P2.18

THE INFLUENCE OF THE GREAT LAKES ON NORTHWEST SNOWFALL IN THE SOUTHERN APPALACHIANS

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1. INTRODUCTION

The Southern Appalachians (Fig. 1) experience diverse weather dependent on elevation and location relative to sources of moisture. During the cold season, roughly November through April, the Southern Appalachians receive anywhere from 30 to near 250 centimeters of snowfall. One of the most common snowfall producers occurs during northwest flow snowfall (NWFS) events.

Perry et al. (2007) used backward air parcel trajectory analysis to show the difference between trajectories moving over the Great Lakes and those not moving over the lakes especially in terms of lower-tropospheric moisture. Their findings suggest that the Great Lakes do impact snowfall patterns across the Southern Appalachians.

The research contained in this study is a continuation of Holloway's (2007). Holloway (2007) used the Weather Research and Forecasting model (WRF) to simulate conditions for three NWFS events, including an event that took place on February 10 and 11, 2005 (Fig. 2). The model domain featured 24 km horizontal grid spacing. The purpose of this research is to build on Holloway (2007) and look at the same experiments using the identical 24 km domain as well as an 8 and a 2 2/3 km grid for finer details.

We want to determine if the conclusions of Holloway (2007) for this case study apply to model simulations in which the mountains are more accurately resolved.

1.1. Northwest Snowfall

The Southern Appalachians receive NWFS periodically throughout the cold season. It occurs with a northwest wind advecting a cold, moist flow at low levels. In combination with local instability, the mountains act to force this flow upward producing increased vertical motions. The increased vertical motions are confined to the general vicinity of the windward side of the mountains which produce or enhance the snowfall amounts there.

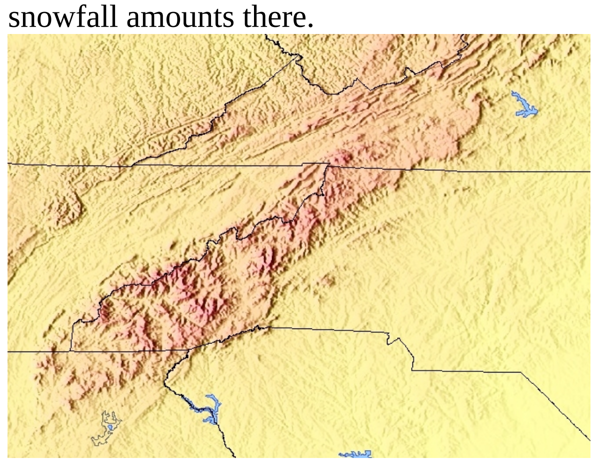

Figure 1. Relief map for the Southern Appalachians.

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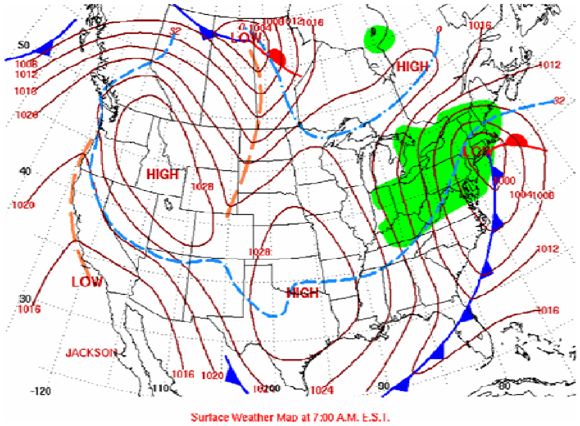

Figure 2. Sea-level pressure and frontal analysis valid 7:00 am EST 11 February 2005.

1.2. Types of Northwest Snowfall

There are three distinct types of NWFS (Lee 2005); post-frontal, cut-off low, and wrap-around. Post-frontal NWFS occurs after the passage of a cold or occluded front when winds at the surface back to a northwesterly direction producing snowfall if the lower atmosphere is moist.

Cut-off low type NWFS occurs when northwest winds from the system carry moist, sometimes unstable air at low levels. When this flow reaches the mountains it is forced upward producing snow.

Wrap-around snowfall is produced on the backside of a low pressure system that literally wraps moisture around from the northwest. The synoptic lift in these events often is associated with an upper-level disturbance.

2. METHODOLOGY

The focus of this research is to find out if the Great Lakes have an impact on the intensity and coverage of snowfall amounts and to see how higher model resolutions are impacted by different Planetary Boundary Layer (PBL) schemes and by fluxes over the Great Lakes. At issue is whether the computational cost of running a high resolution model simulation provides further insight into the intensity and location

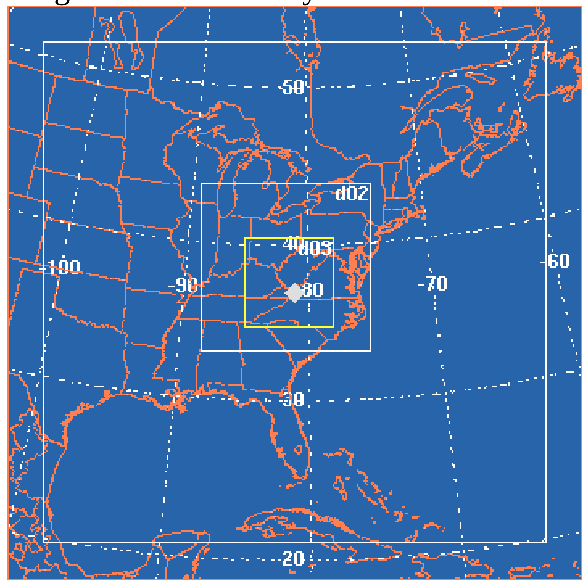

Figure 3. Triple nested WRF domains (24, 9, 8/3 km) used in this study.

Of snowfall, and the possible influence of the Great Lakes in the northwest snowfall forecast problem.

The WRF model is used to simulate the conditions over the Southern Appalachians for the duration of the February 2005 northwest snowfall event.

2.1. The Domain

The outermost domain (Fig. 6) serves to show the synoptic forcing. It lacks detail that could be important in deciphering small scale impacts such as the terrain over the Southern Appalachians with a significant amount of smoothing done for a large scale. Therefore, the nested domains (8km, 8/3 km Fig. 6) in addition to the largest domain (Fig. 7) are examined to find more detail of local effects within the mountains being resolved at a finer scale.

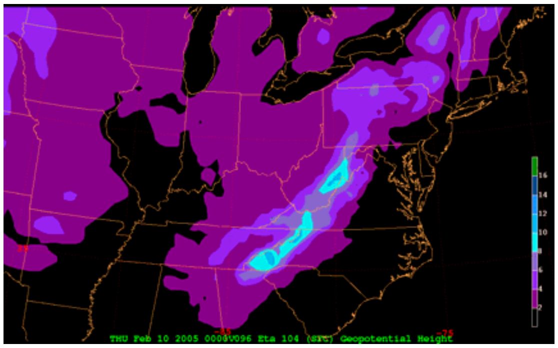

Figure 4. 24 km domain (topo map)

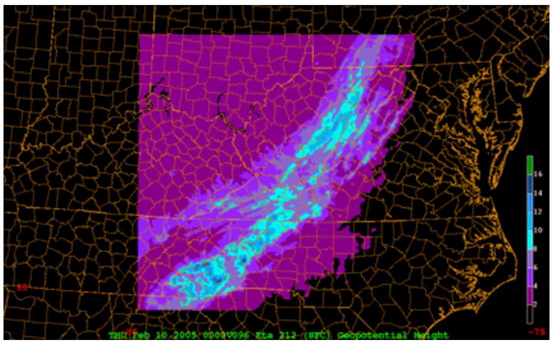

Figure 5. 8/3 km domain (topo map)

2.2. Planetary Boundary Layer

Low level moisture and instability are important for producing a substantial northwest snowfall event. PBL schemes are

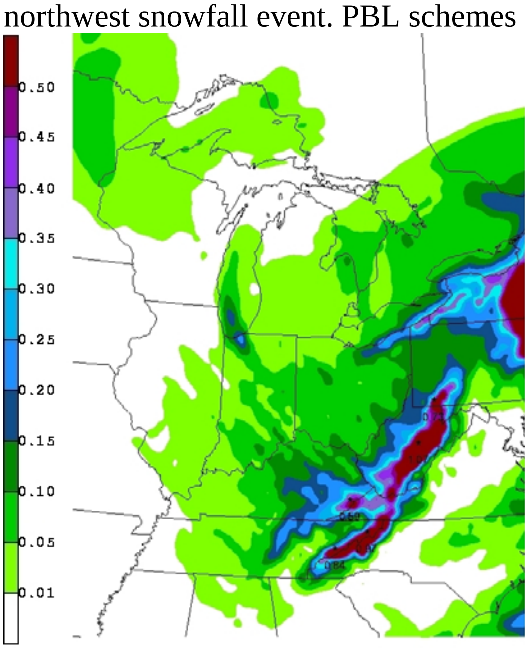

Figure 6. Liquid water equivalent accumulated precipitation (inches) over 36-h in domain 1 (24 km) for the period ending at 1800 UTC 11 February 2005.

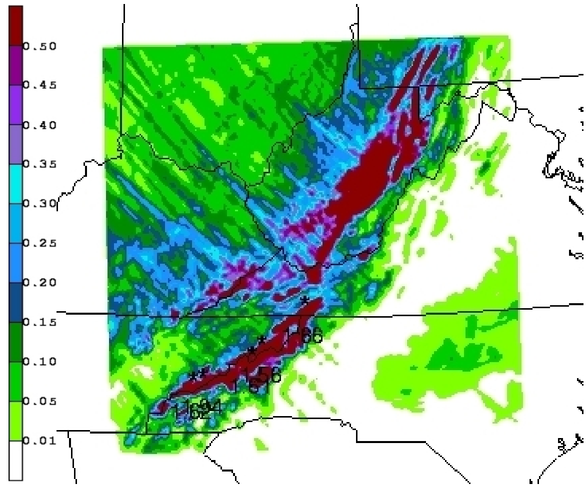

Figure 7. As in Figure 4 except in domain 3 (8/3 km).

used within the WRF model to approximate the surface heat, momentum, and moisture fluxes, and the distribution of these quantities through turbulent mixing in the lower atmosphere. PBL schemes are vital for accurately simulating NWFS events because by definition northwest snowfall events are low level features. The control simulation (CTRL)

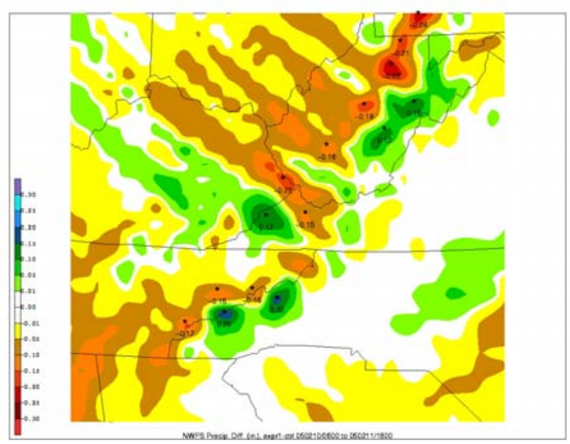

Figure 7. Difference in 36-h accumulated precipitation (inches) [MYJPBL – CTRL] in domain 1 (24km) for the period ending at 1800 UTC 11 February 2005.

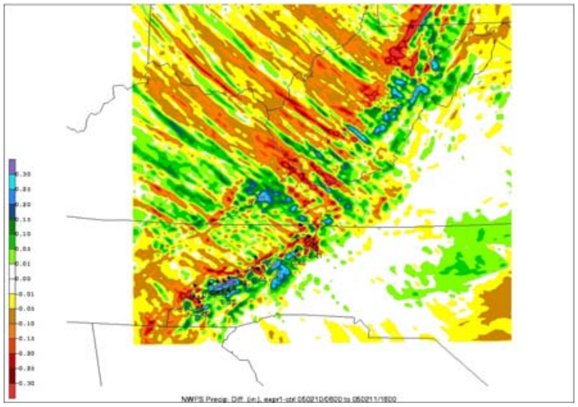

Figure 8. As in Figure 6 except in domain 3 (8/3 km).

utilizes the Yonsei University (YSU) PBL scheme whereas the Mellor Yamada Janjic PBL (MYJPBL) is used as the basis for one of the experiments.

3. RESULTS

3.1. Synoptic Pattern

On February 10 and 11, 2005 there was a significant post-frontal northwest snowfall event in the Southern Appalachians (Fig. 2).

On this date there was a positive PNA (Pacific/ North American) pattern in place across the United States with a ridge in the west and the center of the trough axis over the Ohio River Valley pushing eastward (not shown).

Figure 9. Infrared Satellite Imagery – February 10, 2:15 EST.

A low pressure system developed and moved northeast along a cold front draped across the south. When the storm reached the ocean in the Mid-Atlantic region it strengthened further. The peak of the NWFS occurred while the storm was deepening rapidly as it moved towards the New England States.

3.2. The Great Lakes Influence

Following the logic that low level moisture and instability are important to produce northwest snowfall, the focus of the presentation is to find the influence of the Great Lakes on the intensity and amounts of snowfall in the Southern Appalachians.

The fluxes will be turned off in the model as in Holloway (2007) to find out how the moisture and instability from the lakes contribute to snowfall amounts downstream for the February 10 and 11, 2005 case study.

Through Holloway's (2007) experiments comparing MYJPBL and turning fluxes off to a control run Holloway (2007) was able to conclude that convective instability is an important factor in NWFS events. By shutting off the lake fluxes Holloway (2007) was able to contrast to the control run and conclude that the Great Lakes can produce important instability downstream along the Southern Appalachians in a northwest snowfall event.

3.3. WRF Simulation Results

The purpose for looking over precipitation totals over the Southern Appalachians at finer scales in general is to gain a greater understanding of the impacts of the terrain in the mountains. Domain 1 shows the impacts of the mountains accurately but fails to give fine details due to its limitations at a 24 km grid size.

Finer resolution model runs such as domain 3 (Fig. 7) resolves the mountains at 8/3 km which enables it to model the mountains with significantly more detail. The finer resolution model can therefore run the same initial conditions and produce precipitation totals that match the more detailed terrain.

Domain 3 (Fig. 7) shows more significant precipitation totals at the highest elevations due to the more accurate simulation of the mountains. The greater changes in elevation result in more realistic, steeper slopes which, in turn concentrate the same amount of orographic lift into smaller areas. This may explain the greater extremes of precipitation modeled at finer resolutions.

Similarly, the MYPBL and control PBL schemes show greater extremes in precipitation amounts at finer resolution. Comparing the control run to the MYPBL scheme in domain 1 (Fig. 6) the greatest discrepancies occurred in areas of greatest change in elevation. Looking at the difference in the finest domain (Fig. 7) it was clear that the MYJPBL run produced higher precipitation totals over the higher elevations while producing significantly less precipitation at the lowest elevations when compared to the control run.

4. PRESENTATION

The focus of the poster presentation will be taking the results of turning off the fluxes over the Great Lakes and observing the differences between the domains, concentrating on how much if any reduction of moisture and instability are present along the Southern Appalachians.

5. REFERENCES

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