AN INSIDE SLIDER WITH VERY LOW ELEVATION SNOW AND HIGH WINDS IN EXTREME SOUTHWESTERN CALIFORNIA

Ivory J. Small and Daniel V. Atkin
Weather Forecast Office San Diego, California

INTRODUCTION

On 21 November 2004 a classic example of an inside slider that produces very low elevation snow (at or below 2000 feet MSL) hit extreme southwestern California (Fig 1 and Fig 2). Inside Sliders are troughs or lows where the stronger portion of the storm (the “main dynamics”) typically moves inland to the north (producing little or no rainfall in southern California). The case being presented in this TA-Lite (an inside slider that produces very low elevation snow) is a variation of this type of inside slider. This classic “low elevation snow producing inside slider” actually drifts to the southwest (or “retrogrades”) as the upper level high noses in behind it (Figure 3). This seems to be especially true during strong Northwest Express patterns. (These patterns are characterized by a strong, more “meridianal” jet from the Gulf of Alaska or Canada, which feeds cold air into and guides storms dropping down from the Pacific Northwest or adjacent waters). This is different than the dry inside sliders which pass by to the north and continue to move to the east.

Heavy snows of between 2 and 3 feet developed in the mountains with this storm. Around a foot of snow fell in the upper desert areas, (which are around 2000 feet MSL). By morning the snow developed below passes and canyons and spread out into the valleys west of the mountains. Snow was reported down to 1000 feet, with some valley locations receiving about 9 inches of snow. Since the snow event was so early in the season there were plenty of leaves still on the trees. Heavy snow captured by the leaves brought down trees and tree branches on power lines. In addition to damage by the snow, strong downslope winds resulted in a peak wind of 84 mph in the Santa Ana Mountains at Fremont Canyon (FMC) just east of KSNA. These winds helped to increase the overall wind damage from the storm. With 500 mb temperatures falling to -20 deg C for quite a while, along with sufficient moisture still in place, thunderstorms developed over the area as the cold front swept southward. This WES TA-Lite will explore the sequence of events surrounding this pattern that resulted in such very low elevation snowfall and high winds.

CHARACTERISTICS OF THE SYNOPTIC SCALE PATTERN

This event was a rather classic example of the type of inside slider that produces very low elevation snow (about 2000 feet MSL and below). Many lows simply move inland over northern California with a relatively warm airmass from the Pacific, and although they may develop over the interior and drop southwest over southern California as an inside slider, they generally do not produce the very low snow levels found with this storm.

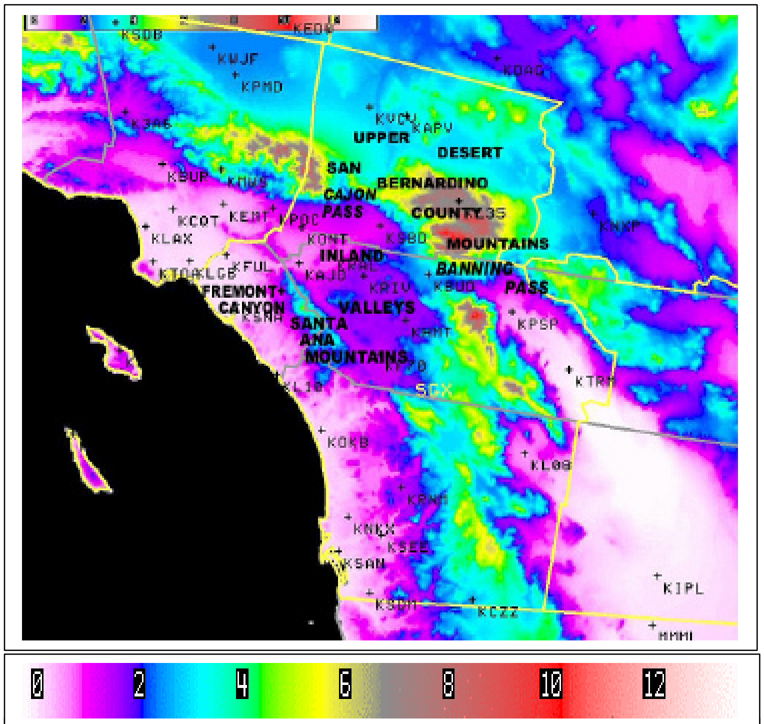

Fig. 1. Map of the terrain and selected locations in the WFO San Diego (SGX) County Warning Area. Values in the legend are in thousands of feet MSL.

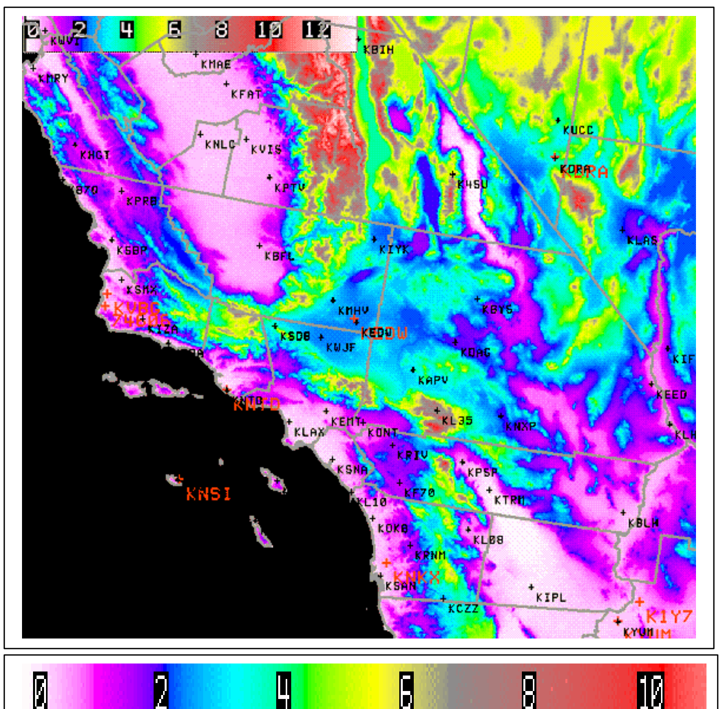

Fig. 2. Map of the terrain and selected locations. Sounding sites are in red. Values in the legend are in thousands of feet MSL.

This storm moved inland further north (over western Canada, north of the region where the “warmer” storms move in from the Pacific) and picked up cold air from western Canada before dropping southwest over southern California. Figure 3 shows the 0600 UTC 21 November 2004 water vapor imagery overlaid with the 0600 UTC ETA12 500 mb heights, the one hour lightning strike data, and the surface METAR observation data. At that time, the low center was still over southern Nevada with the cold front dropping south-southwest into southern California. Also the moisture, dynamics and instability had increased enough over southern California at the leading edge of the front to result in the first thunderstorm west of the coastal mountain ranges. [The first strike was just west of Ontario (KONT)]. The front can be seen as the bright area of cloudiness stretching from near Las Vegas (KLAS) Nevada westward to near Sandberg (KSDB), California. The obvious dark (often banana shaped) region of strong synoptic scale subsidence and drying that typically moves over the area during strong offshore flow events was well to the northwest, which places it over the Bakersfield/Fresno (KBFL/KFAT) area.

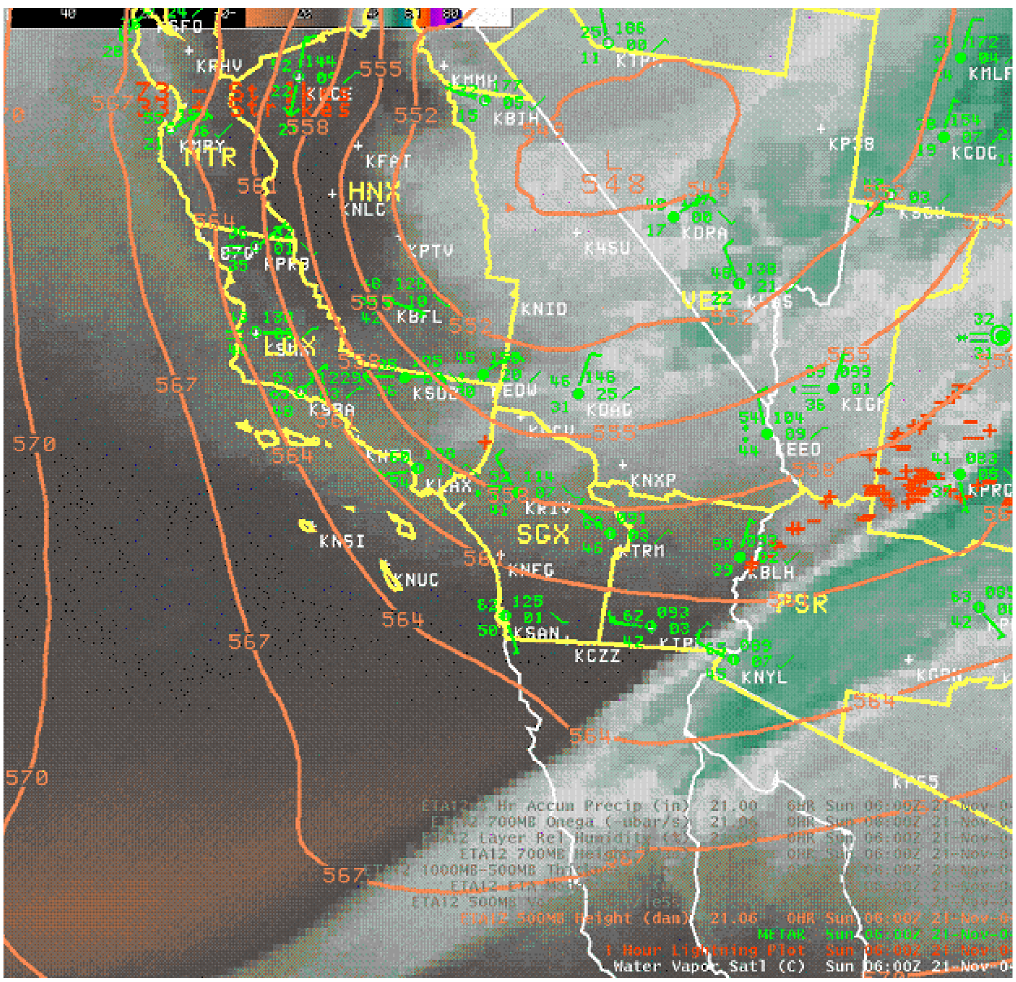

Fig. 3. 0600 UTC 21 November 2004 Water Vapor Imagery overlaid with the 0600 UTC ETA12 500 mb heights (orange, solid), the one hour lightning strike data (red), and the surface METAR observation data (green station plots).

In this case southern California was in a portion of the upper low characterized by synoptic scale upward vertical motion.

Figure 4 shows the 0600 UTC 21 November 2004 ETA12 500 mb heights and ETA12 700 mb Omega. At 0600 UTC 21 November 2004 the leading edge of the wind shift can be seen stretching along a line from near Sandberg (KSDB) in the mountains north of southern California, through KWJF in the upper deserts, and southeast to Palm Springs (KPSP) in the southern deserts. Wind gusts can be seen at both KSDB and KPSP. The maximum value of the 700 mb vertical velocity was +38 –ubars/s near KDAG and the minimum value was -22 –ubars/s near KNID. The large red/white area over the upper deserts is the upward vertical velocity associated with a developing back door front (a front moving east to west rather than the typical west to east motion). The large blue/magenta area was a developing area of 700 mb downward vertical velocity behind the front.

Some interesting features are apparent on the 1800 UTC 12 November 2004 ETA12 500 mb heights and ETA12 700 mb Omega (fig. 5). In spite of the large area of rather strong synoptic scale ascent at 700 mb as shown by the red/white area, there was a strip of strong mesoscale downward vertical velocity in the middle of it, as shown by the blue/magenta area. The strip corresponds to the region to the lee of the mountains where northeasterly downslope flow can be expected. During the more "dry types" of offshore flow events, the mesoscale downward vertical velocity is embedded in synoptic scale downward vertical velocity. This case shows that in the vicinity of the low center there can be a fight between the synoptic scale upward motion and the mesoscale downward motion, but the storm can still create very strong winds without the deep synoptic scale and mesoscale vertical motions being positively correlated.

CHARACTERISTICS OF THE VERTICAL PROFILE

Fig. 6 shows the 1200 UTC Miramar (KNKX) sounding near San Diego, and the 1200 UTC Desert Rock (KDRA) sounding in southern Nevada. The KDRA sounding shows a strong low level jet behind the front near 850 mb heading toward southern California. Above this strong northeasterly flow associated with the low level jet, there is a dramatic wind shift to a more westerly flow, along with an increase in stability near 700 mb, which is known to help strengthen mountain waves. The sounding is rather dry in the boundary layer with a dewpoint depression in excess of 10 degrees C, which should cause some concern about the lowering of the snow level via "wet bulb zero effects".

Near the coast, the KNKX sounding shows a rather moist airmass below about 650 mb (below about 12,000 feet). The sounding shows that initially there was a southwest flow of boundary layer moisture into the system rather than only having upper level moisture. This supports the fact that the storm moved far enough west to be modified by low level moisture from the Pacific. The sounding is rather moist, but not saturated near the surface.

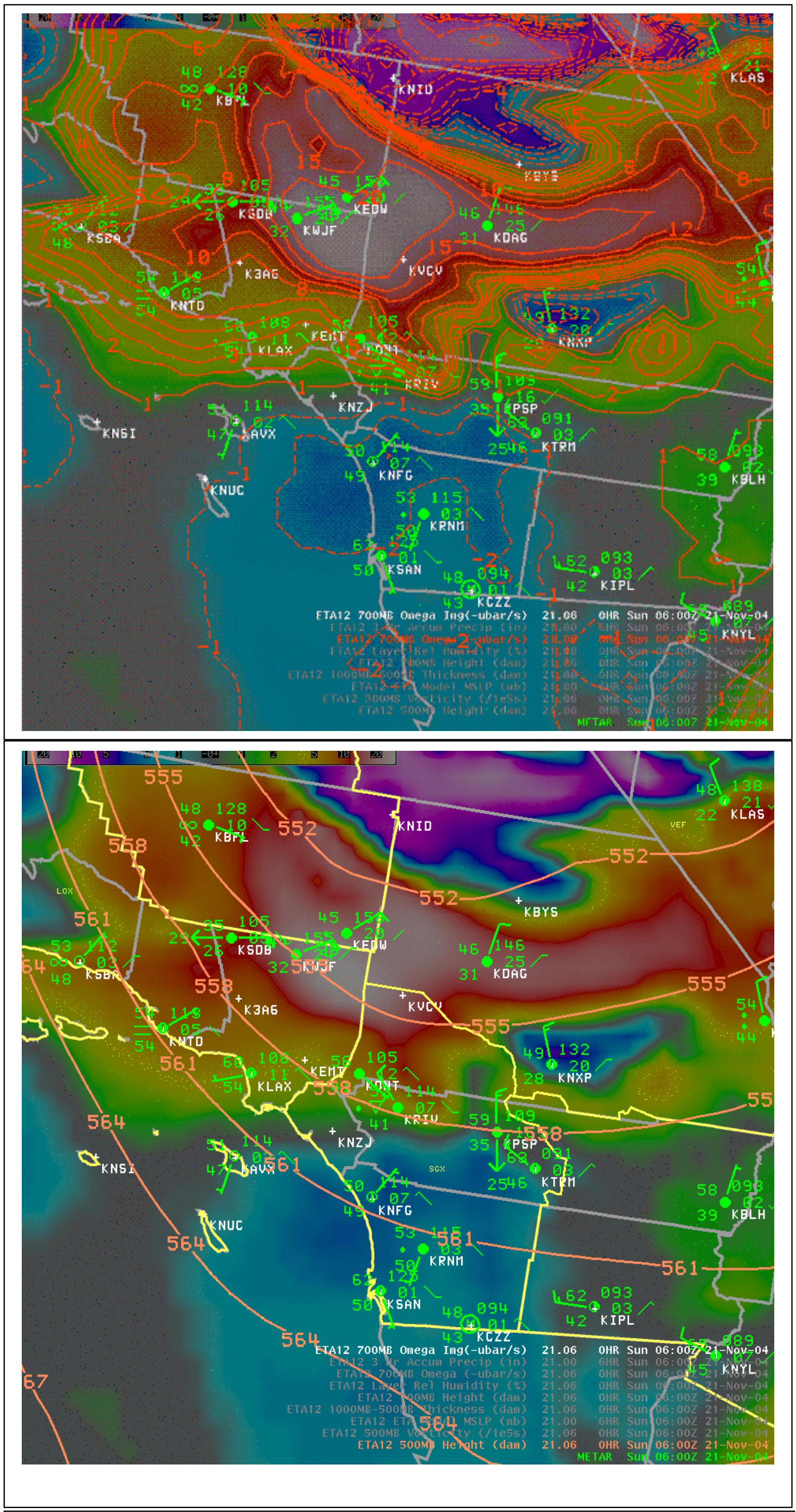

Fig. 4 (a) 0600 UTC 21 November 2004 ETA12 700 mb omega (orange contours and shaded) in –ubars/second. (b) 0600 UTC 21 November 2004 ETA12 500 mb heights in decameters (orange, solid) and omega (shaded) in –ubars/second without the omega contours.

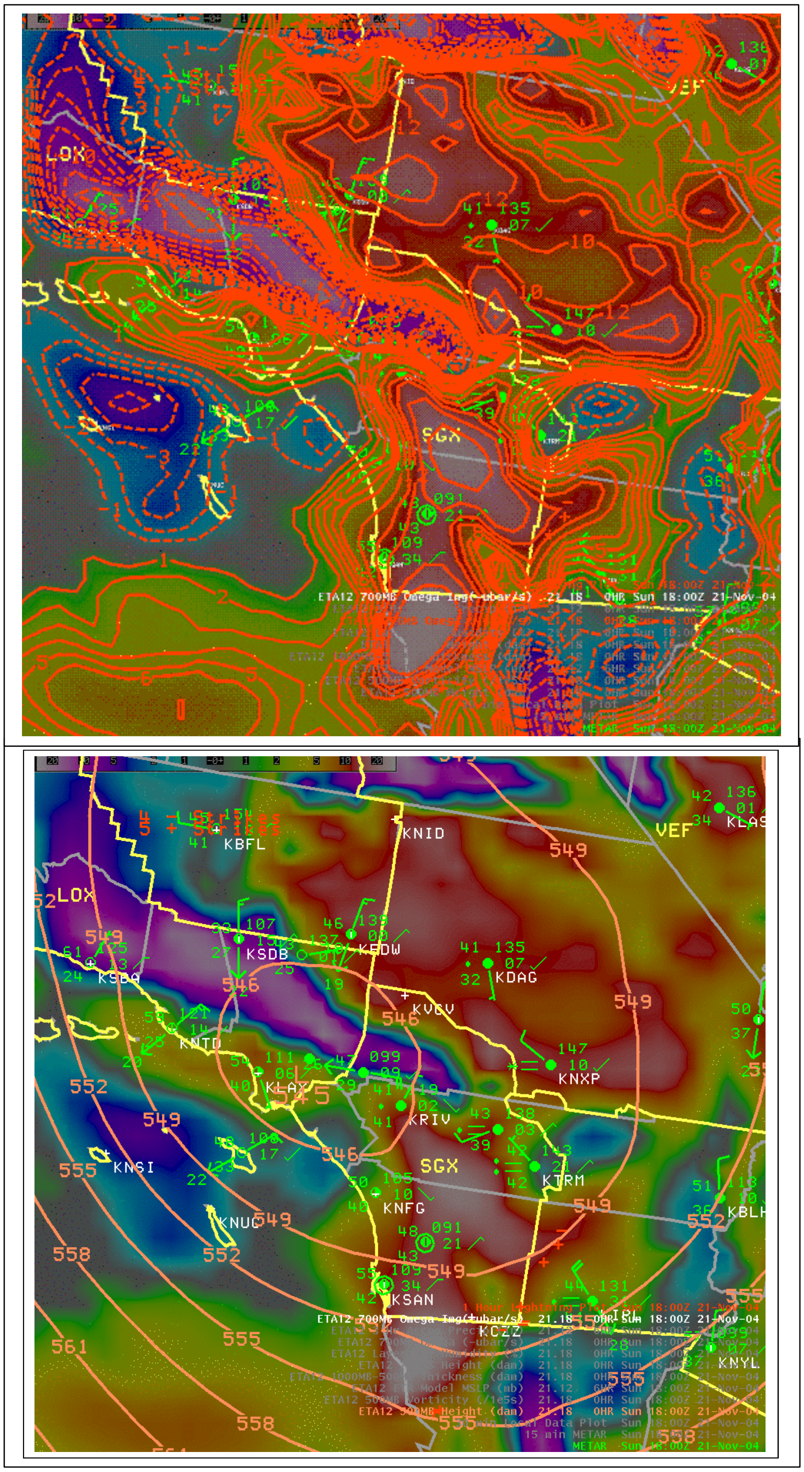

Fig. 5 (a) 1800 UTC 21 November 2004 ETA12 700 mb omega (orange contours and shaded) in –ubars/second. (b) 1800 UTC 21 November 2004 ETA12 500 mb heights in decameters (orange, solid) and omega (shaded) in –ubars/second without the omega contours.

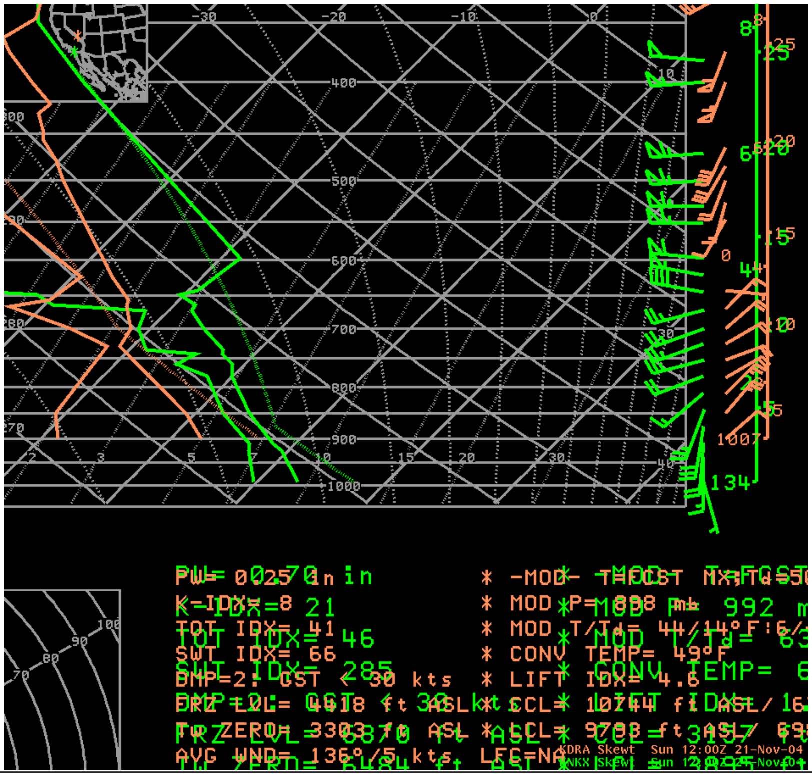

Fig. 6. 1200 UTC 21 November 2004 KNKX sounding (green) and KDRA sounding (orange).

OTHER CHARACTERISTICS ASSOCIATED WITH THE CASE

Outside of the strong straight line winds and maybe some locally strong winds in and around thunderstorms, inside slider type events have not been known for being producers of severe thunderstorms with large hail or tornadic activity. For more severe activity to occur, the storm system is more apt to move in off the ocean rather than drop in from the east. In this case there appears to be an inversion at around 750 mb, which may help cap the vertical development of the thunderstorms and somewhat limit the updraft strength. The total totals index at KNKX was 46 (not particularly high). Even though the 0-3 km storm relative helicity was 188 m^2/s^2 and the CAPE was 220 J/Kg, (both rather respectable numbers for this area) there was no severe hail, no severe thunderstorm wind gusts, or tornadic activity in the area. Still, steady state, long lasting updraft/downdraft couplets (easily seen in the base data via the storm relative velocity) should be watched for possible rotation, especially in the post frontal environment and along convergence zones.

SUMMARY AND CONCLUSION

When a rather strong upper low moved overhead carrying with it sufficiently strong dynamics and 700-500 mb relative humidity in excess of 40 percent, thunderstorms developed over extreme southwestern California. Temperatures at 500 mb of -20 deg C or less also supported at least a slight chance of thunderstorms for the region. Since it was an inside slider type of storm that approached the area from the interior (northeast of southern California, severe convection was not expected to be much of a problem. In this case, no severe convection developed.

This inside slider type of storm, which resulted in 500 mb heights in the mid 540's (decameters) was not terribly deep, especially when compared to storms that move in from the west with westerly flow and similar snow levels. The heights of such storm from directly off the Pacific are more likely to be in the mid to upper 530s (decameters) if the snow levels are to dive to near 1000 feet MSL with mainly low level west to northwest flow off the Pacific.

Several major snowstorms that hit the valley areas, (and sometimes the coast) in the past have been associated with high wind events characterized by easterly downslope flow. The ensuing wet bulb zero effects on the snow level during these "somewhat drier" easterly downslope wind patterns with precipitation can drop the snow level about 1000-1500 feet lower than what is normally expected when compared to the nearly saturated airmasses that move in from the west during west to northwest flow cases. (This dip in the snow level is especially apparent in and below canyons and passes and in thunderstorms). The counterpart to the temporary lowering scenario, but during westerly flow, is when overrunning precipitation occurs out ahead of a storm, which can result in snow levels lowered by wet bulb zero effects, especially in the mountains and deserts. The snow at the very low levels continues until the airmass is modified, the snow level rises to a more typical level associated with the more saturated air mass, and the very low level snow changes over to rain.

As seen in this case, upward vertical velocity over the area on the synoptic scale does not guarantee that there will not be downward vertical velocities associated with mountain wave activity that can drive very high downslope winds. The area was blanketed by synoptic scale upward motion strong enough to produce showers and thunderstorms. In spite of that fact, very strong downslope winds reached 84 mph. The strong mesoscale downward motion was created by mountain wave development. This case was different than many other downslope wind cases since the synoptic scale downward motion and mesoscale downward motion often combine to produce the strongest winds over the area. This shows that the deep synoptic scale downward motion and the mesoscale downward motion fields do not have to combine to create such strong winds.