AN ANALYSIS OF A WINTERTIME FRONTAL PASSAGE EVENT OFF THE CALIFORNIA COAST 2 FEBUARY 2004

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Introduction

The wintertime synoptic pattern off the California coast is very much the ‘other side of the coin’ when compared to the summertime pattern over the same region. The East Pacific High (EPH), which dominates the pattern in the summer, is further south in winter. This means that the area is no longer dominated by large-scale subsidence. Without this subsidence and its warming effects from above, adiabatic warming aloft in the region along the California coast is significantly curtailed. Also, the wind pattern is not dominated by the EPH off the coast anymore. When the EPH is positioned in the north then ~~the~~ its strong northwesterly winds will cause Ekman divergence in the water below them. This causes the sea surface temperature to become much cooler as Ekman pumping replaces the warmer water up top with the cooler water from below. Without the steady northwesterly winds from the high this upwelling is less pronounced.

The net effects of the movement of the EPH to a more southern position are to decrease the amount of subsidence in the region and significantly decrease the strength of the inversion off the coast. Also, without the presence of the high to block them from the coast~~;~~ , migratory low-pressure systems continually pass over the region churning up the troposphere along the coast and influencing the weather throughout the region.

The frontal boundaries associated with these migratory systems modify the wind patterns along the coast of California. Near the surface, the frontal boundaries themselves are modified as they interact with the steep and varied topography of the California coast. Some of the net effects upon the wind as a result of these frontal boundary/topographical interactions include: wind shifts, wind intensifications, and pressure fluctuations. One such frontal passage during early February of 2004 is the focus of this study.

Measurement Techniques

The data for this study were collected during the second leg of the OC 3570 Winter cruise from 30 JAN – 3 FEB 2004. The focus is from 1 – 3 FEB 2004 when the frontal passage in question took place. These data were collected using several different methods. Rawinsondes were launched at regular intervals to acquire information about temperature, dew point, wind speed, and wind direction at the location of the R/V Pt. Sur. This study is chronologically categorized according to the times of these rawinsonde launches. Measurements were taken using the R/V Pt. Sur's Underway Data Acquisition System (UDAS). This information was used to get wind speed, wind direction, and surface pressure measurements. Also used were~~,~~ the student-made shipboard observations at hourly intervals throughout the cruise, satellite images, hourly buoy observations, hourly shore station observations, NOGAPS analysis, and COAMPS analysis.

Data Processing Techniques

The UDAS data used were processed and displayed using MATLAB code. The rawinsonde data was displayed using a FORTRAN program written by Mr. Dick Lind of the NPS Department of Meteorology. The NOGAPS fields, COAMPS fields, Ship/Buoy observations, and satellite images were viewed and analyzed using GARP software in the Meteorology Department's computer laboratory. Finally, the wind profiler at the former Ft. Ord was utilized to obtain additional time series of the frontal passage event further inland. All of the figures in this document were generated by one of the above methods. In this report the key figures are included at the end. All additional figures are found on the accompanying Power Point presentation.

Synoptic Overview

A shortwave trough began to enter the California region on 31 January 2004. By 12Z on 1 February, the warm front was off the California coast and the associated cold front was not far behind. Prior to the passage, a pattern of a slight inversion was present along the coast. When the front passes over the area it shifts winds, lowers pressures, and mixes the atmosphere around it. It also has the effect of eliminating whatever was there in terms of an inversion, and this is seen in the soundings taken by R/V Pt. Sur. By approximately 19Z on 2 February, the cyclone’s cold front has made landfall. After the landfall a bit of subsidence returns to the area along with its characteristic inversion by 3 February 2004.

Onboard Pt. Sur: Sonde 21

Sonde twenty-one (Figure 1) takes place before the pattern is under the influence of the oncoming cold front. It can be seen that the characteristic inversion had not reestablished itself from the previous frontal passage on 1 FEB 04. The winds of the sonde are light and variable. This is an interesting contrast to the observations made by the nearby buoy observations and the synoptic pattern revealed by the COAMPS analysis. The wind direction in the COAMPS fields is what is from the southwest for this synoptic time, but the winds are stronger than the sonde. This is an exception to the findings throughout the rest of this case study. The remainders of the sondes have wind speeds that are faster than their corresponding COAMPS winds. Buoy observations for this time period show that the flow is more southerly and is about five to ten knots faster than the sonde. The reason the sonde is a bit light during this time is that the Pr. Sur was sheltered from the higher winds by either some obstruction. At the time of this sonde the Pt. Sur was close to the protection of Monterey Bay’s physical features. Surface observations for this time indicate that the winds were a steady five to ten knots from the south.

Onboard Pt. Sur: Sonde 22

Sonde 22 (figure 2) tells a decidedly different story than sonde 21. The winds are a steady southwesterly flow at a constant thirty to forty knots all the way up through the length of the sonde. Temperatures in the sonde steadily decrease with height as is expected. At this time the oncoming front’s influence on the atmosphere around the Pt. Sur is clearly seen. The winds are backing consistently with the oncoming frontal passage. This is in good agreement with the synoptic pattern that COAMPS model is analyzing for its 12Z run. However the COAMPS winds are slightly less than those observed on Pt. Sur. Surface observations during this time give the telltale signs of a frontal passage that is soon to arrive in a few hours time. It is overcast with the winds shifting to a southwesterly flow. Also, visibility had dropped a significant amount in the same time. Buoy observations show a southerly flow as the winds are forced into backing significantly. All observations surrounding this sonde show agreement with one another. This sonde is most representative of what is going on in the mesoscale picture around it. The phenomena of backing winds at 14Z are not the actual frontal passage. At first glance it is easy to mistake these winds for a frontal passage, however it is not, as will be discussed later. Rather these winds are likely a result of a gravity wave event that preceded the frontal passage. The Fort Ord wind profiler (figure 4) has winds backing at its location at 19Z or so. This would coincide with a frontal passage in that area. A look at the UDAS data (figure 3) from 2 FEB 04 reveals the whole story.

For the 19Z time the UDAS shows a wind shift from around 260 degrees to 200 degrees or so. The temperature for this time drops four degrees in the course of an hour.

Finally, UDAS shows that the pressure drops steadily around this time. This is consistent with a frontal passage event. Therefore, it is reasonable to say that we have a frontal passage at 19Z according to the UDAS.

Onboard the Pt. Sur: Sonde 23

By the time of sonde 23 (figure 5) we see that the front has passed and the synoptic scale pattern is beginning to have more influence over the region. The winds are coming from the West at a steady speed of twenty to thirty knots. COAMPS synoptic scale flow away from the coast supports this. However, an interesting thing is observed by looking at the buoy observations in Monterey bay. The flow across the buoys is flowing in a southwesterly pattern up toward the coast. However, the COAMPS wind fields this close to the coast show a much more northerly flow. This is the result of the coastally trapped winds flowing in a coast parallel fashion. However, by this time, these winds have shifted themselves according to the buoy observations and the sonde observations on the R/V Pt. Sur. It is indicative of COAMPS inability to resolve wind features close to the coast in a timely manner. The model does not correct for the new influence of the synoptic pattern and is still showing the influence of the approaching front that has already passed. Further study for this case will reveal exactly how much difference there is between the buoy wind speed/direction and what COAMPS analyzed for the same period of time. Previous analysis of cases along the coast during the winter of 2003-2004 shows the same tendency.

Onboard the Pt. Sur: Sonde 25

Close to 00Z/3 FEB 2004 the synoptic pattern begins to make its presence known in the sonde launched by the R/V

Pt. Sur. Sonde 25 (figure 6) reveals that at this time the Mid-latitude cyclone has crossed over and made landfall in Canada. Off the coast the Pt. Sur is seeing sustained westerly winds at lower speeds of ten to fifteen knots. COAMPS synoptic scale fields reinforces this with good agreement. The COAMPS winds along the coast are finally coming around to the west as well. They are making their transition around to the west responding to the synoptic forcing.

Conclusions and Future Study

Several tendencies for the COAMPS model were revealed during the course of this analysis. First, the winds predicted by the model tended to be about five to ten knots light when compared to buoy observations. Second, and most interestingly, COAMPS was slow to correct for the renewed influence of the synoptic scale forcing when fields were analyzed against the coastline of California. It was also shown given the initial error in frontal position analysis that several inputs of data are helpful to get a sense of the ‘whole picture’. Future study for series frontal passage events should include a statistical analysis of the error between model analysis and observed values. This way a mean tendency for the model could be formulated and guidance made for forecasters using the model data.

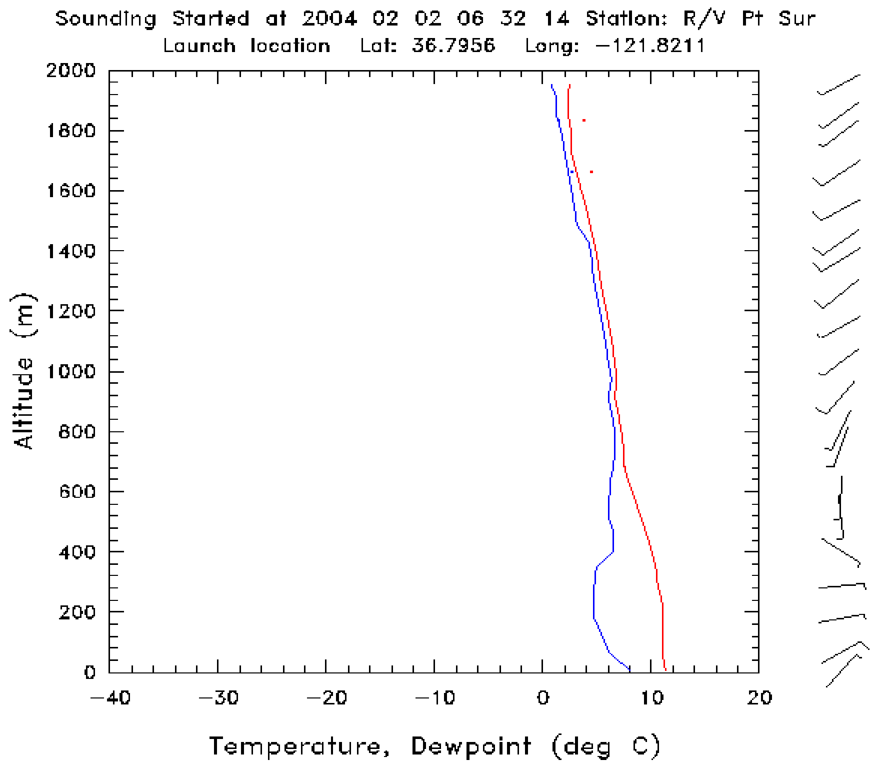


Figure 1: Sonde 21

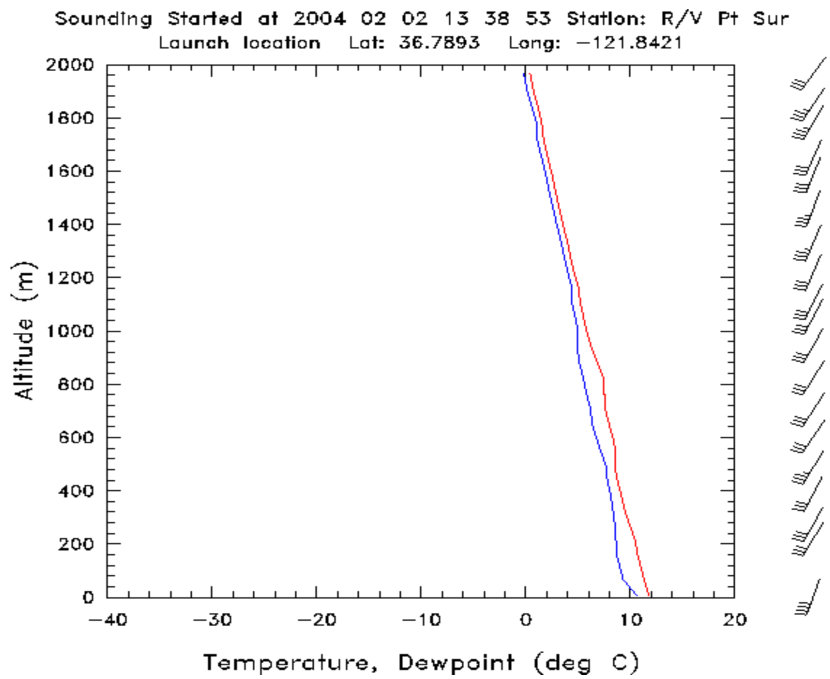
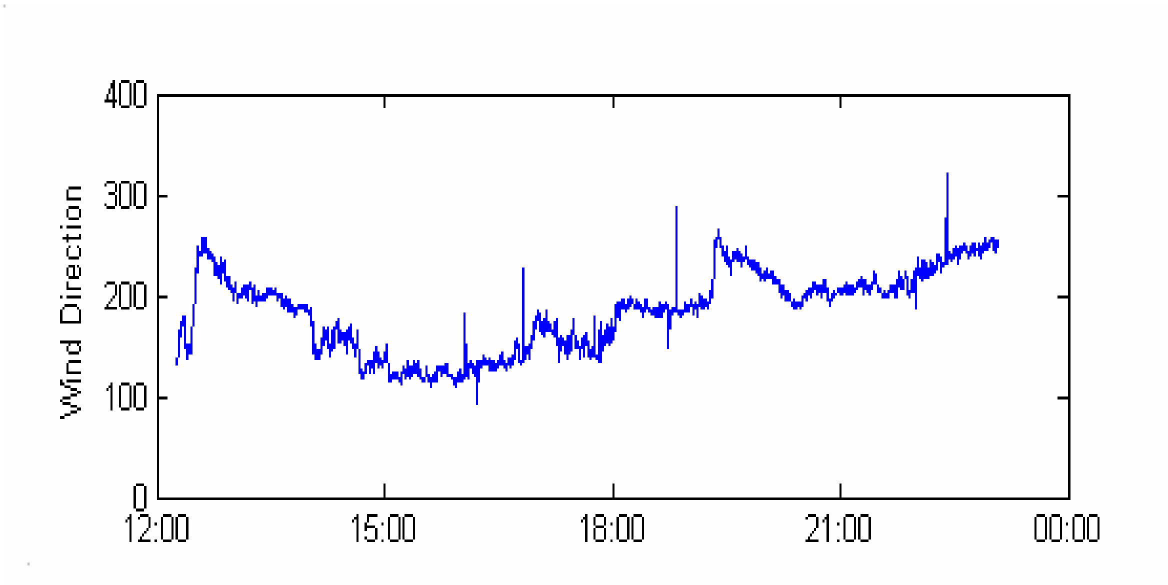


Figure 2: Sonde 22



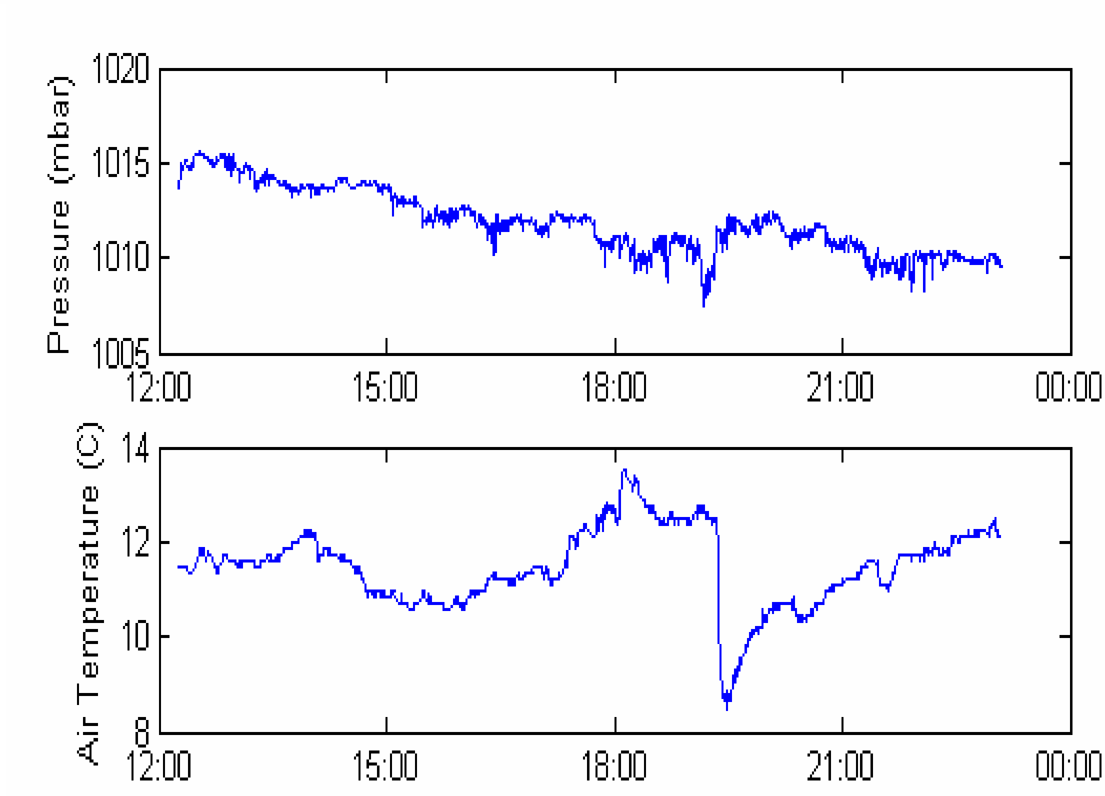


Figure 3: UDAS from Pt. Sur

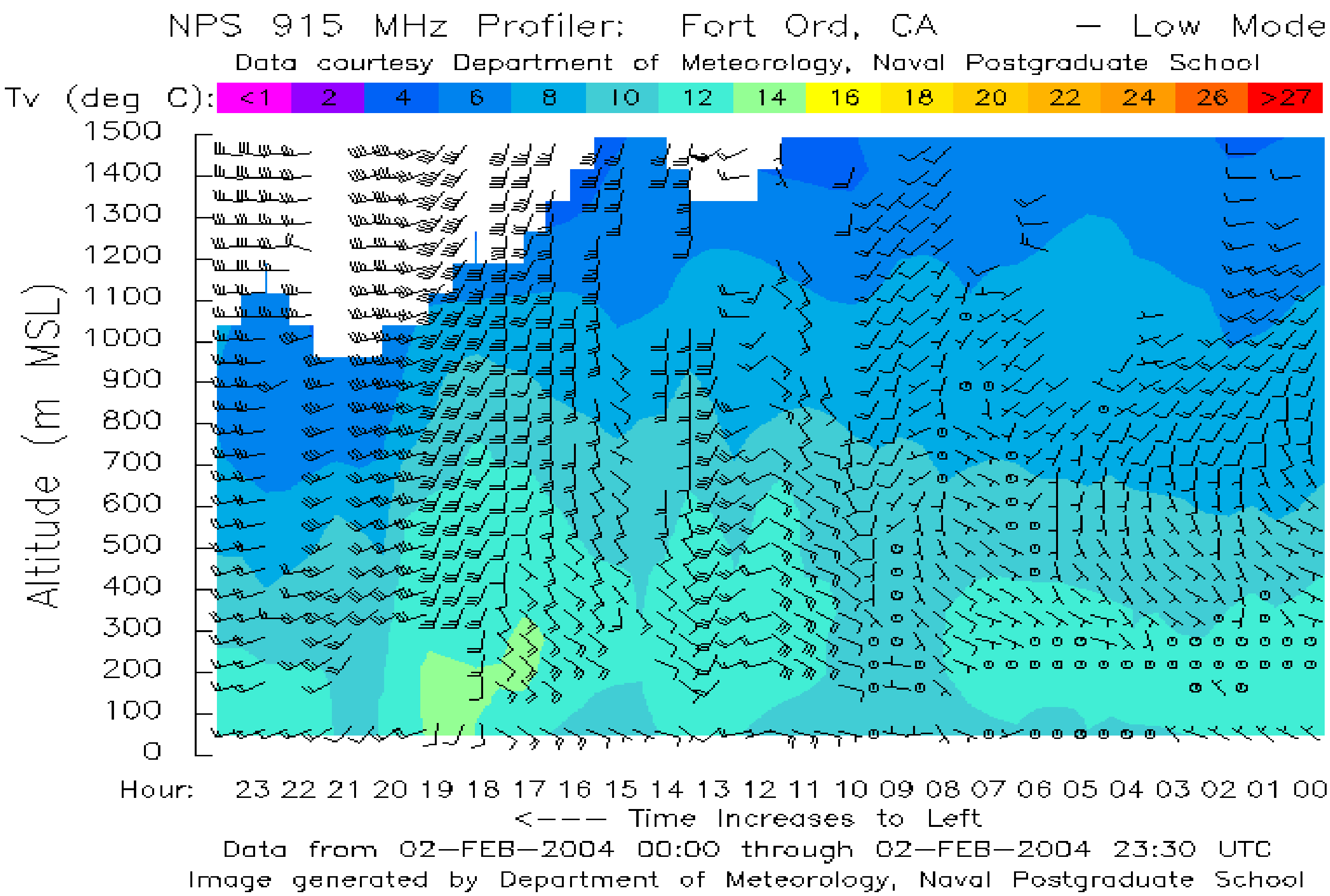


Figure 4: Ft. Ord Profiler

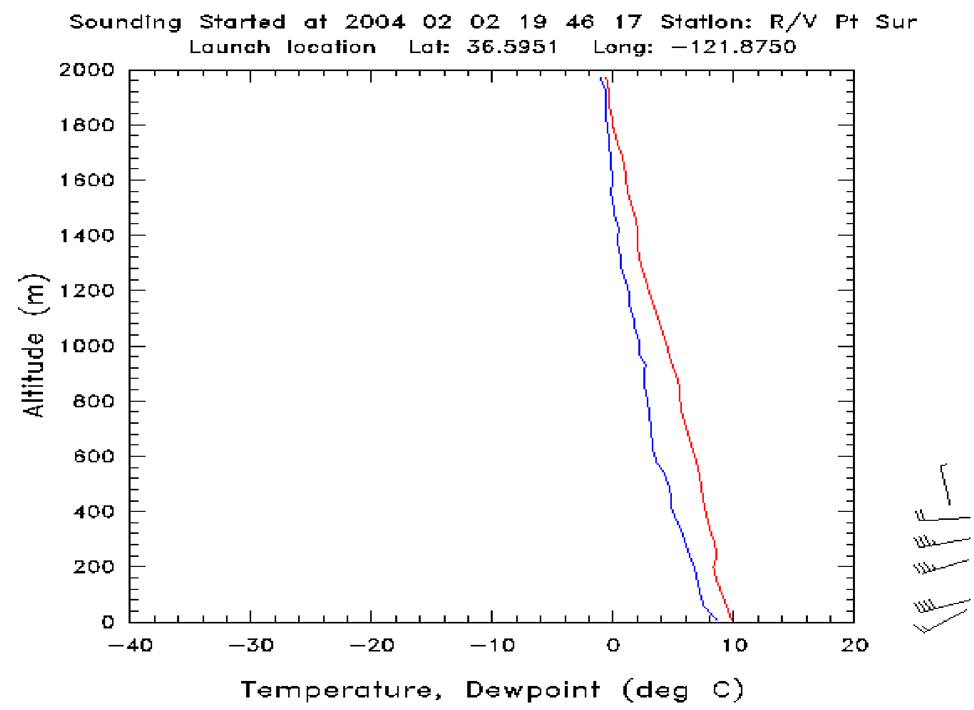


Figure 5: Sonde 23

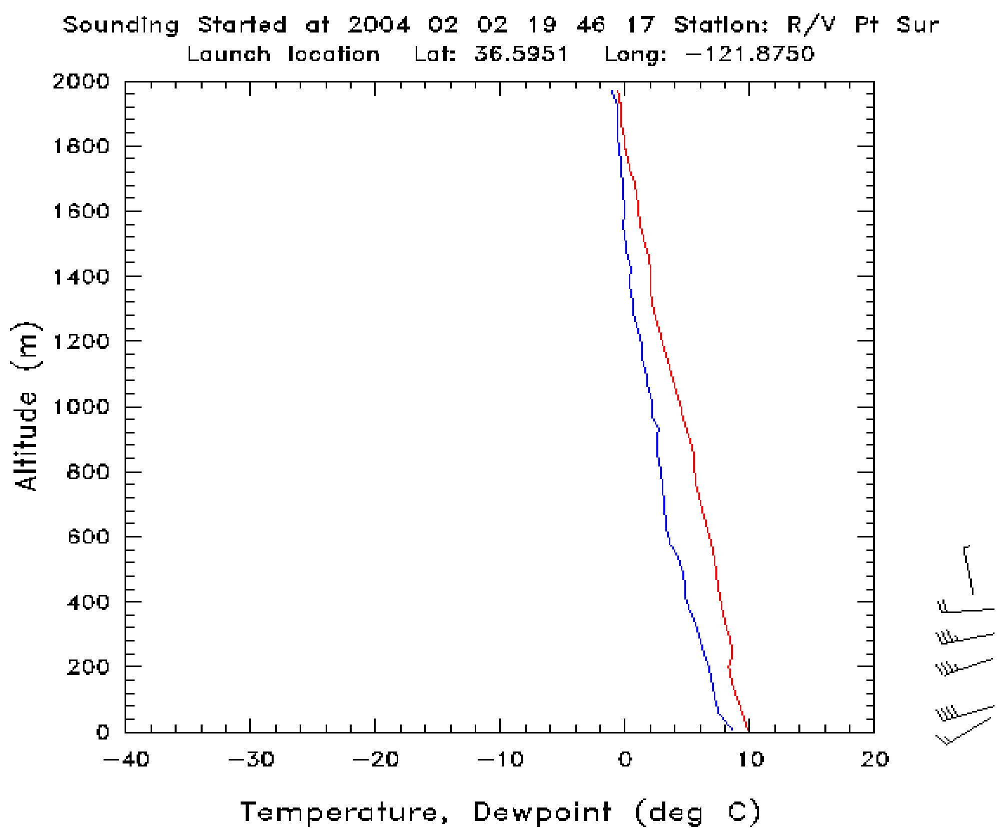


Figure 6: Sonde 25