P1.33 A COMPREHENSIVE VALIDATION OF THE ANTARCTIC MESOSCALE PREDICTION SYSTEM (AMPS)

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) is an experimental system run at the Mesoscale and Microscale Meteorology Division of the National Center for Atmospheric Research (NCAR) and dedicated to real-time numerical weather prediction in Antarctica (Powers et al. 2003a; http://www.mmm.ucar.edu/rt/mm5/AMPS/). AMPS employs the Polar MM5 (PMM5), a version of the Pennsylvania State University/NCAR fifth generation mesoscale model (MM5; Grell et al. 1994) optimized for the environment of polar ice sheets by the Polar Meteorology Group (PMG) of the Byrd Polar Research Center at Ohio State University (Bromwich et al. 2001, Cassano et al. 2001; www-bprc.mps.ohio-state.edu/PolarMet/pmm5.html). The role of PMG in AMPS is to provide validation and continual model development. AMPS consists of five domains: 1) a 90-km domain covering most of the Southern Hemisphere; 2) a 30-km domain covering the Antarctic continent; 3) a 10-km domain covering the western Ross Sea; 4) a 3.3-km domain covering the immediate Ross Island region (the hub of the U.S. Antarctic Program); and 5) an additional 10-km domain encompassing Amundsen-Scott South Pole station. A more detailed description of AMPS and a diagram of the domains can be found in Powers et al. (2003b; this issue).

PMM5 has shown promising skill over Antarctica (Guo et al. 2003). The authors' evaluation of a complete annual cycle of 72h nonhydrostatic simulations indicates that the Polar MM5 accurately captures both the large and regional scale circulation features with minimal bias in the modeled variables. The observed synoptic variability of the pressure, temperature, wind speed, wind direction, and mixing ratio, as well as the diurnal cycle of temperature, wind speed, and mixing ratio are reproduced by the Polar MM5 with reasonable accuracy.

Model verification is integral to developing a system such as AMPS. Currently, a comprehensive validation is underway in order to examine the performance of AMPS since its inception. Here, a preliminary verification study of Dec 2001-Mar 2002 is presented to assess model strengths and weaknesses. AMPS output from the 30-km and 3.3-km domains are interpolated to manned and automatic weather station locations and compared to observations at the surface and 500 hPa. Output from the 24-h forecasts, initialized at 0000 and 1200 UTC daily, are used to compile the statistics for the 30-km domain. Output from the 24-h (upper air) and 12-h and 24-h (surface) forecasts are used to compile the statistics for the 3.3-km domain.

2. RESULTS

2.1 30-km domain results

Figure 1a shows the correlations and biases between PMM5 and observations for the 30-km surface pressure at several sites over Antarctica for Dec 2001-Mar 2002. High correlations (r>0.95) are observed over the entire continent, indicating that the model is capturing synoptic variability with good skill. Slightly positive pressure biases are noted at many of the coastal stations, which may be partly due to the interpolation and adjustment of the pressures from the modeled elevations to the station heights. Figure 1b shows the correlations and biases of the 30-km surface temperature over Antarctica. Correlations generally exceed 0.85, indicating that the model is capturing the temperature trends with good skill. A systematic negative bias is present. This is slightly exaggerated at the coast, as the interpolated model elevations are often higher than the station heights, and have not been adjusted for the dry adiabatic lapse rate (DALR). Even after accounting for the DALR, the cold biases are sill present at the coast and over the interior. Guo et al. (2003) have suggested that the PMM5 cold biases in winter are due largely to deficient simulated cloud cover. Further investigation is required here to determine if this is a major factor in the summer months examined here. Figure 1c shows the correlations and biases of the 30-km surface wind speed over Antarctica. AMPS skill varies widely over the continent (0.30≤r≤0.77), and appears to be strongly related to the topography. For instance, the lowest skill is noted in the mountainous regions along the Antarctic Peninsula, and in the areas surrounding the Ross Ice Shelf. Both positive and negative wind speed biases are present around the continent.

Figure 2a shows the correlations and biases between PMM5 and the observations for the 30-km 500-hPa geopotential height. Correlations are above 0.90 at most sites, indicating the model is capturing upper level

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variability with very good skill. Geopotential height biases are generally positive and less than 16 gpm at all but one site (Terra Nova Bay (TNB), which has less than 50 observations available). This suggests that the surface cold bias is not significantly affecting the surface-to-500-hPa column temperature. Figure 2b shows the 30-km 500-hPa temperature correlations and biases. Model skill is greater than 0.90 at 7 of the 10 sites with data available. Overall, temperature biases are slightly positive. Figure 2c shows the 30-km 500-hPa wind speed correlations and biases. Correlations are generally above 0.80. Biases are slightly negative at most of the sites. Despite a very high correlation at Rothera (r=0.99), a strong positive wind speed bias exists.

When inspecting Figs. 1a-c and 2a-c as a composite, it is noteworthy that the lowest overall model skill occurs in the coastal sector encompassing Dumont D'Urville, TNB, and McMurdo (approximately 140°E-180°E). This is especially perplexing when considering that two of the stations, TNB and McMurdo, are within the higher resolution AMPS domains that are in the Western Ross Sea. Because AMPS is configured for two-way nesting, the data from the higher resolution domains (i.e., the 3.3-km and 10-km grids) is interpolated back to the 30-km domain, and thus, the statistics for McMurdo and TNB in Figs. 1 and 2 actually represent model simulations from higher resolution grids (which one might expect to be more accurate) interpolated onto the 30-km grid. The fact that the forecasts at these stations are not of higher skill than forecasts from other stations around the continent, and in some instances exhibit lower skill, merits further attention. It suggests the need for a closer examination of two-way nesting mechanism, and of the model physics at very high resolutions to determine if all processes are being properly represented at these scales.

2.2 3.3-km domain results

Figure 3a shows the correlations and biases between PMM5 and observations for 3.3-km surface pressure at several sites surrounding McMurdo for Dec 2001-Mar 2002. Similar to the 30-km results, at 3.3-km the surface pressure is well captured by AMPS. No large or systematic biases are indicated. Figure 3b shows the correlations and biases for the 3.3-km temperature. Correlations are greater than 0.85 at most of the sites. There is some indication of a general cold bias, although this is not present at all sites. This may be in part due to the strong positive wind speed bias, which is indicated in Fig. 3c. The winds are predominantly from the south, and a positive bias may advect too much cold air into the region. Similarly, a low-level moisture bias is present in the radiosonde data at McMurdo (not shown), which may also be related to the strong positive wind speed bias and the enhanced advection of cold, dry air from the south which is implied. The low correlations of surface wind speed (r<0.60) and strong positive wind speed biases suggest the boundary layer processes are not well represented, even at this high resolution.

Figure 4 shows the correlations of 3.3-km temperature, geopotential height, wind speed, and relative humidity for PMM5 versus the McMurdo radiosonde data for Dec 2001-Mar 2002. With the exception of geopotential height, it is noteworthy that the model skill is lowest in the near-surface layer. Wind speed skill also drops at the 850 hPa level, which is approximately level with the mountain tops in the area (i.e., an area of higher wind shear). The temperature skill drops at the tropopause (~300 hPa), but is still reasonable (r~0.80). Figures 3 and 4 suggest that, in this case, high spatial resolution does not significantly improve near-surface simulations, and that other dynamical issues in the boundary layer need to be addressed.

3. CONCLUSIONS

The performance of AMPS has been evaluated for a 4-mo period (Dec 2001-Mar 2002). At 24-h, the 30-km AMPS domain shows high skill in capturing the variability of geopotential height (r~>0.90), temperature (r~>0.90), and wind speed (r~>0.80) in the free atmosphere over all of Antarctica. Similar skill is observed for surface pressure (r~>0.90), slightly lower skill for surface temperature (r~>0,85), and a wide range of skill is observed for surface wind speed, depending largely on topographic complexity ($0.30 \le r \le 0.77$). A systematic cold bias is present near the surface. Over the interior, the cold bias may be associated with deficient simulated cloud cover. The lowest model skill for near-surface variables is observed in the area around Ross Island (the hub of U.S. operations), especially for wind speed, despite the use of higher resolution domains in this region. This indicates the need for improvement to model dynamics and/or model numerics and/or the interaction between nested domains.

Acknowledgments

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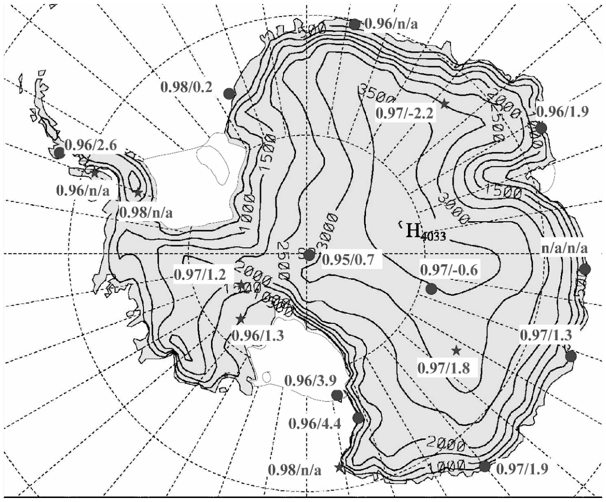


Fig. 1a. Correlation/Bias (hPa) for 30-km PMM5 vs. observed surface pressure. (Period=Dec 2001-Mar 2002).

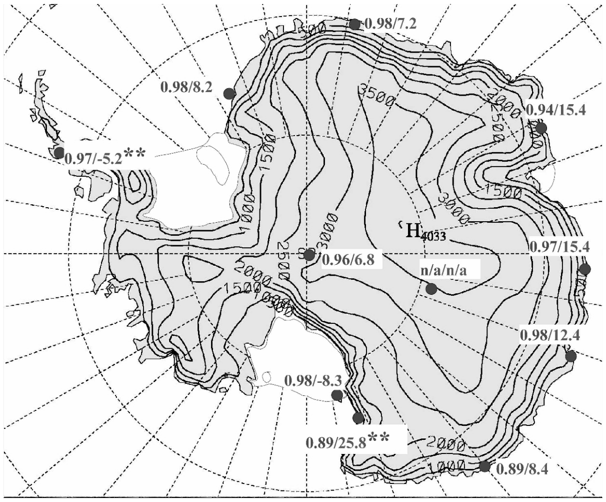


*Fig. 2a. Same as Fig. 1a, but for 500-hPa geopotential height (gpm). ("**" means <50 observations available).*

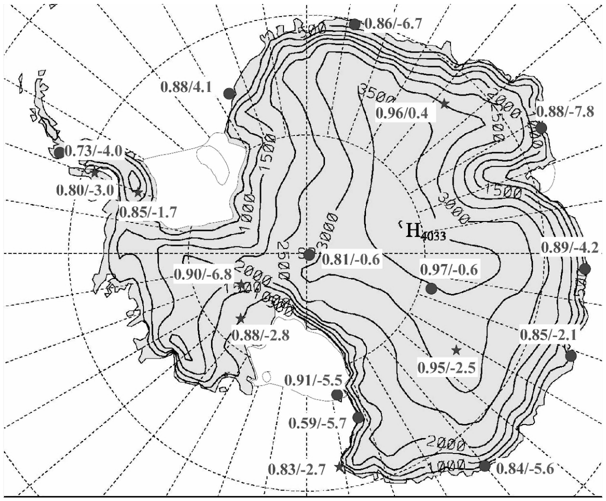
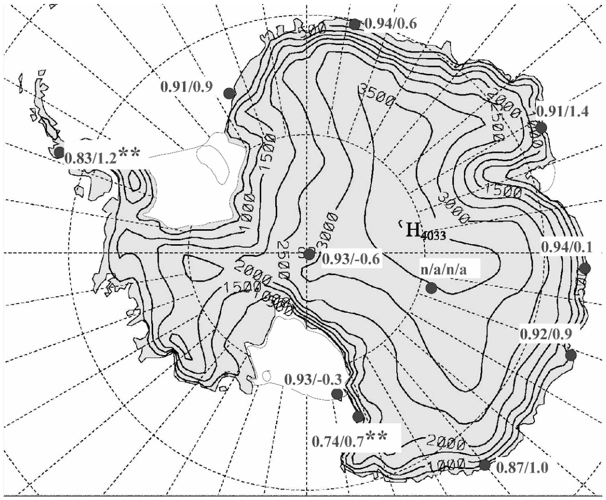


Fig. 1b. Same as Fig. 1a, but for 2-m temperature (^oC).



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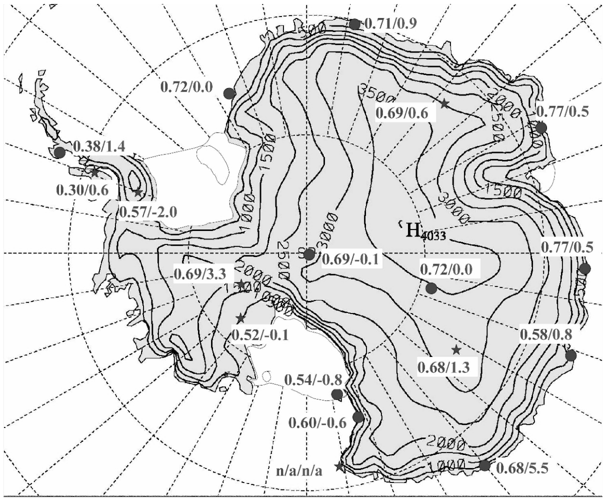
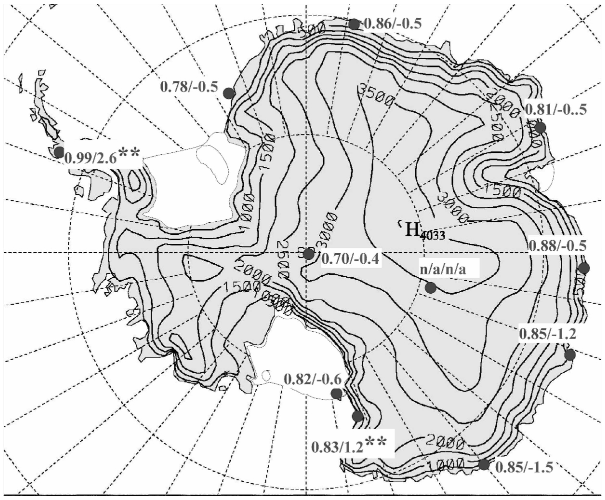


Fig. 1c. Same as Fig. 1a, but for 2-m wind speed (m s^{-1}).



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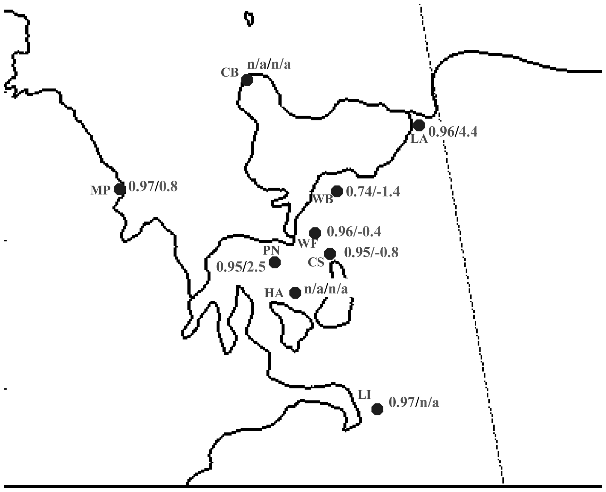

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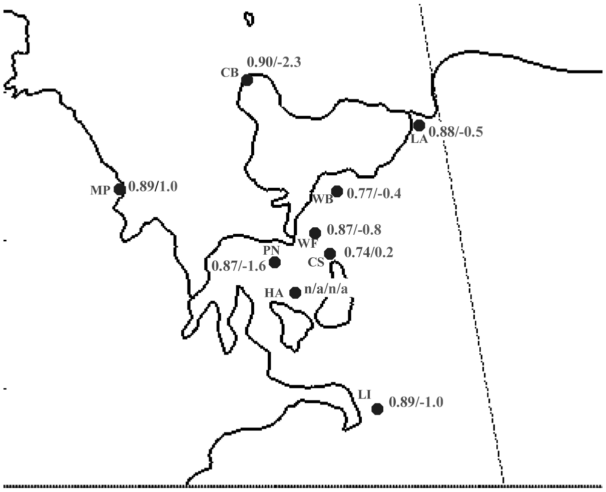

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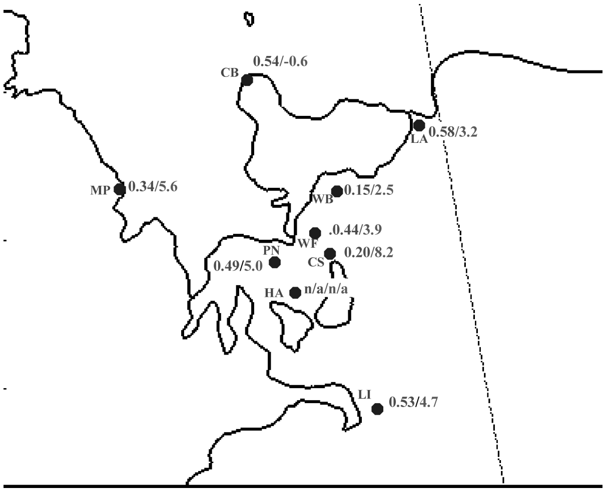

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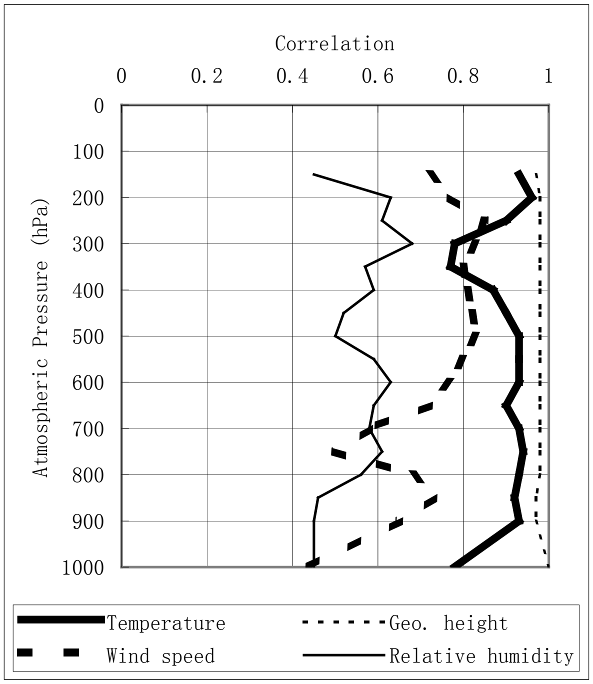

Fig. 4. Correlations throughout the troposphere for PMM5 vs. McMurdo radiosonde observations for temperature, geopotential height, wind speed, and relative humidity for Dec 2001- Mar 2002.

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