft – Airbus A320; Turbulence – Moderate chop between 12,000 and 15,500 feet.

Routine pilot report (UA); 5 miles from Reno, Nevada, on the 270° radial; Time – 1310 PDT (2010Z); Altitude – 5,000 feet msl; Type aircraft – Boeing 737; Remarks – +/- 20 knots at 5,000 feet during descent.

Urgent pilot report (UUA); Over Reno, Nevada, on final to runway 16R; Time – 1405 PDT (2105Z); Altitude – 500 feet agl; Type aircraft – Boeing 737; Remarks – +/- 20 knots below 500 feet agl.

Routine pilot report (UA); 13 miles from Marysville, California, on the 270° radial; Time – 1423 PDT (2123Z); Altitude – 17,000 feet msl; Type aircraft – Boeing 737; Turbulence – Light to moderate chop between 13,500 and 17,000 feet.

Routine pilot report (UA); Over Reno, Nevada, on final to runway 16R; Time – 1444 PDT (2144Z); Altitude – 1,000 feet agl; Type aircraft – Boeing 737; Remarks – +15 knots below 1,000 feet agl.

Urgent pilot report (UUA); 20 miles from Bishop, California, on the 250° radial; Time – 1501 PDT (2201Z); Altitude – 16,000 feet msl; Type aircraft – Cirrus SR22; Turbulence – Severe.

Routine pilot report (UA); 1 miles from Modesto, California, on the 100° radial; Time – 1506 PDT (2206Z); Altitude – FL220; Type aircraft – Airbus A320; Turbulence – Moderate.

Routine pilot report (UA); 10 miles from Modesto, California, on the 090° radial; Time – 1507 PDT (2207Z); Altitude – FL250; Type aircraft – Airbus A320; Turbulence – Moderate.

Routine pilot report (UA); Over Santa Rosa, California; Time – 1606 PDT (2306Z); Altitude – 14,500 feet msl; Type aircraft – Cessna Citation V; Icing – Light rime.

Routine pilot report (UA); Over Napa, California; Time – 1608 PDT (2308Z); Altitude – 16,000 feet msl; Type aircraft – Boeing 747; Icing – Moderate rime.

Routine pilot report (UA); Over South Lake Tahoe, California; Time – 1625 PDT (2325Z); Altitude – FL200; Type aircraft – Airbus A319; Temperature – -20° C; Icing – Light rime.

Routine pilot report (UA); 40 miles from Marysville, California, on the 085° radial; Time – 1625 PDT (2325Z); Altitude – FL180; Type aircraft – Boeing 737; Temperature – -4° C; Turbulence – Light to moderate chop between FL180 and 11,000 feet msl; Icing – Light rime between 17,500 and 14,500 feet msl; Remarks – During descent.

Routine pilot report (UA); 29 miles from Modesto, California, on the 070° radial; Time – 1630 PDT (2330Z); Altitude – 12,000 feet msl; Type aircraft – McDonnell Douglas MD-83; Turbulence – Moderate; Remarks – During descent between 12,000 and 10,000 feet msl.

Routine pilot report (UA); Over South Lake Tahoe, California; Time – 1645 PDT (2345Z); Altitude – FL220; Type aircraft – Boeing 737; Temperature – -22° C; Icing – Light rime.

Routine pilot report (UA); Over Reno, Nevada, on final to runway 16R; Time – 1645 PDT (2345Z); Altitude – 600 feet agl; Type aircraft – Embraer E175; Remarks – +15 knots at 600 feet agl.

Routine pilot report (UA); 6 miles from Red Bluff, California, on the 013° radial; Time – 1659 PDT (2359Z); Altitude – FL240; Type aircraft – Bombardier Dash 8; Icing – Light mixed.

Routine pilot report (UA); 8 miles from San Francisco, California, on the 005° radial; Time – 1701 PDT (0001Z); Altitude – 11,000 feet msl; Type aircraft – Boeing 737; Turbulence – Moderate; Remarks – Moderate chop between 10,000 feet msl and FL300, mostly smooth between FL320 and FL340.

Routine pilot report (UA); 21 miles from Williams, California, on the 006° radial; Time – 1702 PDT (0002Z); Altitude – FL220; Type aircraft – Bombardier Dash 8; Temperature – -5° C; Icing – Light mixed.

Routine pilot report (UA); 20 miles from South Lake Tahoe, California, on the 180° radial; Time – 1714 PDT (0014Z); Altitude – FL230; Type aircraft – Bombardier CRJ700; Turbulence – Light to moderate chop; Icing – Light rime.

Routine pilot report (UA); 10 miles from Reno, Nevada, on the 120° radial; Time – 1716 PDT (0016Z); Altitude – 12,000 feet msl; Type aircraft – Boeing 737; Turbulence – Moderate.

Routine pilot report (UA); 25 miles from Modesto, California, on the 210° radial; Time – 1733 PDT (0033Z); Altitude – 5,000 feet msl; Type aircraft – Cessna Citation V; Turbulence – Moderate.

## **8.0 SIGMET and CWSU Advisory**

SIGMET November 2 was valid for the accident site at the accident time (figures 16 through 21). The SIGMET warned of occasional severe turbulence below FL180 due to strong low-level winds and mountain wave activity with strong updrafts and LLWS. SIGMET November 2 was issued at 1527 PDT and valid through 1927 PDT, with SIGMET November 2 replacing SIGMET November 1 that was issued at 1232 PDT and valid through 1632 PDT. SIGMET November 1 was issued before the accident flight took off and warned of occasional severe turbulence below 15,000 feet msl due to strong low-level winds and mountain wave activity with strong updrafts and LLWS:

WSUS06 KKCI 151932  
WS6N  
\_SFON WS 151932  
SIGMET NOVEMBER 1 VALID UNTIL 152332

CA NV  
**FROM 90SSW REO TO BTY TO 40NNW EHF TO 30N RBL TO 90SSW REO**  
**OCNL SEV TURB BLW 150. DUE TO STG LOW LVL WNDS AND MTN WV ACT AND**  
**STG UDDFS AND LLWS. CONDS CONTG BYD 2332Z.**

....

WSUS06 KKCI 152227  
WS6N  
\_SFON WS 152227  
SIGMET NOVEMBER 2 VALID UNTIL 160227  
CA NV

**FROM 90SSW REO TO BTY TO 40NNW EHF TO 30N RBL TO 90SSW REO**  
**OCNL SEV TURB BLW FL180. DUE TO STG LOW LVL WNDS AND MTN WV ACT**  
**AND STG UDDFS AND LLWS. REPLACES SIGMET NOVEMBER 1. CONDS CONTG**  
**BYD 0227Z.**

....

The Center Weather Service Unit (CWSU) located at the Oakland (ZOA) Air Route Traffic Control Center (ARTCC) issued several weather forecast products on the accident day warning of weather conditions that would affect flights in the area of the accident site and Lake Tahoe region. At 0821 PDT (valid through 1700 PDT) ZOA CWSU issued a Meteorological Impact Statement (MIS) which discussed strong westerly winds impacting the Sierra mountain range and may cause severe turbulence, mountain wave activity, strong up and downdrafts, and LLWS through the early evening hours:

FAUS20 KZOA 151521  
ZOA MIS 01 VALID 151521-160000  
...FOR ATC PLANNING PURPOSES ONLY...  
**STRONG WESTERLY WINDS IMPACTING THE SIERRA MAY CAUSE SEVERE**  
**TURBULENCE...MOUNTAIN WAVE ACTIVITY...STRONG UP AND DOWNDRAFTS AND LOW-**  
**LEVEL WIND SHEAR OVER THE SIERRA AND INTO EASTERN NEVADA. MID AFTERNOON**  
**TODAY THROUGH THE LATE EVENING WILL BE THE PEAK TIME FOR THESE CONDITIONS.**  
=

The first CWSU Advisory (CWA) for the above discussed conditions valid for the accident site area was issued at 0908 PDT and valid through 1108 PDT and warned of areas of LLWS from the surface to 1,000 feet agl, moderate mountain wave activity, and strong updrafts. Conditions were expected to continue beyond 1108 PDT:

FAUS21 KZOA 151608  
ZOA1 CWA 151608  
ZOA CWA 101 VALID UNTIL 151808  
**FROM 35NNW FMG-45SSE OAL-50ENE CZQ-60WNW FMG-35NNW FMG**  
**AREA LLWS SFC-010. MOD MTN WAVE. STRONG UDDF. COND CONTG BYD VALID**  
**TIME.**  
**ZOA CWSU.**  
=

At 1050 PDT the Aviation Weather Center (AWC) called the ZOA CWSU to coordinate a future SIGMET for severe turbulence (SIGMETs November 1 and 2) for the Sierra Mountains and portions of Nevada (attachment 3). The AWC and ZOA CWSU agreed that ZOA CWSU would continue issuing CWAs until the future SIGMET was issued. At 1100 PDT (valid through 1300 PDT) the ZOA CWSU issued the following CWA continuing to warn of areas of LLWS from the surface to 1,000 feet agl, moderate mountain wave activity, and strong updrafts. Conditions were expected to continue beyond 1300 PDT:

FAUS21 KZOA 151800  
ZOA1 CWA 151800  
ZOA CWA 102 VALID UNTIL 152000  
**FROM 35NNW FMG-45SSE OAL-50ENE CZQ-60WNW FMG-35NNW FMG**  
**AREA LLWS SFC-010. MOD MTN WAVE. STRONG UDDF. COND CONTG BYD VALID**  
**TIME.**  
**ZOA CWSU.**  
=

By 1232 PDT SIGMET November 1 had been issued for severe turbulence and so ZOA CWSU issued a CWA at 1236 PDT cancelling CWA 102 (above) and telling pilots to see SIGMET November 1 (figures 17 through 21 and attachment 3):

FAUS21 KZOA 151936  
ZOA1 CWA 151935  
ZOA CWA 103 VALID UNTIL 151950  
**CANCEL ZOA CWA 102. SEE SIGMET NOVEMBER 1. ZOA CWSU.**  
=

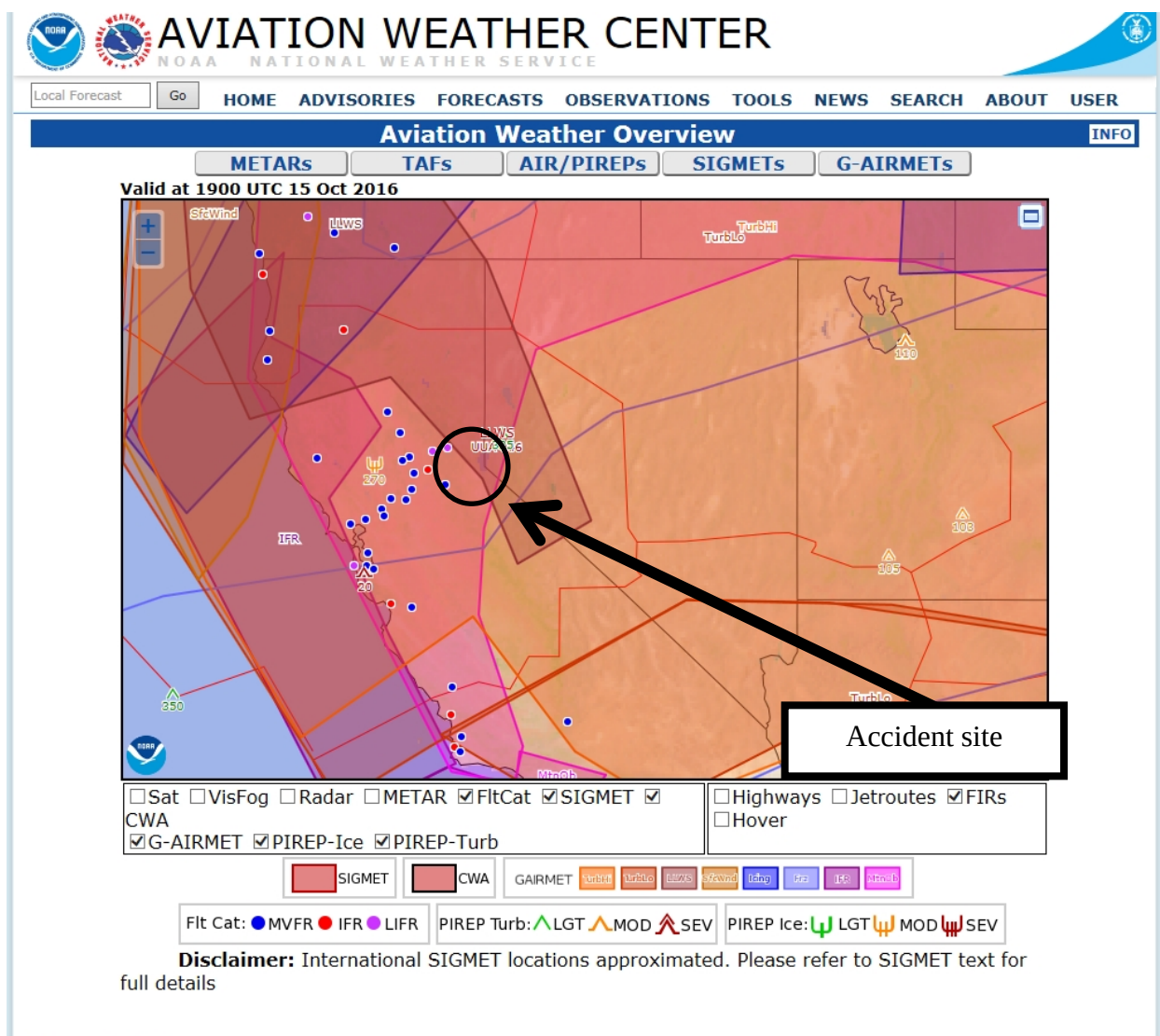
In addition to the ZOA CWSU weather products, the accident flight initially departed in Salt Lake City (ZLC) ARTCC airspace. The ZLC CWSU also had weather forecast products valid on the accident day when the accident flight was passing through their airspace. ZLC CWSU issued two different MISs, one issued at 2005 PDT on October 14 and one issued at 0930 PDT on October 15. These MISs were valid during the time before the accident flight and while the accident flight was enroute. The MISs discussed a large storms system impacting ZLC airspace with widespread rain, showers, mountain snow, low ceilings and visibilities, possible mountain waves, LLWS, and strong surface winds. Areas of moderate to severe icing and turbulence were expected with specific wording for general aviation interests to be monitoring weather forecast closely:

FAUS20 KZLC 150305  
ZLC MIS 02 VALID 150300-161800  
...FOR ATC PLANNING PURPOSES ONLY...  
**A LARGE UPPER LEVEL TROF AND ASSOCIATED STORM SYSTEM WILL CONTINUE**  
**TO IMPACT MUCH OF ZLC THRU SATURDAY. WIDESPREAD RAIN AND SHRA WITH**  
**MTN SNOW...LOW CIGS/VIS AND POSS MTN WAVES AND LLWS CAN BE EXPECTED**  
**ALONG WITH AREAS OF MOD AND ISOLD SEV ICG AND TURB. GENERAL AVIATION**  
**INTERESTS SHOULD PAY CLOSE ATTENTION TO WEATHER FORECASTS THIS**  
**WEEKEND. UNSETTLED WEATHER CONDITONS WILL PERSIST INTO EARLY NEXT**  
**WEEK.**

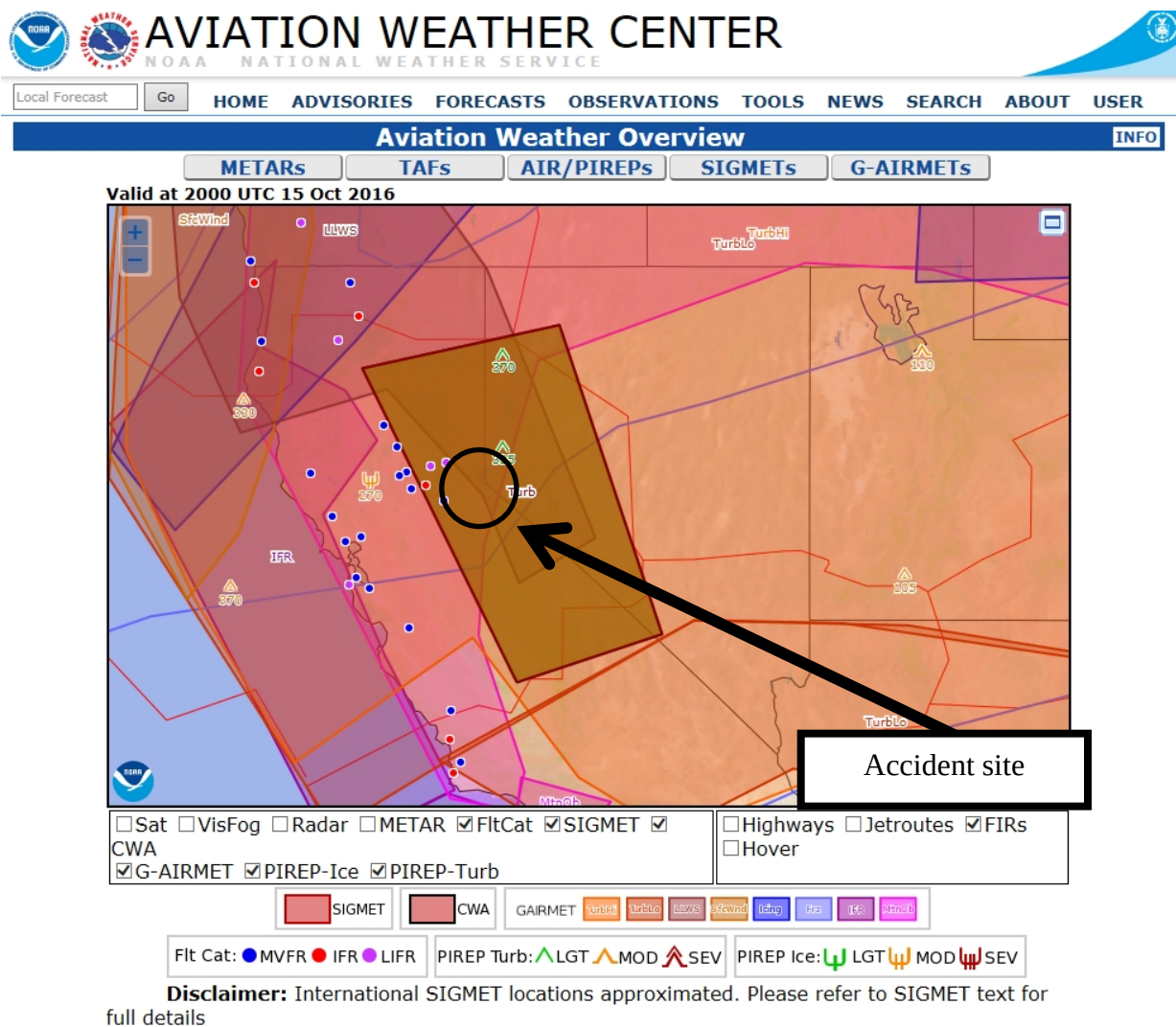
FAUS20 KZLC 151637  
ZLC MIS 01 VALID 151630-160300  
...FOR ATC PLANNING PURPOSES ONLY...  
**A LARGE UPPER LEVEL TROF AND ASSOCIATED STORM SYSTEM WILL IMPACT**

MUCH OF ZLC THRU SATURDAY NIGHT. WIDESPREAD RAIN AND SHRA WITH MTN SNOW...LOW CIGS/VIS...MTN WAVES...POSS LLWS...STRONG SFC WINDS AND OCNL MOD-SEV TURB AND ICG CAN BE EXPECTED. GENERAL AVIATION INTERESTS SHOULD PAY CLOSE ATTENTION TO WEATHER FORECASTS THIS WEEKEND AND INTO EARLY NEXT WEEK AS ADDITIONAL STORMS WILL IMPACT THE WESTERN US.

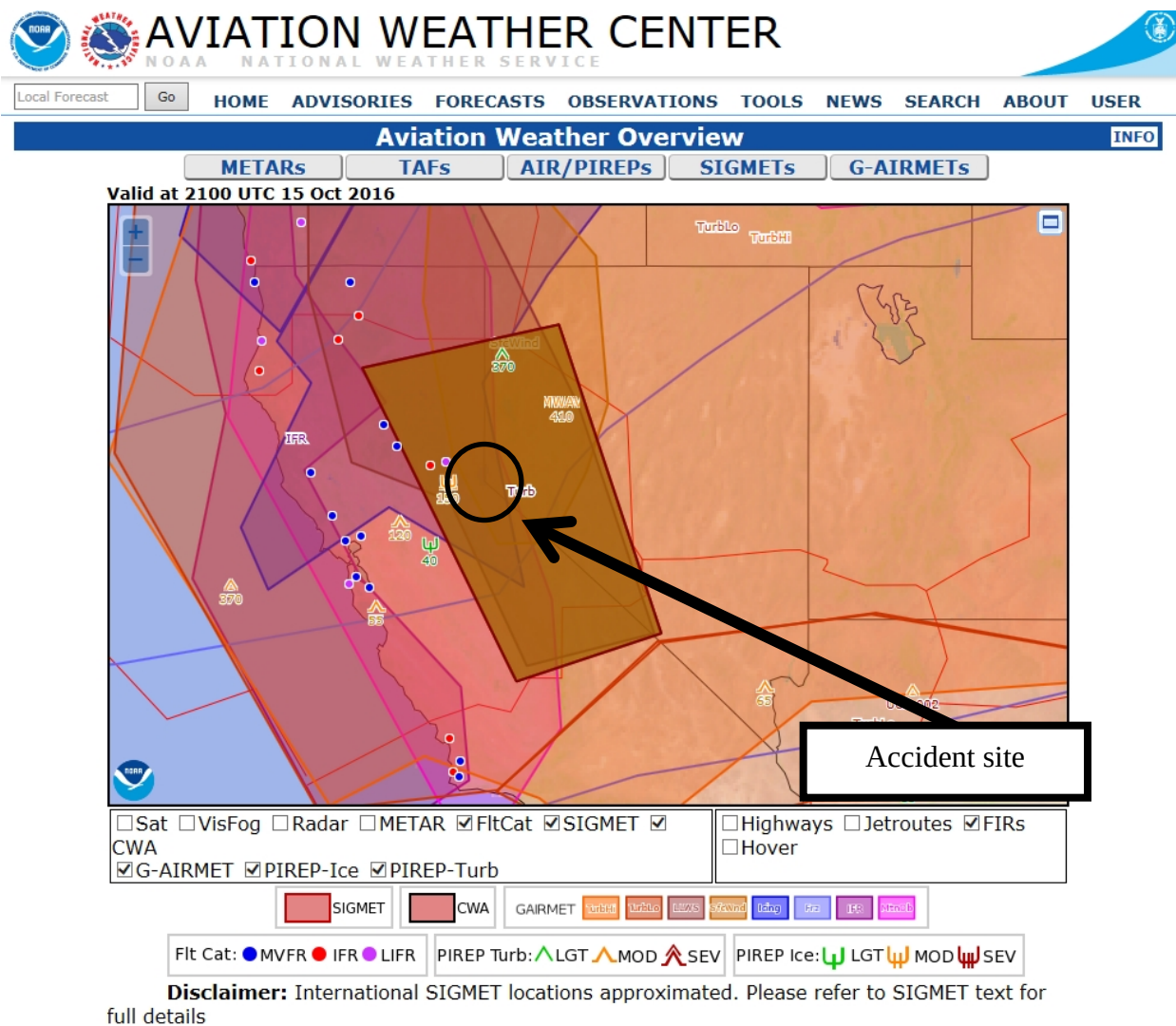
ZLC CWSU also published weather stories on Facebook and Twitter (figures 22 and 23). ZLC CWSU published a weather story on October 13<sup>th</sup> around 1130 PDT (figure 22) that discussed increasing aviation impacts across ZLC ARTCC airspace from October 13<sup>th</sup> through the night of October 15<sup>th</sup>. Another weather story was published around 1050 PDT on October 14<sup>th</sup> warning that weather impacting aviation operations in ZLC ARTCC airspace would continue through October 16<sup>th</sup>. The social media information issued by CWSUs is considered supplemental information, but does provide weather information in a graphic format for pilots.



**Figure 16 – SIGMETs, AIRMETs, CWAs, and PIREPs valid for the accident area at 1200 PDT**

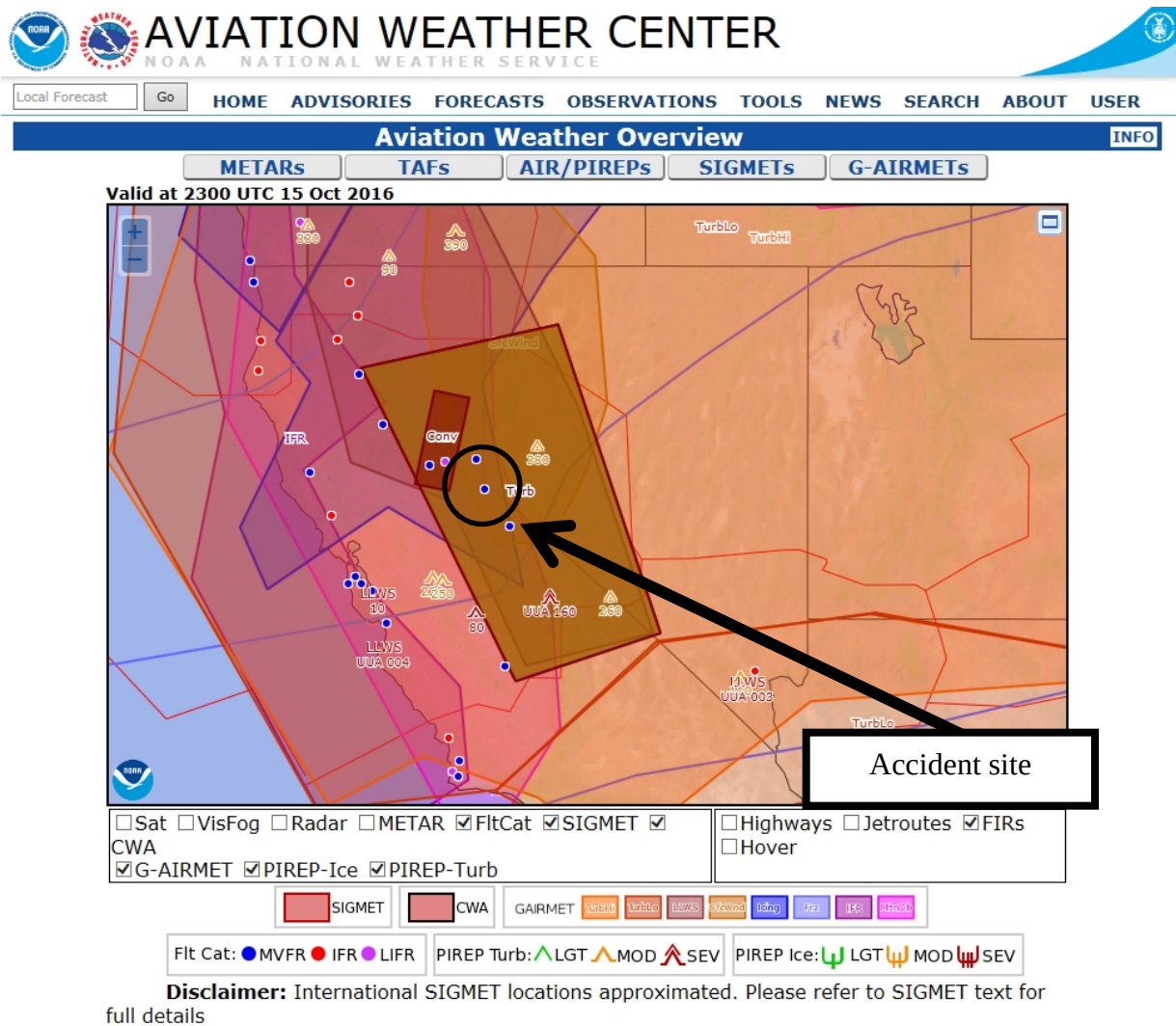


**Figure 17 – SIGMETs, AIRMETs, CWAs, and PIREPs valid for the accident area at 1300 PDT**



**Figure 18 – SIGMETs, AIRMETs, CWAs, and PIREPs valid for the accident area at 1400 PDT**





Interactive Maps:

**Figure 20 – SIGMETs, AIRMETs, CWAs, and PIREPs valid for the accident area at 1600 PDT**



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## Aviation Weather Overview

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METARs

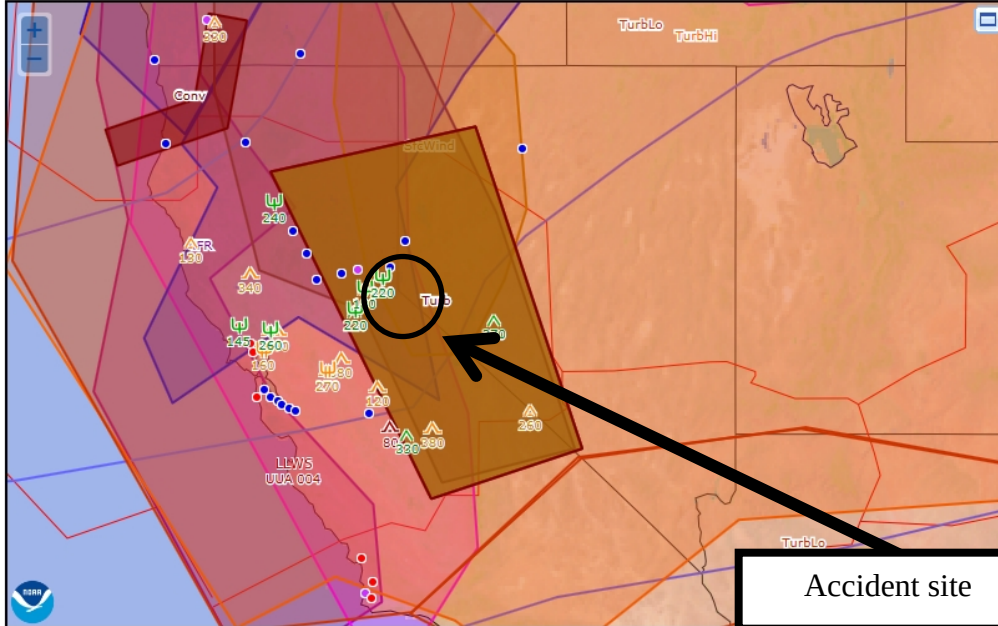
TAFs

AIR/PIREPs

SIGMETs

G-AIRMETs

Valid at 0000 UTC 16 Oct 2016

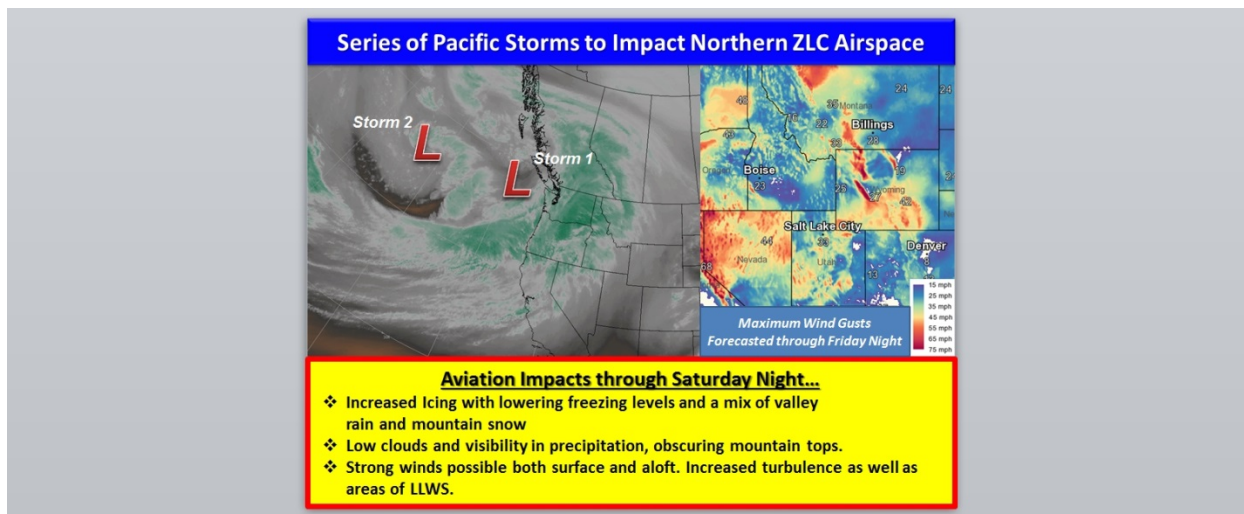


|                                              |                                               |                                                |                                          |                                            |                                            |                                     |
|----------------------------------------------|-----------------------------------------------|------------------------------------------------|------------------------------------------|--------------------------------------------|--------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Sat                 | <input type="checkbox"/> VisFog               | <input type="checkbox"/> Radar                 | <input type="checkbox"/> METAR           | <input checked="" type="checkbox"/> FltCat | <input checked="" type="checkbox"/> SIGMET | <input checked="" type="checkbox"/> |
| CWA                                          |                                               |                                                |                                          |                                            |                                            |                                     |
| <input checked="" type="checkbox"/> G-AIRMET | <input checked="" type="checkbox"/> PIREP-Ice | <input checked="" type="checkbox"/> PIREP-Turb |                                          |                                            |                                            |                                     |
| <input type="checkbox"/> SIGMET              |                                               | <input type="checkbox"/> CWA                   | <input type="checkbox"/> G-AIRMET        | <input type="checkbox"/> Turb              | <input type="checkbox"/> LLWS              | <input type="checkbox"/> Wind       |
| <input type="checkbox"/> Highways            |                                               | <input type="checkbox"/> Jetroutes             | <input checked="" type="checkbox"/> FIRs | <input type="checkbox"/> Hover             |                                            |                                     |

Flt Cat: ● MVFR ● IFR ● LIFR    PIREP Turb: ▲ LGT ▲ MOD ▲ SEV    PIREP Ice: ▲ LGT ▲ MOD ▲ SEV

**Disclaimer:** International SIGMET locations approximated. Please refer to SIGMET text for full details

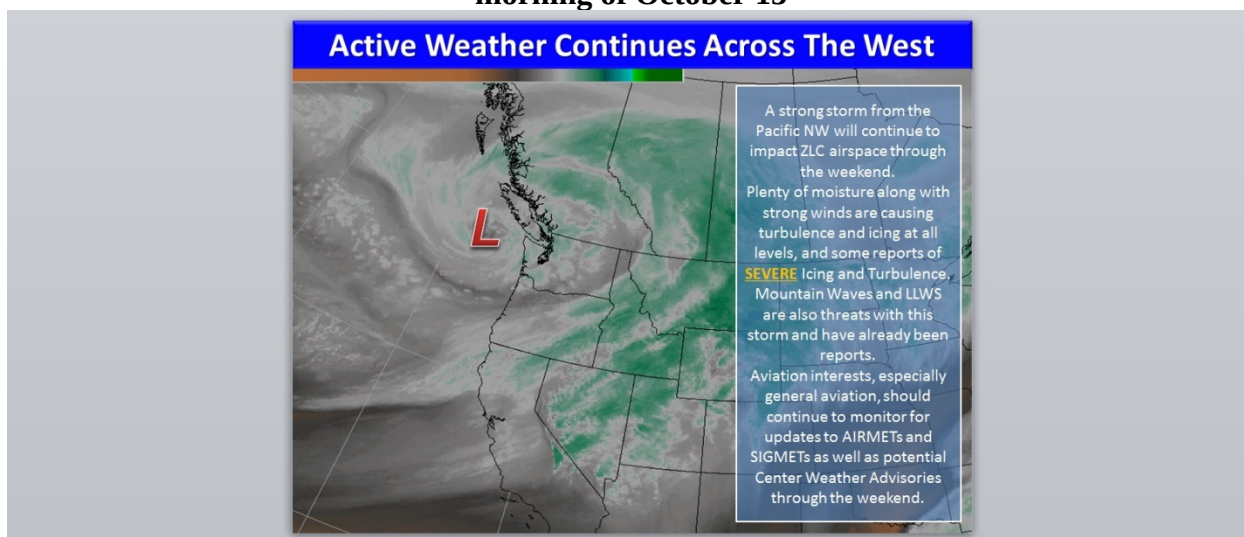
**Figure 21 – SIGMETs, AIRMETs, CWAs, and PIREPs valid for the accident area at 1700 PDT**



The first in a series of storms from the Pacific NW will arrive this afternoon/evening and last into Friday night. The second storm will follow close behind this weekend. Strong winds and plenty of moisture are expected. The winds will increase Thursday afternoon, with strongest winds on Friday. Strong winds will return on Saturday.

There are multiple impacts to aviation weather, especially those with general aviation interests, with these storms. Along with increasing winds, there will be periods of LLWS in MT and WY beginning late tonight. Turbulence will also increase and spread east today and tonight. As precipitation spreads east, ceilings will lower, with reduced visibility within areas of precipitation. With colder air moving in, freezing/snow levels will lower, which increases the threat of icing along with winter conditions for airports/airfields at higher elevations. Be sure to monitor [aviationweather.gov](http://aviationweather.gov) and [weather.gov](http://weather.gov) for updates.

**Figure 22 – Weather Story published by ZLC CWSU on Facebook and Twitter during the morning of October 13**



A strong storm from the Pacific NW will continue to impact ZLC airspace through the weekend. Plenty of moisture along with strong winds are causing turbulence and icing at all levels, and some reports of SEVERE Icing and Turbulence. Mountain Waves and LLWS are also threats with this storm and have already been reports. Aviation interests, especially general aviation, should continue to monitor for updates to AIRMETs and SIGMETs as well as potential Center Weather Advisories through the weekend. Be sure to monitor [aviationweather.gov](http://aviationweather.gov) and [weather.gov](http://weather.gov) for updates.

**Figure 23 – Weather Story published by ZLC CWSU on Facebook and Twitter during the morning of October 14**

## 9.0 AIRMETs

AIRMETs Tango, Zulu, and Sierra were issued at 1345 PDT and valid at the accident time for the accident site (figures 16 through 21). The AIRMETs forecasted moderate turbulence between FL180 and FL420, moderate turbulence below FL180, sustained surface winds greater than 30 knots, LLWS, moderate icing conditions between freezing level and FL220 (freezing level between 6,000 and 11,000 feet msl), IFR<sup>23</sup> conditions with ceiling below 1,000 feet agl, visibility below 3 miles in precipitation and mist, and mountain obscuration conditions due to clouds, precipitation, and mist. The same conditions were forecast at the time of departure of the accident flight from WMC:

WAUS46 KPCI 152045

WA6T

\_SFOT WA 152045

AIRMET TANGO UPDT 4 FOR TURB STG WNDZ AND LLWS VALID UNTIL 160300

...SEE SIGMET NOVEMBER SERIES...

**AIRMET TURB...WA OR CA ID MT WY NV UT CO AZ NM AND CSTL WTRS  
FROM 20W HUH TO 50NNW ISN TO 70SW RAP TO BFF TO GLD TO PUB TO  
60SE ABQ TO 60NNE SJN TO 20WSW EED TO MZB TO 160WSW RZS TO  
140WSW FOT TO 120WNW ONP TO 30WNW TOU TO 20W HUH  
MOD TURB BTN FL180 AND FL420. CONDS CONTG BYD 03Z THRU 09Z.**

**AIRMET TURB...CA NV UT AZ NM AND CSTL WTRS  
FROM 60SSE ILC TO 30S CIM TO 80SE ABQ TO 40SE EED TO 40NNW MZB  
TO 30WSW RZS TO 20WNW BTY TO 60SSE ILC  
MOD TURB BLW 150. CONDS CONTG BYD 03Z THRU 09Z.**

**AIRMET TURB...WA OR CA ID MT WY NV UT CO AZ NM AND CSTL WTRS  
FROM 20ENE HUH TO 20NNW HVR TO 40ESE HVR TO MLS TO BFF TO GLD TO  
TBE TO 30S CIM TO 60SSE ILC TO 20WNW BTY TO 30WSW RZS TO 130WSW  
RZS TO 140WSW FOT TO 110W ONP TO 140W TOU TO 20ENE HUH  
MOD TURB BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.**

**AIRMET STG SFC WNDZ...OR CA NV  
FROM 80ESE DSD TO 30S REO TO 40NNE OAL TO 60WSW OAL TO 50ENE MOD  
TO 50ENE RBL TO 50WSW LKV TO 50NW LKV TO 80ESE DSD  
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG BYD 03Z  
ENDG 03-06Z.**

**AIRMET STG SFC WNDZ...WA OR CA AND CSTL WTRS  
FROM 30NW TOU TO 60SE TOU TO 20W BTG TO 70W OED TO ENI TO 150WSW  
ENI TO 70NW FOT TO 130WSW ONP TO 110WNW ONP TO 150W TOU TO 30NW  
TOU  
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG BYD 03Z  
THRU 09Z.**

**LLWS POTENTIAL...WA OR CA NV AND CSTL WTRS  
BOUNDED BY HUH-50SE YDC-40ESE DSD-40NW REO-60NW BAM-60ENE FMG-  
BTY-40N EHF-30NE SAC-30E ENI-20WSW FOT-70WNW OED-20NW HQM-20NE**

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

**TOU-HUH**  
**LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.**

....

WAUS46 KPCI 152045

WA6Z

\_SFOZ WA 152045

AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 160300

.  
**AIRMET ICE...WA OR CA ID MT AND CSTL WTRS**  
**FROM 20ESE GEG TO 50SE REO TO 40SE LKV TO 40SSW FMG TO 60SSE FMG**  
**TO 40ENE CZQ TO 20ESE PYE TO 120SW PYE TO 150SW FOT TO 30WSW FOT**  
**TO 40NNW FOT TO 60NE RBL TO 50SSE EPH TO 20ESE GEG**  
**MOD ICE BTN FRZLVL AND FL220. FRZLVL 060-110. CONDS CONTG BYD 03Z**  
**THRU 09Z.**

.  
AIRMET ICE...WA OR CA AND CSTL WTRS  
FROM 20S YXC TO 30NNW MLP TO 20ESE GEG TO 50SSE EPH TO 60NE RBL  
TO 40NNW FOT TO 130W OED TO 30WNW ONP TO 100W ONP TO 150W TOU TO  
20W HUH TO 20S YXC  
MOD ICE BTN FRZLVL AND FL220. FRZLVL 060-080. CONDS CONTG BYD 03Z  
THRU 09Z.

.  
OTLK VALID 0300-0900Z  
AREA 1...ICE WA OR CA ID MT AND CSTL WTRS  
BOUNDED BY 60ESE YXC-70SSE FCA-70SSE MLP-20NNE BOI-50NE RBL-60SSE  
OED-20NW OED-30ESE HQM-70WSW HQM-80SW TOU-110W TOU-50NNE  
TOU-40ESE YDC-60ESE YXC  
MOD ICE BTN FRZLVL AND FL200. FRZLVL 060-090. CONDS CONTG THRU  
09Z.

.  
AREA 2...ICE WA OR CA AND CSTL WTRS  
BOUNDED BY 80SW TOU-70WSW HQM-30ESE HQM-EUG-60N FOT-60NW  
FOT-160SW ONP-110WNW ONP-140W HQM-80SW TOU  
MOD ICE BTN 060 AND FL200. CONDS DVLPG 06-09Z. CONDS CONTG THRU  
09Z.

.  
AREA 3...ICE OR CA ID MT WY NV UT  
BOUNDED BY 60ESE YXC-40NNW ISN-100SE MLS-50SSE BIL-40SE JAC-30SE  
BPI-30N SLC-40W BVL-60N OAL-60SSE FMG-60SW OAL-20WSW MOD-30SW  
SAC-RBL-20NNE BOI-70SSE MLP-70SSE FCA-60ESE YXC  
MOD ICE BTN FRZLVL AND FL220. FRZLVL 060-120. CONDS CONTG THRU  
09Z.

.  
FRZLVL...RANGING FROM 060-170 ACRS AREA  
080 ALG 140WSW FOT-60SSW FOT-40NNE RBL-50SSW LKV-20ESE PDT-  
70NNW DNJ  
120 ALG 130SW PYE-110SSW PYE-40SSE MOD-50W OAL  
160 ALG 160WSW RZS-60WSW RZS-40SE HEC-EED

....

WAUS46 KPCI 152045

WA6S

\_SFOS WA 152045

AIRMET SIERRA UPDT 3 FOR IFR AND MTN OBSCN VALID UNTIL 160300

.  
**AIRMET IFR...CA**  
**FROM 30NNE FMG TO 70SSE FMG TO 20NNE MOD TO 60ESE RBL TO 30NNE**

**FMG**

**CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 00-03Z. CONDS CONTG  
BYD 03Z THRU 09Z.**

.  
AIRMET IFR...WA ID MT  
FROM 70E YDC TO 20SSE YXC TO 20SE MLP TO 30ESE GEG TO 30SW GEG  
TO 70SSE YDC TO 70E YDC  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 00-03Z. CONDS CONTG  
BYD 03Z THRU 09Z.

.  
AIRMET IFR...WA OR CA AND CSTL WTRS  
FROM 30W SEA TO 50SE HQM TO 40SSW EUG TO 30E RBL TO ENI TO 60SSW  
CZQ TO RZS TO 170SW RZS TO 150WSW ENI TO 60WSW FOT TO 70NW FOT  
TO 50WNW HQM TO 30W SEA  
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.  
AIRMET MTN OBSCN...CA  
FROM 40E RZS TO 50SSW HEC TO 40E MZB TO 30SSW MZB TO 40SE LAX TO  
30WSW RZS TO 40E RZS  
MTNS OBSC BY CLDS. CONDS DVLPG 00-03Z. CONDS CONTG BYD 03Z THRU  
09Z.

.  
**AIRMET MTN OBSCN...WA OR CA**  
**FROM 70WSW YXC TO 50SSE BKE TO 30SE DSD TO 30SSE LKV TO FMG TO**  
**70SSW OAL TO 30ENE EHF TO 40E RZS TO 30WSW RZS TO 70SW FOT TO**  
**50W BTG TO 30SSW TOU TO 20ENE HUH TO 70WSW YXC**  
**MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.**

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## **10.0 Area Forecast**

The Area Forecast issued at 1245 PDT, valid at the accident time, forecasted a broken ceiling at 10,000 feet msl with cloud tops at FL250, widely scattered light rain showers, and a south wind of 35 knots with gusts to 45 knots. By 1700 PDT the forecast indicated an overcast ceiling at 8,000 feet msl with a visibility between 3 and 5 miles in light rain and mist:

FAUS46 KPCI 151945  
FA6W  
\_SFOC FA 151945  
SYNOPSIS AND VFR CLDS/WX  
SYNOPSIS VALID UNTIL 161400  
CLDS/WX VALID UNTIL 160800...OTLK VALID 160800-161400  
WA OR CA AND CSTL WTRS

.  
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.  
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.  
NON MSL HGTS DENOTED BY AGL OR CIG.

.  
SYNOPSIS...SEE SLC FA.

.  
WA CASCDS WWD  
CSTL SXNS...BKN020 OVC040 TOP FL250. VIS 3-5SM -RA BR. WND SE  
G25KT. 23Z WND S 30G50KT. 05Z OVC020. SCT -SHRA. WND SW 20G30KT.  
OTLK...MVFR CIG SHRA.

STRAIT OF JUAN DE FUCA-PUGET SOUND-INTR VLY...BKN040 OVC070 TOP FL250. -RA. 02Z BKN025 OVC050. VIS 3-5SM -RA BR. WND S 25G40KT. OTLK...VFR SHRA.  
OLYMPICS-CASCDS...OVC070 TOP FL250. VIS 3-5SM -RA BR. VIS 3-5SM -SN BR ABV 060. OTLK...MVFR CIG RASN.

.  
WA E OF CASCDS

OVC060 TOP FL250. OCNL -RA. 04Z WND SW G25KT. OTLK...VFR SHRA WND.

.  
OR CASCDS WWD

CSTL SXNS..OVC020 TOP FL250. VIS 3-5SM -RA BR. ISOL -TSRA POSS SEV. CB TOP FL300. NRN 2/3 WND S 35G50KT BECMG 00Z WND S 25G40KT. SRN 1/3 WND S 25G35KT BECMG 22Z WND SW G25KT. OTLK...MVFR CIG SHRA WND.

WILLAMETTE VLY-SWRN INTR...OVC050 TOP FL250. NMRS -SHRA/ISOL -TSRA. TS POSS SEV. CB TOP FL300. WND S 30G40KT BECMG 23Z WND S 25G35KT. 03Z BKN050. SCT -SHRA. WND S G25KT. OTLK...VFR SHRA.  
CASCDS...OVC070 TOP FL250. VIS 3-5SM -RA BR. VIS 3-5SM -SN BR ABV 070. OTLK...MVFR CIG RASN.

.  
OR E OF CASCDS

N CNTRL-NERN...OVC070 TOP FL250. NMRS -SHRA. WND SE G25KT. 05Z BKN080. WDLY SCT -SHRA. OTLK...VFR SHRA.  
S CNTRL...OVC070 TOP FL250. SCT -SHRA BECMG 2301 NMRS -SHRA. WND S 25G35KT. OTLK...VFR SHRA.  
SE...BKN100 TOP FL250. ISOL -SHRA. 00Z OVC080. SCT -SHRA. OTLK...VFR.

.  
NRN CA...STS-SAC-TVL LN NWD

CSTL SXNS

N 1/2...OVC020 TOP FL250. VIS 3SM -RA BR. WDLY SCT -TSRA POSS SEV. CB TOP FL300. WND S 25G35KT. 02Z OVC010. VIS 3-5SM SCT -SHRA/ISOL -TSRA. TS POSS SEV. OTLK...IFR CIG SHRA.

S 1/2...OVC020 TOP FL250. WDLY SCT -SHRA. 22Z NMRS -SHRA. 05Z OVC015 TOP 120. WDLY SCT -SHRA. OTLK...MVFR CIG SHRA.  
SAC VLY

N 1/2...BKN030 OVC050 TOP FL250. OCNL -RA. WND S 25G35KT. 00Z OVC030. VIS 3-5SM -RA BR. WND S G25KT. 04Z OVC030. SCT -SHRA. OTLK...MVFR CIG SHRA.

S 1/2...OVC050 TOP FL250. 00Z OVC030. VIS 3-5SM -RA BR. WND S G25KT. 06Z OVC030. SCT -SHRA. OTLK...MVFR CIG SHRA.  
SHASTA-SISKIYOU...OVC070 TOP FL250. VIS 3-5SM -RA BR. ISOL -TSRA. CB TOP FL300. WND S 25G35KT. OTLK...MVFR CIG SHRA.

**NERN CA-NRN SIERNEV...BKN100 TOP FL250. WDLY SCT -SHRA. TIL 04Z WND S 35G45KT. 00Z OVC080. VIS 3-5SM -RA BR. 04Z OVC080. VIS 3SM -RA BR. WND SW 20G30KT. OTLK...IFR CIG RA WND.**

.  
CNTRL CA

CSTL SXNS

N 1/2...BKN040 TOP 100. 22Z OVC020. WDLY SCT -SHRA. WND S 20G30KT. 03Z OVC020 TOP FL250. VIS 3-5SM SCT -SHRA. WND S 25G35KT. OTLK...IFR CIG SHRA.

S 1/2...BKN020 TOP 050. 03Z OVC010. VIS 3-5SM BR. OTLK...IFR CIG BR.

SAN JOAQUIN VLY...

N 1/2...BKN060 TOP 100. 03Z OVC050 TOP FL250. OCNL -RA.  
 OTLK...VFR RA.  
 S 1/2...SCT-BKN060 TOP 100. 06Z BKN060 TOP FL250. OCNL -RA.  
 OTLK...VFR RA.  
 SRN SIERNEV  
 N 1/3...BKN100 TOP FL250. WDLY SCT -SHRA. TIL 04Z WND S 35G45KT.  
 00Z OVC080. VIS 3-5SM -RA BR. 04Z OVC080. VIS 3SM -RA BR. WND SW  
 20G30KT. OTLK...IFR CIG RA WND.  
 S 2/3...SCT CI. OTLK...VFR.  
 .  
 SRN CA..VBG-NID-60NNW BIH LN SWD  
 CSTL SXNS...SKC. OCNL SCT020-030. BECMG 0204 BKN020-030 TOP 040.  
 OTLK...MVFR CIG DZ.  
 INTR MTNS-MOJAVE-SRN DESERTS-IMPERIAL-COACHELLA VLYS...SKC OR SCT  
 CI. TIL 06Z WND W 20G30KT. N 1/2 INTR MTNS AND MOJAVE DESERT.  
 OTLK...VFR.  
 .  
 CSTL WTRS  
 WA/OR...BKN020 OVC040 TOP FL250. SCT/NMRS -SHRA/ISOL -TSRA. CB  
 TOP FL300. WND S 40G55KT BECMG 0305 WND S 25G35KT. OTLK...MVFR  
 CIG SHRA WND.  
 NRN CA...BKN020 OVC040 TOP FL250. VIS 3-5SM -RA BR. ISOL -TSRA.  
 CB TOP FL300. WND S 35G50KT. 00Z BKN020. SCT -SHRA/ISOL -TSRA.  
 WND S 25G35KT. OTLK...MVFR CIG SHRA WND.  
 CNTRL CA...BKN020 OVC040 TOP 100. BECMG 2200 OVC020. WDLY SCT  
 -SHRA. WND S 20G30KT. OTLK...MVFR CIG SHRA WND.  
 SRN CA...OVC020 TOP 040. OTLK...MVFR CIG.  
 ....

## 11.0 Terminal Aerodrome Forecast

KTVL was the closest site to the accident site with a NWS TAF. The TAF valid at the time of the accident was issued at 1028 PDT and was valid for a 24-hour period beginning at 1100 PDT. The TAF for KTVL was as follows:

TAF KTVL 151728Z 1518/1618 **19032G45KT P6SM BKN060 WS020/25065KT**  
 FM160000 19028G40KT 5SM -RA BR BKN035 OVC050 WS020/25060KT  
 FM160300 19018G28KT 1SM +RA BR BKN020 OVC030 WS020/25050KT=

The forecast expected a wind from 190° at 32 knots with gusts to 45 knots, greater than 6 miles visibility, a broken ceiling at 6,000 feet agl, wind shear at 2,000 feet agl with wind from 250° at 65 knots.

## 12.0 NWS Area Forecast Discussion

The accident site was located directly on the border of two NWS offices. Both the Reno and Sacramento NWS offices issued Area Forecast Discussion (AFD) around the accident time. NWS Reno issued their AFD at 1459 PDT (closest AFD to the accident time), and the aviation section of the AFD discussed a significant wind impact to area airports with wind gusts of 50 to 60 knots expected, current LLWS PIREPs, and IFR or less conditions in the northern Sierras due to precipitation and clouds. NWS Sacramento issued their AFD at 1530 PDT (closest AFD to the accident time), and the aviation section of the AFD discussed mainly aviation impacts affecting the Sacramento Valley area with IFR conditions expected in the Sacramento Valley as the precipitation moved from west to east across the area the afternoon and evening of the accident:

FXUS65 KREV 152159

AFDREV

Area Forecast Discussion

National Weather Service Reno NV

259 PM PDT Sat Oct 15 2016

.SYNOPSIS...

An intense Pacific storm will continue through the weekend. Periods of strong, gusty winds and heavy rain will continue into Monday morning. The strongest winds this afternoon and evening could produce substantial damage. The heaviest rain and high elevation snow is expected Sunday through Sunday night. Drier weather and much lighter winds return next week.

&&

.SHORT TERM...

The ongoing forecast for the strong storm this weekend is on track. Winds have been slowly increasing all day with current gusts up to 65 mph in the warned area, but no reports of damage so far. We are still expecting a peak in the winds from this writing through 9 PM. Rainfall has also spread into the Tahoe Basin through Western Lassen County with moderate amounts so far. Of note, it is possible the strongest winds are already occurring and may diminish after 5 PM. The precip moving in often acts to diminish the winds with a less well developed breaking wave.

As far as precip, it looks like the heaviest band will move through from 5 PM up north to midnight around Tahoe/Reno and then hanging up in Alpine/Mono Counties after. Rainfall amounts of near 2 inches near the Sierra Crest with around 1 inch in the Tahoe Basin to Western Lassen County and then 1/4 to 1/2" further east looks good. The highway 95 corridor will still see much lighter amounts near or less than a tenth of an inch.

One thing to note is that the precip will be quite heavy along the band with rates up to 1/2" per hour in the Sierra. This could cause issues for the new burn scars (and possibly the Marina Fire if the band makes it that far south). We continued the Flash Flood Watch for debris flows off these burns.

With the break in bands Sunday morning, winds will start to increase again, but the continued moisture aloft will likely keep things in check. Gusts up to 50-55 mph are likely at times during the day. These will continue through the afternoon before diminishing during the evening as the last, and possibly strongest band of precip moves in.

That band will begin tomorrow afternoon and last through Sunday

night with amounts about 50% higher than tonight's band. Snow levels will also begin to fall, starting near 8000-8500 feet and falling to 6500 feet by Monday morning. Some light accumulations over Donner/Echo Passes around 2-4 inches is possible with possible a foot for Mt. Rose and Carson Passes. Will not issue an advisory yet and let the night shift get one more good look. Also, extended the Flash Flood Watch for the burn scars through this second band.

.LONG TERM (Monday onward)...

A few showers will linger across far northeast California and northwest Nevada Monday and Tuesday before a warming and drying pattern settles in. Precipitation amounts will be light with generally under a tenth of inch across these regions as a progressive shortwave trough scrapes the region to the north. By midweek, an upper level ridge builds across the West leading to a period of light winds, warming temperatures, and dry conditions. High temperatures will warm from the lower 60s early week to the lower 70s by next weekend across western Nevada. Sierra valleys will warm from the upper 40s to the upper 60s next week. Fuentes &&

.AVIATION...

**\*\*\*Another round of significant wind impacts today into Sunday\*\*\***

**Current observations showing widespread gusts near 40kts with winds expected to peak between 00z-04z this evening. Downslope winds are still expected to develop through the afternoon with peak gusts up to 50-60 kts possible especially at KRNO and KCXP.**

**Low level winds shear has been reported by several aircraft today.**

**KRNO appears to currently be under the influence of a rotor with southeast flow at the surface and strong southwesterly flow aloft.**

**This wind shear is expected to persist tonight with some weakening of winds after 06z but will remain strong and gusty through Sunday with southwest gusts up to 40-50kts possible.**

**This system will also provide heavy rainfall across the northern Sierra with periods of spillover precipitation to western Nevada.**

**The 1st round will impact the northern Sierra this afternoon and evening from 00z to 12z Sunday. Mountain obscuration and low ceilings and visibilities (IFR or less) will be possible during these heavy rain periods through early Monday morning. The second window will be 21Z Sunday to 12z Monday. The best window for spillover precipitation at KRNO and KCXP looks to be 03z-12z tonight and again 21z Sunday to 12z Monday. Fuentes &&**

&&

.REV Watches/Warnings/Advisories...

NV...High Wind Warning until 11 PM PDT this evening NVZ005.

Wind Advisory from 11 PM this evening to 8 PM PDT Sunday NVZ002>005.

High Wind Warning until 11 PM PDT this evening NVZ002.

Flash Flood Watch from 5 PM PDT this afternoon through late Sunday night NVZ002-003.

Wind Advisory until 8 PM PDT Sunday NVZ001.

High Wind Warning until 11 PM PDT this evening NVZ003-004.

CA...High Wind Warning until 11 PM PDT this evening CAZ070-071.

Wind Advisory from 11 PM this evening to 8 PM PDT Sunday CAZ070>072.

Wind Advisory until 8 PM PDT Sunday CAZ073.

High Wind Warning until 11 PM PDT this evening CAZ072.

Flash Flood Watch from 5 PM PDT this afternoon through late Sunday night CAZ072.

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FXUS66 KSTO 152230

AFDSTO

Area Forecast Discussion

National Weather Service Sacramento CA

330 PM PDT Sat Oct 15 2016

SYNOPSIS...

Additional Pacific storms will move through over the weekend into Monday bringing periods of rain...heavy at times, gusty wind, and high mountain snow. Drier weather expected midweek with warming temperatures.

&&

.DISCUSSION...

Next Pacific frontal system is pushing inland across northwestern portions of Interior Northern California this afternoon. 88D showing widespread precipitation extending from Shasta to Lake county. Front is moving around 30 to 40 kts and should push through the CWA fairly quickly this evening with precip turning showery behind it. Some instability showers showing up ahead of main baroclinic zone over the Motherlode extending into the West Slopes. This in the general area where HRRR is showing increased afternoon CAPE. Precipitation amounts with front look somewhat limited in the Central Valley due to rain shadowing off the Coastal mountains in cross barrier flow. Main bulk of precipitation is expected over the foothills and mountains. Low level strong southerly flow will provide orographic enhancement into the Shasta mountains and moist mid level orographic flow will increase precipitation amounts over the Western Plumas mountains and Sierra Nevada. Precipitation amounts in these areas could range from 1 to 3 inches through Sunday morning. Snow levels are expected to remain above pass levels through early Sunday. Pressure gradients are continuing to tighten ahead of the front and wind speeds have reached or are nearing advisory criteria in the Sacramento Valley. Have expanded the advisory to include the Southern Sacramento Valley, Delta, and Northern San Joaquin Valleys. Strongest winds expected ahead and along the front with winds decreasing with frofa later this evening. Additional waves are forecast to track across Interior NorCal Sunday into Sunday night keeping showers and isolated thunderstorms in the forecast. Best instability depicted Sunday afternoon into early evening. Highest CAPE values depicted over the Northern and Central Sacramento Valley in the afternoon, shifting southward into the Southern Sacramento Valley and Motherlode by early evening. Bufohodographs continue to show significant 0-1 KM and 0-6 KM shear values tomorrow afternoon to support rotating updrafts and mesocyclones. Snow levels will generally remain above pass levels during the day tomorrow but could drop to around 7000-7500 feet in heavier showers. Snow levels then lower Sunday night into Monday. Light snow accumulations are possible at the major pass levels, including Donner Pass on I80 and Echo Summit on Highway 50 Sunday night into Monday. Lassen Park and higher elevations passes such

as Carson Pass, Ebbetts Pass and Sonora Pass could receive more significant amounts of snow impacting travel, especially later Sunday. If significant precipitation continues Sunday night into early Monday, dropping snow levels (~6500 feet) could bring the possibility of travel impacts to the major passes. Will continue to monitor to see if a Winter Weather Advisory for early season snow is warranted.

GEFS/GFS showing integrated water vapor transport decreasing over Interior NorCal Monday with models indicating main threat of light showers confined to the foothills and mountains. Heights increase offshore Tuesday and build inland decreasing threat of precip to just a slight chance over the Shasta mountains. AMS begins to warm Tuesday under increasing subsidence.

PCH

&&

.EXTENDED DISCUSSION (Wednesday THROUGH Saturday)  
High pressure will build over the west coast on Wednesday pushing valley temperatures into the mid 70s which is just a couple of degree below average for this time of year. During this transition to a warmer airmass, surface pressure gradients will tighten on Wednesday which could create some breezy north winds on the west side of the valley. A few more degrees of warming are expected Thursday/Friday with valley temperatures nearing 80 by the end of the week. Over the weekend, the ridge axis shifts to our east although any precipitation will still be well to our north. Wilson

&&

.AVIATION...

**Periods of MVFR/IRF ceilings are expected as rain moves across the valley this afternoon/evening. The strong southerly winds currently associated with this system will weaken behind the front this evening. MVFR and isolated IFR conditions can be expected tonight with the abundant amount of moisture lingering in the valley. South winds will once again pick up Sunday morning/afternoon as another wave moves through. Isolated thunderstorms possible in the northern and eastern sides of the valley tomorrow. Wilson &&**

.STO WATCHES/WARNINGS/ADVISORIES...

Wind Advisory until 11 PM PDT this evening for Burney Basin / Eastern Shasta County-Carquinez Strait and Delta-Central Sacramento Valley-Clear Lake/Southern Lake County-Mountains Southwestern Shasta County to Northern Lake County-Northeast Foothills/Sacramento Valley-Northern Sacramento Valley-Northern San Joaquin Valley-Shasta Lake Area / Northern Shasta County-Southern Sacramento Valley-West Slope Northern Sierra Nevada-Western Plumas County/Lassen Park.

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### 13.0 NWS High Wind Warning

Both the Reno and Sacramento NWS offices issued wind products to warn of the high wind conditions expected. The NWS Reno office issued a High Wind Warning at 1429 PDT which warned of a southwest wind between 25 to 35 mph with gusts to 70 mph and gusts on the Sierra Ridge up to 115 mph. NWS Reno office warned of the possibility of these conditions earlier in the day at 0408 PDT. The NWS Sacramento office also had a wind product issued to warn of the high wind conditions with a Wind Advisory issued at 1410 PDT. The Wind Advisory warned of a southerly wind between 15 and 35 mph with gusts up to 50 mph during the afternoon and evening with higher gusts along the higher terrain near the western slopes of the Sierras:

CAZ072-NVZ002-161200-  
/O.CON.KREV.HW.W.0005.000000T0000Z-161016T0600Z/  
/O.CON.KREV.WI.Y.0016.161016T0600Z-161017T0300Z/  
GREATER LAKE TAHOE AREA-  
INCLUDING THE CITIES OF...SOUTH LAKE TAHOE...TRUCKEE...  
STATELINE...INCLINE VILLAGE  
229 PM PDT SAT OCT 15 2016  
**...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM PDT THIS EVENING...**  
**...WIND ADVISORY REMAINS IN EFFECT FROM 11 PM THIS EVENING TO 8 PM PDT SUNDAY...**  
**\* TIMING: STRONG WINDS WILL CONTINUE THIS EVENING WITH THE HIGHEST GUSTS EXPECTED THROUGH 8 PM. GUSTY WINDS WILL CONTINUE TONIGHT INTO SUNDAY.**  
**\* WINDS THIS AFTERNOON AND EVENING: SOUTHWEST 25 TO 35 MPH WITH GUSTS UP TO 70 MPH. SIERRA RIDGE GUSTS UP TO 115 MPH.**  
**\* WINDS LATE TONIGHT THROUGH SUNDAY: SOUTHWEST 20 TO 30 MPH WITH GUSTS UP TO 55 MPH. SIERRA RIDGE GUSTS UP TO 125 MPH.**  
**\* WAVE HEIGHTS ON LAKE TAHOE: 2 TO 5 FEET. BOATING AND ALL RECREATIONAL ACTIVITY ON THE LAKE IS NOT RECOMMENDED THIS WEEKEND.**  
**\* IMPACTS: TRAVEL IN HIGH PROFILE VEHICLES IS NOT ADVISED WHILE THE STRONGEST WINDS ARE OCCURRING. THESE WINDS COULD PRODUCE SIGNIFICANT DAMAGE TO TREES AND PROPERTY. AVOID WALKING IN AREAS NEAR LARGE TREES AS LARGE LIMBS MAY BE BLOWN DOWN.**  
PRECAUTIONARY/PREPAREDNESS ACTIONS...  
LOOSE OUTDOOR ITEMS SUCH AS PATIO FURNITURE... HOLIDAY DECORATIONS... AND TRASH CANS SHOULD REMAIN SECURED OR MOVED INDOORS THROUGH THIS WEEKEND. MAKE SURE YOU HAVE EXTRA FOOD AND WATER ON HAND... FLASHLIGHTS WITH SPARE BATTERIES AND/OR CANDLES IN THE EVENT OF A POWER OUTAGE.  
&&  
\$\$

WWUS75 KREV 151108  
NPWREV  
URGENT - WEATHER MESSAGE  
NATIONAL WEATHER SERVICE RENO NV  
408 AM PDT SAT OCT 15 2016  
CAZ072-NVZ002-160000-  
/O.CAN.KREV.LW.Y.0054.000000T0000Z-161015T1800Z/  
/O.EXB.KREV.HW.W.0005.161015T1800Z-161016T0600Z/  
/O.EXT.KREV.WI.Y.0016.161016T0600Z-161017T0300Z/

GREATER LAKE TAHOE AREA-

INCLUDING THE CITIES OF...SOUTH LAKE TAHOE...TRUCKEE...

STATELINE...INCLINE VILLAGE

408 AM PDT SAT OCT 15 2016

**...HIGH WIND WARNING IN EFFECT FROM 11 AM THIS MORNING TO 11 PM PDT THIS EVENING...**

**...WIND ADVISORY NOW IN EFFECT FROM 11 PM THIS EVENING TO 8 PM PDT SUNDAY...**

**THE NATIONAL WEATHER SERVICE IN RENO HAS ISSUED A HIGH WIND WARNING, WHICH IS IN EFFECT FROM 11 AM THIS MORNING TO 11 PM PDT THIS EVENING. THIS REPLACES THE LAKE WIND ADVISORY. THE WIND ADVISORY IS NOW IN EFFECT FROM 11 PM THIS EVENING TO 8 PM PDT SUNDAY.**

**\* TIMING: WINDS WILL INCREASE LATE THIS MORNING WITH STRONG WINDS LIKELY THIS AFTERNOON AND EVENING. GUSTY WINDS WILL CONTINUE TONIGHT INTO SUNDAY.**

**\* WINDS THIS AFTERNOON AND EVENING: SOUTHWEST 25 TO 35 MPH WITH GUSTS UP TO 70 MPH. SIERRA RIDGE GUSTS UP TO 115 MPH.**

**\* WINDS LATE TONIGHT THROUGH SUNDAY: SOUTHWEST 20 TO 30 MPH WITH GUSTS UP TO 55 MPH. SIERRA RIDGE GUSTS UP TO 125 MPH.**

**\* WAVE HEIGHTS ON LAKE TAHOE: 2 TO 5 FEET. BOATING AND ALL RECREATIONAL ACTIVITY ON THE LAKE IS NOT RECOMMENDED THIS WEEKEND.**

**\* IMPACTS: TRAVEL IN HIGH PROFILE VEHICLES IS NOT ADVISED WHILE THE STRONGEST WINDS ARE OCCURRING. THESE WINDS COULD PRODUCE SIGNIFICANT DAMAGE TO TREES AND PROPERTY. AVOID WALKING IN AREAS NEAR LARGE TREES AS LARGE LIMBS MAY BE BLOWN DOWN.**

**PRECAUTIONARY/PREPAREDNESS ACTIONS...**

**LOOSE OUTDOOR ITEMS SUCH AS PATIO FURNITURE... HOLIDAY DECORATIONS... AND TRASH CANS SHOULD REMAIN SECURED OR MOVED INDOORS THROUGH THIS WEEKEND. MAKE SURE YOU HAVE EXTRA FOOD AND WATER ON HAND... FLASHLIGHTS WITH SPARE BATTERIES AND/OR CANDLES IN THE EVENT OF A POWER OUTAGE.**

**&&**

**\$\$**

CAZ013>016-063-064-066-068-069-160600-

/O.CON.KSTO.WI.Y.0025.000000T0000Z-161016T0600Z/

SHASTA LAKE AREA / NORTHERN SHASTA COUNTY-

BURNEY BASIN / EASTERN SHASTA COUNTY-NORTHERN SACRAMENTO VALLEY-CENTRAL SACRAMENTO VALLEY-

MOUNTAINS SOUTHWESTERN SHASTA COUNTY TO NORTHERN LAKE COUNTY-CLEAR LAKE/SOUTHERN LAKE COUNTY-

NORTHEAST FOOTHILLS/SACRAMENTO VALLEY-

WESTERN PLUMAS COUNTY/LASSEN PARK-

WEST SLOPE NORTHERN SIERRA NEVADA-

INCLUDING THE CITIES OF...SHASTA DAM ...BURNEY...REDDING...

RED BLUFF...CHICO...OROVILLE...MARYSVILLE/YUBA CITY ...

ALDER SPRINGS...LAKEPORT...PARADISE...CHESTER...QUINCY...

BLUE CANYON

210 PM PDT SAT OCT 15 2016

**...WIND ADVISORY REMAINS IN EFFECT UNTIL 11 PM PDT THIS EVENING...**

**\* TIMING...STRONG WINDS WILL CONTINUE INTO THE EVENING HOURS.**

**\* WINDS...SOUTHERLY WIND 15 TO 35 MPH WITH GUSTS UP TO 50 MPH ARE POSSIBLE THIS EVENING WITH STRONGER WIND POSSIBLE OVER HIGHER TERRAIN.**

**\* IMPACTS...DIFFICULT DRIVING CONDITIONS...ESPECIALLY FOR SMALL CARS AND HIGH PROFILE VEHICLES. TOPPLED TREES AND DOWNED BRANCHES MAY CAUSE POWER OUTAGES.**

&&

INTERACT WITH US VIA SOCIAL MEDIA [WWW.FACEBOOK.COM/NWS.SACRAMENTO](http://WWW.FACEBOOK.COM/NWS.SACRAMENTO)  
[WWW.TWITTER.COM/NWSSACRAMENTO](http://WWW.TWITTER.COM/NWSSACRAMENTO)

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## **14.0 Winds and Temperature Aloft Forecast**

The NWS 1259 PDT Winds and Temperature Aloft forecast valid for the flight is included below:

FBUS31 KWN0 151959

2016289 2000

FD1US1

\_DATA BASED ON 151800Z

VALID 160000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

\_RNO 2238 2263+04 2361-01 2476-13 2487-23 750339 740044 740349

The Reno, Nevada, (RNO) forecast point (closest Winds and Temperature Aloft forecast point to the accident site) indicated a wind at 6,000 feet from 220° at 38 knots, a wind at 9,000 feet from 220° at 63 knots with a temperature of 4° C, and a wind at 12,000 feet from 230° at 61 knots with a temperature of -1° C.

## **15.0 Pilot Weather Briefing Information**

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS) and Direct User Access Terminal Service (DUATS), revealed that the accident pilot did not contact LMFS or DUATS. A search of archived ForeFlight information indicated that ForeFlight did not have any record of the accident pilot accessing weather information. According to an interview with a ForeFlight technical representative<sup>24</sup>, with no internet access while in flight, ForeFlight is still able to access weather information directly from the FAA, but leaving no remote record of such access. There is no record of the accident pilot receiving or retrieving any other weather information before the accident flight.

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<sup>24</sup> Conducted by the investigator in charge (IIC).

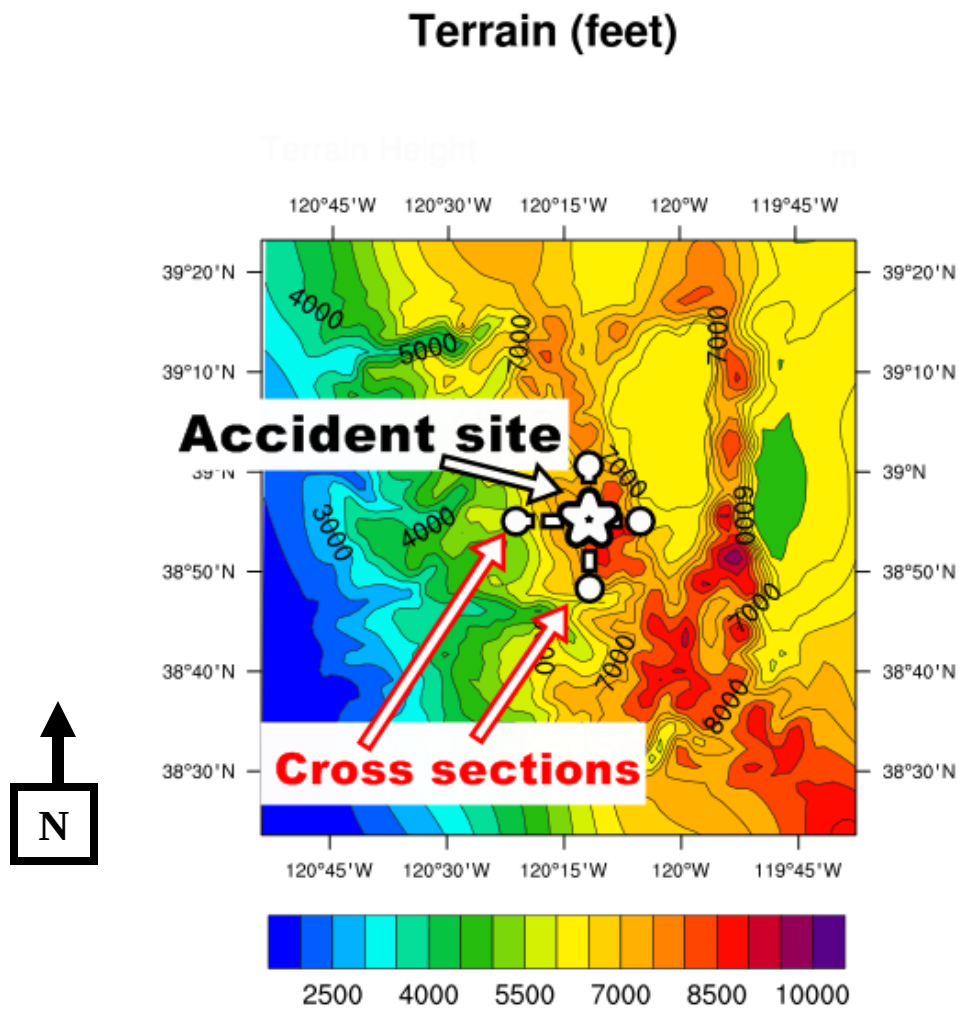
## 16.0 Weather Research and Forecasting Model Simulation

A Weather Research and Forecasting Model (WRF) simulation was run to simulate the weather conditions surrounding the accident site at the accident time. 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: 50 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 feet) used in domain 2 is shown in figure 24 along with the location of the cross sections used figures 25 through 34 (along with attachments 4 through 9) with the location of the accident site marked. Each grid point indicated in the bottom of figures 25 through 34 and attachments 4 through 9 is 320 meter horizontal distance. Figures 25 and 26 depict the potential temperature<sup>25</sup> in degrees Kelvin (solid lines) and horizontal wind speed in knots (color fill) at 1550 and 1600 PDT, respectively, around the accident site with the location of the accident site marked and the cross section oriented from north to south. The horizontal wind speed increased near the accident site and the top of the mountains between 1550 and 1600 PDT from near 60 knots at 1550 PDT to above 70 knots at 1600 PDT. The increase in wind speed is in the west to east cross sections at 1550 and 1600 PDT (figures 27 and 28). At the flight level the accident flight was travelling at before the encounter with terrain, the accident flight<sup>26</sup> would have encountered wind speeds between 50 and 70 knots (attachments 4 and 5). Figures 29 and 30 depict the potential temperature in degrees Kelvin (solid lines) and relative humidity in percent (color fill) at 1550 PDT along a north to south cross section (figure 29) and west to east cross section (figure 30) with the accident site marked. The accident flight and accident site were located in areas of greater than 95 percent relative humidity at 1550 PDT with the relative humidity remaining at or above 90 percent between 1450 through 1650 PDT (attachments 6 and 7). Figures 31, 32, 33, and 34 depict the potential temperature in degrees Kelvin (solid lines) and vertical velocity in feet per minute (color fill) at 1550 and 1600 PDT along a north to south cross section (figures 31 and 32) and west to east cross section (figures 33 and 34). The vertical velocity data indicated that the accident flight was in an area of downdrafts with a velocity between 1,000 and 1,500 feet per minute (figures 31, 32, 33, and 34) with increasing downdraft velocity near the terrain (attachments 8 and 9). Even though the accident flight did have head wind conditions (section 4.0, figures 25 through 28) around the accident time, it was in an area of downdrafts and mountain wave conditions (figures 31 through 34, attachments 8 and 9, and section 4.0).

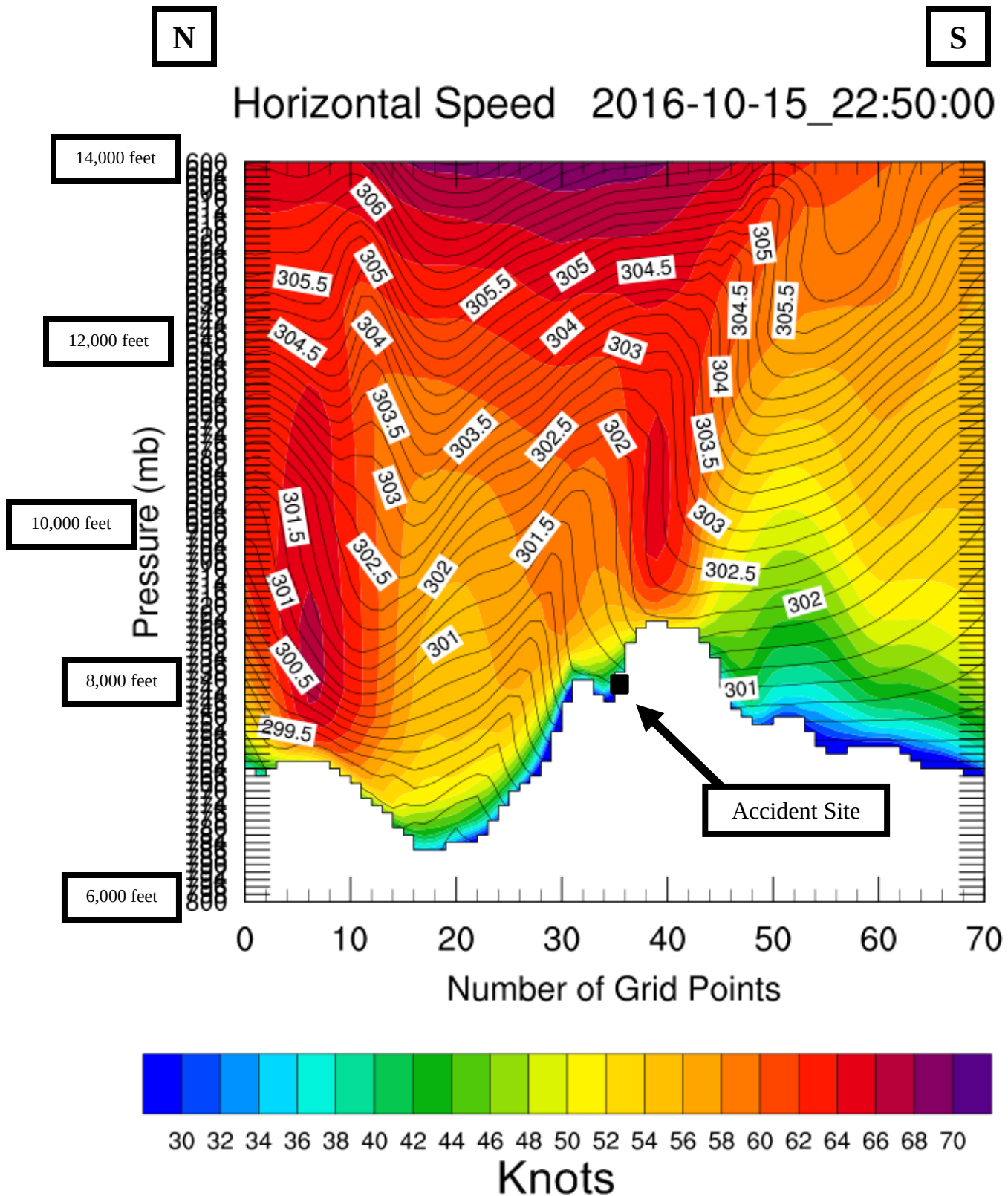
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<sup>25</sup> Potential temperature of a [parcel](#) of fluid at pressure  $P$  is the temperature that the parcel would acquire if [adiabatically](#) brought to a standard reference pressure  $P_0$ , usually 1000 hPa.

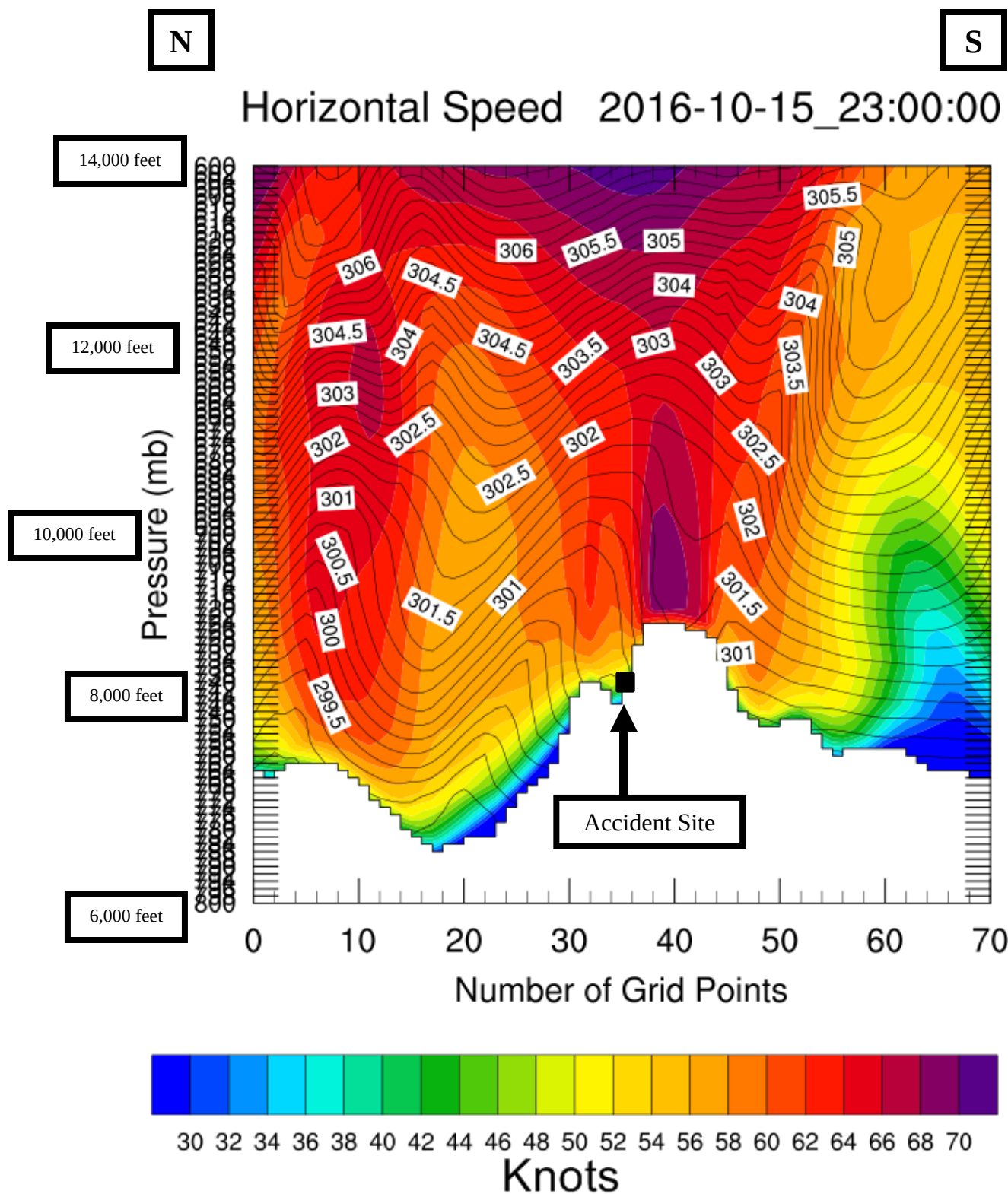
<sup>26</sup> For more information please see the ATC data contained in the docket of this accident.



**Figure 24 – WRF simulation terrain in feet with the accident site marked and the locations of the cross sections in the following figures**



**Figure 25 – WRF cross section from 1550 PDT of horizontal wind speed in knots (color fill) and potential temperature in kelvin (black lines) from north to south across the terrain with the approximate accident site marked**



**Figure 26 – WRF cross section from 1600 PDT of horizontal wind speed in knots (color fill) and potential temperature in kelvin (black lines) from north to south across the terrain with the approximate accident site marked**

W

E

Horizontal Speed 2016-10-15\_22:50:00

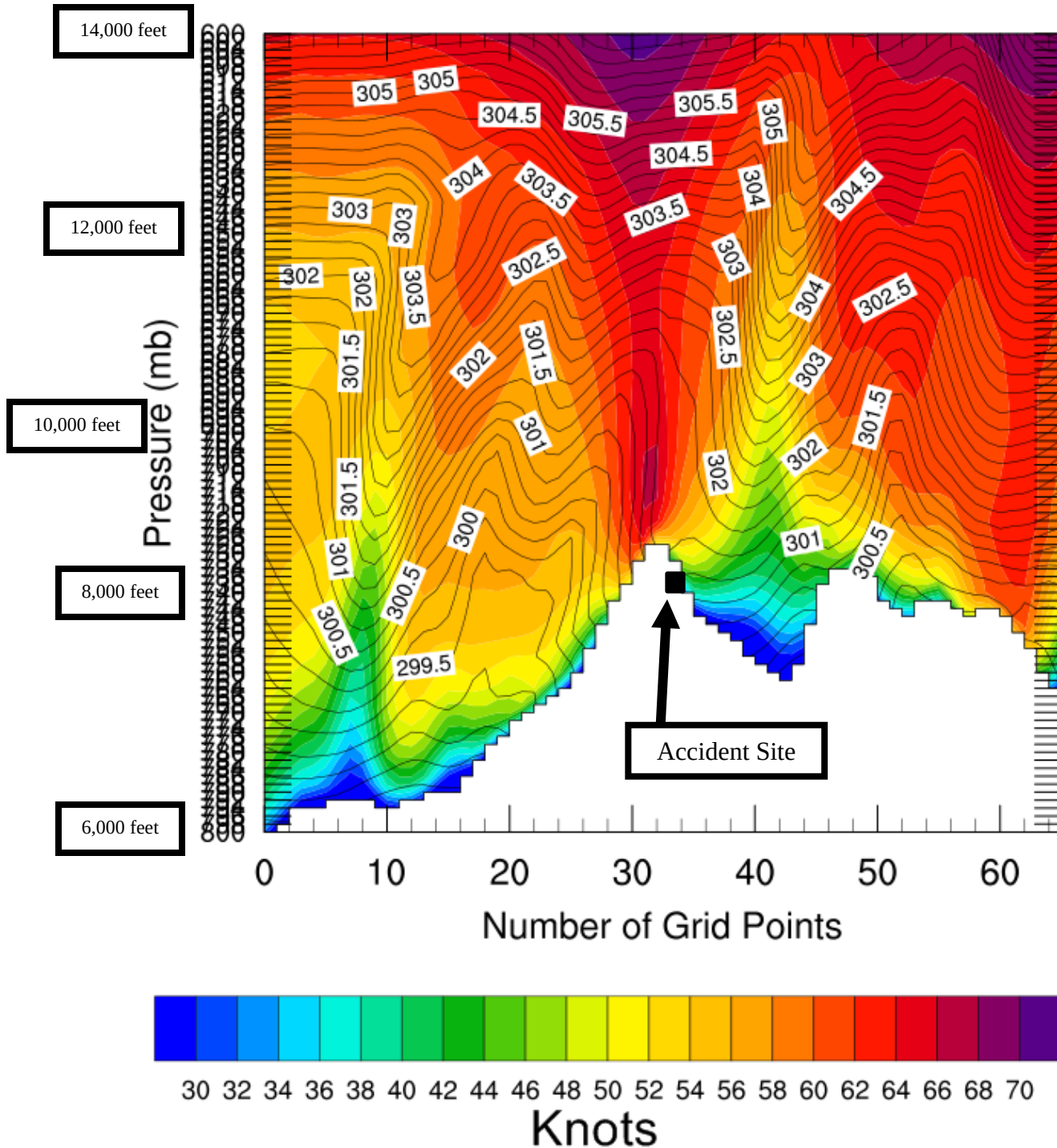
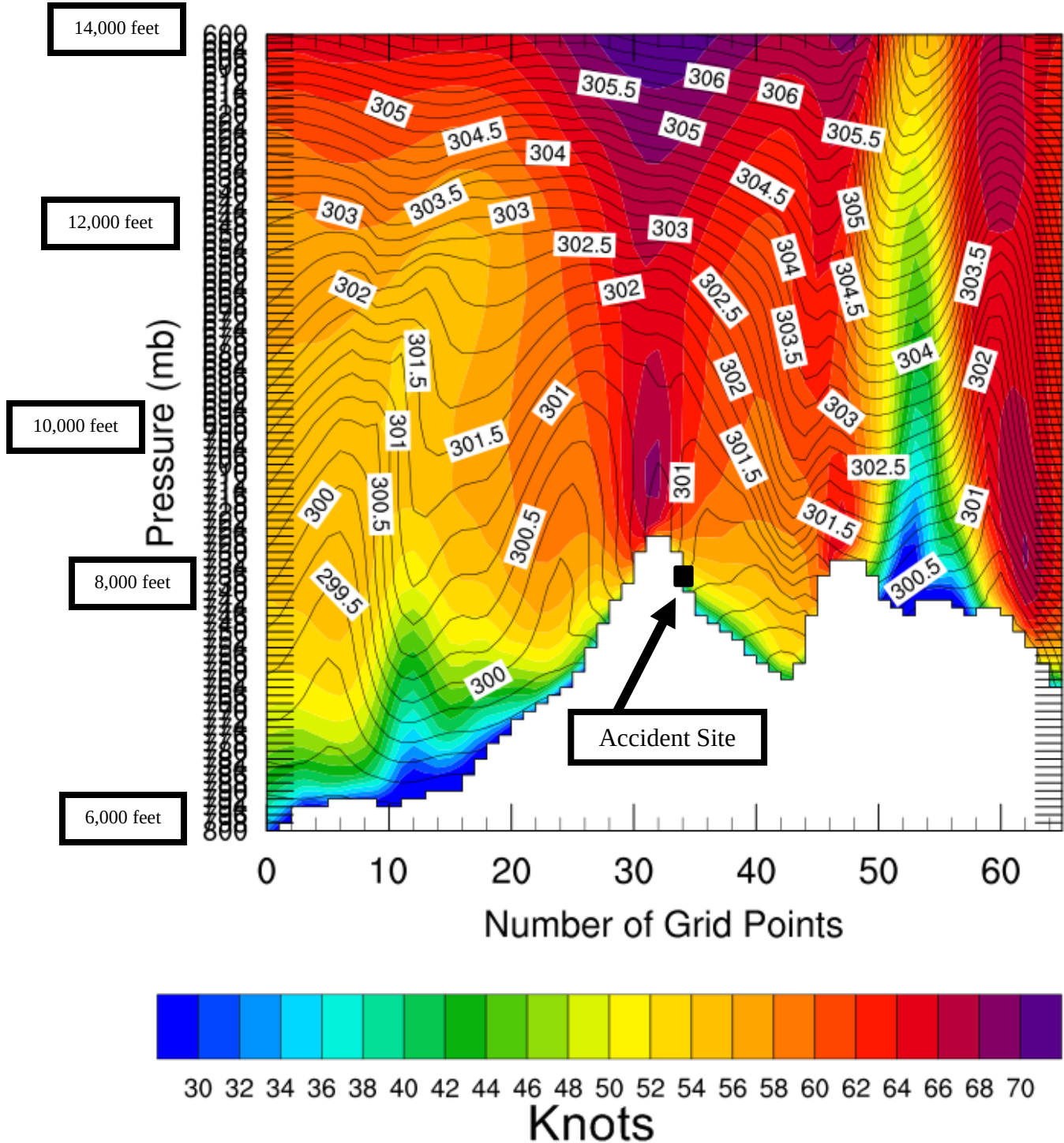


Figure 27 – WRF cross section from 1550 PDT of horizontal wind speed in knots (color fill) and potential temperature in kelvin (black lines) from west to east across the terrain with the approximate accident site marked

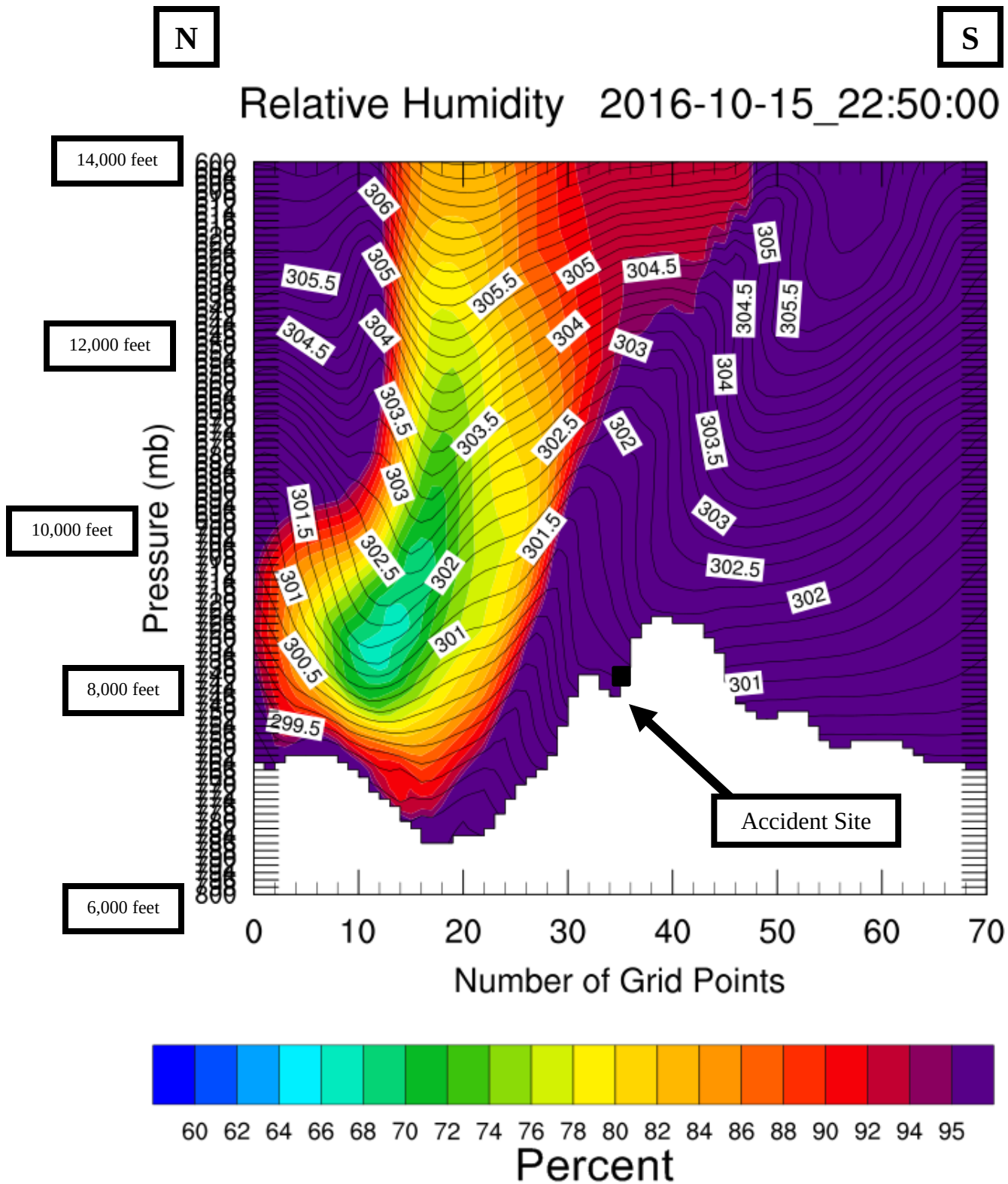
W

E

## Horizontal Speed 2016-10-15\_23:00:00



**Figure 28 – WRF cross section from 1600 PDT of horizontal wind speed in knots (color fill) and potential temperature in kelvin (black lines) from west to east across the terrain with the approximate accident site marked**

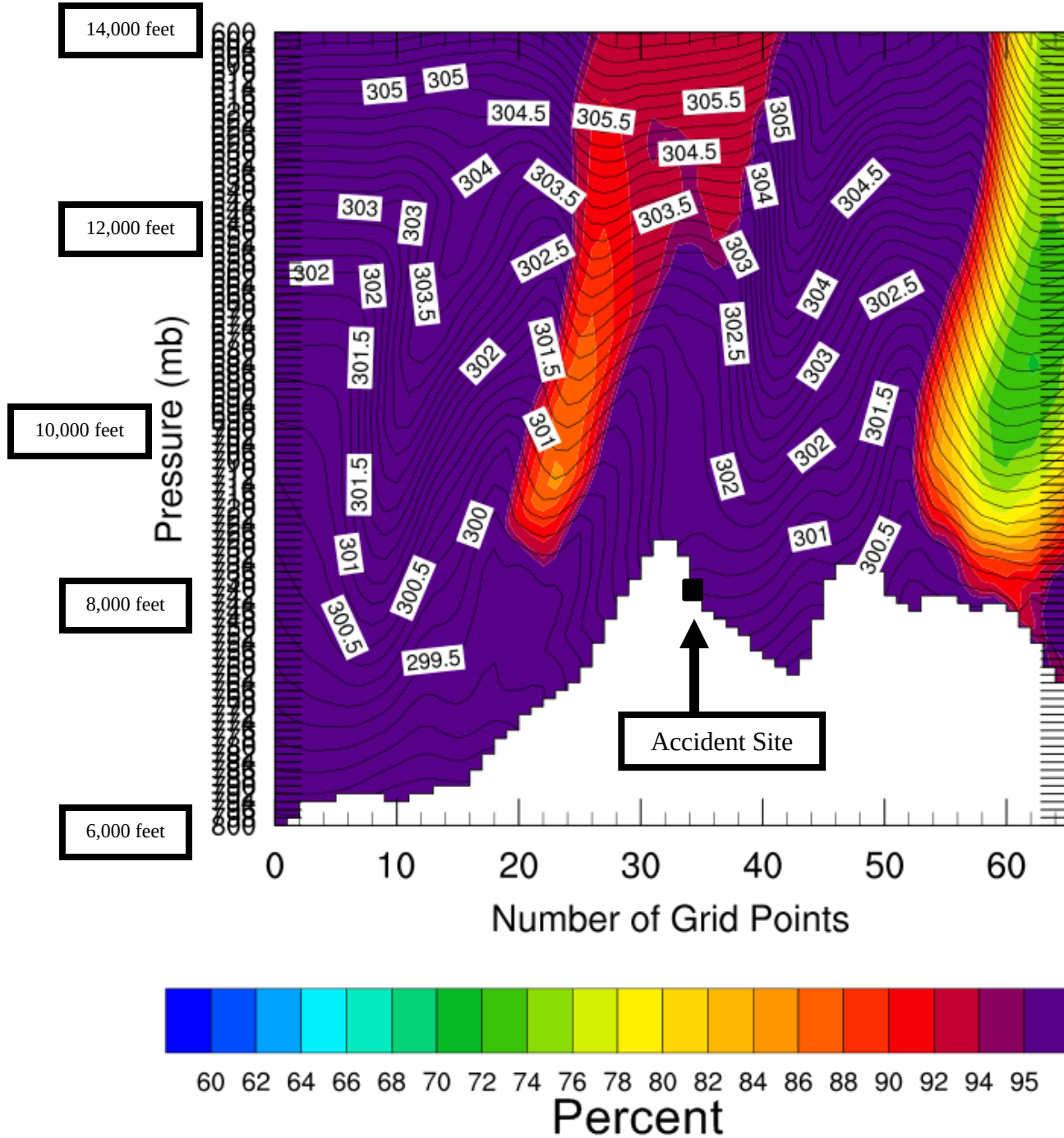


**Figure 29 – WRF cross section from 1550 PDT of relatively humidity in percent (color fill) and potential temperature in kelvin (black lines) from north to south across the terrain with the approximate accident site marked**

W

E

Relative Humidity 2016-10-15\_22:50:00



**Figure 30 – WRF cross section from 1550 PDT of relatively humidity in percent (color fill) and potential temperature in kelvin (black lines) from west to east across the terrain with the approximate accident site marked**

N

S

Vertical Velocity 2016-10-15\_22:50:00

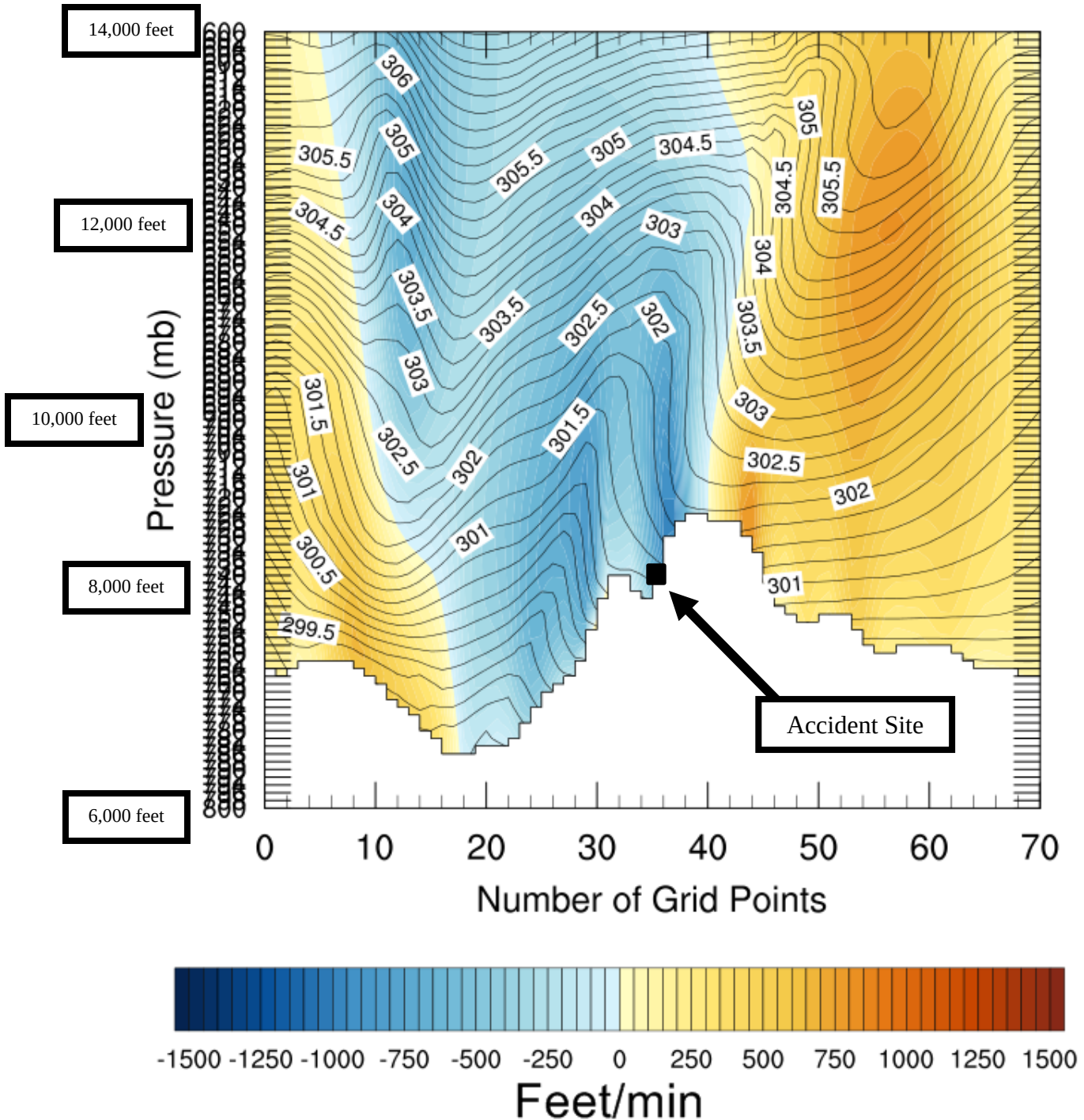


Figure 31 – WRF cross section from 1550 PDT of vertical velocity in feet per minute (color fill) and potential temperature in kelvin (black lines) from north to south across the terrain with the approximate accident site marked

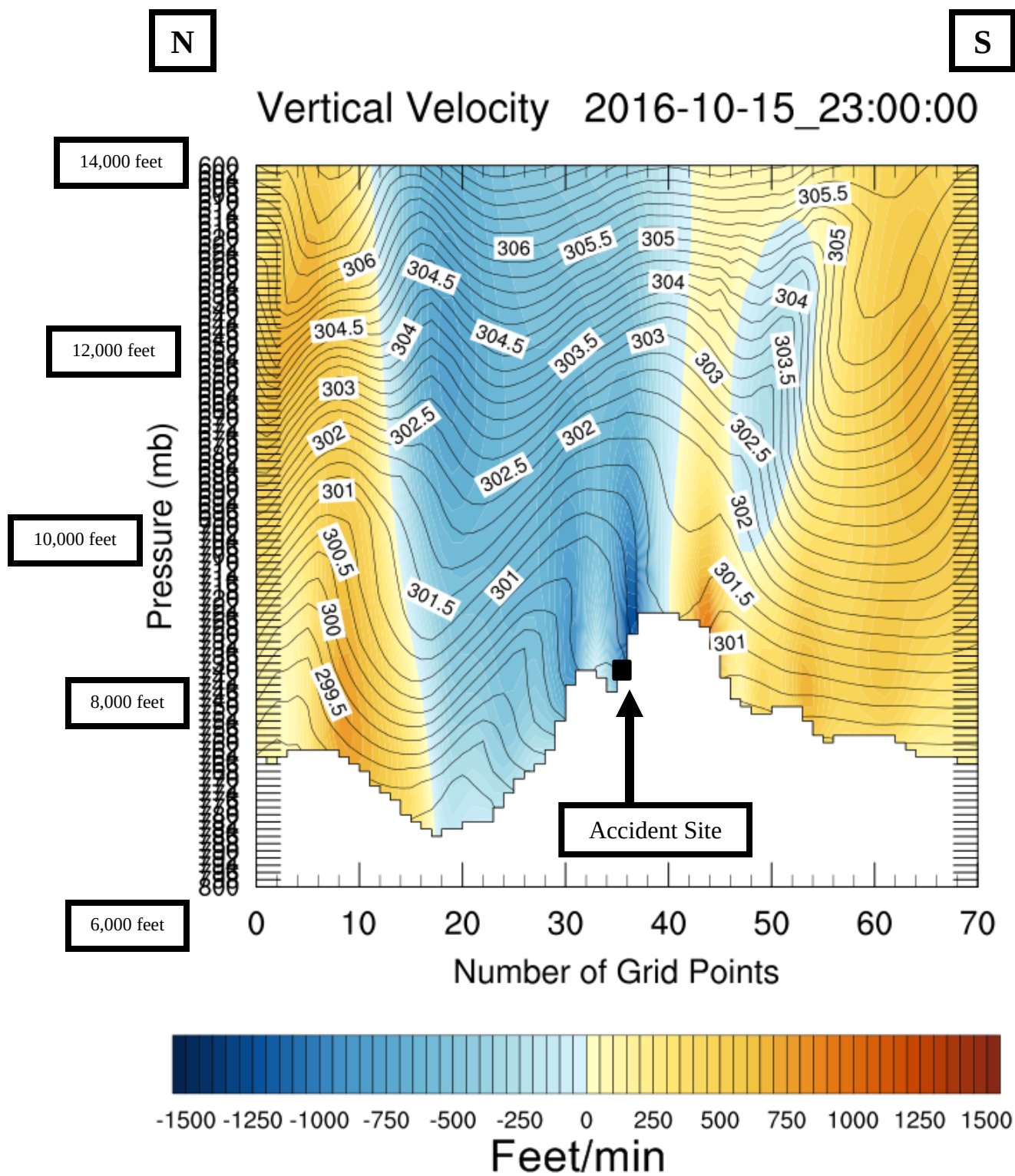
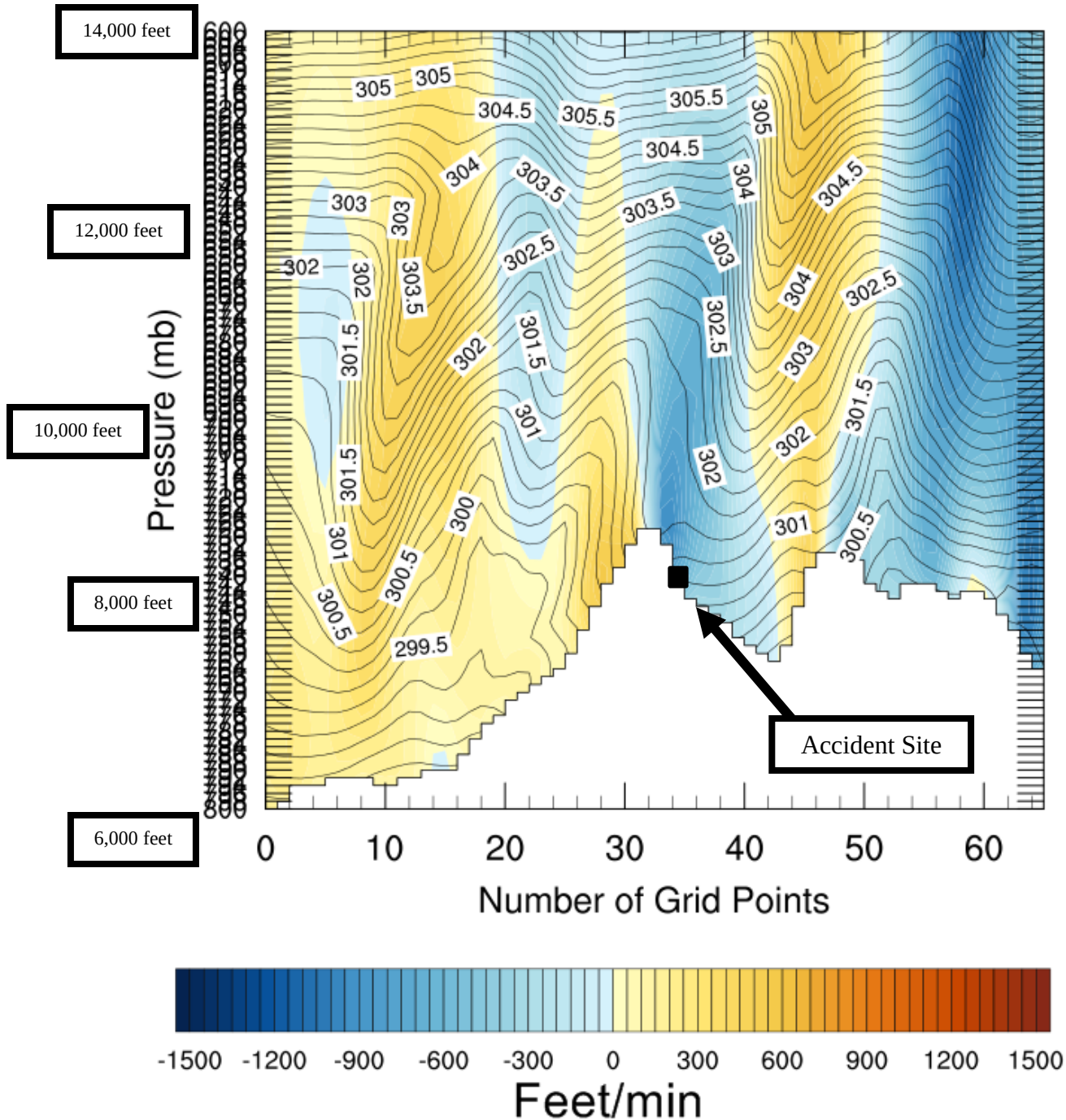


Figure 32 – WRF cross section from 1600 PDT of vertical velocity in feet per minute (color fill) and potential temperature in kelvin (black lines) from north to south across the terrain with the approximate accident site marked

W

E

## Vertical Velocity 2016-10-15\_22:50:00

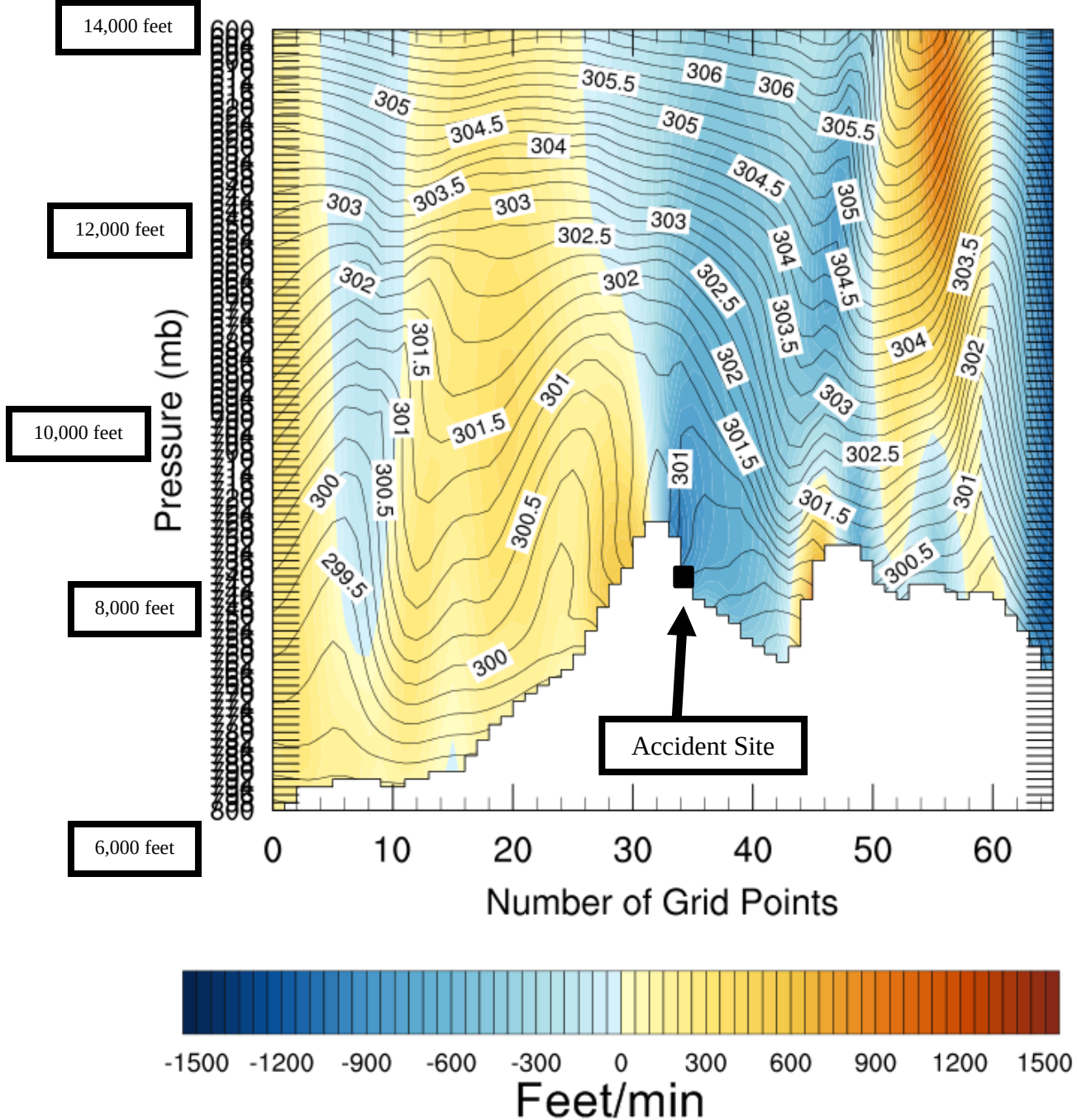


**Figure 33 – WRF cross section from 1550 PDT of vertical velocity in feet per minute (color fill) and potential temperature in kelvin (black lines) from west to east across the terrain with the approximate accident site marked**

W

E

# Vertical Velocity 2016-10-15\_23:00:00



**Figure 34 – WRF cross section from 1600 PDT of vertical velocity in feet per minute (color fill) and potential temperature in kelvin (black lines) from west to east across the terrain with the approximate accident site marked**

## 17.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on October 15, 2016, indicated the following:

### SUN

|                      |          |
|----------------------|----------|
| Begin civil twilight | 0644 PDT |
| Sunrise              | 0711 PDT |
| Sun transit          | 1246 PDT |
| Sunset               | 1821 PDT |
| End civil twilight   | 1848 PDT |

## F. LIST OF ATTACHMENTS

Attachment 1 – GOES-15 visible satellite animation from 1445 to 1645 PDT

Attachment 2 – KRGX base reflectivity animation of 0.5° data from 1522 to 1600 PDT

Attachment 3 – Timeline of weather products issued by ZOA CWSU

Attachment 4 – Animation of a north to south WRF cross section of horizontal wind speed and potential temperature from 1450 to 1650 PDT

Attachment 5 – Animation of a west to east WRF cross section of horizontal wind speed and potential temperature from 1450 to 1650 PDT

Attachment 6 – Animation of a north to south WRF cross section of relative humidity and potential temperature from 1450 to 1650 PDT

Attachment 7 – Animation of a west to east WRF cross section of relative humidity and potential temperature from 1450 to 1650 PDT

Attachment 8 – Animation of a north to south WRF cross section of vertical velocity and potential temperature from 1450 to 1650 PDT

Attachment 9 – Animation of a west to east WRF cross section of vertical velocity and potential temperature from 1450 to 1650 PDT

Submitted by:

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Paul Suffern  
Senior Meteorologist

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