Warm Advection with Interesting Details
December 1, 2005
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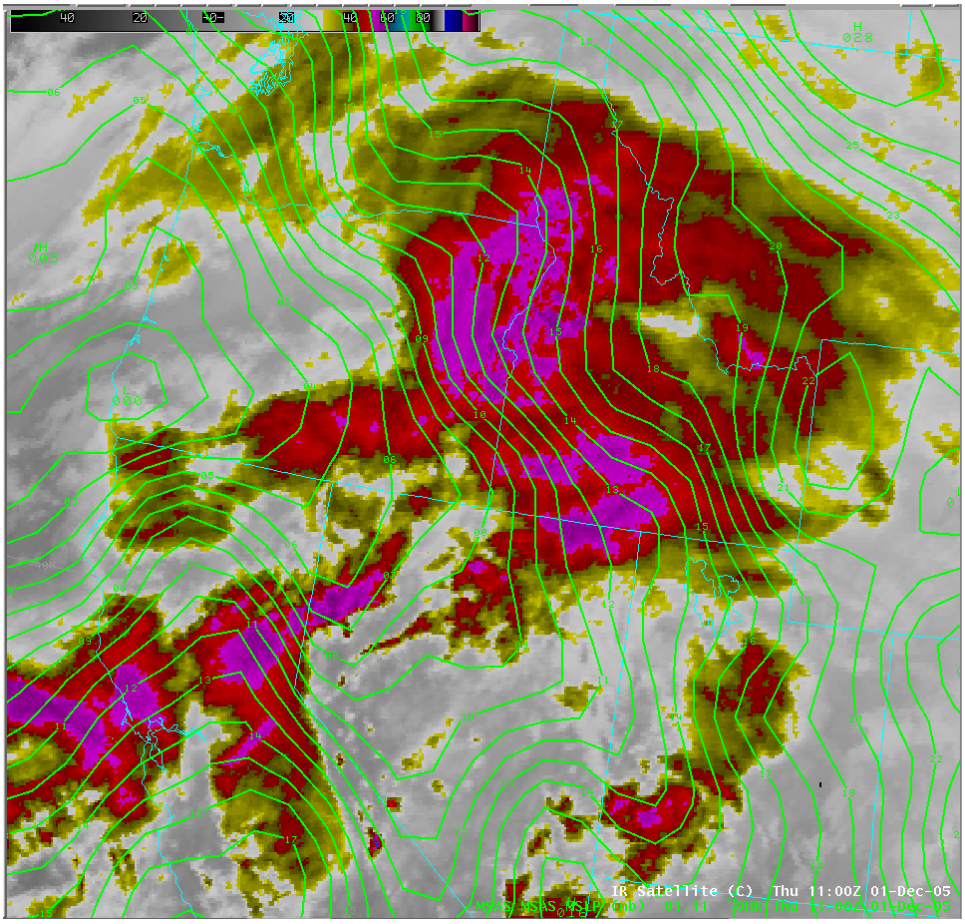
Introduction:

Cold-season snow events that rely on topographic lift typically have very tight gradients of snowfall – with the heaviest amounts close to steep mountain slopes. However, warm-advection events are driven by upper-level dynamic forcing that typically creates a much broader area of precipitation, and less spatial variation in the amount of snowfall. These events can often cause the most problems for the Boise metropolitan area, since they can produce widespread snow across the entire Snake River Valley, rather than a small band of snowfall along the front-range of the Boise Mountains.

This case from December 1, 2005 is a strong warm advection case and widespread snow might be expected. However, stability characteristics created strong gradients of snowfall within the Snake River Valley.

Satellite:

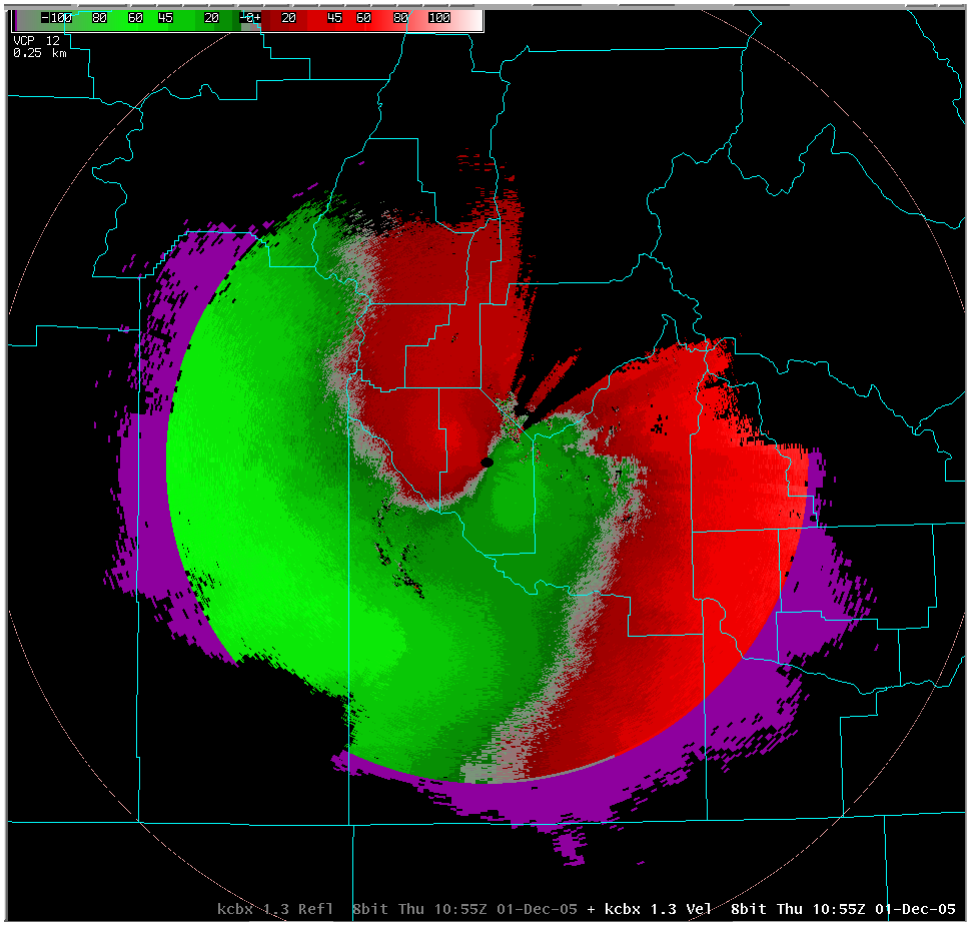
The infrared satellite image from 11Z Dec 1, 2005 shows a large area of cold cloud tops overspreading the Boise forecast area:



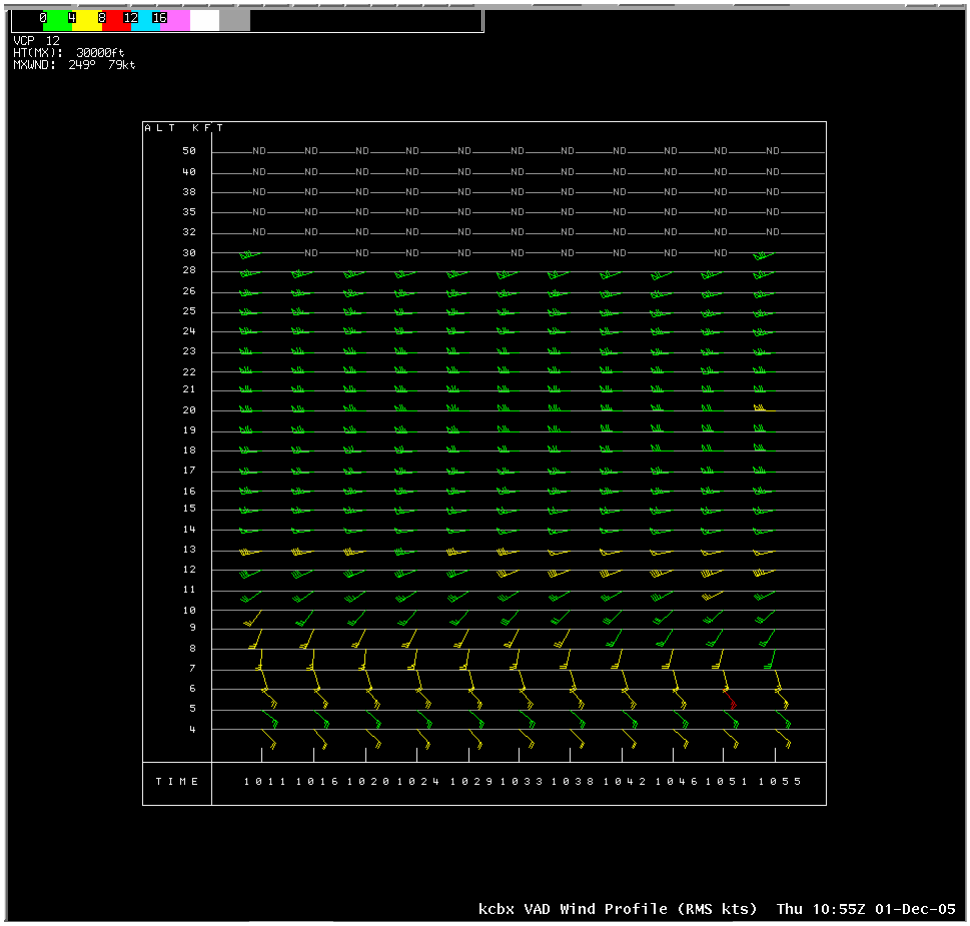
The sea-level pressure lines overlaid on the satellite imagery shows the surface low center still far to the west, along the southern Oregon Coast. The pressure gradient is quite strong over southwest Idaho, producing significant surface winds.

Radar:

The 11Z 1.5 degree velocity image from the Boise radar is shown here:



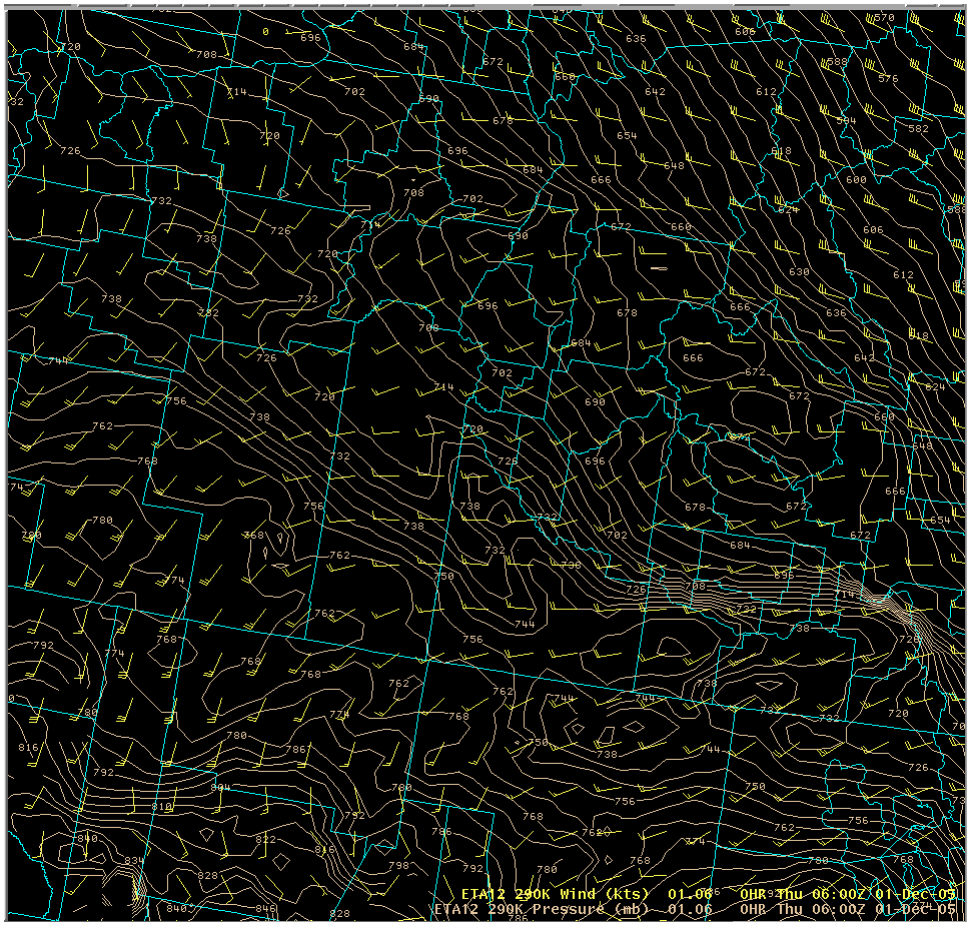
The typical “S” pattern shows the strong warm advection taking place, with winds at the surface coming from the southeast, and veering around to the west aloft. The VAD wind profile at 11Z is shown here:



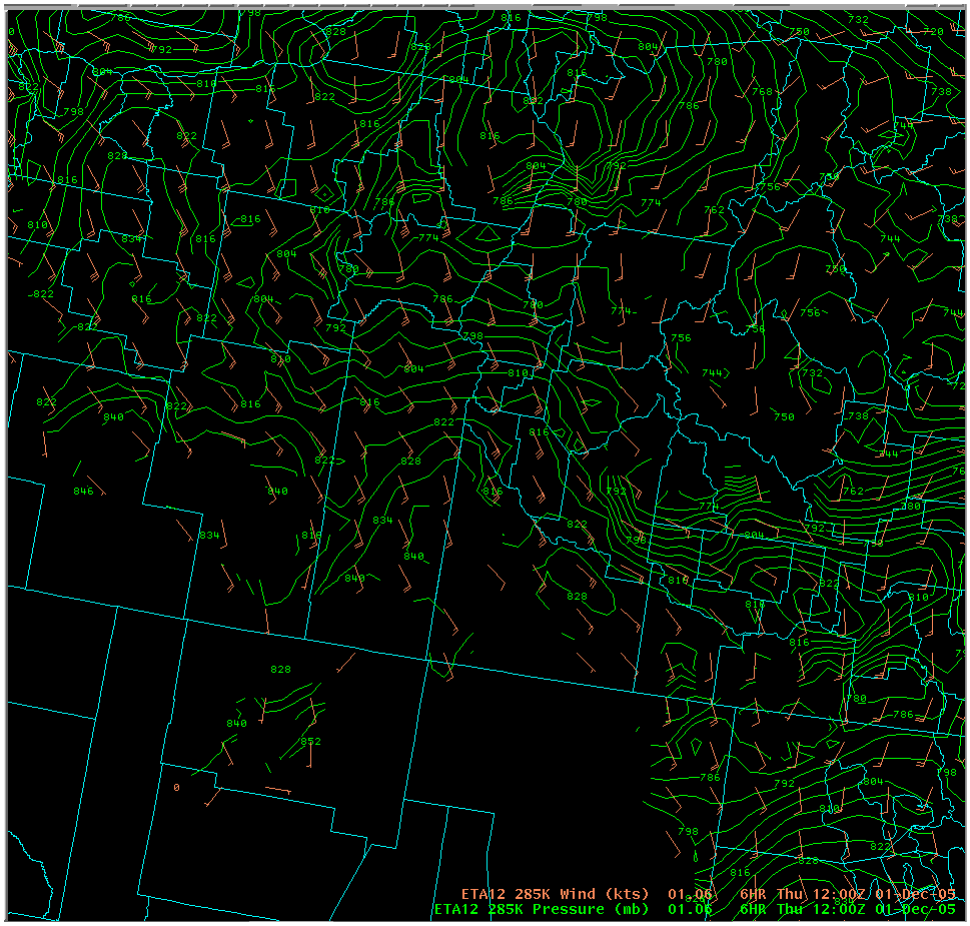
Winds of up to 25 knots are observed just above the surface, with stronger winds aloft.

Isentropic Surfaces:

The southwest flow aloft crosses over the Owyhee Mountains, just southwest of Boise, creating downslope conditions as it enters the Snake River Valley. At 06Z, the southwest flow on the 290K isentropic surface shows an interesting pressure pattern over the Owyhee Mountains:



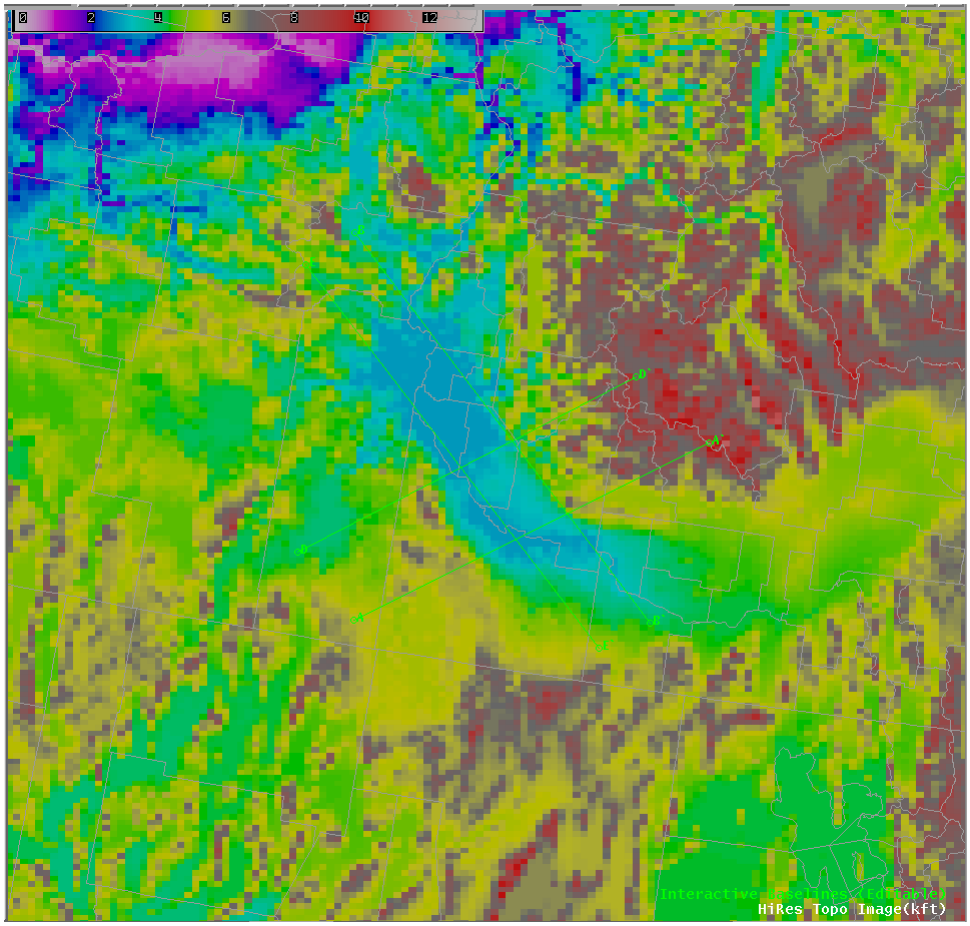
The pressure of the isentropic surface is relatively low on the upwind side of the mountains and relatively high on the downwind side of the mountains. This is indicating that the air going up and over the Owyhee Mountains is cooling as it is lifted on the upwind side, and warming as it descends on the downwind side. This downslope warming helps to erode the cold nighttime air mass that is usually present in the Snake River valley on winter mornings like this. See, for example, the 06Z Eta forecast of the 285K isentropic surface at 12Z:



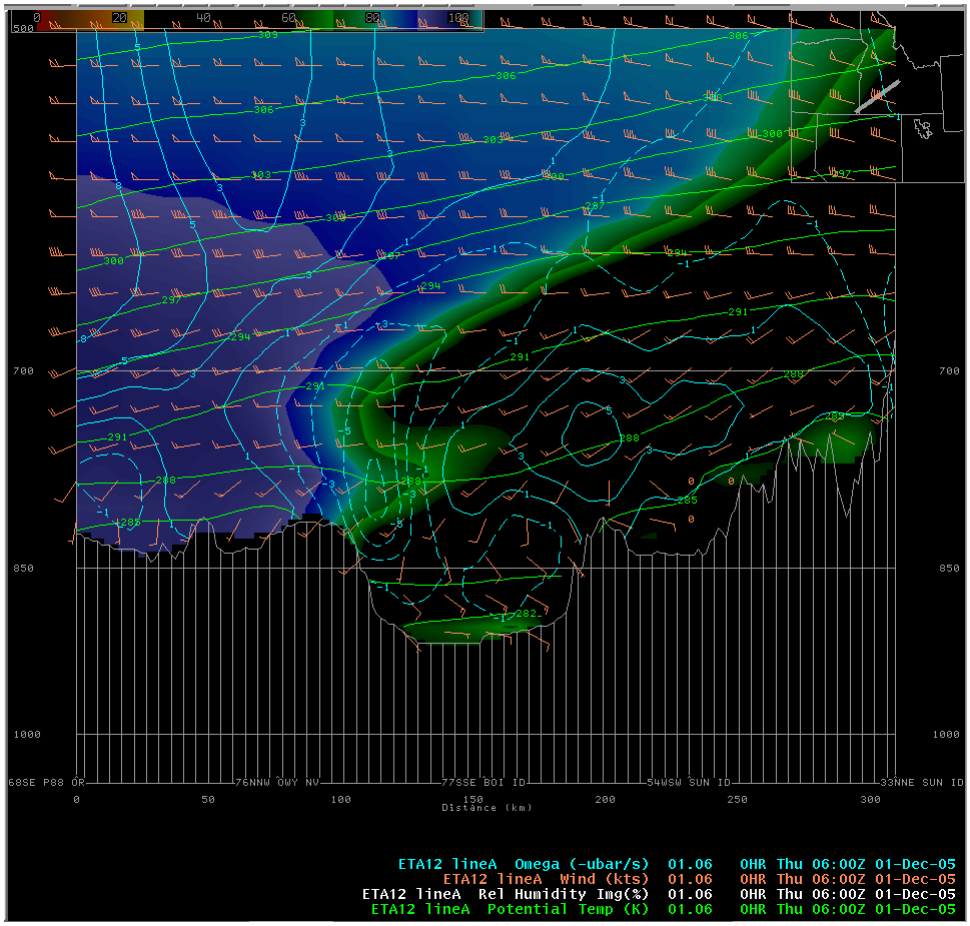
This surface is very close to the ground in the Snake River valley. The air on this surface is forecast to be moving from the southeast, to the northwest, just like we are observing on the Boise radar displays at this time. Interestingly, though, the highest pressure on this isentropic surface in the Snake River valley is about 830mb in northern Owyhee County. Air that continues to move northwest from there, starts rising and eventually reaches 800mb near Ontario Oregon, along the Oregon/Idaho border. These high pressure values in northern Owyhee Co., indicating the lowest level of the 285 isentropic surface, just downwind from the Owyhee mountains, indicates that the southwest flow aloft has warmed the low levels in the area, creating an area of enhanced uplift to the northwest of this area – especially toward Ontario Oregon.

Cross Sections:

Several cross sections of Eta model forecast guidance will be shown below along these baselines:

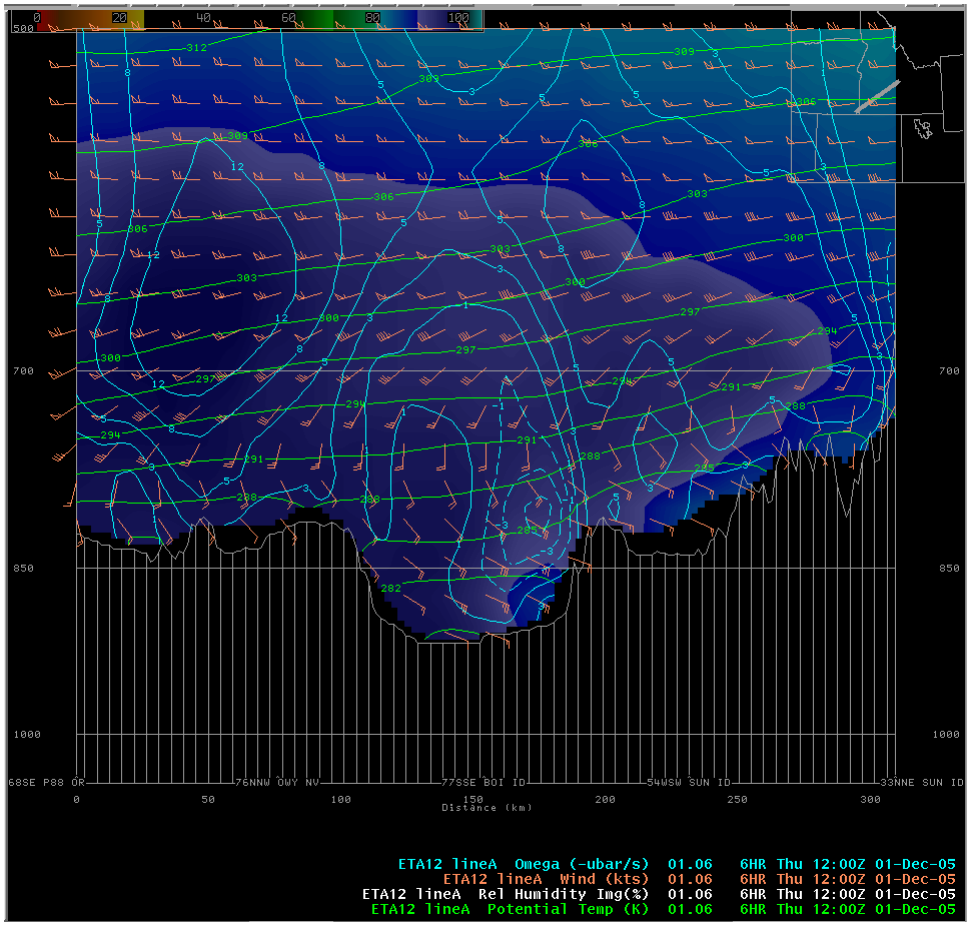


First, we will look at a cross section along the A-A’ baseline at the 06Z ETA Analysis:



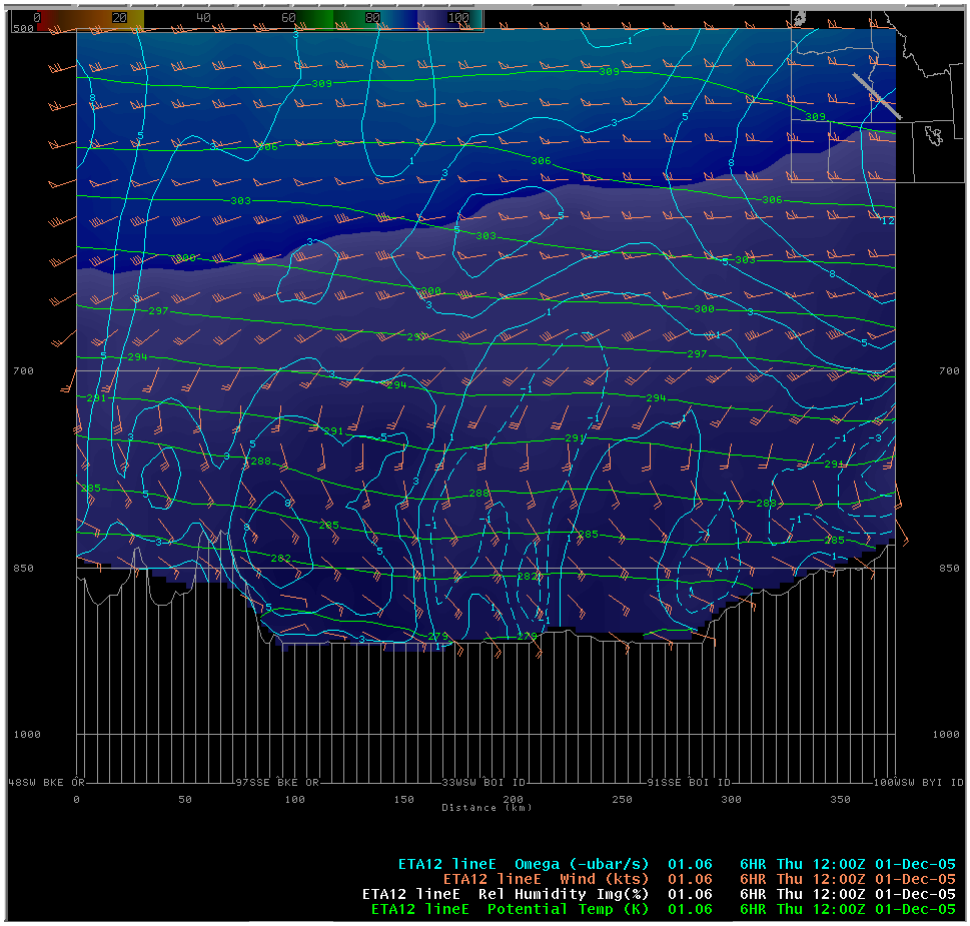
This cross section shows the Snake River valley, and the influence of the southwest flow over the Owyhee Mountains. Note the strong downward motion (dashed blue lines) just east of the Owyhee Mountains, and the relatively warm air (with low potential temperature) in the Snake River valley. The large area of upward motion aloft, related to the warm advection, is moving in from the southwest.

Now, let's look at the same cross section from the 06Z ETA 6-hour forecast valid at 12Z:



The large area of lift has spread across the whole cross section, and relative humidity is now well above 90% everywhere. However, note that the flow across this part of the Snake River valley has turned a bit more easterly, creating a component across the Boise Mountains to the east, and producing an area of downward motion on the northeast side of the Snake River valley.

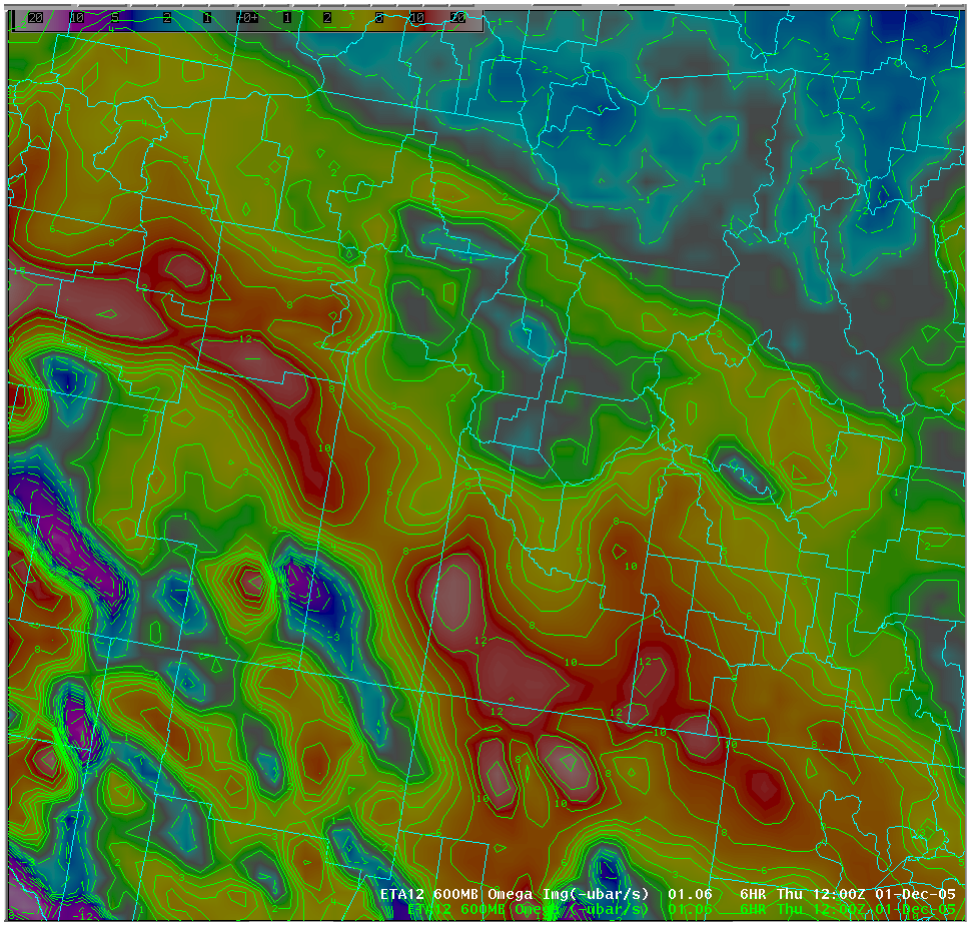
Let's now look at the forecast cross section for baseline E-E', which runs along the length of the Snake River Valley:



While there is general lift aloft, there are interesting patterns of upward and downward motion at the low levels across this section of the Snake River Valley. Of most interest is the strong area of low-level lift along the left edge of this cross section. This is the air that we saw on the 285K surface, raising as it moves from southeast to northwest along the Snake River valley. The area of descending motion in the center of the valley is what we saw in the other cross section – with air coming downslope off the Boise Mountains.

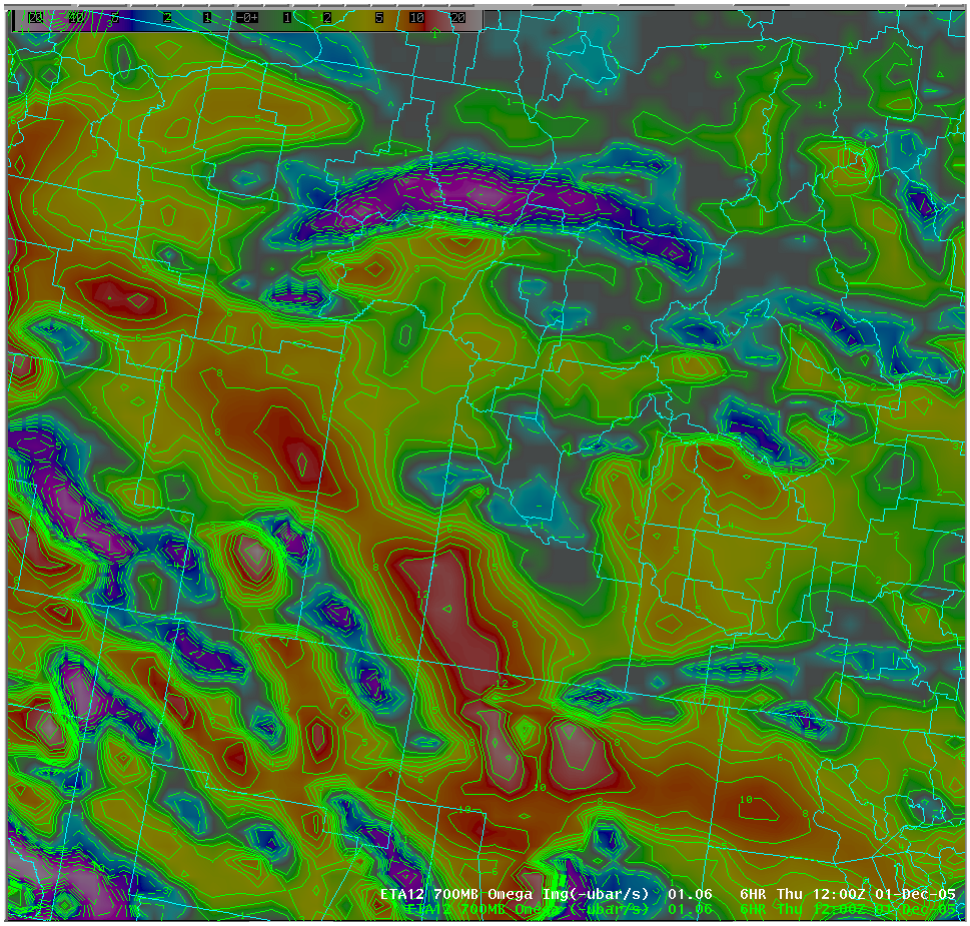
Plan-view Omega charts:

Here we show the 600mb Omega field forecast for 12Z 1 Dec 2005 by the 06Z Eta.



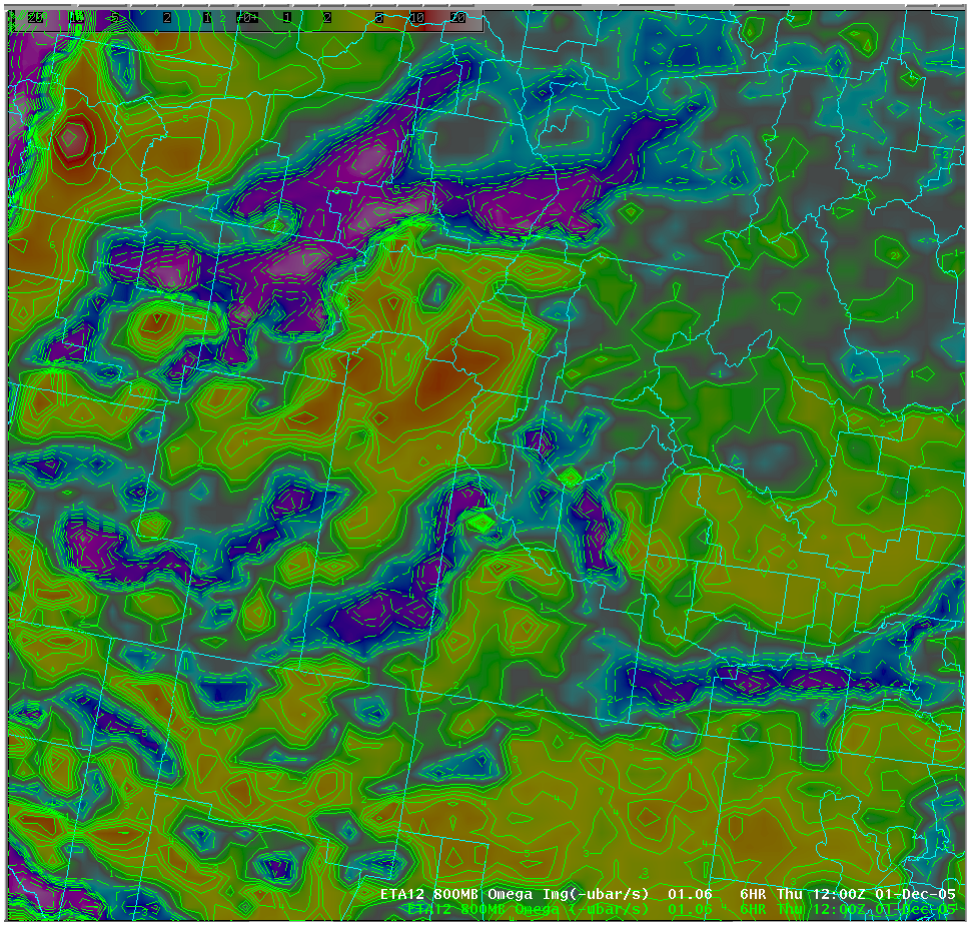
At this level, the widespread area of lift (positive omega) is overspreading the entire area. Again, this might lead us to forecast a large area of precipitation with relatively uniform coverage.

However, at 700mb, the picture is a little different:



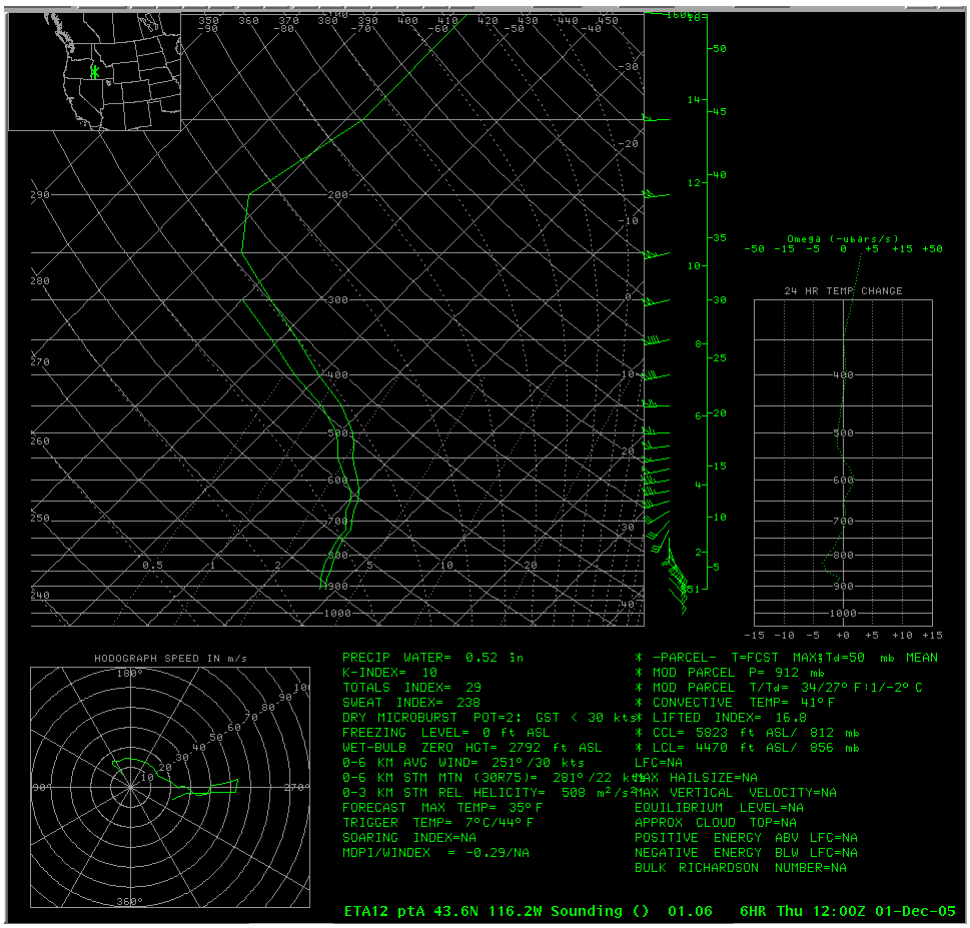
Areas of downward motion are now evident over Ada County, and the Boise area, while stronger upward motion is found to the northwest, over Ontario. However a large line of strong upward motion is approaching from the southwest, so a forecast of generally uniform snowfall might be expected.

However, at 800mb, the picture is quite different:



Here, the center of upward vertical motion is centered near Ontario, where the air flowing from southeast to northwest through the Snake River valley is lifted as it rises over colder air, and mountains, to the northwest. Areas of strong downward motion are seen across much of the Boise area.

The forecast sounding at Boise for this time is shown here:



Note that the sounding is quite stable at the lower levels, indicating the upslope/downslope components to the wind will be particularly effective in cooling/warming the atmosphere and creating areas of moistening/drying.

Summary:

In this case, where a first-glance forecast of general snowfall across the entire Snake River valley might seem reasonable, there were strong differences across the valley. Areas near Ontario Oregon received over 8 inches of snowfall, whereas some parts of the Boise area received as little as one inch, and areas further southeast, toward Mountain Home, received only trace amounts of snowfall.

Keep in mind that stable conditions make downslope warming and drying more effective, and subtle differences in wind direction can create areas of enhanced or diminished precipitation, even when the large-scale dynamics would indicate a large area of uniform precipitation.