An Example of Conveyor Belts in a Pacific Northwest Storm– A Weather Event Simulation

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December 15, 2003

Introduction

The text book "Images in Weather Forecasting" (Bader et al 1995) as well as the VISIT View session on Cyclogenesis put forth an analysis of extratopical cyclones in terms of the Warm, Cold, and Dry conveyor belts. The storm system on 27 Dec 2002 is an excellent example of these conveyor belts and their impact on the WFO Spokane forecast area.

Discussion

On December 27th, 2002 a strong Pacific storm moved onshore in the northwestern U.S. region. The water vapor image for this event with the 300mb height contours shows a fairly typical scenario for these storms (Fig 1). A ridge is located over the western U.S. with a long-wave trough out in the eastern Pacific. The resulting southwesterly flow is a favorable pattern for precipitation events. However, the complex topography in the Inland Northwest (Fig 2) has a profound affect on the details of the storm. Trapped cold air will result in snow or ice rather than rain. And the low-level wind flow will modulate the precipitation distribution due to orographic lifting. With mountains to the west, north, east, and southeast, just about any low-level wind direction will result in upslope in some part of the CWA while producing downslope in other areas.

While examination of an extratropical cylcone in terms of fronts is informative, a model based on conveyor belts is sometimes more insightful. The combination of Warm, Cold, and Dry conveyor belts is shown in a figure from Bader et al (1995) in Figure 3. The Warm conveyor belt (WCB, denoted on Fig 3 as W-W) begins at low levels in the warm sector of the storm, curves anticyclonicly ahead of the cold front as it ascends to jet stream level in the northeast part of the storm. The Cold conveyor belt (CCB, denoted on Fig 3 as C-C) begins in the cold sector north of the warm front. It ascends gradually underneath the WCB in relative easterly flow. The Dry conveyor belt (DCB) is the dry punch of air behind the cold front. It's drying is due to strong subsidence as well as the possible intrusion of stratospheric air.

The water vapor imagery in Figure 1 along with infrared imagery (Fig 4)clearly shows these three conveyor belts. The DCB is easy to identify in water vapor as the dry (dark) air behind the system. The WCB is the plume of cold clouds from just off the northern California coast to southern BC. The majority of the CCB is hidden by the WCB, but it can be seen as the band of enhanced clouds in the infrared imagery extending southwestward from Vancouver Island. The 295K isentropic surface from the Eta model (Fig. 5) also does a good job of showing these three features. Widespread precipitation from the WCB is due to the isentropic lift as the WCB ascends over the cold air ahead of the warm front. This lift is large-scale and provides precipitation to all locations. The CCB is not as well evident in Figure 4 since it lies underneath the WCB over eastern Washington.

Figure 6 is an 850mb forecast from the Eta model. It shows the low-level easterly flow over eastern Washington. This is an upslope flow into the east slopes of the Cascades and acted to enhance snowfall in this area. Valley snow fall amounts of 10-15" were common.

Twelve hours later the cold front has swept through the area (Fig. 7). It is easily seen as the tightly packed pressure contours from northwest Montana into central Oregon. Immediately behind it is the DCB with dry air in central Washington. This drying is enhanced by the downslope effects from the Cascades.

Summary

All locations in the Spokane CWA received measurable precipitation from this event due to the widespread isentropic upglide from the WCB. The easterly upslope from the CCB enhanced the lift along the Cascades and maximized the precipitation there.

References

Bader, M.J., G.S. Forbes, J.R. Grant, R.B.E. Lilley and A.J. Waters: 1995: Images in Weather Forecasting.

Figure 1

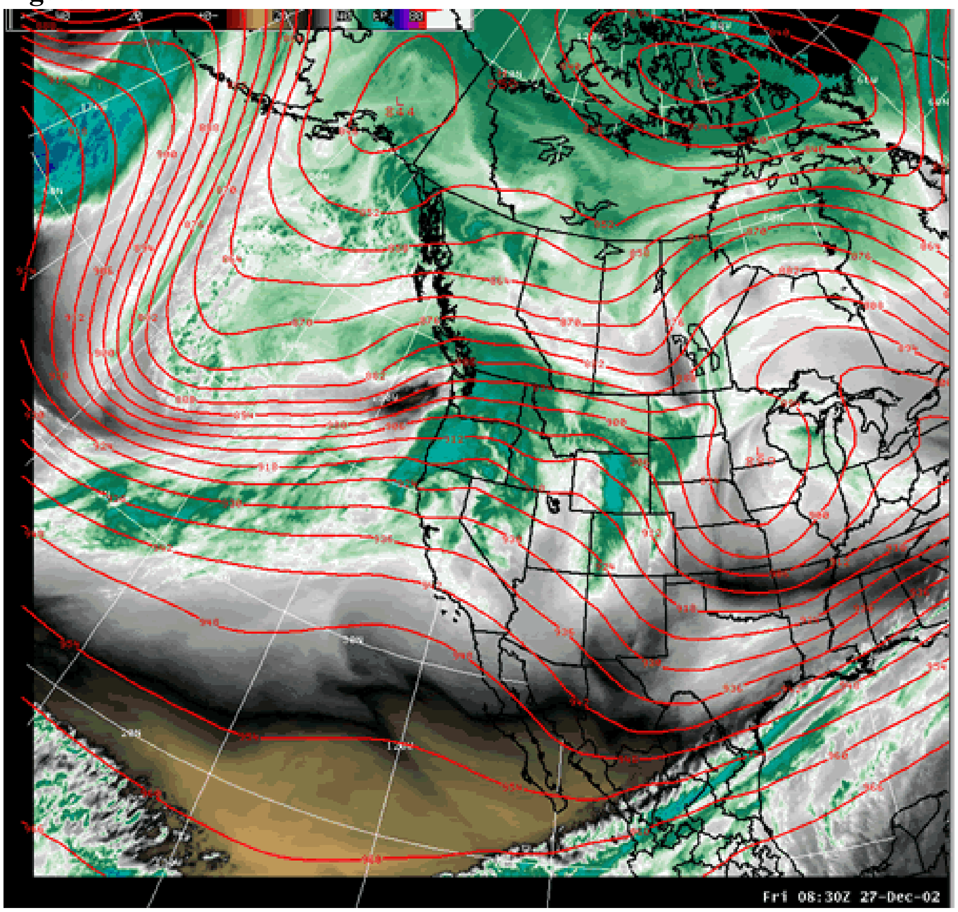


Figure 2

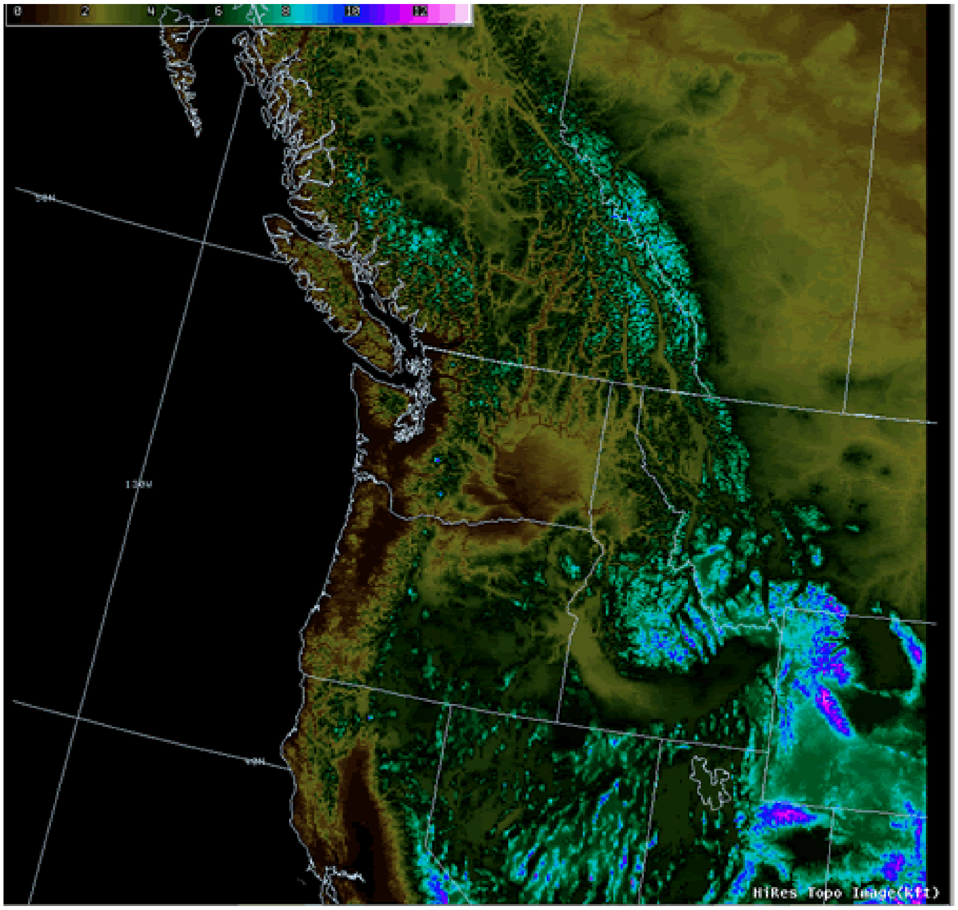
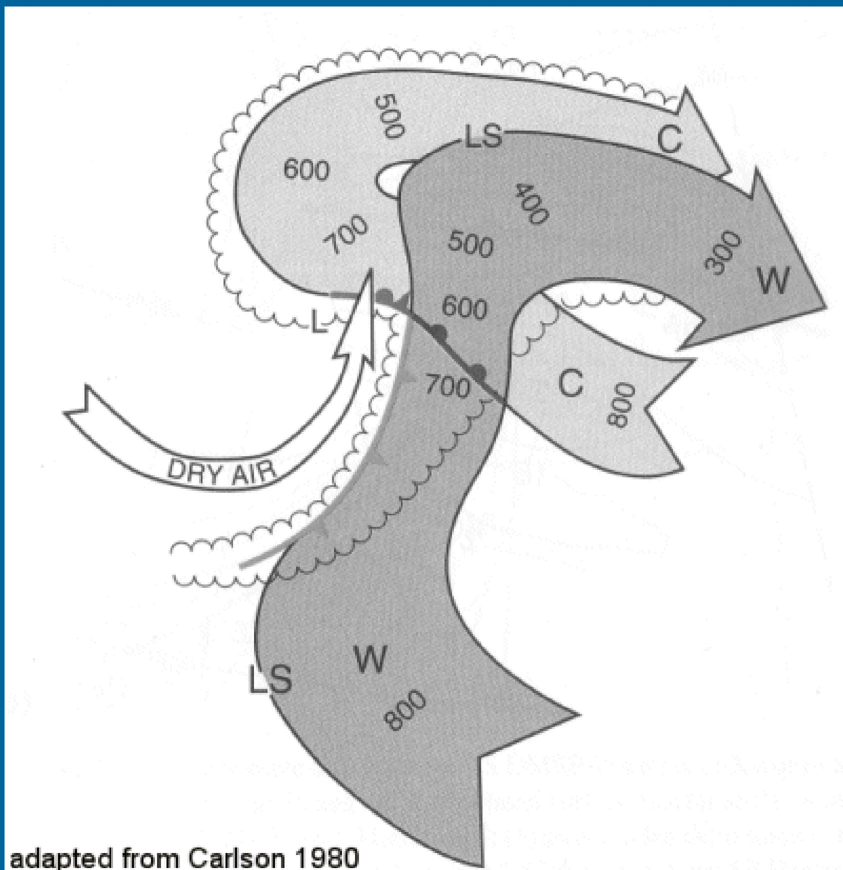


Figure 3

Warm and Cold Conveyors Belts



- W-W depicts the warm conveyor belt
- C-C depicts the cold conveyor belt
- Arrow indicates subsiding dry air south and east of the developing surface low.
- Scalloped area represents advanced baroclinic leaf
- LS represents the so-called ‘limiting streamline,’ where moist air in relatively easterly flow east of the trough and dry air in the upper troposphere west of the trough converge.

Figure 4

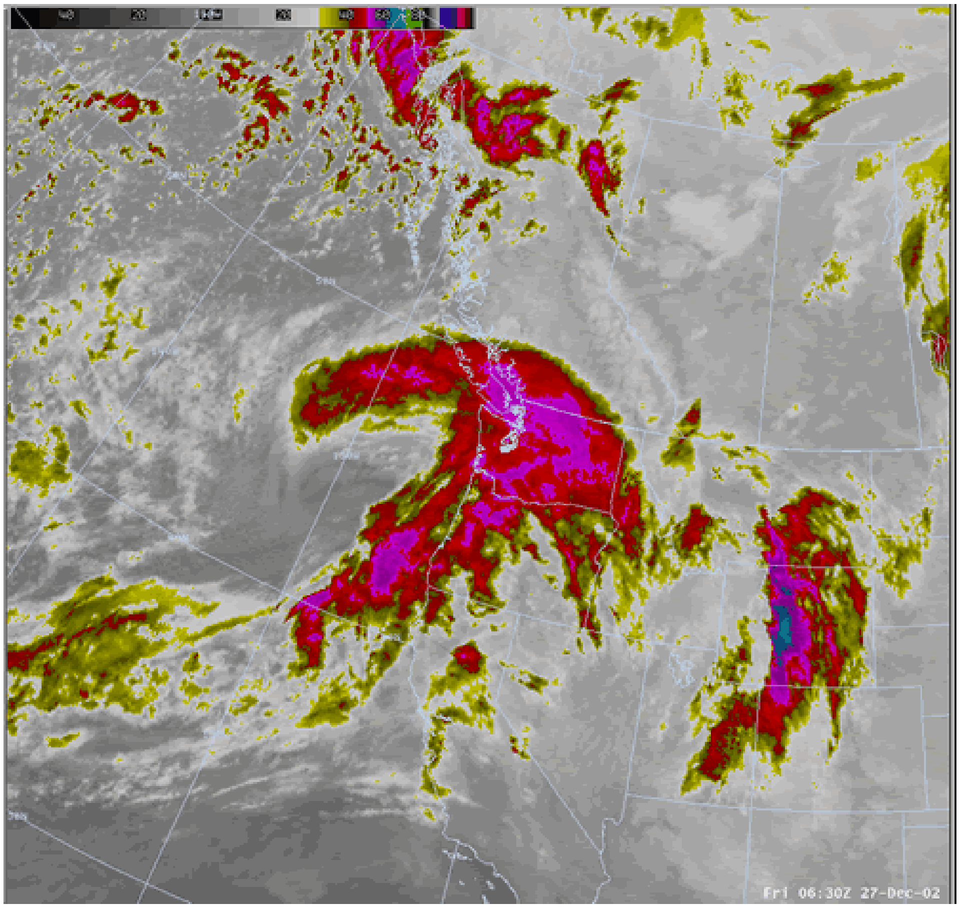


Figure 5

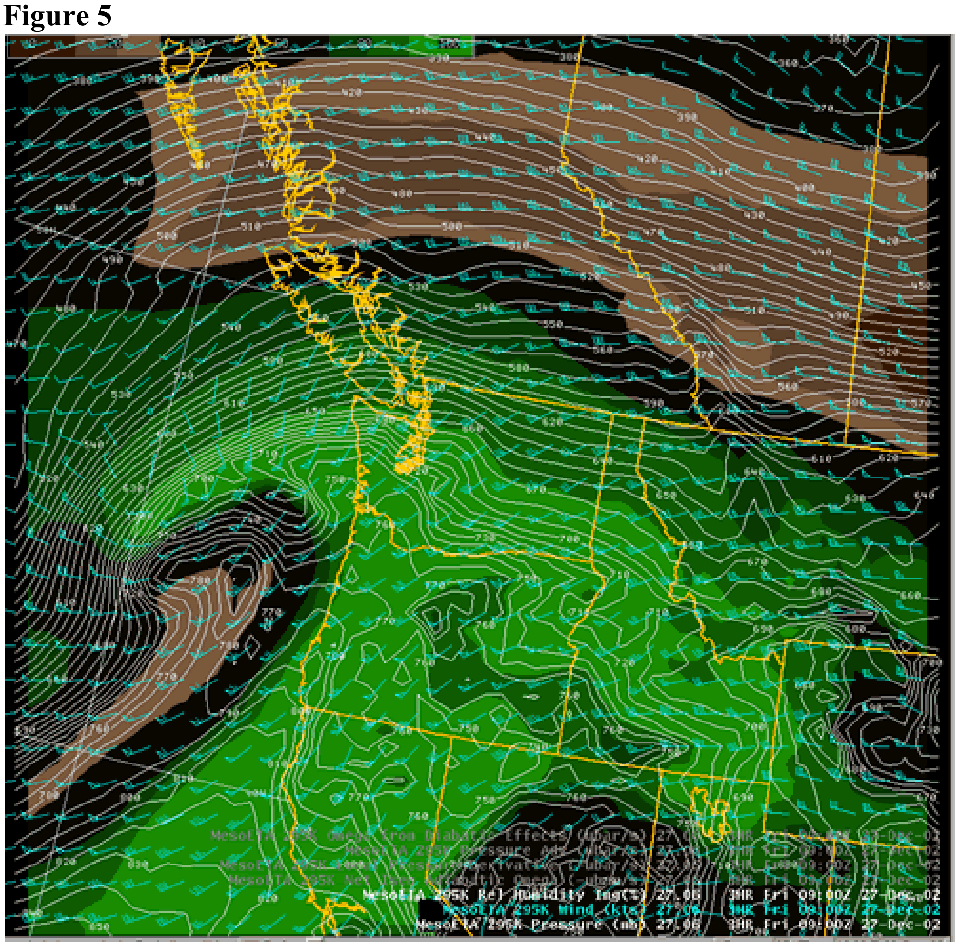


Figure 6

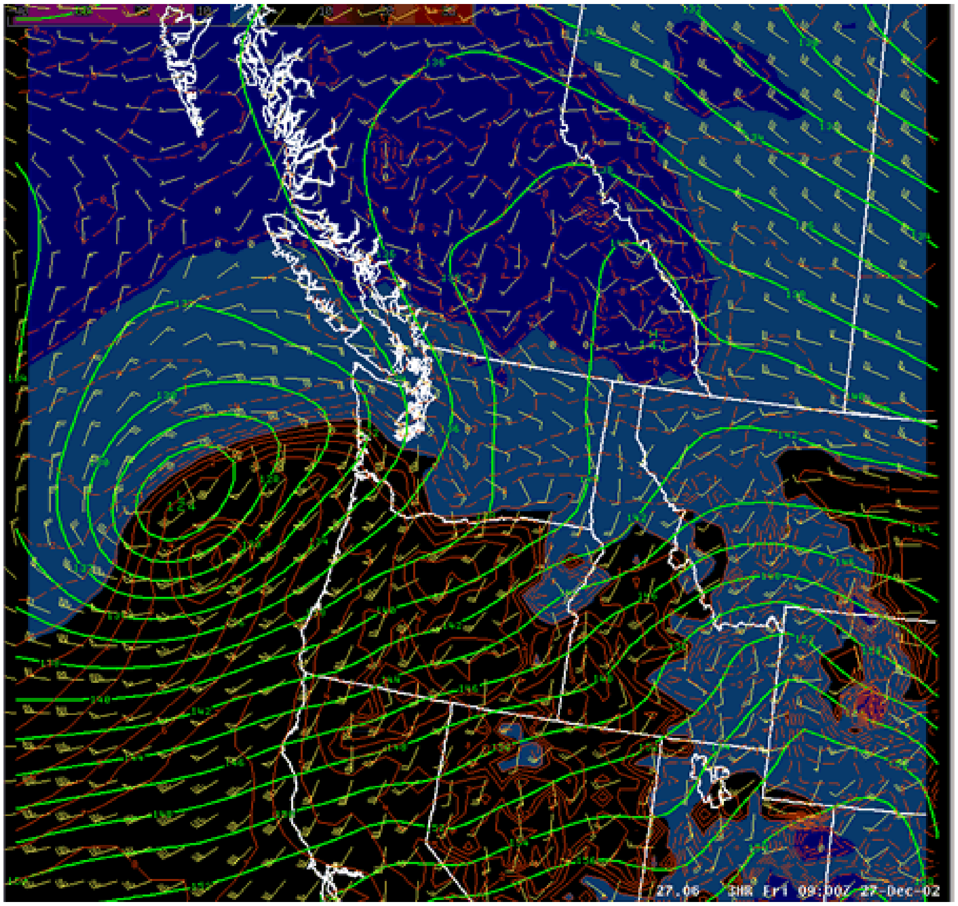


Figure 7