Western Region Technical Attachment
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PRE-FRONTAL SAN JOAQUIN VALLEY WIND EVENTS AND THE USE OF SURFACE AND UPPER AIR DATA TO FACILITATE THEIR PREDICTION

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Introduction

a. Overview. Widespread high wind events are quite rare in the central and southern San Joaquin Valley, owing to the region's prevailing fair weather and especially the terrain-induced shadowing of the valley from high winds aloft, as shown in Figure 1. However, during the cool months of the year, strong mid-latitude cyclones approaching from the Pacific Ocean occasionally induce strong southerly surface winds, particularly across western portions of the valley. Given their infrequent occurrence and the presence of vegetation and structures unaccustomed to such winds, their development has proven particularly destructive.

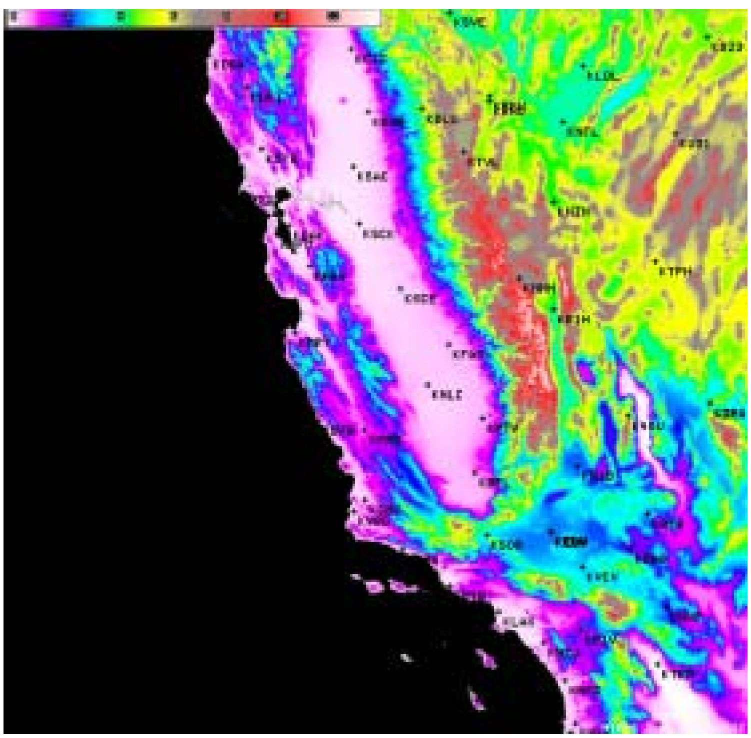

Figure 1. Topographical map of central and southern California. The central and southern San Joaquin Valley (KMCE-KFAT-KBFL corridor) lies adjacent to higher elevations to the east, south, and west.

b. Methodology and Data. Automated Surface Observing System (ASOS) data were archived from Merced (KMCE), Fresno (KFAT), and Bakersfield (KBFL) from November, 2001 through January, 2005, inclusive. From this set, only south to north-directed surface pressure gradient events occurring between November and April of each year were given further consideration. Six cases emerged in which all three locations observed peak wind speeds of 30 MPH or higher during the same day. For these resultant days, the maximum surface pressure gradient from KBFL to KMCE was derived from hourly METAR observations and recorded as an indicator of the strength and orientation of the surface pressure pattern. Additionally, an upstream rawinsonde, Oakland (KOAK), was used to measure the maximum wind speeds aloft occurring between 00Z the afternoon before the event and 00Z the following day, in an effort to objectively measure upper level wind support. Finally, for these six cases, the 12Z North America surface analysis and 500 mb height plot from the National Centers for Environmental Prediction (NCEP) were employed as a subjective measure in the determination of any synoptic patterns common to most or all wind events.

Meteorological Pattern

a. **Surface.** In all cases, a surface low was located between 40 N and 46 N latitude, along or inside 130 W longitude, with the surface front typically draped over northwestern California, or just west of the coastline. Figure 2, adopted from the December 19, 2002 event, is quite representative of the cases studied and provides an excellent graphical depiction of the prevailing surface pressure pattern. The central pressure of the surface low varied widely among the cases, with estimated pressures ranging between 980 mb and 1004 mb. The most severe wind event, measured by the highest peak wind speeds averaged over the three sites, occurred on January 7, 2005. On this day, the surface map captured two distinct, but relatively shallow, surface lows, one off the coast of the San Francisco Bay and another west of Portland, Oregon, as seen in Figure 3. Not surprisingly, all cases featured the surface pressure gradient oriented southeast to northwest across the valley, with the center of the surface high typically in the Four Corners region, never residing northwest of Salt Lake City or southeast of Gallup, New Mexico. The surface gradient between the high and the low varied between approximately 20 mb and 44 mb for the cases included herein.

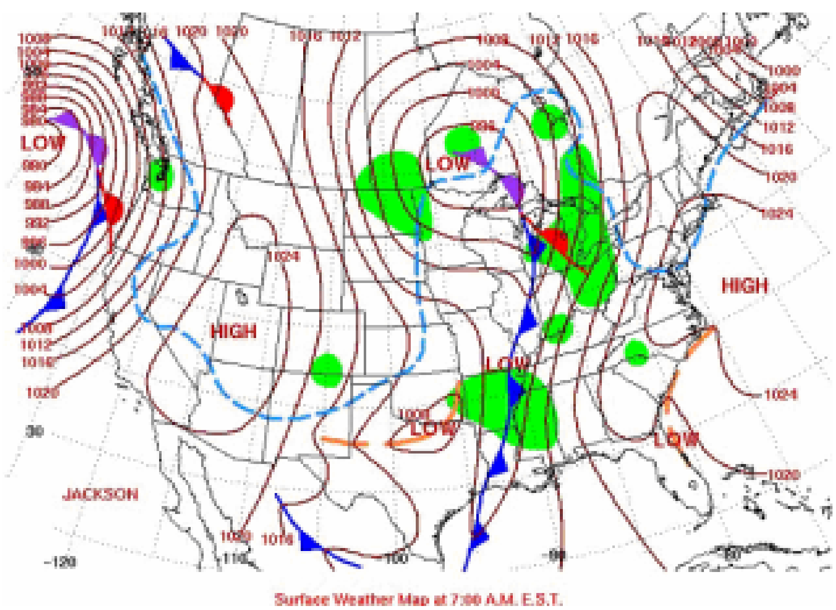

Figure 2. Surface map for the morning of December 19, 2002. Courtesy NCEP.

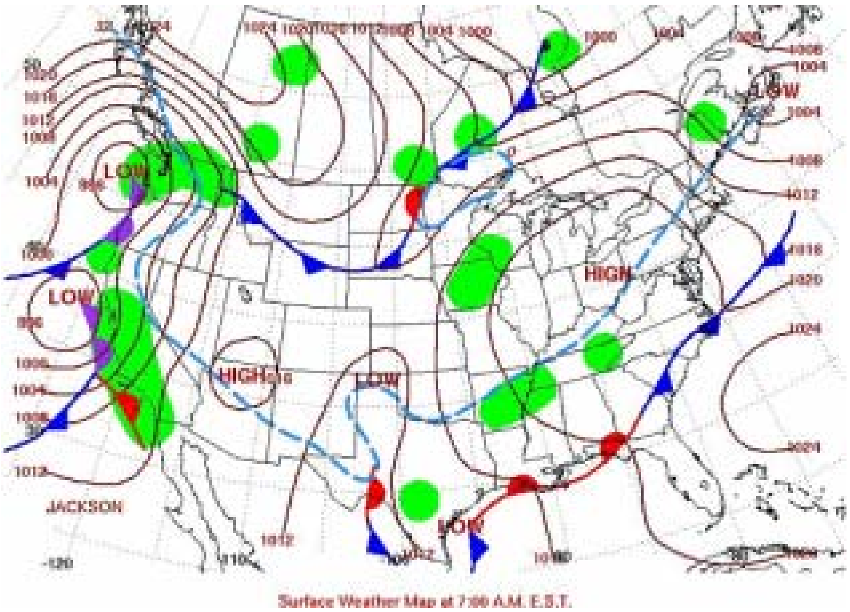

Figure 3. Surface map for the morning of January 7, 2005. Courtesy NCEP.

b. Upper Air. Most often, a closed low at 500 mb would be located between 125 W and 135 W longitude, and near 45 N latitude, although there were exceptions. Figure 4, once again garnered from the December 19, 2002 event, is fairly typical of most synoptic upper-level patterns conducive to strong and widespread valley winds. One high wind case resulted from an open trough situated along 130 W, while another event kept the closed low much farther north, near 55 N latitude, with the strong jet well to the south across California. The violent January 7, 2005 event, typical to other events, witnessed a relatively deep upper low off the Washington coast, but unlike other cases, a secondary low embedded within the mean trough axis was present just west of the San Francisco Bay (see Figure 5).

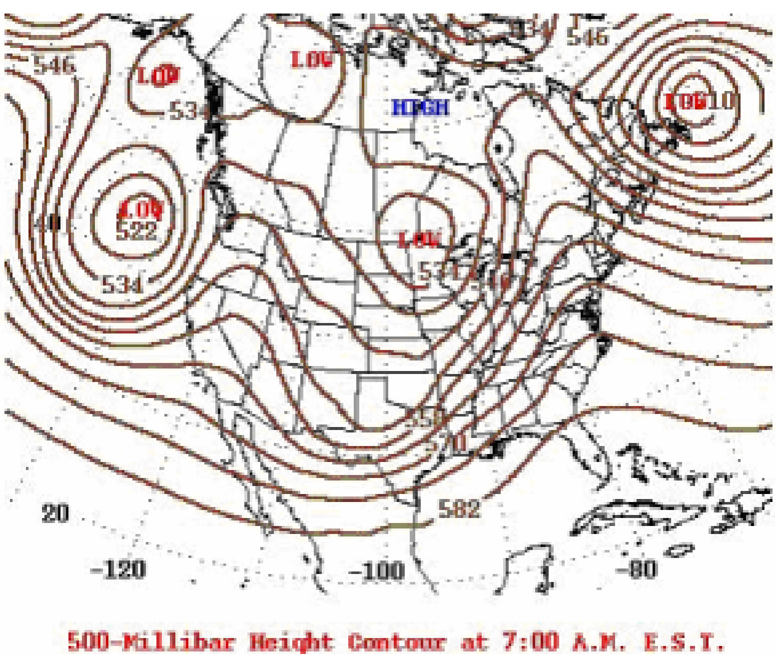

Figure 4. 500 mb height analysis for the morning of December 19, 2002. Courtesy NCEP.

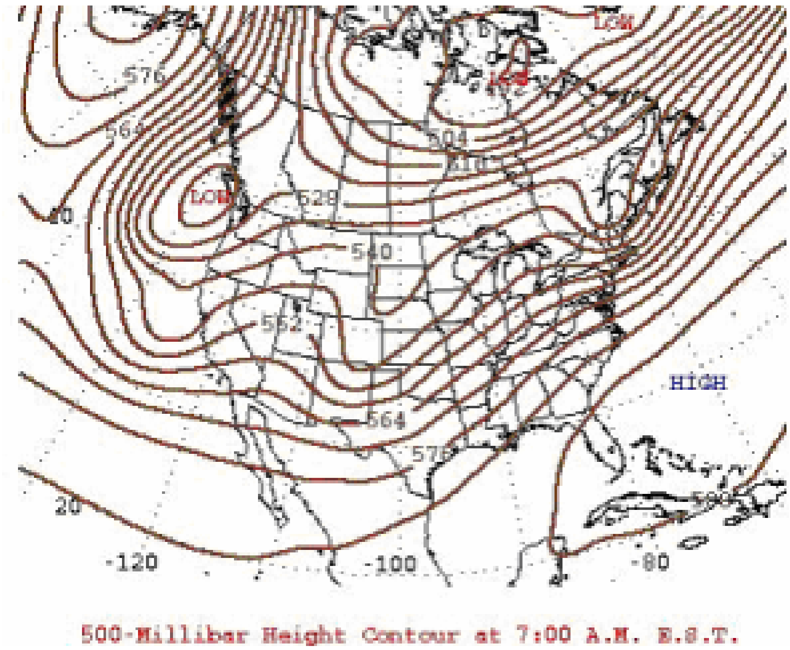

Figure 5. 500 mb height analysis for the morning of January 7, 2005. Courtesy NCEP.

Objective Parameters and Results

a. **Data.** Table 1 provides information concerning peak wind speed at each site, along with the maximum surface pressure gradient and Oakland 850 mb wind speed, sorted by date of occurrence.

Date	Peak wind speed (MPH) KMCE	KFAT	KBFL	Maximum KBFL-KMCE surface gradient (mb)	Maximum 850 mb KOAK wind (knots)
12/16/2002	38	31	30	7.5	58
12/19/2002	31	30	46	4.2	35
12/28/2002	39	33	43	4.4	35
2/2/2004	33	30	39	5.2	26
2/25/2004	46	31	36	5.6	50
1/7/2005	46	46	49	8.0	44*

Table 1. Peak wind speed at selected sites related to maximum observed surface pressure gradient and wind speed aloft. The asterisk appended to the 850 mb wind speed for the January 7, 2005 case indicates unavailability of some wind data.

A supplemental examination indicated that the 850 mb highest wind speed registered the highest Pearson correlation to the average peak wind speed at the surface, +0.49, and was therefore included for comparison purposes (note that this correlation was only derived for the four dates in which 700 mb, 500 mb, and 300 mb wind data were also available). The data also indicate that surface peak wind speeds at or above 30 MPH at all sites could occur with the surface BFL to MCE gradient as low as 4.2 mb, given 35 knot winds at 850 mb. Despite the relatively weak surface gradients and winds aloft for the December 19, 2002 and December 28, 2002 events, the analyses indicate that in both cases the San Joaquin Valley was positioned under the right-front quadrant of the upper jet, an area favored for downward transfer of momentum. A higher surface gradient may help compensate for relatively weak winds aloft, as shown by the February 2, 2004 episode. However, a surface gradient above 5.5 mb combined with winds at or above 50 knots at 850 mb suggest a good likelihood for significant and widespread wind events across the valley. The 850 mb wind speed for the January 7, 2005 case was appended with an asterisk since other mandatory levels reported their highest winds at a sounding time when no 850 mb wind speed was registered, likely indicating that the actual speeds were higher.

b. Local Implications. All cases presented resulted in wind advisory criteria being met for at least one valley forecast zone, which, for gusts, is achieved with speeds of at least 35 MPH. Thus, the forecaster should interpret Table 1 as being a "sliding scale," in which at least one overly positive factor, such as favorable upper jet positioning, high winds at 850 mb, or robust surface gradient may compensate for one or more quantities which, when taken at face value, may appear to be lacking or unfavorable.

A Contrarian Event

On December 28, 2004, only KBFL registered a peak wind speed of at least 30 MPH of the stations considered. However, this case was unusual in that the east portion of the valley, along with the adjacent Sierra Nevada foothills, experienced particularly strong winds. A surface low of approximately 1004 mb was situated west of Monterey at 12Z (see Figure 6), with a closed upper low of about 540 dm at 500 mb roughly coincident with the surface low's position (Figure 7).

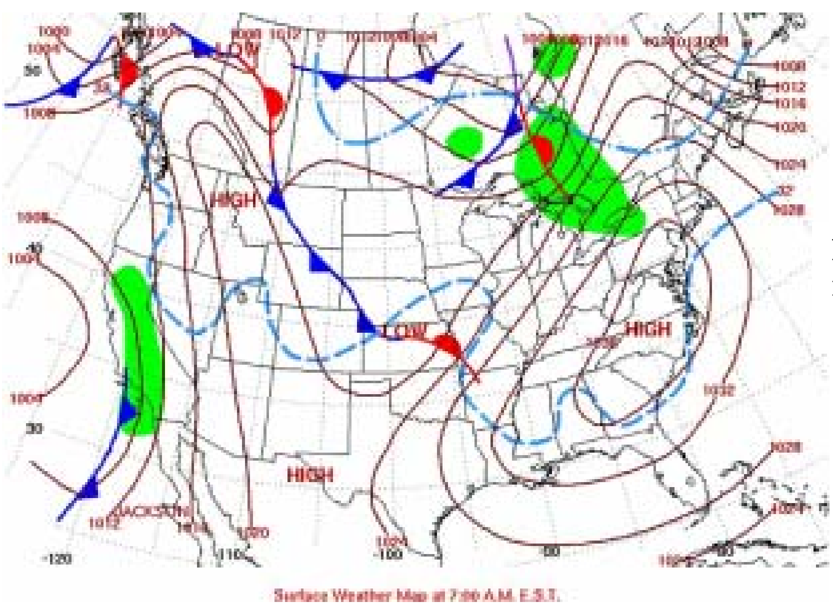

Figure 6. Surface map for the morning of December 28, 2004. Courtesy NCEP.

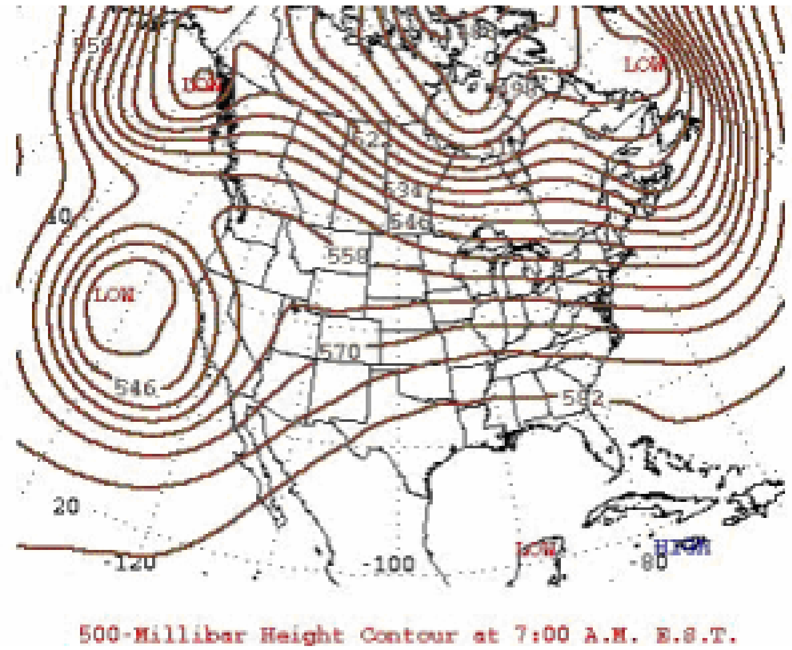

Figure 7. 500 mb height analysis for the morning of December 28, 2004. Courtesy NCEP.

The positioning of the surface and upper lows were much farther south than the other events presented, while the surface ridge, which extended into western Montana, was much farther north. The resulting flow at the surface and aloft coincided, with the isobars and isohypses running nearly longitudinal. Given this orientation, the surface pressure gradient across the valley was quite small and oscillated between north and south-directed throughout the day. The maximum recorded value, 2.3 mb, was actually attained with the surface gradient directed from north to south, opposite the other cases presented in this paper. Winds aloft, as measured at KOAK at 850 mb, were only around 15 knots at the 00Z sounding the afternoon before and the afternoon of the event, although 500 mb winds of 58 knots from the south were recorded the day before the wind event. Radar data indicate that the strong winds followed the trailing edge of a stratiform band of precipitation as it moved north across the eastern portion of the valley and adjacent foothills, presumably allowing for higher winds aloft to briefly mix down to the surface. Recorded wind speeds ranged between 42 MPH and 55 MPH, with multiple reports of downed trees and damaged structures along a lengthy path in the Sierra Nevada foothills and adjacent portions of the valley.

Summary

Through the examination of several years' worth of data, this study quantifies the strength of the surface pressure gradient and upper level winds as reported during six widespread San Joaquin Valley pre-frontal wind events meeting pre-defined criteria. The underlying synoptic conditions found among these events were quite uniform. This should aid in achieving this study's central goal: advance forecaster recognition of surface and upper air patterns and tendencies such that appropriate advisories may be hoisted with adequate lead time. Additionally, a slightly different event, which produced significant wind damage in an area typically immune from such, was also included to heighten forecaster awareness of particular patterns which may prove conducive to strong and unusual wind events, especially when "traditional" elements such as surface gradient or winds aloft seem rather innocuous.

Acknowledgements

Thanks to Larry Greiss for his review of this study.

Appendix : Technical Limitations

a. **Surface Data.** Surface pressure observations, taken only once per hour, form the basis from which the hourly pressure differential between KBFL and KMCE was derived. Given the inability to develop a continual measure of this differential, it is probable that the maximum attained pressure gradient was actually slightly higher than reported, although this difference is expected to be minor.

b. **Upper Air Data.** KOAK, from where rawinsonde data were collected, is located over 100 miles from even the closest anchor point for surface observations, separated by significant topographical barriers from the valley. This combined with the fact that, at most, three upper air observations at each level were available over a 24 hour period in which the event occurred (as explained in the Methodology and Data section of the Introduction) suggests a very high potential for significant temporal and spatial error in reporting a "maximum" 850 mb wind speed as shown in Table 1. Thus, these data were mainly provided for comparison purposes and in no way represent a rigorous attempt to formulate the highest 850 mb wind speed actually occurring during the time of highest surface pressure gradient and/or surface wind speed.