A Review of the 2004 Thanksgiving Weekend Snow Event in Western Nevada

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A complex weather pattern evolved Thanksgiving Day weekend to bring widespread heavy snowfall to northeast California and western Nevada. In fact, the pattern was so complicated that models not only had trouble projecting a likely path for this storm, but they also underestimated the precipitation amounts, even up to the evening prior to the storm. The purpose of this paper is to point to data that indicated both jet dynamics and frontogenesis combined to produce strong vertical motion fields. These strong upward motions interacted with an available deep moisture profile to produce efficient microphysics and resultant heavy snowfall. Recognition of these ingredients can help forecasters assess the situation more accurately and trend forecasts away from model deficiencies.

The QPF forecasts issued by the HPC reflect an underestimation of the precipitation; especially east of the Sierra Nevada mountain range. (Refer to Figure 1 and 2 below). Forecasters issued special weather statements beginning on the early morning of Wednesday, November the 24th, and subsequent updates to this statement continued until Thanksgiving Day.

Figure 1: HPC's 24-hr QPF forecast valid at 12z on 11/27. Moderate to heavy precipitation actually was ongoing across the Sierra and western Nevada at this time, as will be evident in a later radar picture.

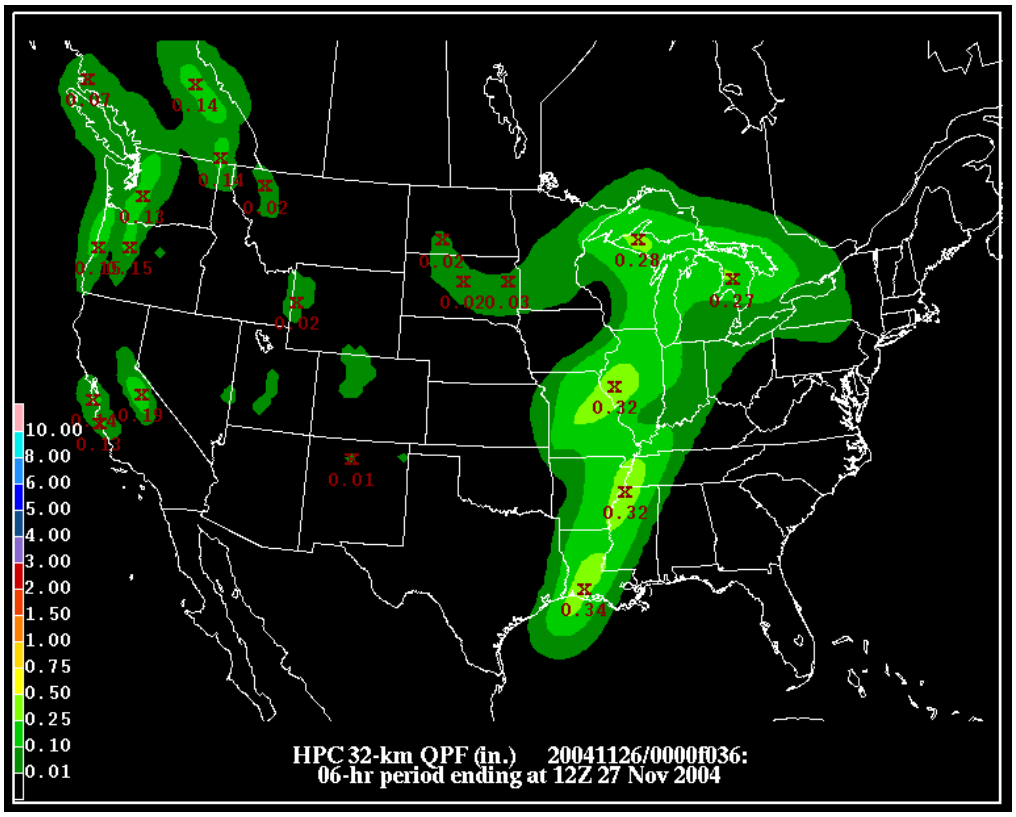
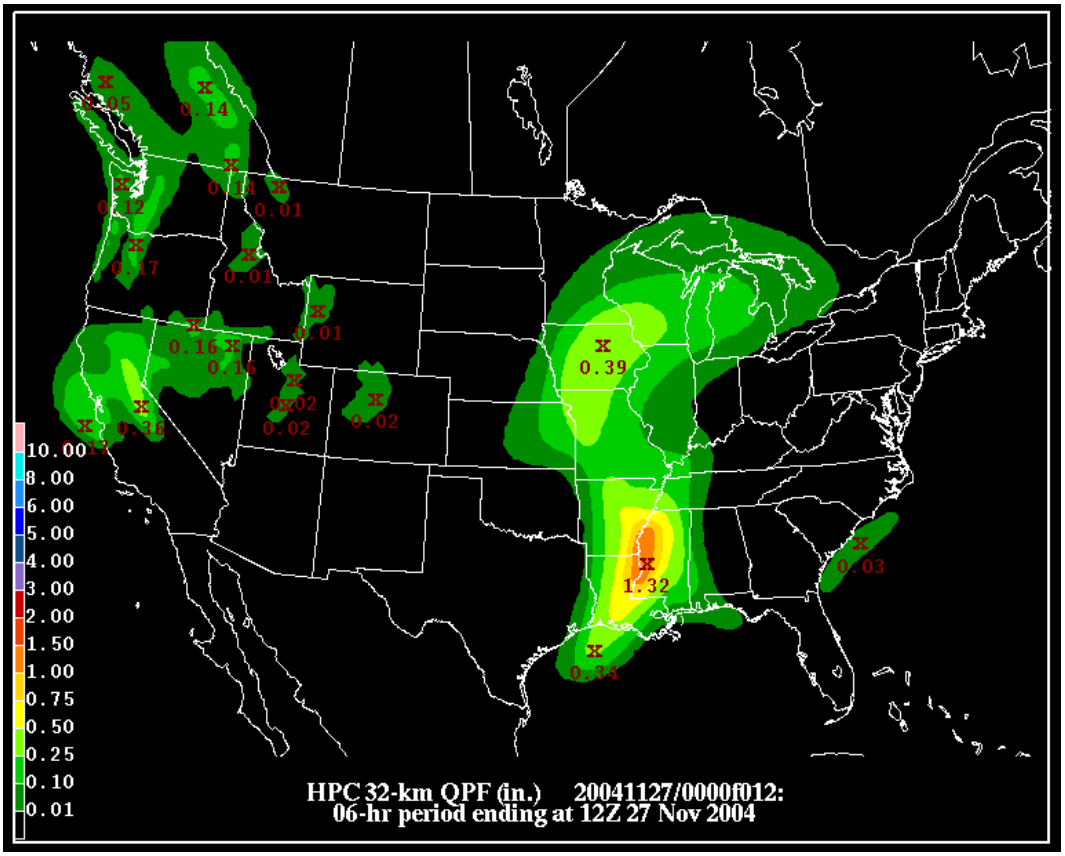


Figure 2: HPC's 12 hour QPF forecast valid at 12z on 11/27. Moderate to heavy precipitation was actually ongoing across the Sierra and western Nevada at this time. Models were beginning to improve by the 00z run on 12/27.



Models finally started to gain some insight to the track of the system starting with the 00Z run on 11/26 (Refer to Figures 3 and 4 below). Snow advisories were issued with the morning package on Friday, the 26th for much of eastern California to inform the public of potential snow Friday night and Saturday.

Figure 3: 18z GFS model run on 11/26 valid at 12z on 11/27. Top left image depicts 500 mb vorticity (shaded) and height (green contours), top right depicts the 700 mb relative humidity (shaded) and wind, bottom right depicts the 300 mb wind speed, and the bottom left is the 500 mb relative humidity.

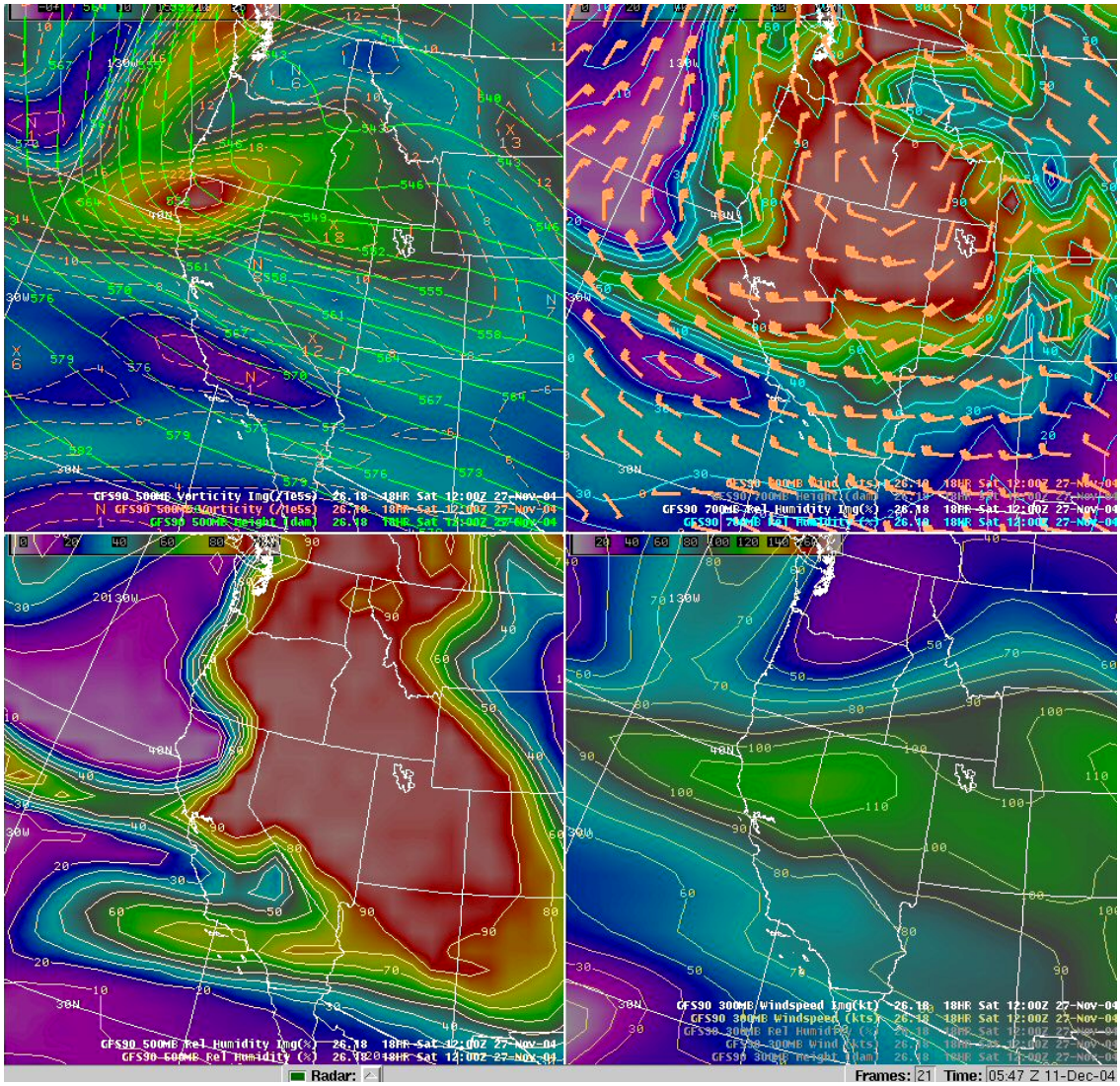
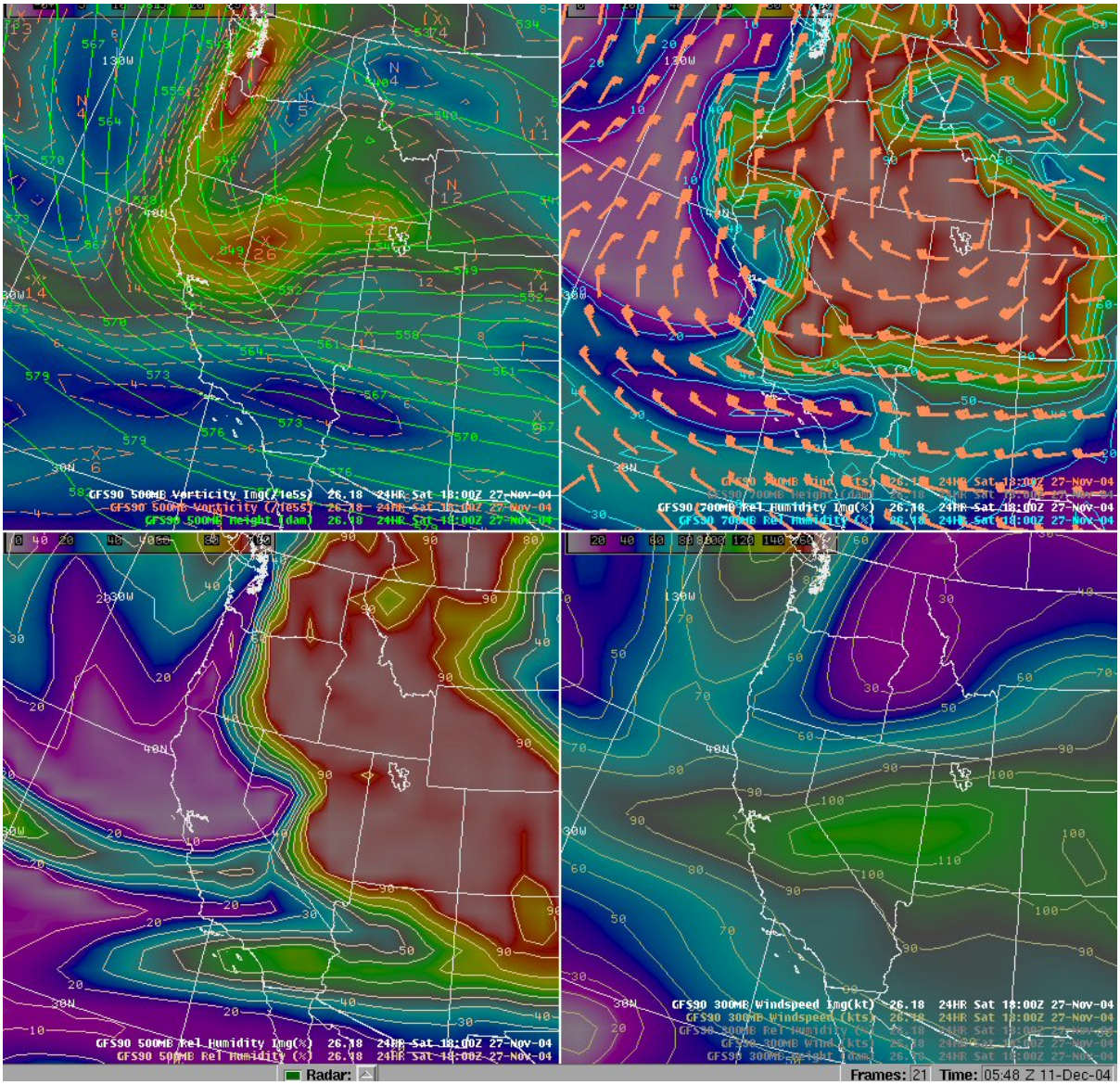
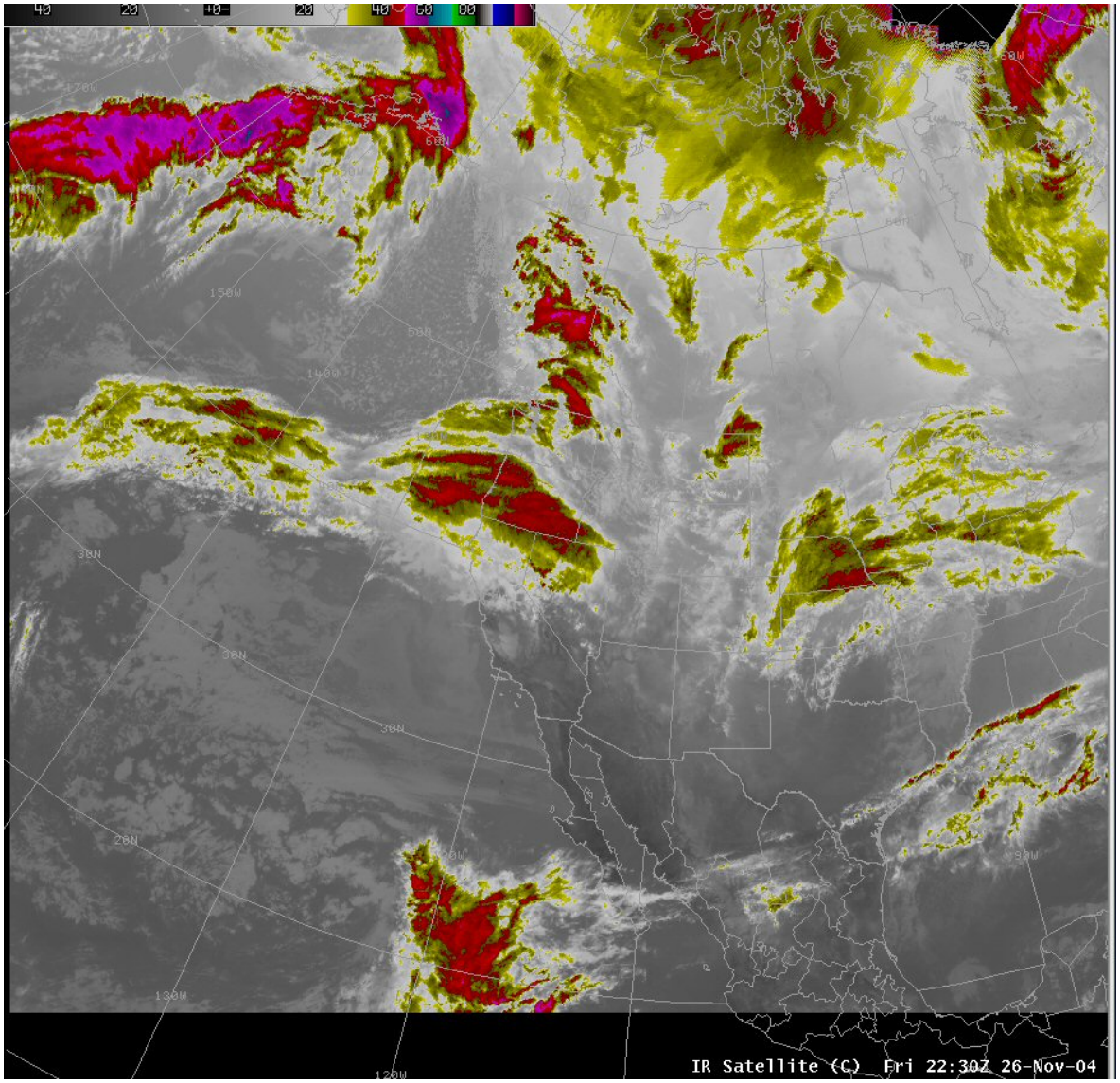


Figure 4: 18z GFS model run on 11/26 valid at 18z on 11/27. The top left image depicts 500 mb vorticity (shaded) and height, the top right depicts 700 mb relative humidity (shaded) and wind, the bottom right is 300 mb wind speed, and the bottom left is the 500 mb relative humidity.



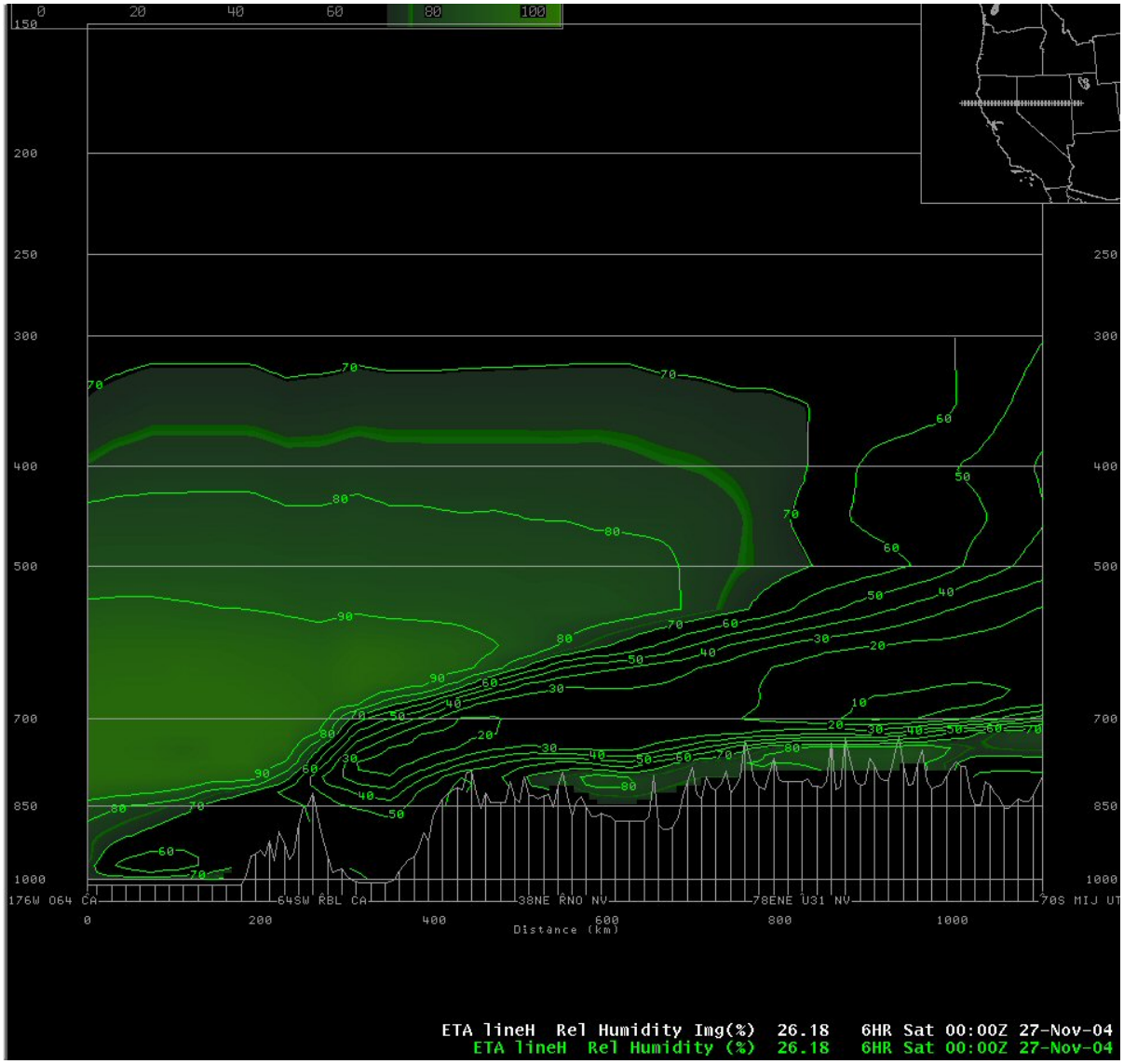
Satellite pictures on the 26th showed a significant plume of moisture streaming across the eastern Pacific near 40N (Refer to Figure 5 below).

Figure 5a: IR satellite image valid on 11/26 at 2230z, showing significant moisture plume streaming across the eastern Pacific along 40N, and moving into northern California, Oregon and northern Nevada.



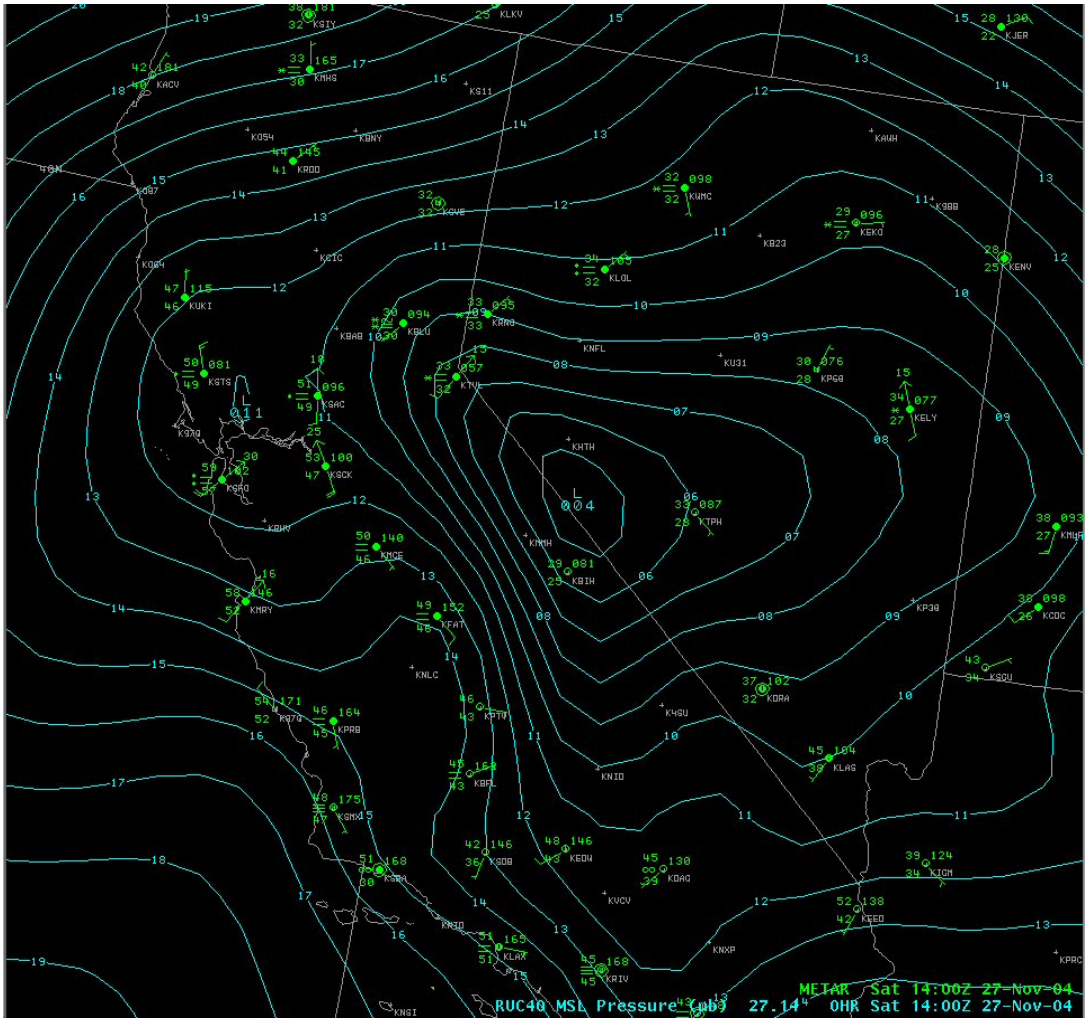
Precipitable water within this plume of moisture was 1 to 1.5 inches (not shown). Although models were slow to pick up on the depth of this moisture, the models did trend wetter (Figure 5b below) and it was becoming evident that enough cold air would be in place when the dynamics caught up with the moisture, such that advisories would also be needed across valley areas of eastern Lassen County and northern Washoe County.

Figure 5b: ETA Cross Section of RH at 00Z, 27 Nov 04, showing deep moisture as system approached.



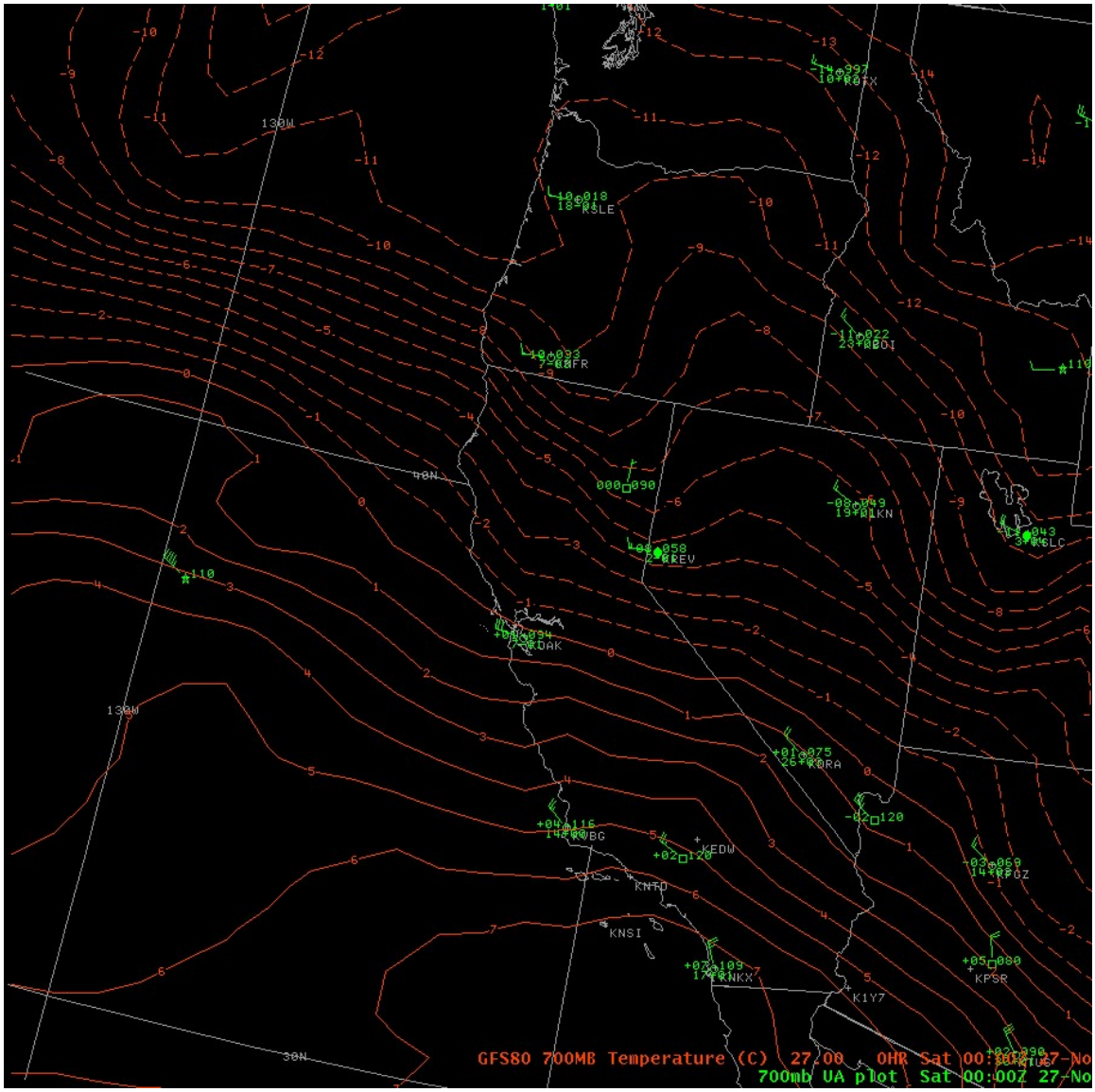
A shortwave continued to push southeast from the Pacific Northwest into northern California Friday night, with a band of precipitation initially developing over northern areas. Pressures began to fall over western Nevada as a surface low over north central California redeveloped northeast of Bishop. (Refer to Figure 6 below).

Figure 6: RUC Analysis and Surface Plot at 14Z, 27 Nov 04. Rain and Snow was occurring over western Nevada at this time.



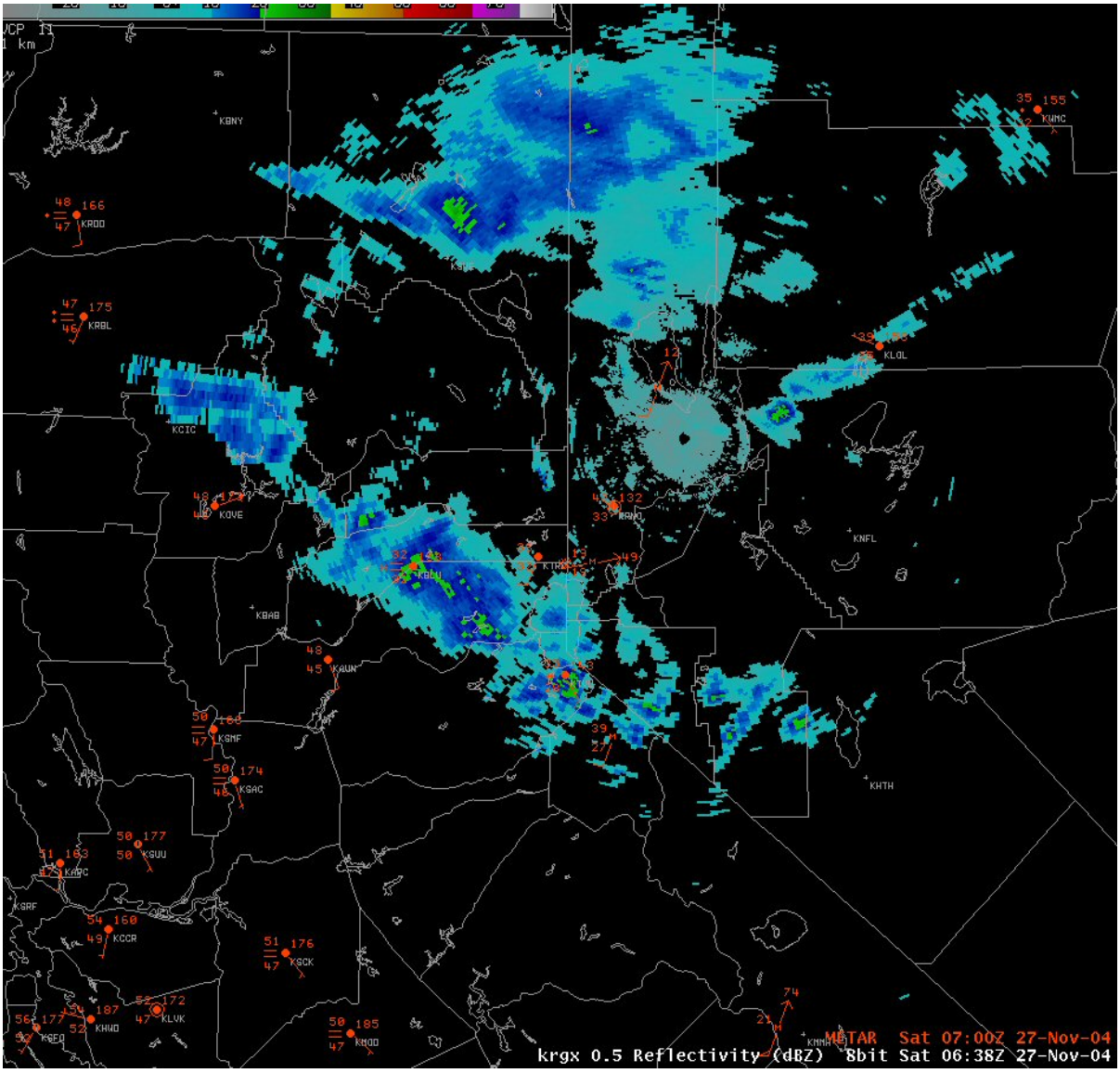
This allowed cold, low level air to become further entrenched over western Nevada prior to the formation of heavier precipitation. This was going to be key to the heavy snowfall at lower elevations as snow levels dropped to the valley floors almost at the onset of heavier precipitation, with only a brief period of rain at the lowest elevations. The 27/00Z 700mb upper air plot (Refer to figure 7 below) showed a strong baroclinic zone in place from north central California to southern Nevada with temperatures near or just above 0C to the south of the boundary and from -8C to -11C behind it. Reno had a 700mb temperature of -8C, which suggested that the leading edge of the boundary was further south.

Figure 7: 700 MB Analysis and RAOB plot at 00Z, 27 Nov 04.



Furthermore, radar imagery showed a band of precipitation extending from northwest to southeast along the baroclinic zone, with light snow being reported at Lake Tahoe by late evening of the 26th. (Refer to Figure 8 below). Some light warm advection snow and valley rain also occurred on Friday evening around Reno and Carson City eastward to Lovelock…Pyramid Lake and Fernley. That area of light snow eventually extended south to just north of Hawthorne suggesting frontal zone stretched across the southern two zones of the Reno CWA. Snow levels were close to 5000 feet and accumulations remained light. The boundary was not going to push north given the low amplitude of the upper level flow and influx of cold air from the northeast close to the surface. In addition, the well defined boundary would likely play some role in enhancing vertical velocities to the lee of the Sierra which is traditionally shadowed under strong westerly flow near ridgetop and above. The snow advisory was expanded once again to include areas above 5000 feet around Reno to inform the public of 2 to 4 inches of snow potential by Saturday morning the 27th.

Figure 8: 0.5 degree reflectivity at 0638z indicating precipitation falling near the front or baroclinic zone.



Deep moisture, strong lift associated with frontogenesis (Refer to Figure 9a) or strengthening baroclinic zone and jet dynamics from incoming system combined to produce a prolonged period of strong vertical velocities within the frontal zone north of the main surface low (Refer to Figure 9b below). In addition, strong vertical motion and saturated conditions were present in the -10 to -20 C range (12z KREVsounding on the 27^{th,} not shown) to produce very efficient microphysical processes and resultant moderate to heavy snowfall rates.

Figure 9a: ETA 24 hour forecast from the 12z 11/26 model run. This shows strong frontogenesis.

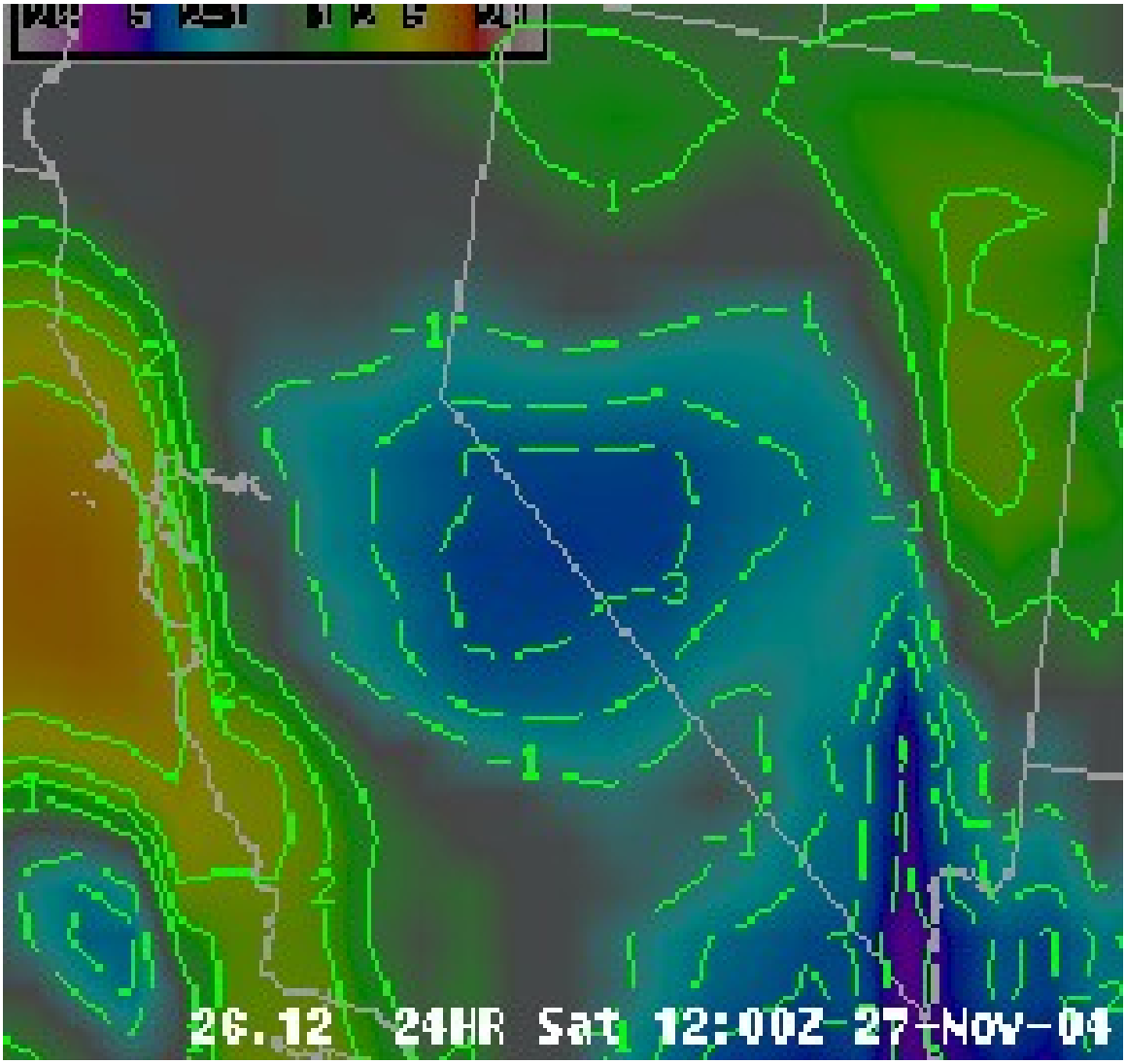
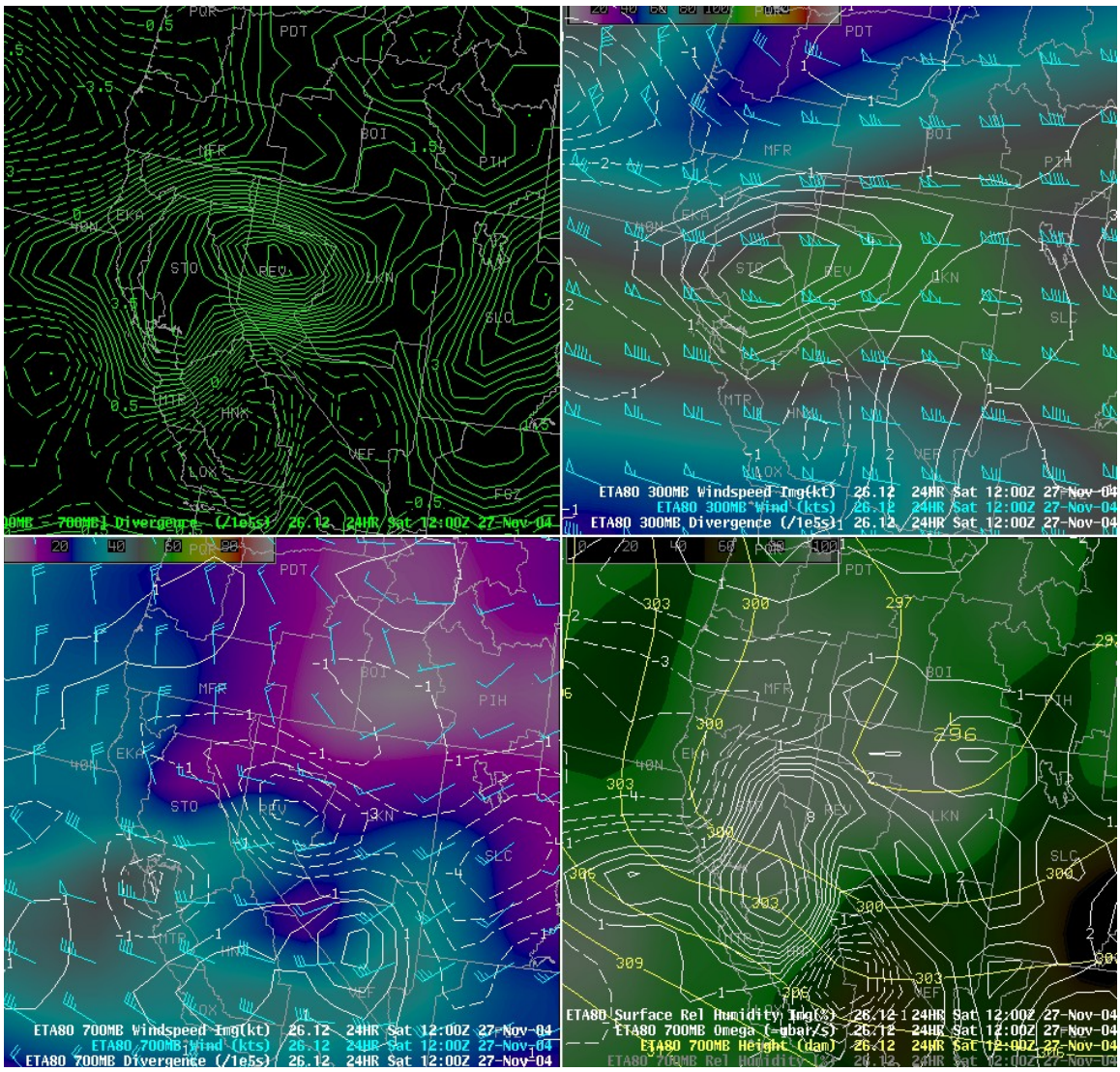


Figure 9b: ETA 24 hour forecast from the 12z 11/26 model run. The ETA indicated strong convergence at 700 mb across western Nevada (lower left panel), as well as a strong couplet at 300-700 mb (upper left panel), 105 kt jet at 300 mb moving across the northern Sierra and central Nevada (upper right panel), and strong omega and abundant moisture at 700 mb (lower right panel).



The precipitation band and intensity and low level cold air are very evident in the reflectivity and velocity data of the 88-D. (Refer to Figures 10 and 11 below). The low deepened and pushed southward allowing for increasing northerly flow to advect drier air into western Nevada from the northeast by midday on the 27th and hence cutting off the snowfall.

Figure 10: 0.5 degree Reflectivity data from 1418Z showing large area of snow falling across western Nevada and northeast California north of surface low.

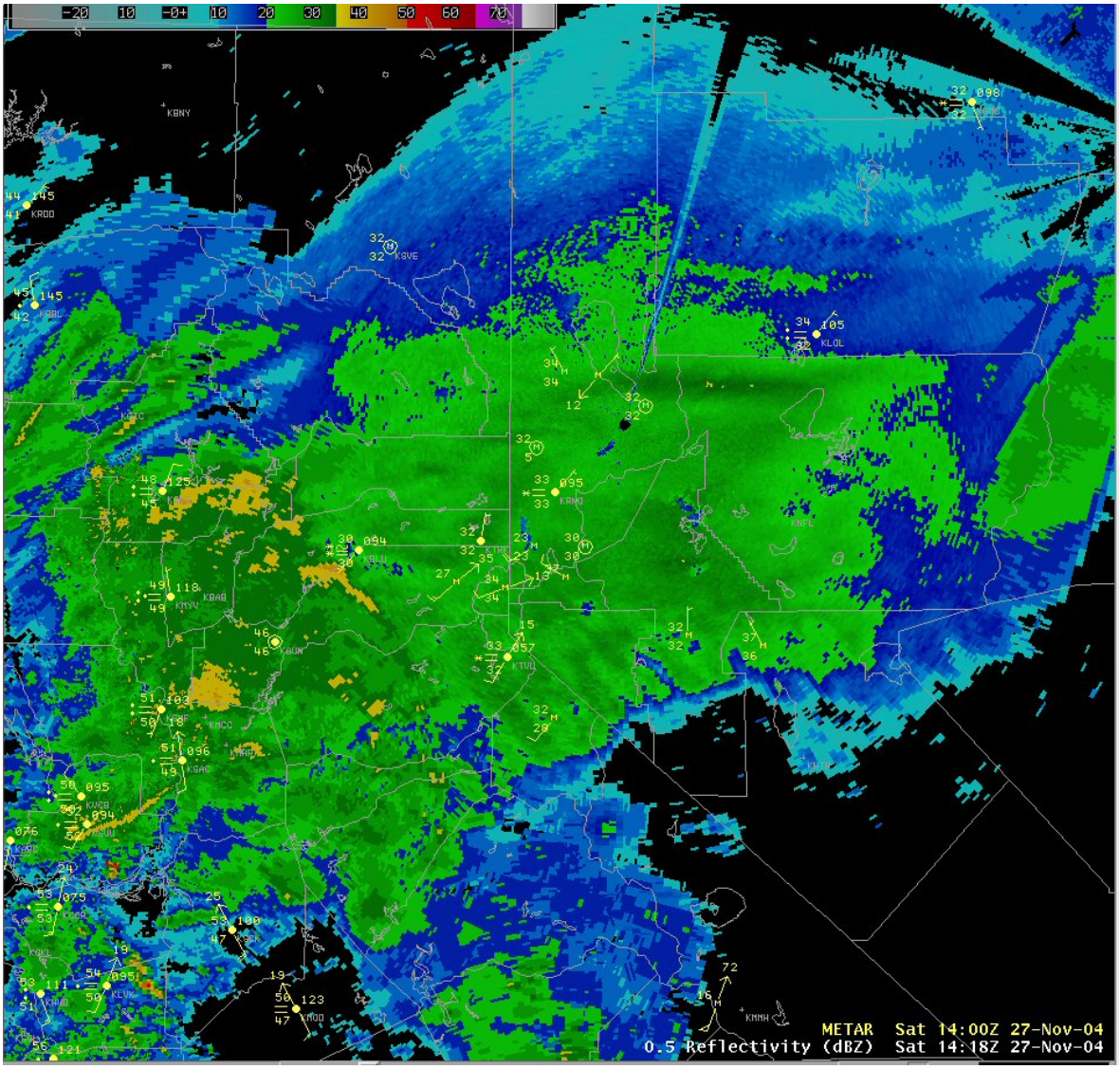
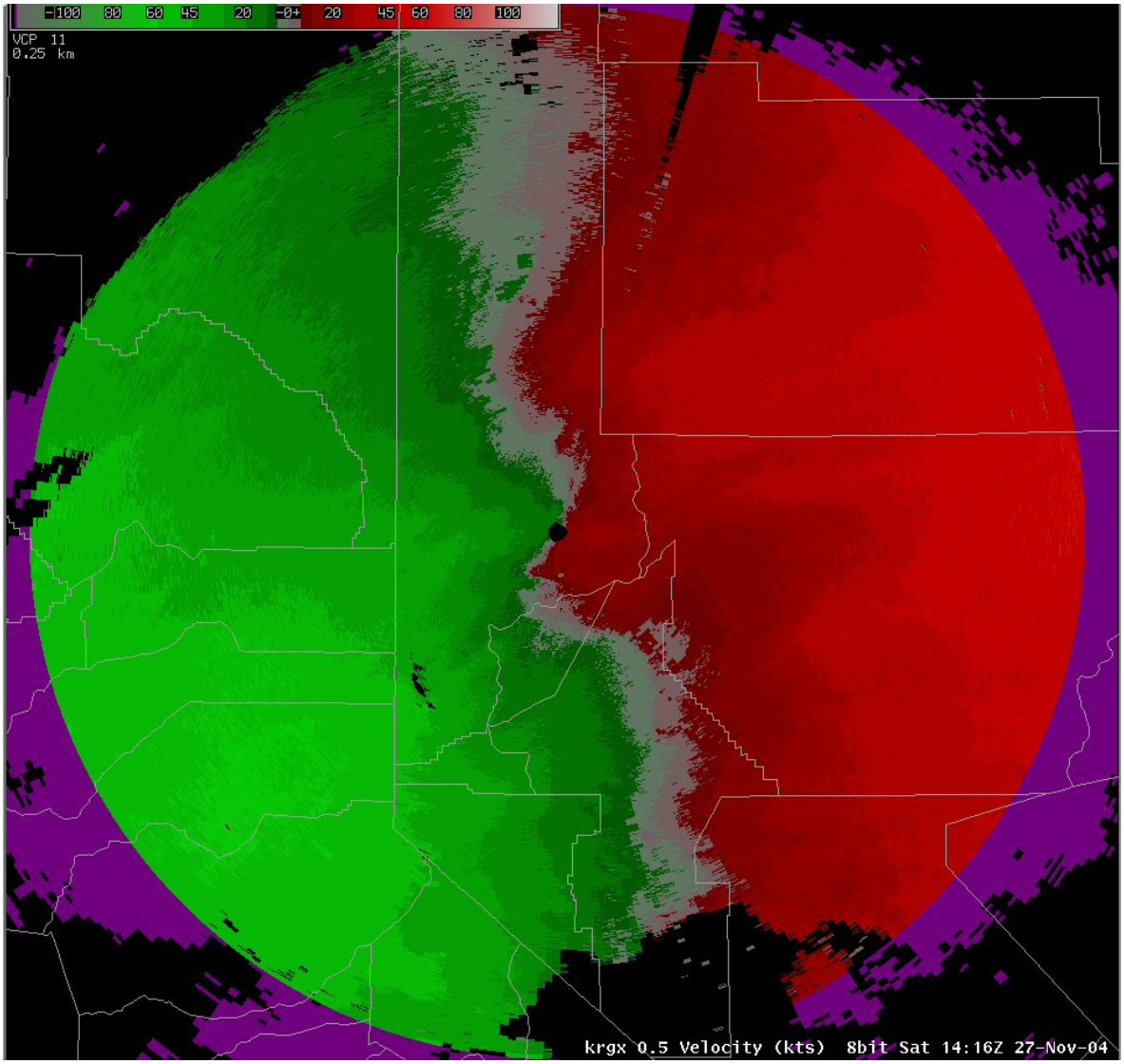


Figure 11: 0.5 degree Velocity data valid at 1416Z on 11/27. Backward "S" shape evident in velocity data suggests backing winds and cold air advection.



It is interesting to note that after reviewing satellite imagery prior to the event and beginning on Tuesday evening the 23rd, this system consisted of a mid latitude wave that originated over the north central Pacific, an upper level disturbance that originated with a large area of convection south of Hawaii, and a higher latitude polar disturbance that brought the very cold air southward. The combination of the abundant moisture from the tropical region, the cold polar air arriving from the north, and dynamics present in all three features came together perfectly for heavy snow to develop in the Sierra and western Nevada.

Snow amounts were widespread, ranging from 5 to 12 inches over many western Nevada valley locations from Doyle and Lovelock to just north of Hawthorne. This included the Reno and Carson City areas. 6 to 12 inches were common in the Sierra with as much as 18 inches around the Truckee area.