The Importance Of Model Grid Spacing For Two January 2004 Ice Storms

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Introduction

Ice storms in the WFO Pendleton County Warning Area (CWA) can occur when warm-frontal precipitation moves inland from the Pacific Ocean and falls into cold air trapped east of the Cascade Mountains. These events can cause serious highway and aircraft accidents and bring down trees and power lines. Because the low-level flow is blocked by terrain, it is typical in these events for the trapped cold air to be deeper over some locations and removed from others. This results in precipitation types (snow, sleet, freezing rain and rain) that vary greatly over small distances (often from one adjacent valley to another) and over short time periods. This paper briefly examines the importance of grid spacing for two such ice storms that occurred in January of 2004. It will be shown that for these two events, the 12-km Eta model successfully captured several features of the trapped cold air and blocked flow. In contrast, the coarser GFS model is not able to capture these features.

Two January 2004 Ice Storms

An event on January 8/9, 2004 involved a surface low inside (east) of 140 W that moved north along the Pacific Northwest coast. Modified arctic air in the Columbia Basin was dammed up against the Cascade Mountains by easterly low-level flow. Widespread ice accumulations of ½ inch or greater occurred near the east slopes of the Cascade Mountains from central Oregon to central Washington. A second event on January 23/24 involved an upper low that moved westward across southern Oregon. Light ice accumulations occurred at various locations across the Columbia Basin (less than 1/8 inch), while westerly upslope flow contributed to over 1 inch of ice in the Meacham Valley of the Blue Mountains. The following photo shows ice accumulation on a roadway sign and tree damage from the Meacham Valley ice storm. It is interesting to notice in the photograph that there is also approximately an inch of ice on the leeward side of the pole.

Model Analysis

The 12-km Eta model is capable of capturing many of the features of cold air trapped in the Columbia Basin. For example, at a time when freezing rain was falling along the east slopes of the Cascades, the 9 January 2005 06z Eta-12 model initialization shows sub-freezing temperatures in the lower elevations of the Columbia Basin and adjacent valleys (Fig. 1). Figure 1 also correctly shows easterly surface flow along the east slopes of the Cascade Mountains.

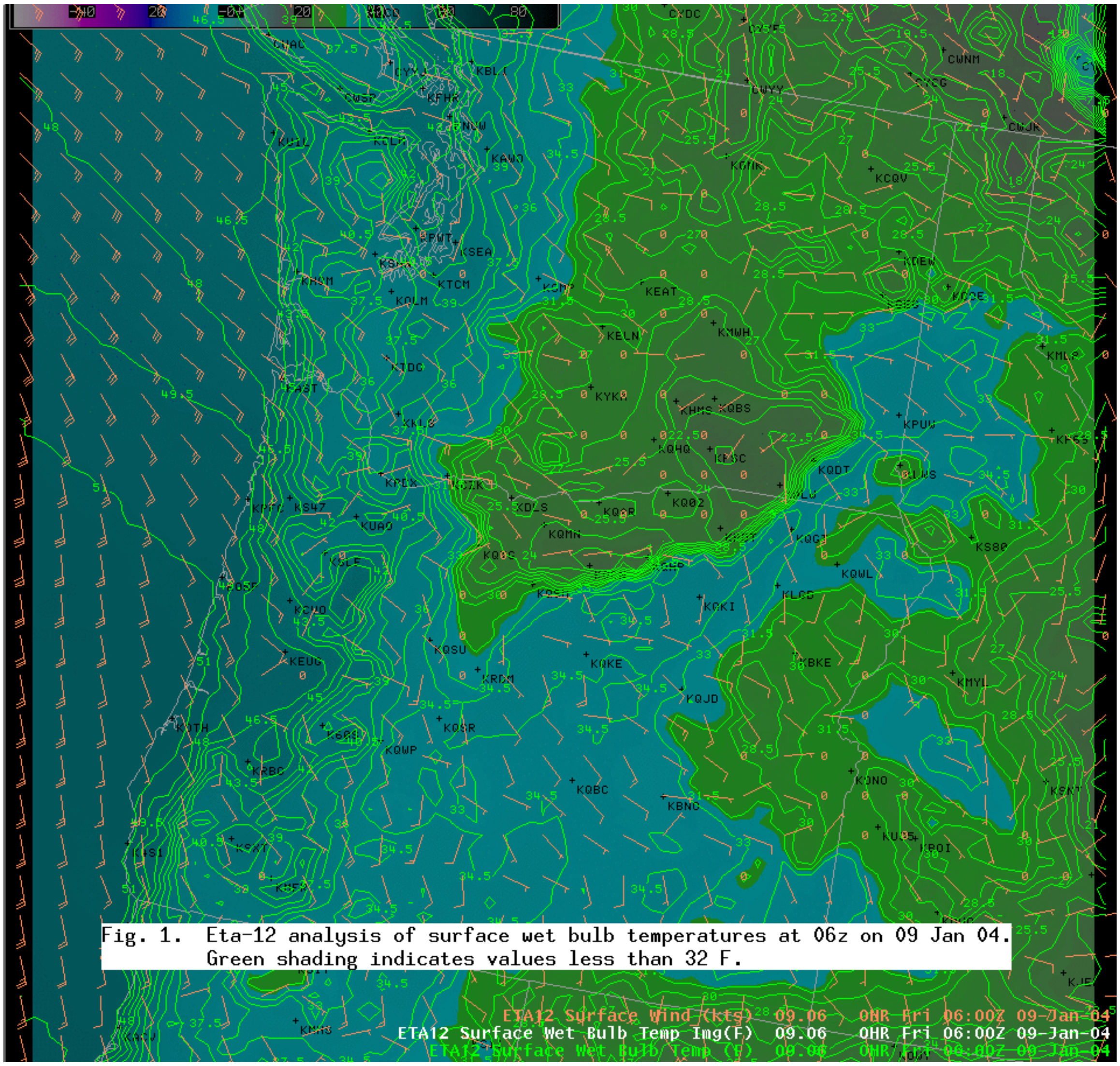

Fig. 1. Eta-12 analysis of surface wet bulb temperatures at 06z on 09 Jan 04. Green shading indicates values less than 32 F.

Figure 1

The trapped cold, stable air is also revealed by a northeast-to-southwest cross-section (fig. 2) across the Columbia Basin showing a strong vertical potential temperature gradient near the surface. Eta-12 forecasts were also capable of maintaining the Columbia Basin cold pool through at least 60 hours of simulation, i.e., through at least two diurnal cycles (not shown).

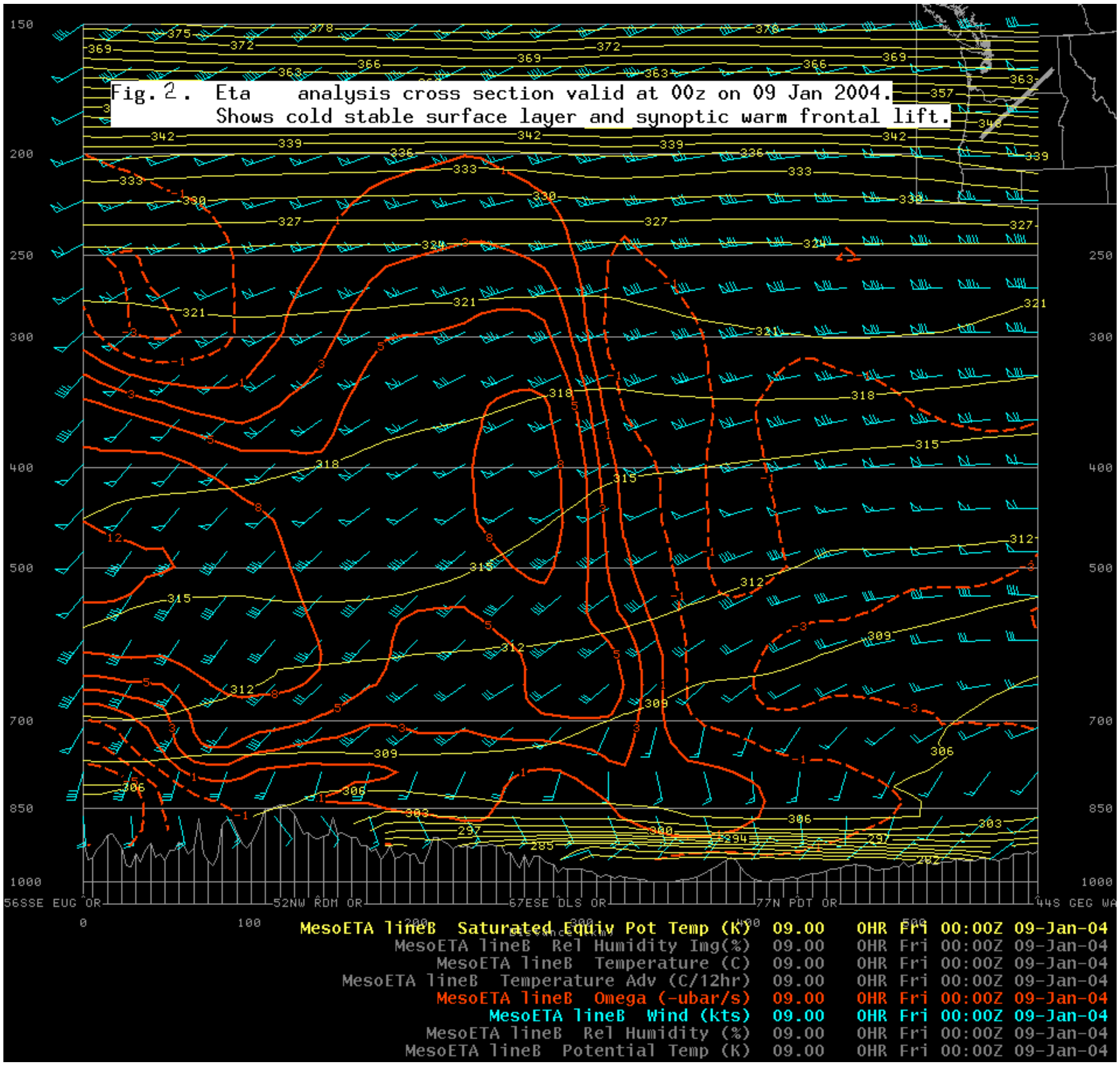

Figure 2

Figure 3 compares surface temperatures on an 80-km grid from both the Eta-12 and from the GFS models. (The GFS model grid spacing is equivalent to roughly 55 km.) The values from the two models on the 80-km AWIPS grid are similar west of the Cascades Mountains. However, in the Columbia Basin the Eta model shows a 25 degree Fahrenheit closed contour while the GFS model has values near 30 degrees. (Model soundings [not shown] reveal the Eta model is even closer to observed values then what this 80-km AWIPS grid reflects.)

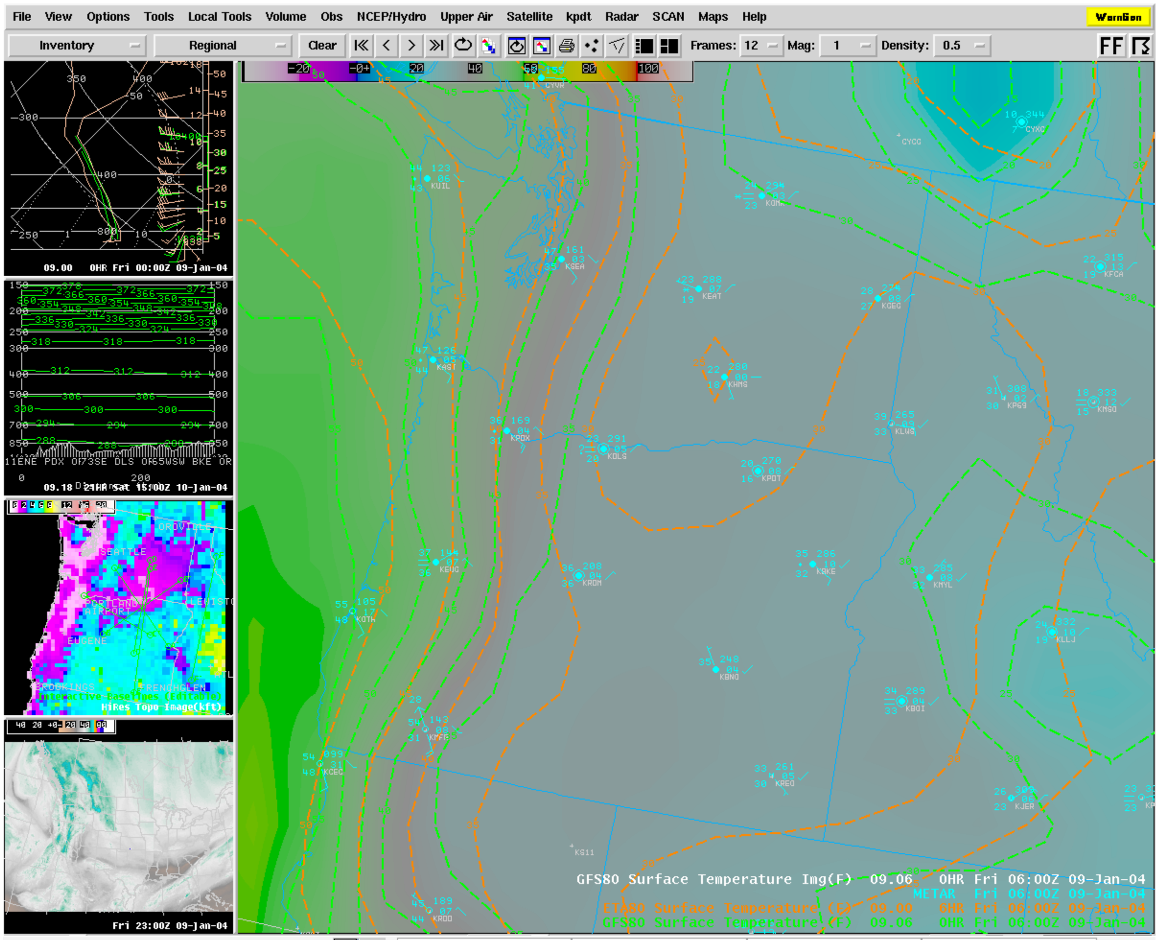

Figure 3: Eta-12 (red dashed) and GFS (green dashed and color filled) surface temperature contours valid at 06 UTC 09 January 2004.

The two models performed similarly for the ice storm on January 23/24. For example, figure 4 shows that the Eta model maintained freezing temperatures in the Columbia Basin as well as the colder temperatures to the southeast of the Blue Mountains. In addition, the Eta correctly captured the highest surface pressure in extreme southeast Oregon and low-level convergence over the Blue Mountains (not shown). The Coarser GFS model is unable to capture these features.

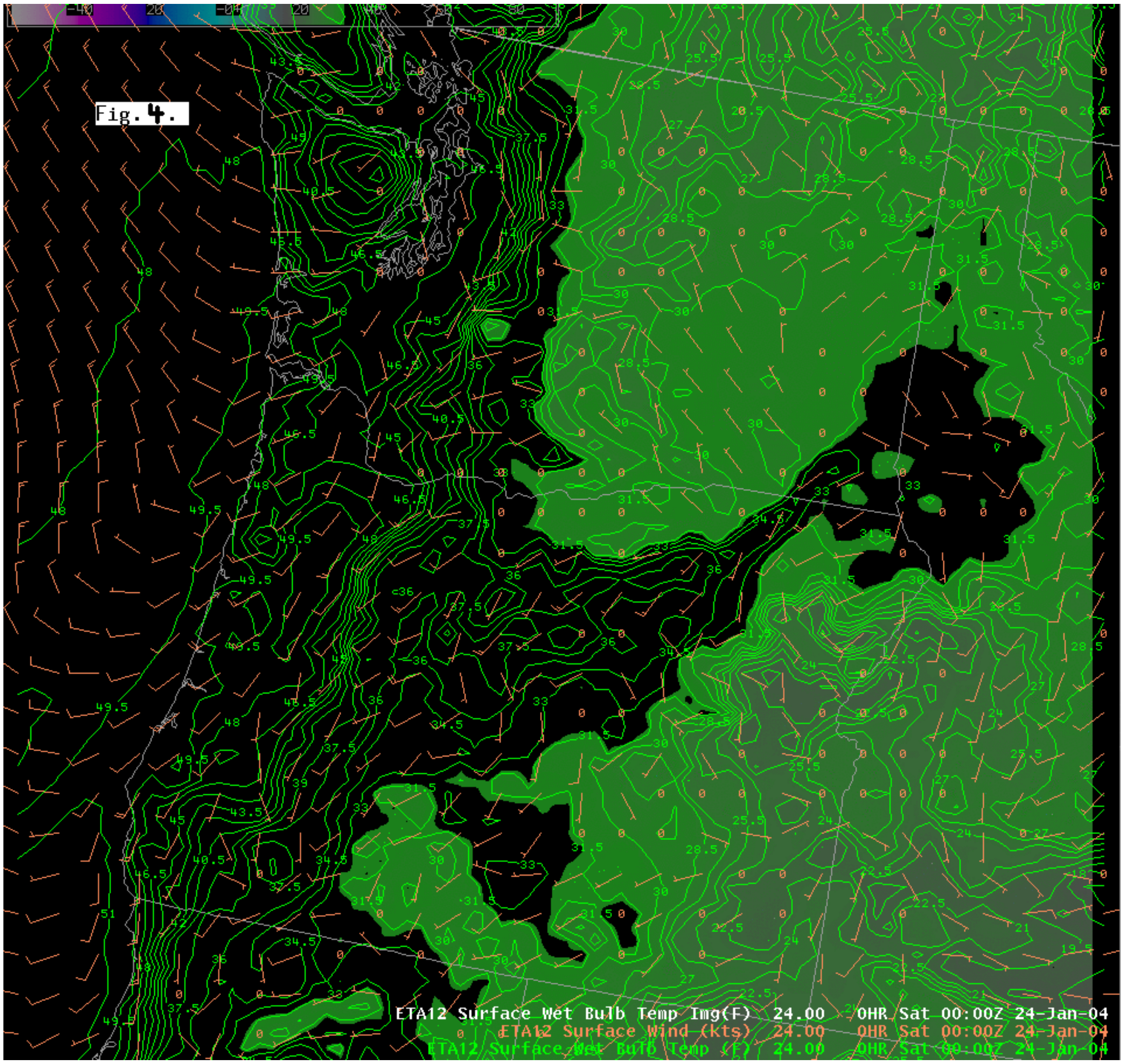

Figure 4: Eta-12 Wet Bulb and Surface Winds valid at 00 UTC 24 January 2004

Discussion

In September 2000 the Eta model grid spacing was improved from 32 km to 22 km. However, even at 22-km the Eta model had a consistent (warm) bias of failing to trap cold air in the Columbia Basin. It was not until November of 2002, when the Eta grid spacing was decreased from 22 km to 12 km that the model was able to simulate trapped cold pools in the Columbia basin. In fact, with 12-km grid spacing events have even been noted when the Eta model held cold air in the Columbia Basin for longer than reality. However, the Columbia Basin is a broad topographic feature and many modeling studies have shown that even finer grid spacing is needed to capture cold air trapped in smaller valleys. For example, Sharp (2002) showed that 1.5 km grid spacing was required to capture gap flow through the Columbia River Gorge.

For the two January 2004 Ice Storms examined here, the locations of significant ice accumulations depended on the location of the warm conveyer belt, terrain forcing, and the evolution of cold pools. At a minimum, 12 km model grid spacing is a requirement to begin capturing the terrain forcing and trapped cold air in the Columbia Basin. Even as finer resolution models become available, careful analysis of observational data and an understanding of terrain impacts on basin and valley cold pools will be critical to forecasting precipitation type and the location of ice accumulations.

References

Sharp, J., December 2002: Columbia Gorge Gap Flow, *Bull. Amer. Meteor. Soc.*