San Francisco State University
Department of Earth & Climate Sciences

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Fall 2017

Inclass Exercise 10: **Case Study: Diablo Wind Event of October 8-9, 2017**
(100 pts)
Due Tuesday November 16, 2017

On October 8-9, 2017, a strong ridge in the middle and upper troposphere moved across the Pacific Northwest into the Great Basin (Fig. 1) The upper tropospheric convergence at the inflection point between this ridge and downstream trough was associated with large surface pressure rises and a surface dynamic high pressure area in the same region (Fig. 2).

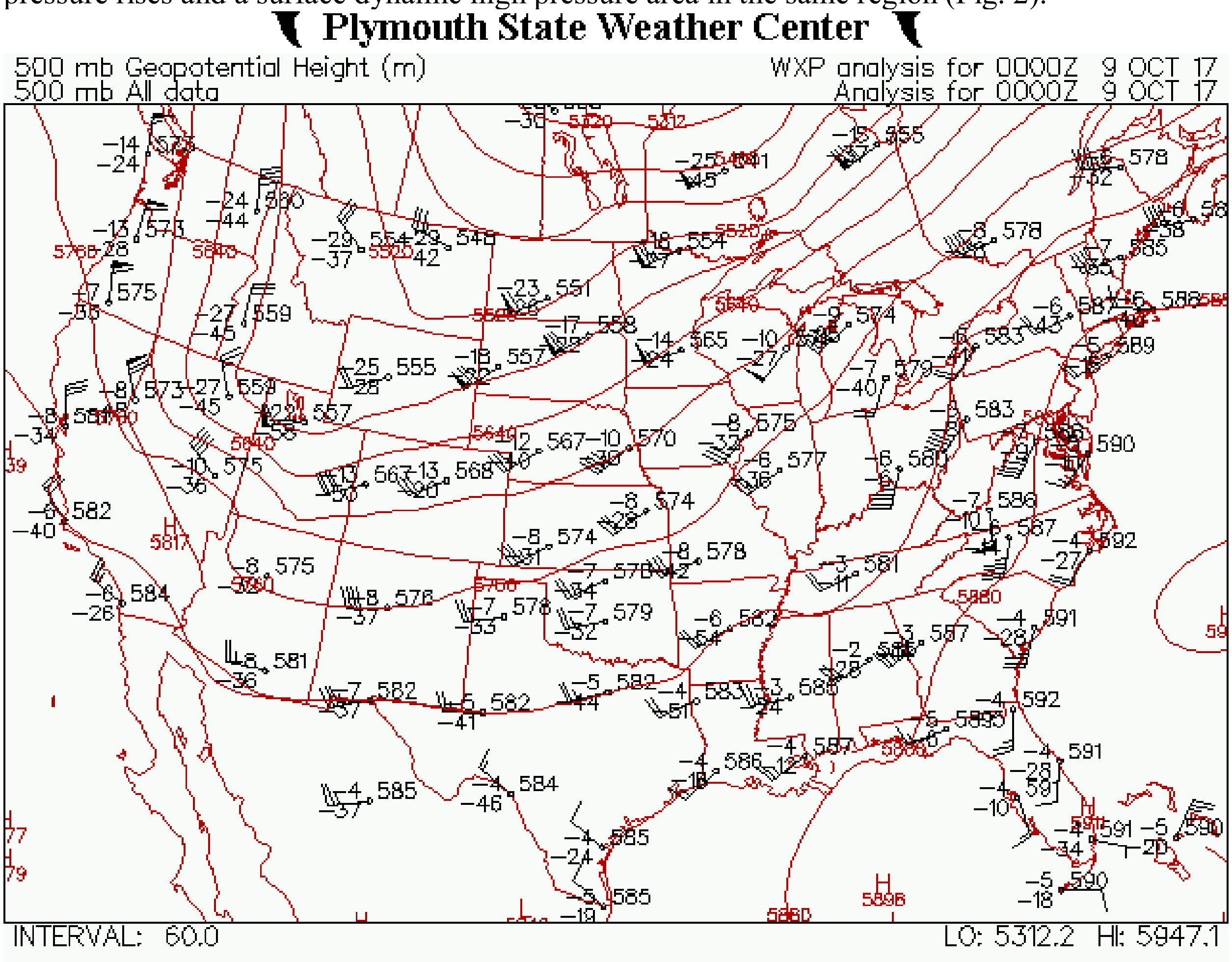

Fig. 1: 500 mb heights (dm) and contours at 6 dm intervals, 0000 UTC 9 October 2017

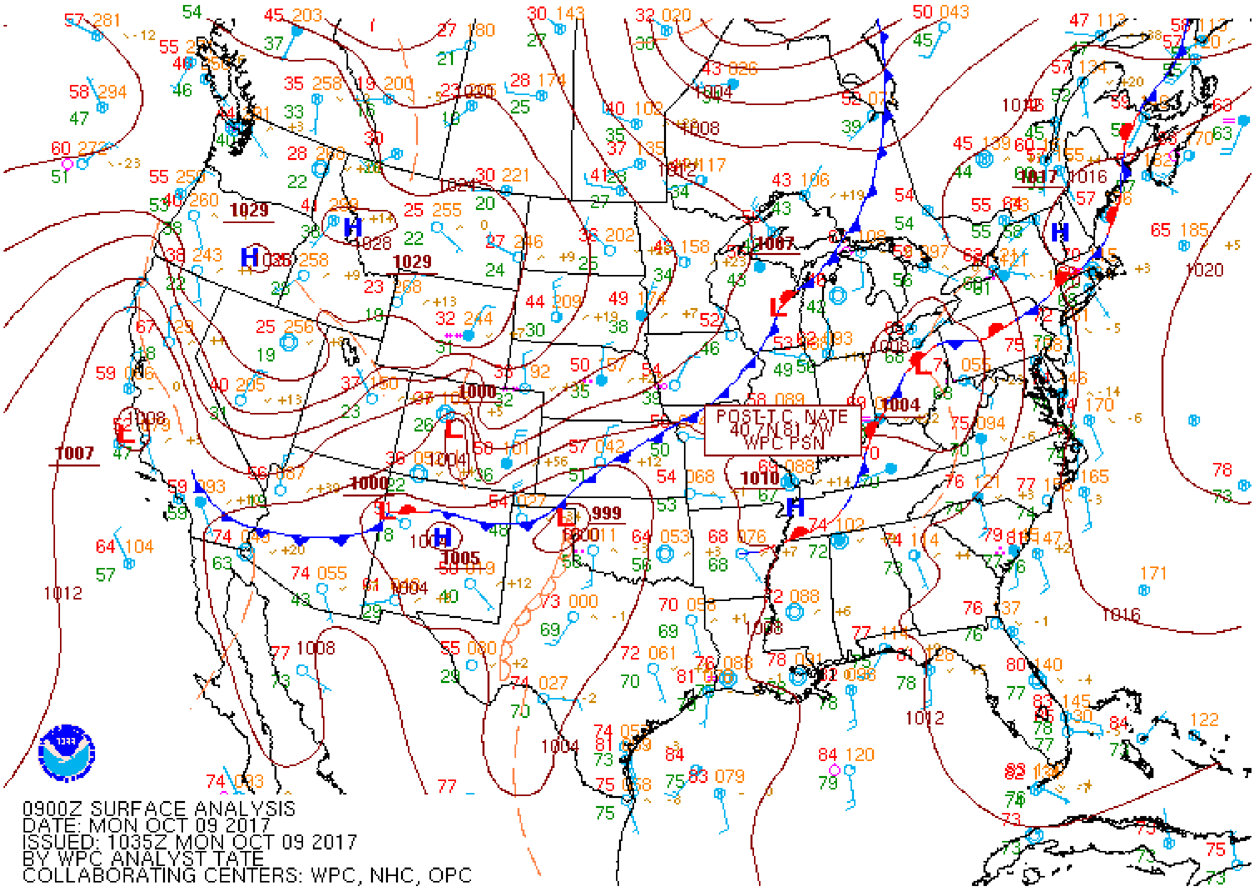

Fig. 2: Sea level pressures at 4 mb intervals, 0000 UTC 9 October 2017

This set up a northeast to southwest pressure gradient over Northern California. This pressure gradient gradually increased from the night time hours into the early morning of 9 October 2017. Thus this was a classic “Diablo Wind” event for Northern and north-central California.

This cross mountain flow was associated with a stable layer/inversion just above the top of the mountains for the Mayacamas Range, and a little higher over the Mt. St. Helena area. The NAM estimated sounding for near Santa Rosa at 12 UTC (Fig. 3) , the time of maximum winds in the Santa Rosa area, shows a strong inversion based at about the 900 mb level. The NAM also sampled strong downslope flow at that location, as one can see on the hodograph, with sustained 37 knot winds at around the 925-900 mb levels.

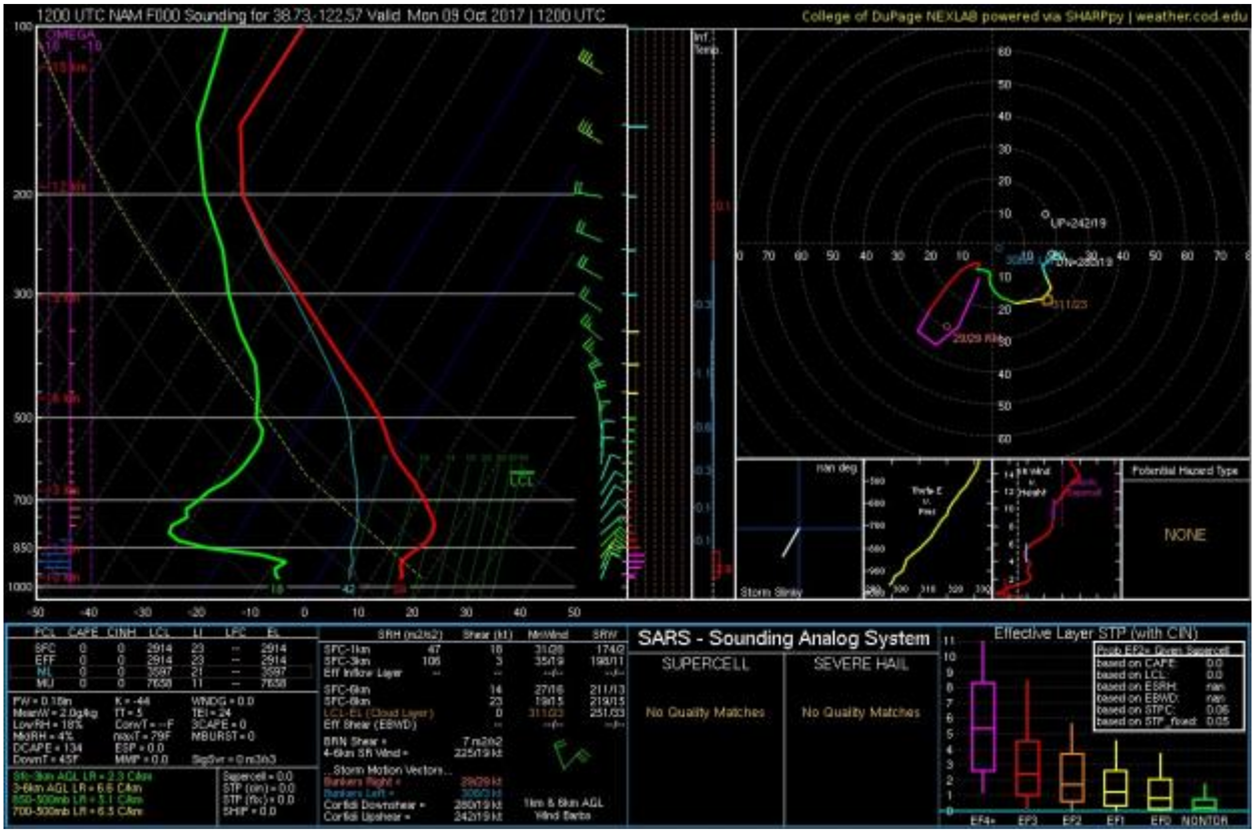

Fig. 3: NAM estimated sounding for a grid point near Santa Rosa at 12 UTC 9 October 2017

Question 1:

The difference in the elevation of the northern Napa Valley and the Mayacamas Mountain range is 1100 m. Assume that that is the height to which air parcels were forced in the northeasterly flow. The sounding in Fig. 3 indicates that an isothermal layer was present near the top of the mountains. Note that the surface temperature was around 16C and assume that the winds at the top of the ridge were 20 m s^{-1} (due to pressure gradient alone) and the wind was at right angles to the topography. (25 pts)

Use the Froude Number calculator here (you may have to setup a free account to use the calculator):

http://www.meted.ucar.edu/mesoprim/lff/froude_calc.htm

Calculate the Brunt-Vaisala Frequency and the Froude Number for these conditions. [Hint: the calculator will only let you select the end points for these conditions. so drag the end of the sounding at 500 mb over until the temperature at 500 mb is also 16C.]

Question 2:

How is the pattern shown in the model cross-section given in Fig. 4 consistent with the Froude Number you obtained in (1) over the Mayacamas Mountains (the range in the middle of the chart and also in the middle of the cross-section line shown in Fig. 5)? These figures are courtesy of Dr. Cliff Mass of University of Washington. (25 pts)

Question 3:

Further east, over the Mt. Konocti area (the mountain on the far right of the cross-section given as Fig. 4) a mountain wave is evident but with no hydraulic jump. Would the Froude Number be > or < than 1 in this area? Explain (this does not involve use of the online calculator you used in Question 1). (25 pts)

Question 4:

Further south, over the Bay Area, the conditions were exactly the same, However, the Diablo Winds encountering the East Bay Hills, a much lower mountain range, were lofted only about 700 m (or less). The cross-section of isentropes and a cross-section of vertical velocity are shown in Figs. 6 and 7. Courtesy of Dr. Dave Dempsey of San Francisco State University. (25 pts)

a) Use the Froude Number calculator (Question 1) to determine the Froude Number (the Brunt-Vaisala Frequency won't change, since the sounding is the same) to calculate the Froude Number over the Bay Area. (12 pts)
b) How is the isentropic cross section from Mt. Diablo to KSFO consistent with your result? (13 pts)

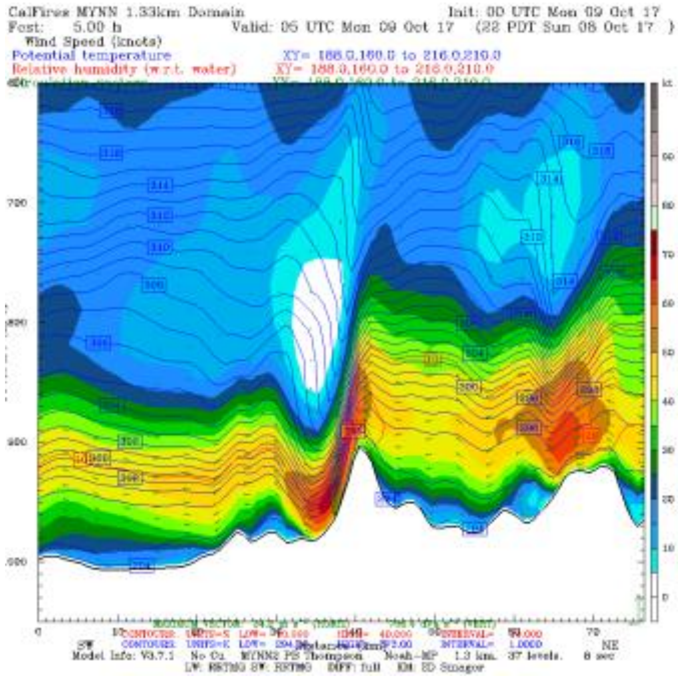

Figure 4: Cross-section of modeled isentropes and isotachs along the line showin in Figure 7b across the Mayacamas Mountains and the Mt. St. Helena area on the evening of 8 October 2017.

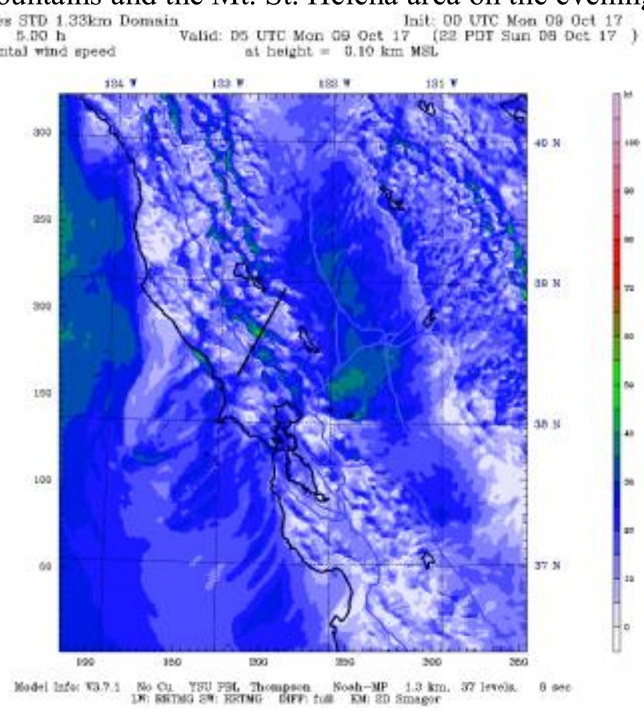

Figure 5: Modeled horizontal wind speeds at 100 m MSL at 05 UTC 8 October 2017, with the cross-section location given in Fig. 7a shown as a solid black line.

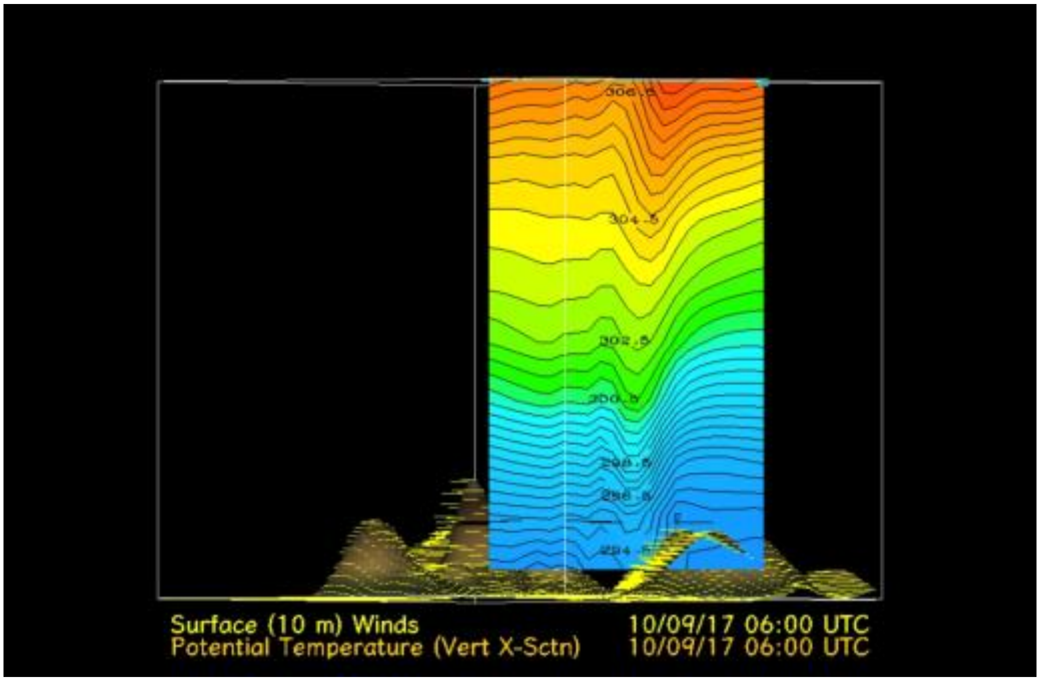

Figure 6: Cross-section of modeled isentropes from Mt. Diablo to the San Francisco Peninsula.

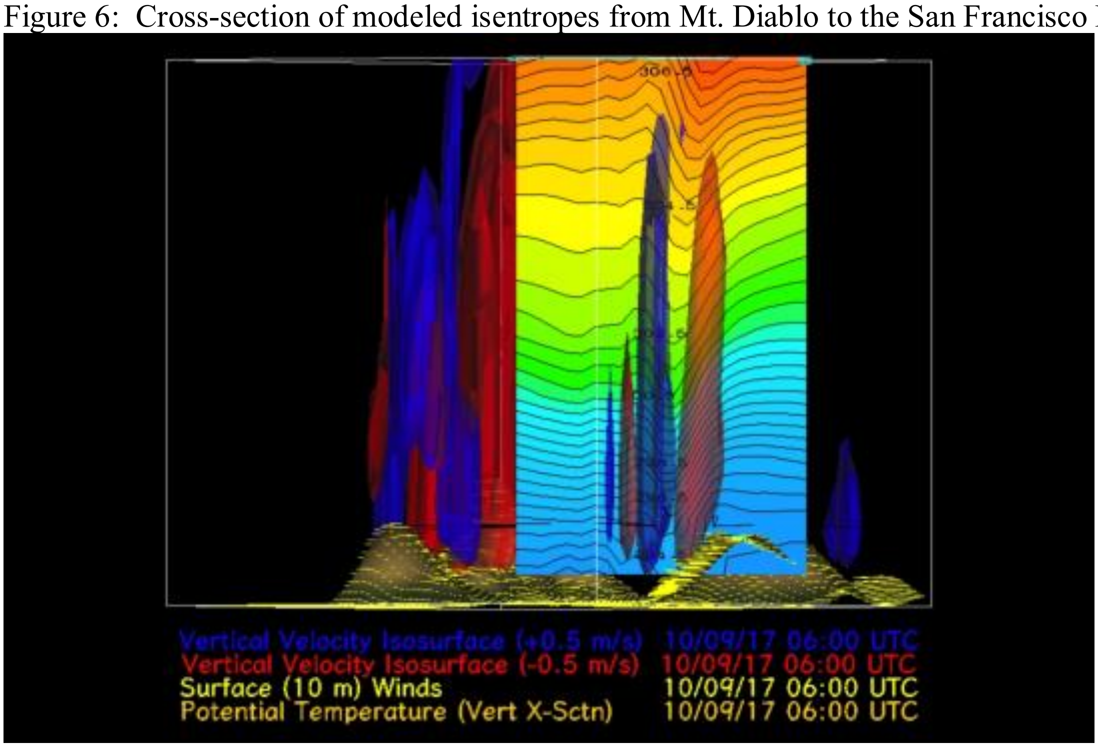

Figure 7: Cross-section of modeled isentropes and vertical velocities (red shading indicate upward vertical motion) from Mt. Diablo to the San Francisco Peninsula, showing a well-developed mountain wave, but without the marked hydraulic jump seen further north.