The 14 December 2000 Winter Storm in the Inland Northwest – A Weather Event Simulation
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Introduction

During the winter of 2000-2001, the Inland Northwest experienced an extreme drought with precipitation about half of normal. Coincident with this winter, Spokane set a record for consecutive days with snow on the ground, 117 days. This string of days started with an early season snow storm on 9 Nov 2000 and was perpetuated by a large scale ridge that would significantly weaken storms as they moved into the area. This persistent snow pack also helped play a role in the winter storm on 14 December 2000. This storm was one of the few strong storms to move through the area that winter.

Discussion

The topography of the Columbia Basin in Eastern Washington is ideal for trapping cold air, with the Cascade Range to the west and the Selkirk Range across the north (Fig. 1). This is further aided by a snowpack on the lower elevations of the basin. Post-frontal cold air is often cooled further by long-wave radiational cooling over the snowpack. In fact, even in the absence of a synoptic-scale cold air mass, the radiational cooling alone is often sufficient to create a shallow dome of cold air that can later be dammed.

The damming process typically occurs as a Pacific low pressure system approaches the Pac NW coast. In Figure 2 at 12 UTC 14 Dec 2000, a post-frontal cold air mass lies over the Inland Northwest with light westerly flow at 850 mb. As a low pressure system approaches the coast 12 hours later (Fig. 3), the low-level flow switches to southerly or even southeasterly. The result is that the cold air over the Columbia Basin is pushed northward and westward. But the mountain ranges to the north and west restrict the movement of this low-level air mass. The result is a dome of cold air which is banked up against the east slopes of the Cascades.

In addition to the damming of the cold air, the southerly/southeasterly winds also ride up and over this air mass isentropically. The result is a lifting of the lower levels of the atmosphere resulting in further cooling and eventually precipitation.

After the low pressure system passes by the area, the flow switches to westerly (Fig 4). If the flow is strong, the westerly wind will push the cold air mass out of the Columbia Basin. But in many cases, the cold air mass remains although the "damming" of the air mass is lessened.

It is insightful to examine this from vertical cross section perspective. Looking along the line shown in Figure 1, we can easily see the dome of cold air in the western half of the Columbia Basin at the same time as Fig. 3, which is indicated by the tight packing of the potential temperature contours (Fig. 5). If we overlay the circulation streamlines at this same time (Fig. 6), we see the gradual upslope flow over the dome of cold air, with stronger vertical lift in the mid-layers due to the lifting of the synoptic scale system. Six hours later, the mid-level flow has already switched to westerly and there is synoptic scale downward motion (Fig. 7). However, the low-level cold air mass is not removed immediately. Additionally, the low-level wind flow continues to favor and upslope lift and the continuance of precipitation, albeit not has heavy as in the preceding panel due to the loss of the mid-level lift. After another 6 hours, the low-level cold air mass has been almost completely removed and the flow has switched to westerly at all levels (Fig. 8). The synoptic scale subsidence coupled with the orgraphic downslope should result in a rapid cessation to the precipitation and cloud cover. However, numerical models often have a difficult time with this aspect of the forecast. This this particular instance, a shallow layer of cold air persisted near the surface and the strong westerly winds did not mix all the way down to the ground.

Figure 9 shows the snowfall totals for this event across the Inland Northwest. Note the 4.9" of snow at Wenatchee and 4" at nearby Waterville. Farther to the east and south of the cold air damming, in the central Columbia Basin, snowfall totals are less.

Summary

The topography of the Columbia Basin is ideally suited to cold air damming events in the winter. The dome of cold air which is banked up against the eastern slopes of the Cascades is a critical factor in the weather for this area. The isentropic lift that it generates aides in the precipitation formation and helps to overcome downslope affects due to westerly flow across the Cascades. Additional, the type of the precipitation is often dictated by the depth of this cold dome. Snow levels west of the Cascade crest will often rise to 5000-8000 feet or more, while on the other side of the crest snow levels remain at the surface due to the cold air damming. Freezing rain events are also not uncommon in these situations as the warmer air aloft from western Washington rides over the cold air dome.

Figure 1

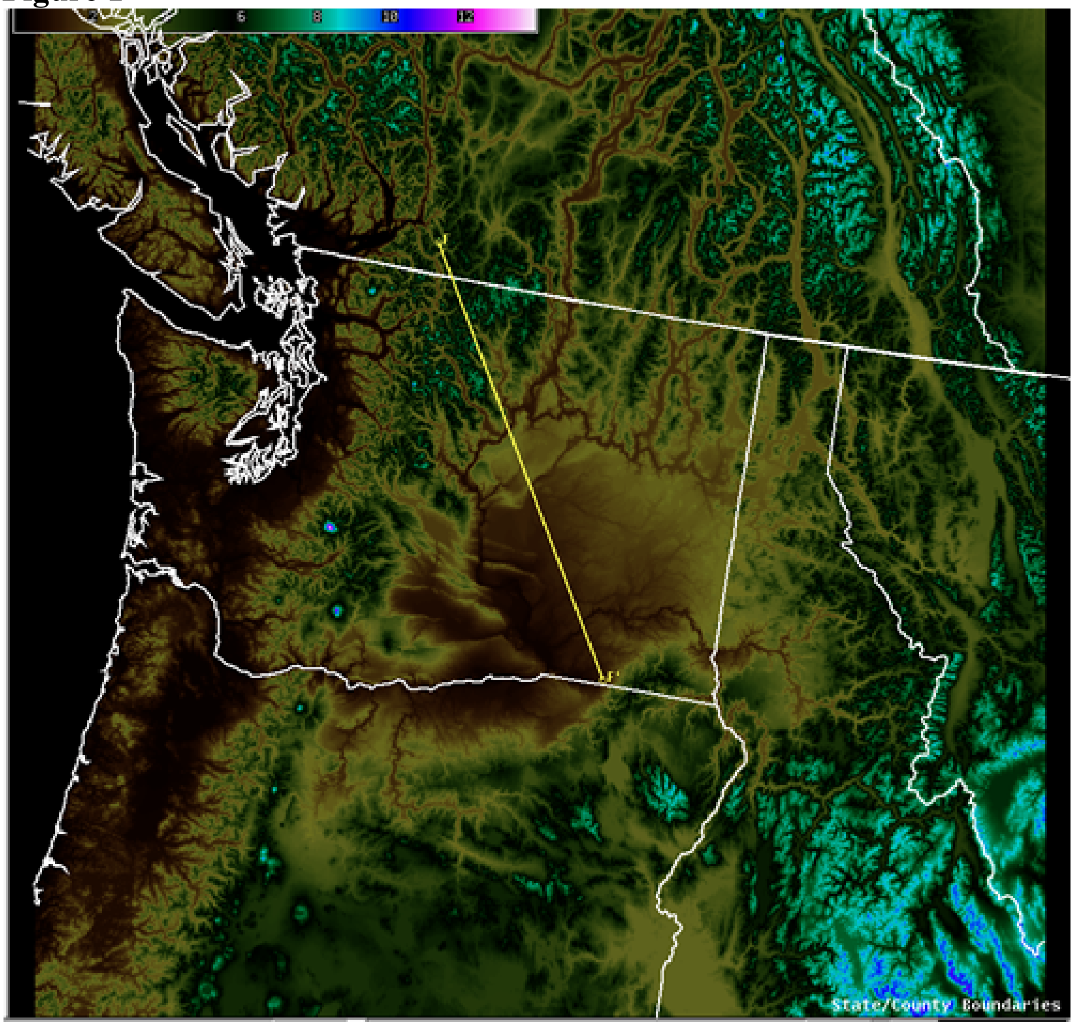


Figure 2

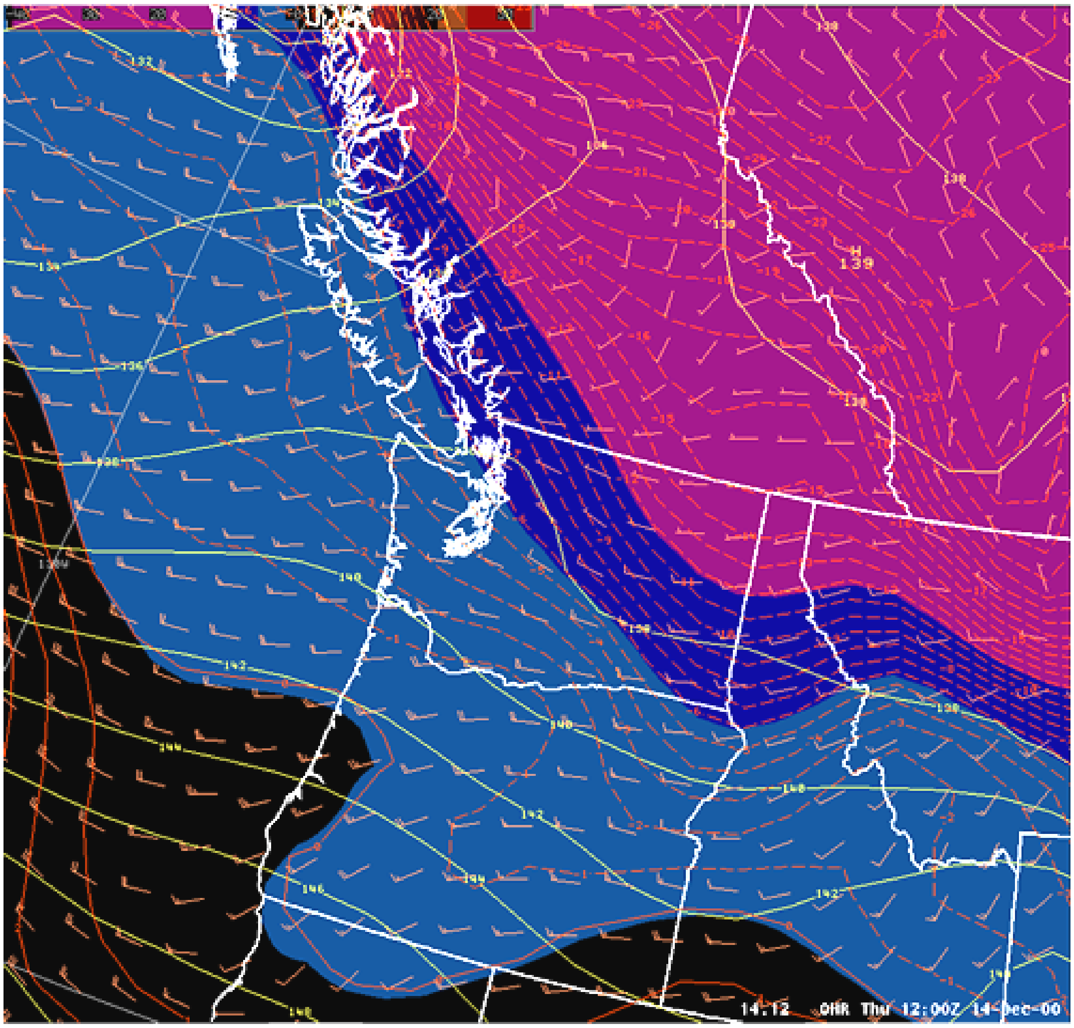


Figure 3

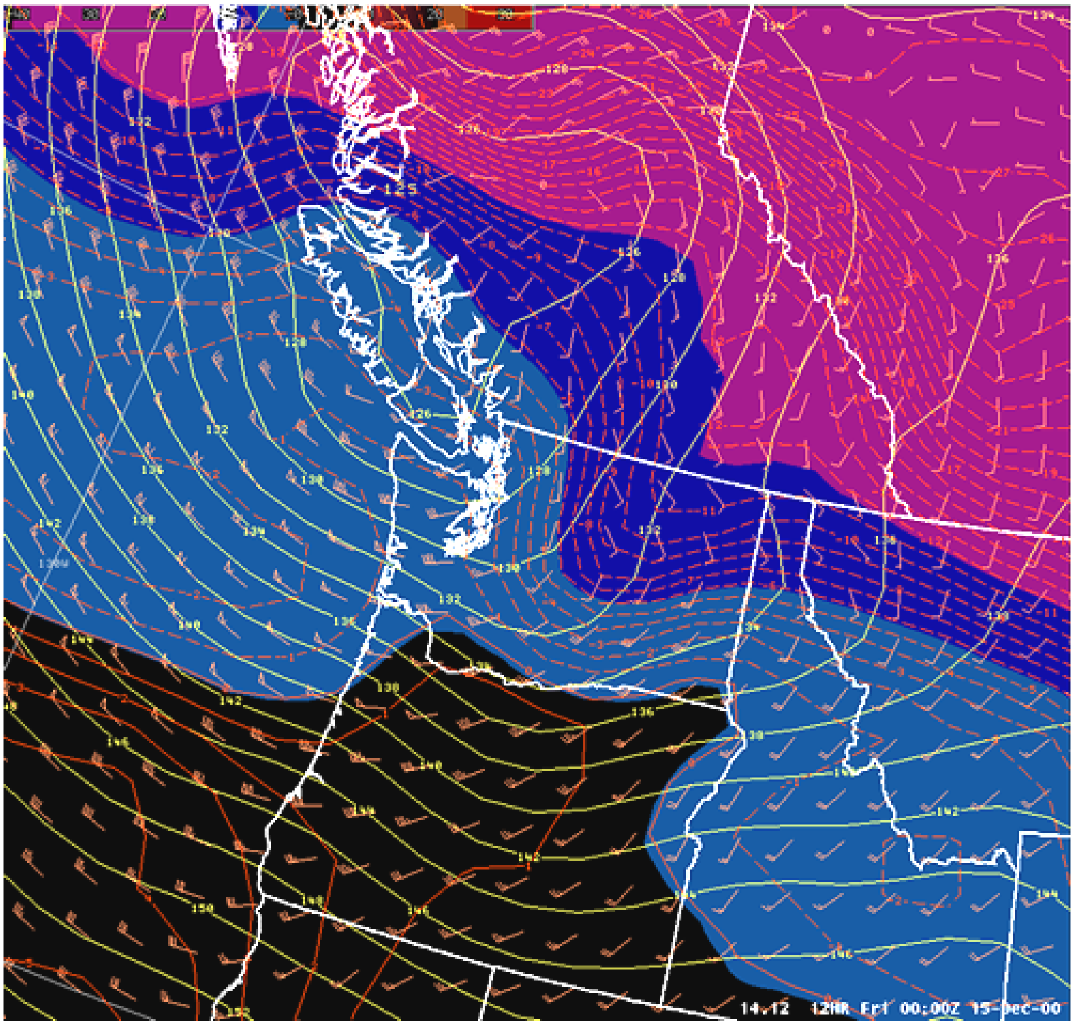


Figure 4

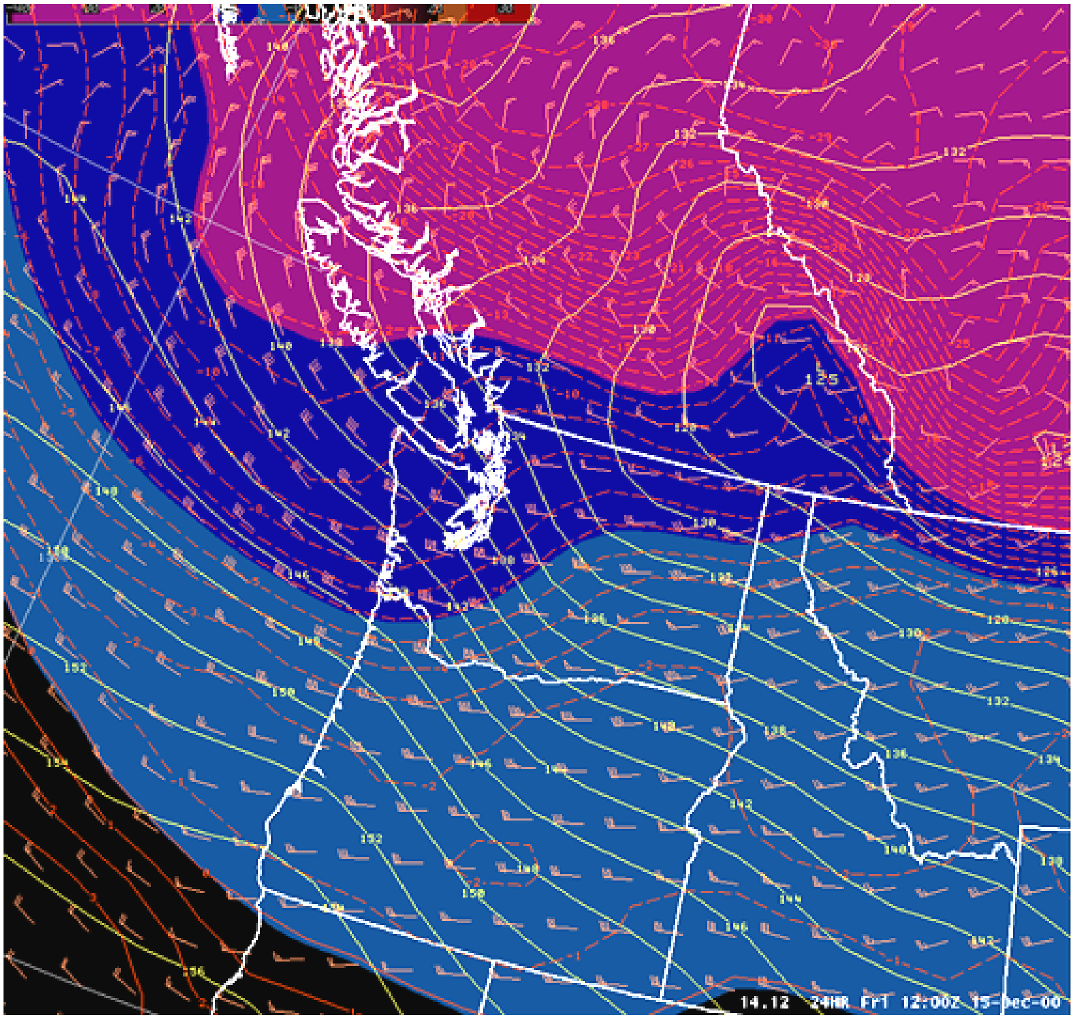


Figure 5

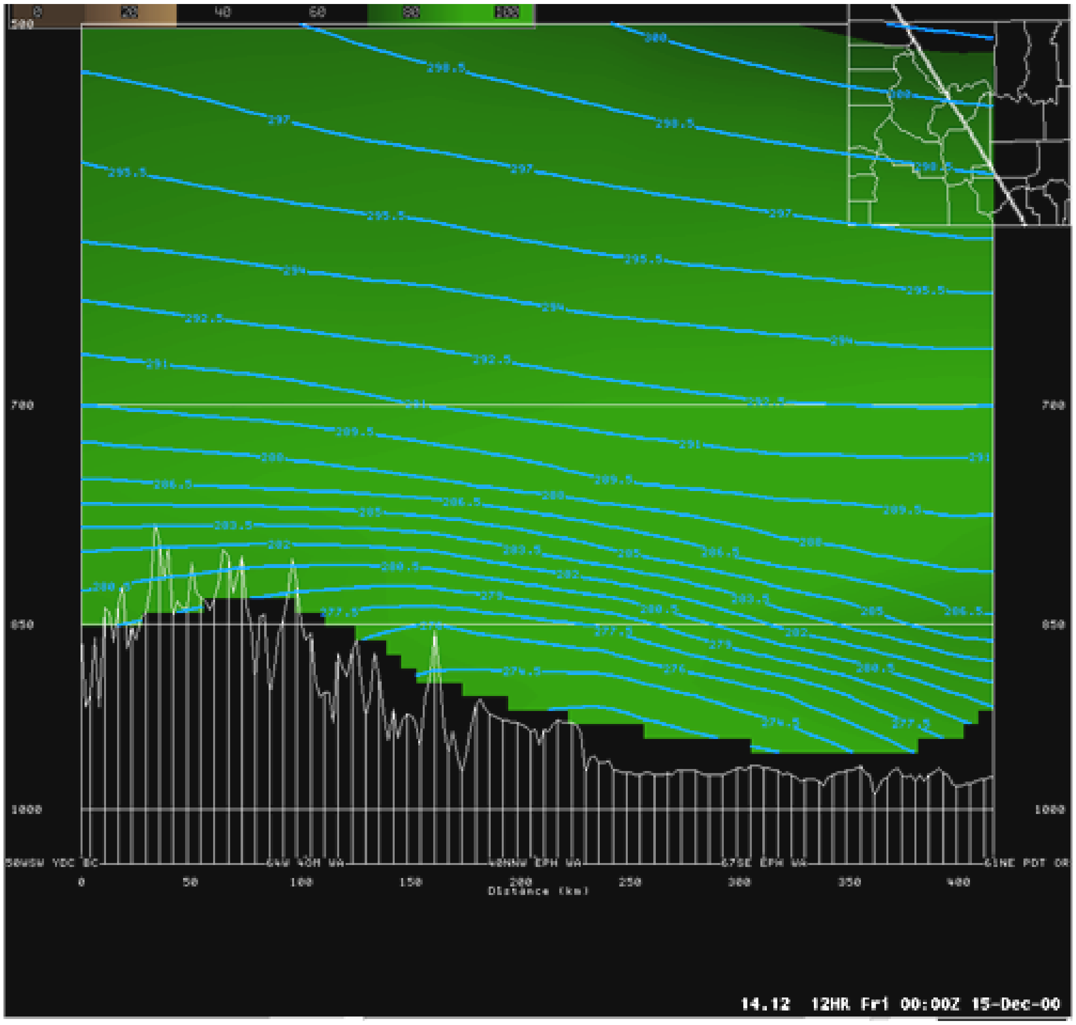
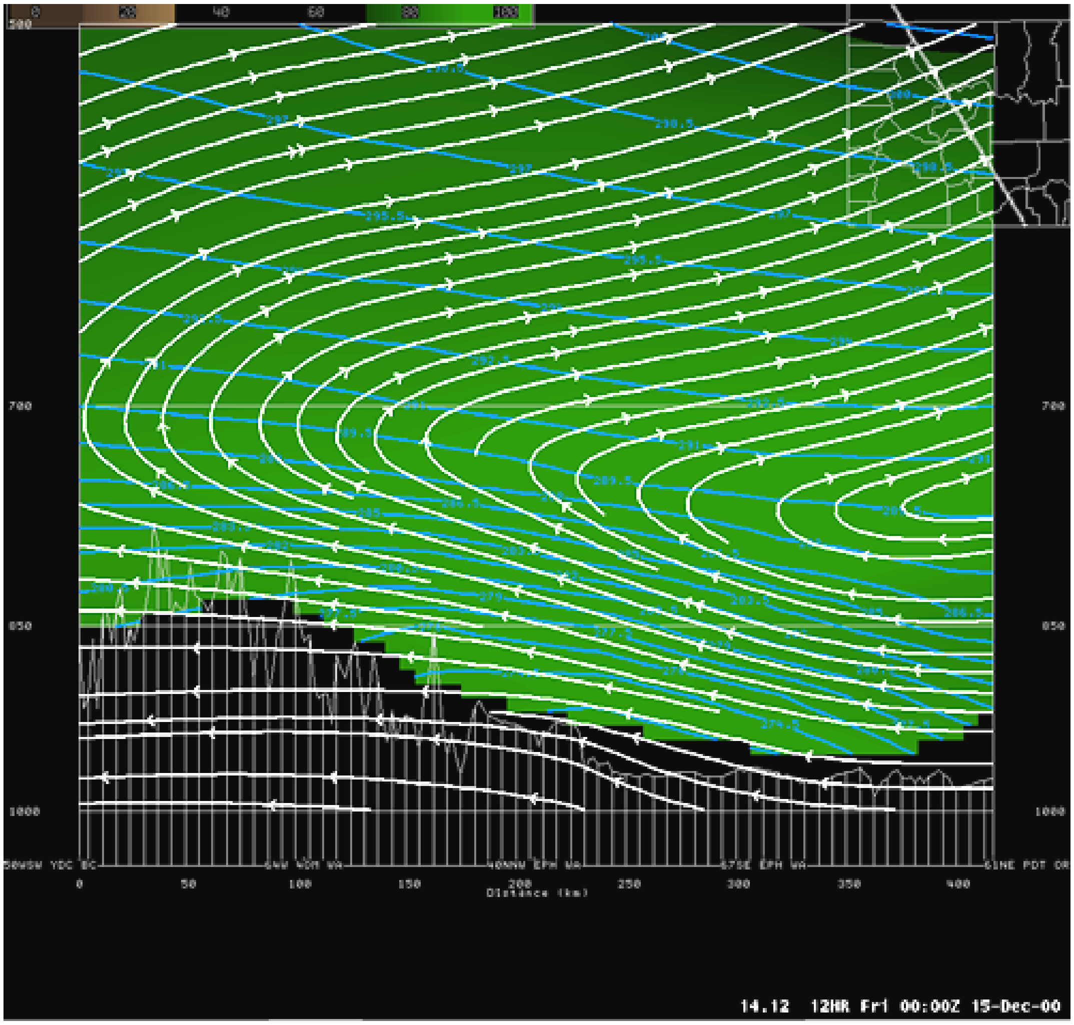


Figure 6



700
850
1000
0
50
100
150
200
250
300
350
400
Distance (km)
14.12 12HR Fri 00:00Z 15-Dec-00

Figure 7

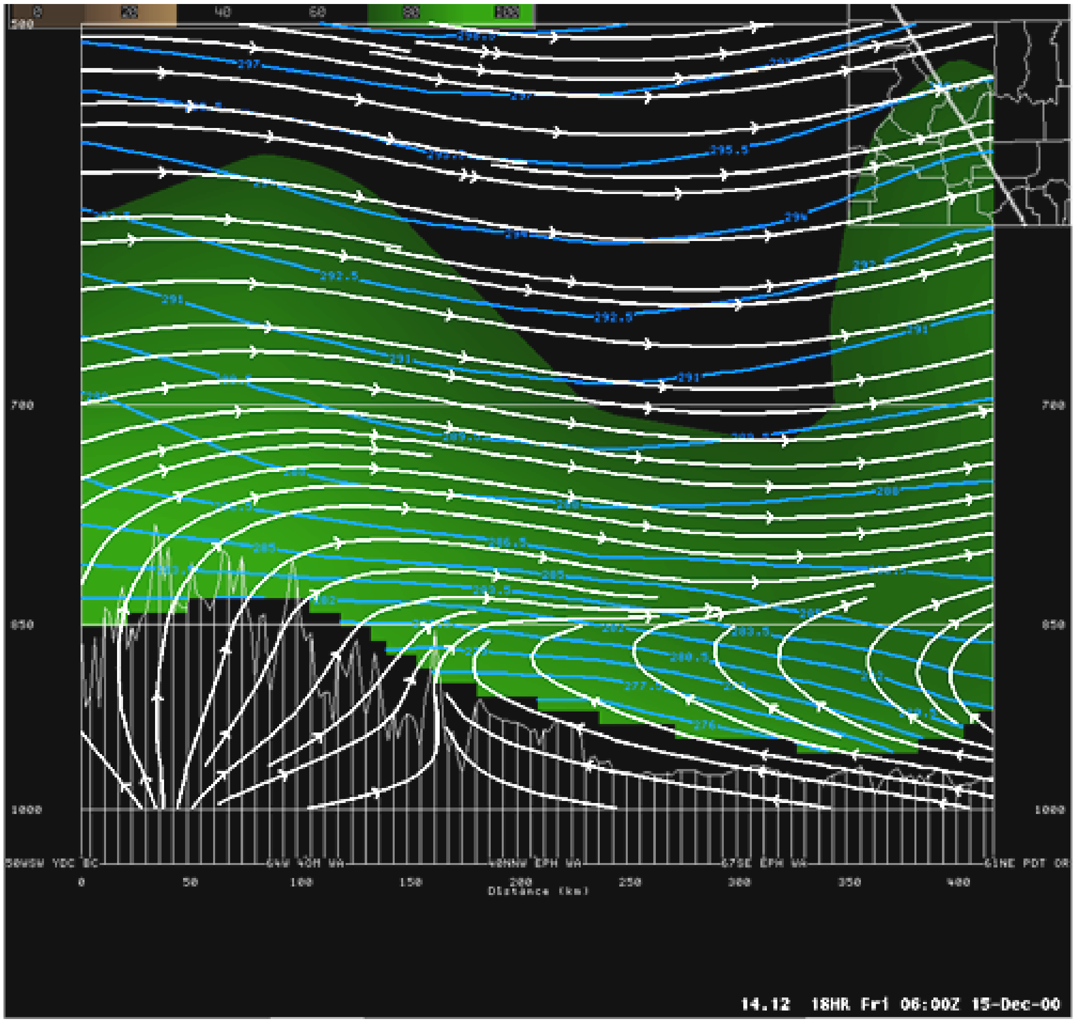
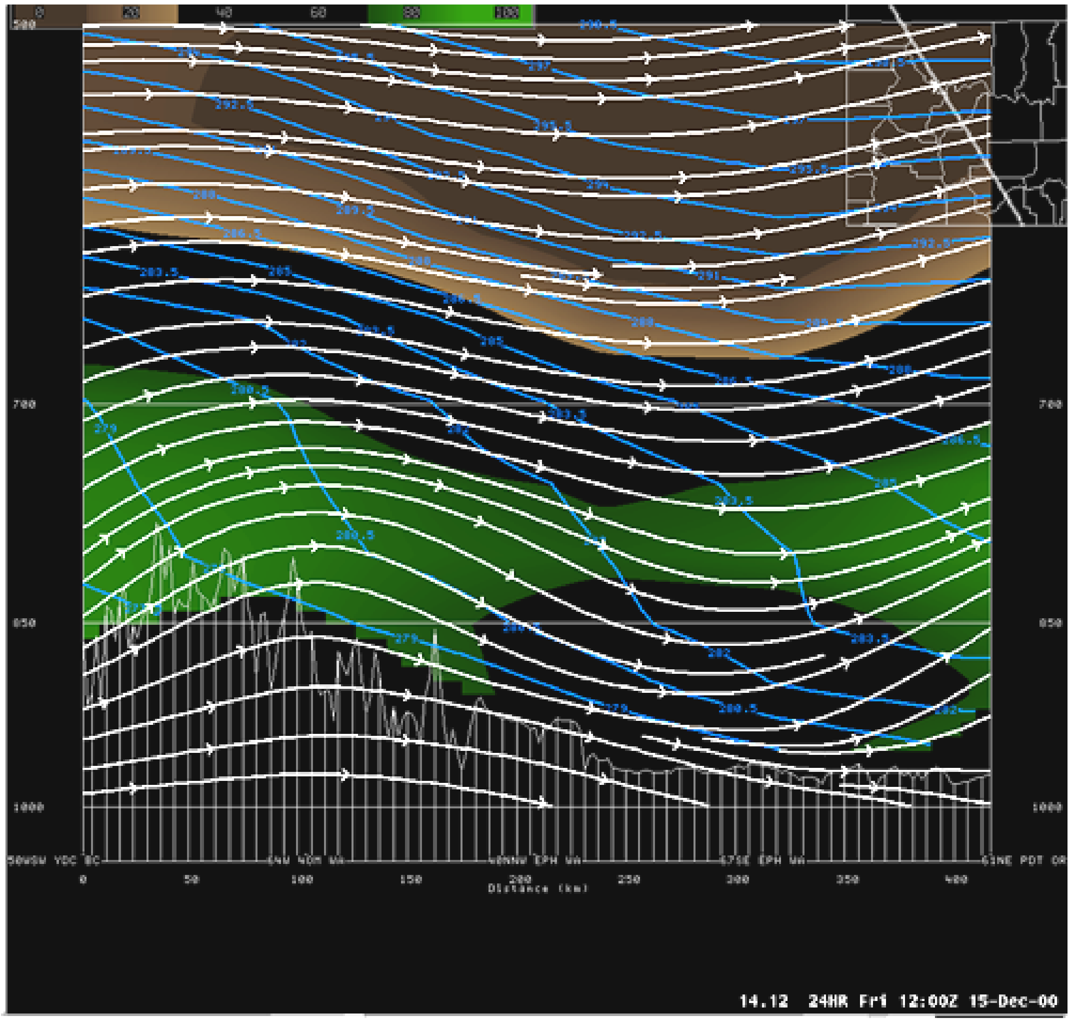


Figure 8


700
850
1000
0
50
100
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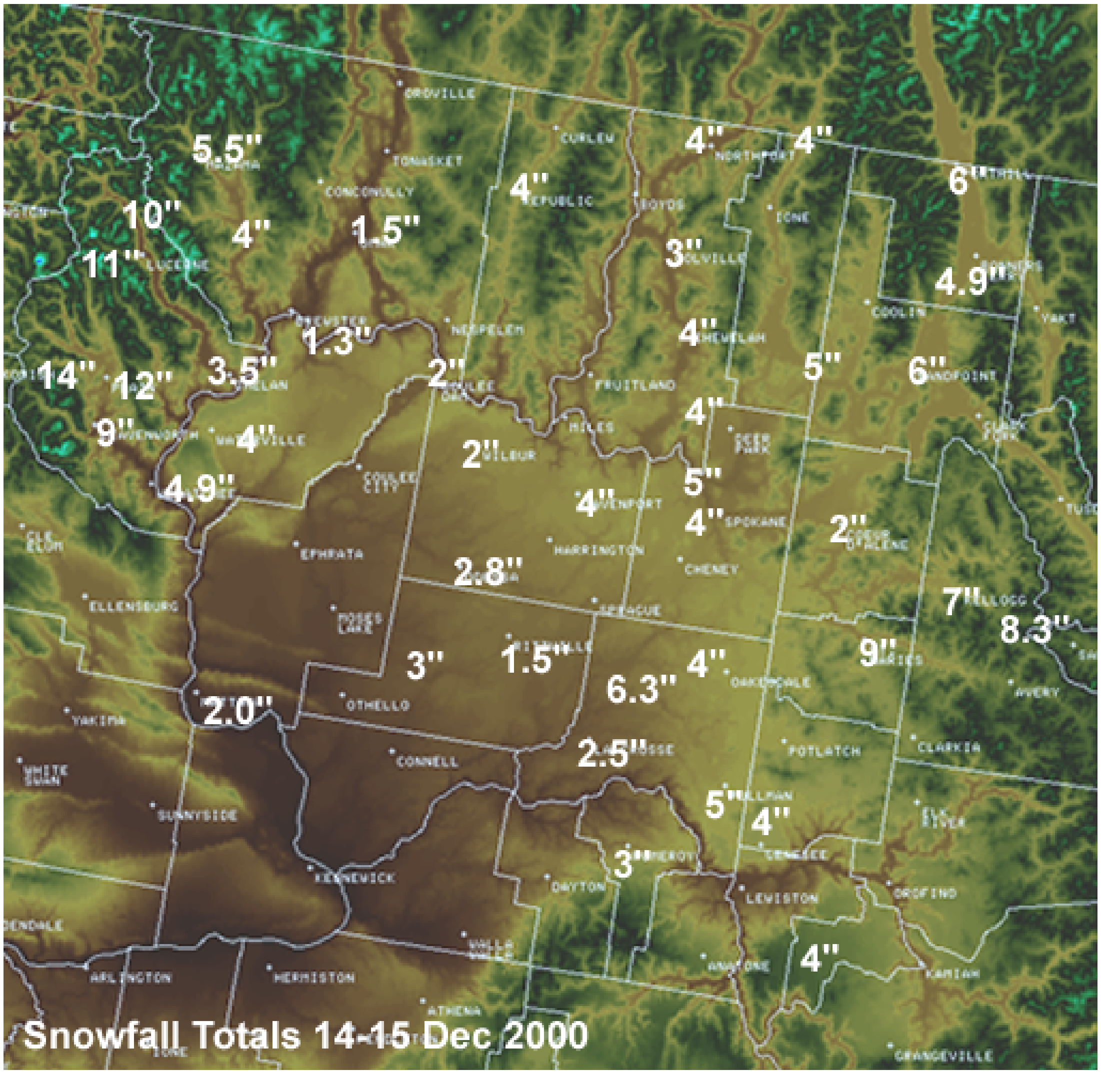
300
350
400
Distance (km)
14.12 24HR Fri 12:00Z 15-Dec-00

Figure 9


Snowfall Totals 14-15 Dec 2000
OROVILLE
CURLEW
NORTHPORT
TONASKET
CONCONULLY
REPUBLIC
BOYDS
IONE
COLVILLE
BONNERS FERRY
COOLIN
YAAK
NESPELEM
BREWSTER
CHEWELAH
FRUITLAND
SANDPOINT
CHELAN
MILES
DEER PARK
WILBUR
COULEE CITY
SPOKANE
EPHRATA
HARRINGTON
CHENEY
ELLENSBURG
MOSES LAKE
SPRAGUE
OTHELLO
YAKIMA
CONNELL
POTLATCH
CLARKIA
AVERY
WHITE SWAN
SUNNYSIDE
KENNEWICK
DAYTON
LEWISTON
OROFINO
GENESEE
ARLINGTON
HERMISTON
ATHENA
KAMIAH
GRANGEVILLE
5.5"
4"
4"
6"
10"
4"
1.5"
4"
3"
11"
4.9"
1.3"
4"
14"
12"
3.5"
2"
5"
6"
9"
4"
4"
2"
4.9"
5"
4"
4"
2"
2.8"
7"
8.3"
3"
1.5"
4"
9"
6.3"
2.0"
2.5"
5"
4"
3"
4"