ULTRA-HIGH RESOLUTION SIMULATIONS OF THE COLUMBIA GORGE - VERIFICATION CHALLENGES AND PROBLEMS

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1 INTRODUCTION

The Cascade Mountain range, located about 250 km inland from the Pacific Ocean, extends from north to south through the entirety of Washington and Oregon. This barrier is continuous except for a handful of gaps, of which only the Columbia Gorge provides a near sea-level conduit. Because of this, gap flow is common in the Columbia Gorge and plays a profound role in defining the climate of the surrounding region, which includes the city of Portland. Examples of phenomena associated with Columbia Gorge gap flow are damaging winds, frigid cold, snowfall and freezing rain.

A detailed study has been undertaken to improve existing knowledge of the impact of the Gorge and the dynamical processes occurring within it. This was achieved through three separate sub-projects. A climatological study assessed quantitatively the influence of gap flow through the Gorge on weather phenomena in the study area. Synoptic composites were produced for different Gorge weather events to identify associated synoptic patterns. Finally, a detailed case study of a Gorge gap flow event, including both observational analysis and high-resolution modeling, was performed. The numerical modeling was performed using the Penn State MM5 mesoscale model with five nested domains. The outer domain used 36 km grid-point spacing and the innermost domain had a grid point spacing of 444.4 meters (Figure 1). The problems and challenges encountered when attempting to compare the performance of the model simulation within Gorge and its exit region (i.e. at resolutions of 1.333 km and 444.4 **meters**) against reality are the focus of this presentation.

2 CASE DESCRIPTION

Between December 11 and December 15, 2000 an easterly gap flow event in the Columbia Gorge brought a sustained period of moderate winds and freezing temperatures to the western exit of the Columbia Gorge. Overrunning precipitation falling into the gap outflow resulted in a mix of frozen precipitation in the Portland metropolitan area.

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The case was modeled at very high resolution using the Penn State MM5 mesoscale model. An analysis of the case was undertaken using the model output, traditional surface-based data assets, and more recently developed observing platforms. In particular, extensive use was made of ACARS data from commercial aircraft arriving and departing Portland International. Radial velocity data from the NWS WSR-88D radar were also utilized. The purpose of the study was twofold. The first objective was to verify that the Columbia Gorge region can be modeled using a high-resolution mesoscale model and determine the vertical and horizontal resolution required to accurately represent the airflow through it. The second was to use model output with the observational analysis to define the structural characteristics of the flow within the Gorge and the exit region and to gain a better insight into the dynamical processes governing the flow. Detailed results of the study will be presented in an upcoming paper.

3 VERIFICATION ISSUES

Comparison of output from domains of different horizontal and vertical resolution shows obvious improvement in the simulation as resolution is increased. Nevertheless, the best benchmark of model performance is a thorough objective comparison with the real atmosphere. However, such comparisons are fraught with problems: grid-point and observation locations rarely intercept in the horizontal or the vertical so model data must be interpolated to observation locations or vice versa; the majority of observations are in low lying areas and clustered around urban areas while regions of complex terrain, where the largest meteorological gradients exist, are under-represented; errors in model timing may result in poor verification statistics even if the forecast evolution is good; most observations are obtained from sources close to ground level where output from numerical models is typically least representative; and routine observations to verify the complex three dimensional structures present in the PBL are almost non-existent. Mass et al, (2002) discusses many of these problems and provides a comprehensive source of references.

Increasing horizontal resolution reduces the disparity between model and actual terrain and reduces the distance between grid points and observations, thereby reducing interpolation errors. However, increased resolution exacerbates most of the other problems and

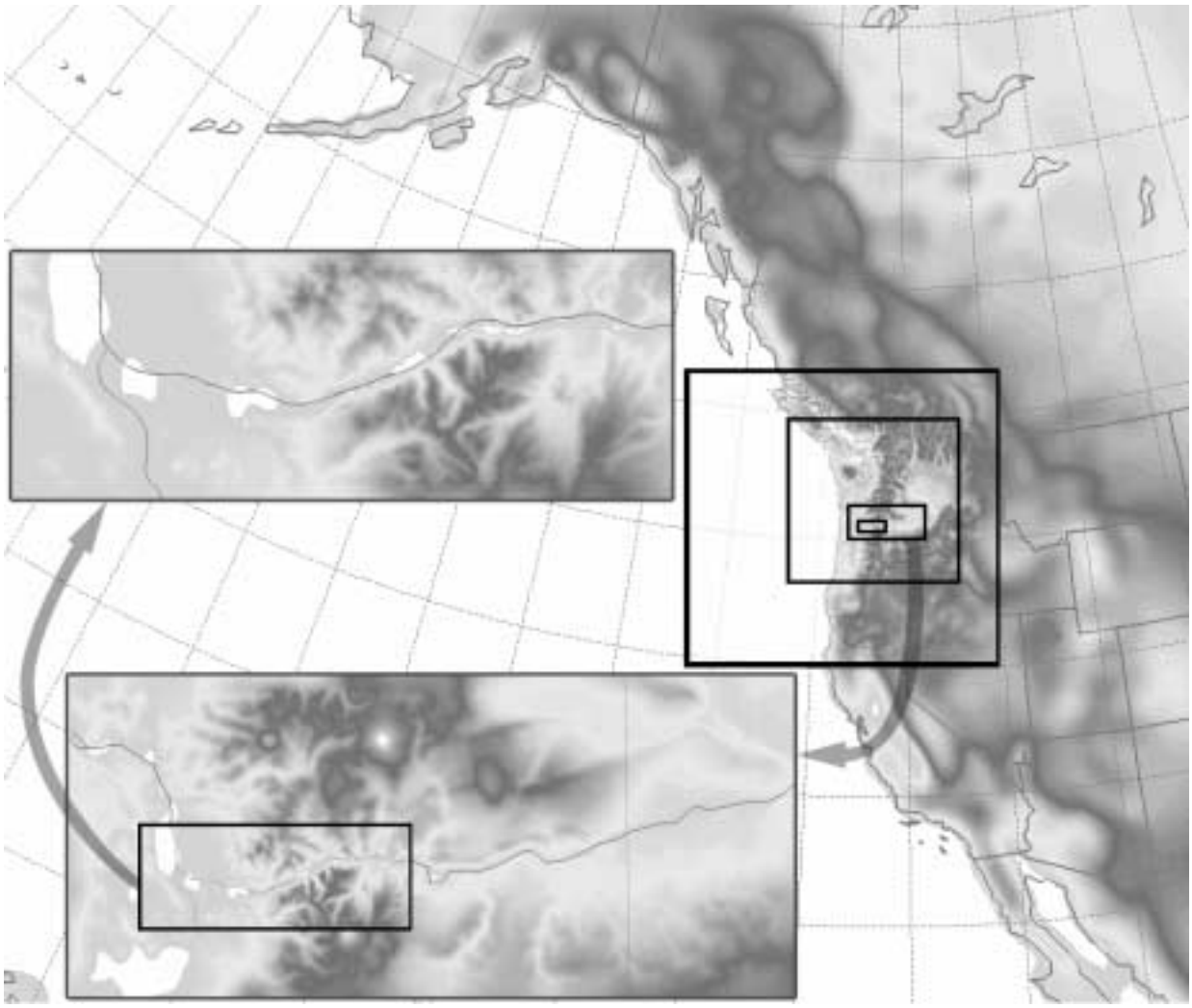

Figure 1: Location of the five nested domains (36 km, 12 km, 4 km, 1.333 km and 0.444 km) used in the Columbia Gorge simulations. Model topography in for each domain is plotted to show the increasing detail for each domain.

introduces new concerns. The relative density of observations compared to grid points becomes so low that the vast majority of grid points are not evaluated in the verification even in areas with dense observing networks. This makes it very difficult to objectively verify features such as the expansion fan observed at the exit of the Columbia Gorge during gap flow events as only a handful of the hundreds of grid points with the structure are compared to observations. In addition, such structures are zones containing very strong horizontal and vertical gradients in temperature, wind, humidity and other fields. When analyzed with using tradition methods, even slight timing and position errors may indicate a reduction in skill as resolution increases and may even result in the forecast appearing to be a complete failure when in reality it is both qualitatively and quantitatively superior to a lower resolution forecast. Verification of vertical structure, especially at low levels, problematic even at relatively low resolution, is even more difficult at very high resolution, where very large vertical gradients can exist and the time scale of variability is much shorter.

The objective of this presentation is to illustrate these problems using examples taken from the December 2000 Gorge gap flow case study. It is not the intent to come up solutions, though a few tentative suggestions will be given.

4 REFERENCES

Mass, C. F., D. Ovens, K. Westrick and B. A. Colle: Does increasing horizontal resolution produce more skillful forecasts. Bull. Amer. Meteor. Soc., 83, 407-430.