P 4.16 DIAGNOSIS OF WINTER TIME COLD BIAS IN THE ETA AND NMM MODELS

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1. INTRODUCTION

Low-level cold biases in both NCEP Meso Eta and Nonhydrostatic Meso Models (e.g., NMM) have been frequently observed in the past winter. These cold biases usually occurred during the night time when the atmosphere was relatively stable. While the two models have very similar physics packages, the cold biases were usually more pronounced in the NMM than in the Eta models. In addition, the comparisons of shelter temperature between forecast and observations at individual sounding locations indicated there are worse cold biases over the mountainous regions.

Difficulty with parameterizing turbulent heat fluxes in the stable boundary layer has been noted in many studies partially because most micrometeorology observations were taken in the moderate stability range (Arya, 1988). Andreas (2002) noted that there was little consensus on representing gradient functions for very stable boundary layer. After examining the behavior of profile metrics for gradient functions of various parameterizations, he recommended using formulations developed by Holtslag and de Bruin (1988). On the other hand, cold biases in Meso Eta and NMM could just be caused by under-prediction of downward longwave fluxes.

Tests have begun which will investigate the sources of nighttime cold biases in both models. The key surface energy budget components at nighttime are compared between model predictions and observations at the locations where cold biases existed. In addition, a comparison between the Eta and NMM models is made to investigate why the cold biases are usually greater in the NMM. The results of these cold bias diagnoses and of the experiments that are carried out to correct the cold biases will be presented.

2. METHODOLOGY

The Meso Eta model is run four times daily at 12 km horizontal resolution and 60 levels. The NMM is run once daily over each of the three CONUS nests, western initialized at 6Z, central initialized at 12 Z, and eastern initialized at 18 Z, at 8 km resolution and 60 levels. Both models used GFDL radiation, Mellor-Yamada-Janjic surface layer and boundary layer, and Noah land surface schemes.

To take advantage of available full flux measurements at SURFRAD/ISIS sites, shelter temperature forecast from Meso Eta and NMM was retrieved from archive and compared against obervational shelter temperature at three of these sites for January and February of 2003 to identify wintertime cold bias cases. The three chosen sites are Walker Branch, TN (WB), Goodwin Creek, MS (GC), and Fort Peck, MT (FP). After cold bias cases were identified, the sounding profiles, skin temperature, downward longwave, sensible heat, latent heat, ground heat, and upward longwave flux forecasts from Meso Eta and NMM were compared with those from SURFRAD/ISIS measurements during the evolution of cold bias events.

There have been upgrades to NMM after February of 2003 which include changes to land surface scheme to increase ground heat fluxes under shallow snow cover conditions. Therefore, NMM reruns using updated code were carried out for chosen cold bias cases to examine whether or not changes to ground heat flux formulations improve cold biases.

3. SUMMARY

After comparing archived shelter level temperature forecast from Meso Eta and NMM against observations at WB, GC, and FP, it was found that, there were most shelter level cold bias occurrences at FP. No shelter level cold bias was found for GC for January and February of 2003 cases, and only five cold bias cases were identified for WB. Three FP and one WB cold bias cases were chosen for further comparisons of nighttime fluxes between model forecast and observations. In addition, NMM reruns as mentioned in section 2 were performed for these cases.

The results of NMM re-runs indicated that NMM shelter level cold biases at FP improved significantly in two of the chosen cold bias cases. Note that Meso ETA shelter level temperature forecasts were only slightly

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colder than observations in these two cases. Now both Meso Eta and new NMM simulations produced results close to observation shelter level temperature even though the skin temperature is still 2 to 7 °C colder. Examination of heat flux forecast indicated that changes to ground heat flux formulations under shallow snow covers did increase ground heat fluxes by about 14 Watt/m^2 in new NMM simulations which then improved shelter level cold biases. In addition, improved cold biases in new NMM simulations were also attributed to increases in downward longwave radiation which were results of increased cloud covers in NMM reruns.

Comparisons between Meso Eta and NMM flux forecast and SURFRAD/ISIS measurements for the four cold bias cases indicated that there was 15 to 80 Watt/m^2 under-prediction of downward longwave radiation at nighttime. Figure 1 shows such comparisons between observation and Meso Eta and NMM forecast for one of the cold bias cases at Fort Peck, MT. The under-prediction of downward longwave fluxes could be caused by under-prediction of cloud cover. Examination of GOES-IR images, which are only available at 00 Z and 12 Z, shows existence of clouds at 00 Z even though Meso Eta and NMM forecasted clear sky. On the other hand, under-prediction of downward longwave fluxes could be the result of atmospheric cold biases rather than the cause. As shown in Fig. 1, the under-prediction of downward longwave started at about the same time as the under-prediction of skin temperature for this particular case. In addition, comparisons of sounding profiles between observations and forecast at 00Z Jan. 18 2003 (not shown) indicated the model forecast was too cold for the lower 500 hPa for this case. Wilczak et. al. (2004) also found that the Meso Eta under-predicted downward longwave in their New England experiment during the summer of 2003. They suggested that downward longwave biases were results of cold biases because these biases tend to increase through the night and were most pronounced at sunrise. Further investigation of existing and new cold bias cases is ongoing to understand the reasons for under-prediction of downward longwave radiation and its effects.

Both sensible and ground heat fluxes were over-predicted throughout most of nighttime, which is contrary to what was believed. In spite of over-prediction of sensible and ground heat fluxes, they were not enough to offset large amounts of under-prediction of downward longwave fluxes and ground heat sources in Meso Eta and NMM forecast were still much lower than observations.

In all four cases, the skin temperature forecast in the Meso Eta and NMM cooled off much faster than observations at night. The newly upgraded Noah package uses more realistic higher heat capacity for soils; the reruns for Meso Eta and NMM using the new Noah LSM package are performed and results will be presented.

4. REFERENCES

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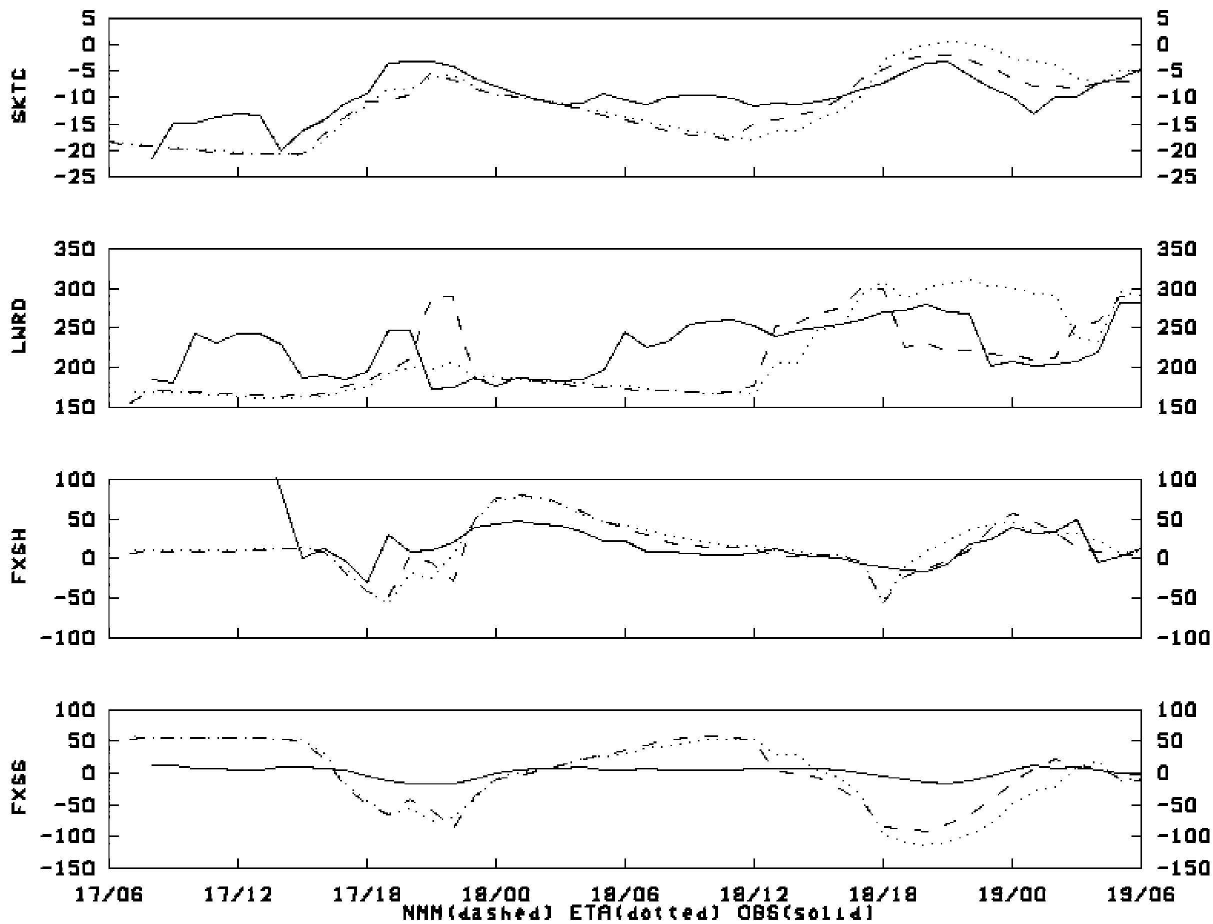

Fig. 1 Comparisons between SURFRAD/ISIS measurements and model forecast (48 h forecast initialized at 06 Z Jan. 17 2003) from Meso Eta and new NMM rerun for skin temperature (first panel), downward longwave fluxes (second panel), sensible heat fluxes (third panel), and ground heat fluxes (fourth panel) at Fort Peck, MT.