

Verification of WRF Forecast over Northeastern United States

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1. Introduction

Analyzing and interpreting numerical weather prediction models have become an important and integral part of undergraduate meteorology education. A large number of institutions including Kean University ingest low resolution NCEP operational model data via Unidata Internet Data Distribution (IDD) (Unidata real time IDD statistics is available from <http://www.unidata.ucar.edu>). Although high resolution NCEP operational model data is also available via Unidata CONDUIT feed, transferring large volume of high resolution model data will put a big burden on local Internet traffic. With the development and the availability of the Weather and Research Forecasting (WRF) Model, it is now possible that local users can configure and generate high resolution weather forecasting model data according to local interest and need. Such high resolution model data has been found extremely helpful for short term forecast of mesoscale phenomena (Hart et al., 1998).

Using a personal desktop from the student computer laboratory, Kean University Department of Geology & Meteorology has successfully installed and been running WRF v2 in real time since late summer of 2005. The model grid resolution is about 15 km, which is close to the resolution of the operational NAM model. The model is run once a day for a 36 hour forecast starting 00 UTC and hourly output are generated for analysis. This is the first step for Kean University meteorology program to incorporate interactive, user selected high resolution (both spatial and temporal) numerical weather prediction model for students' learning and research.

The focus of this paper is to evaluate the performance of this locally configured WRF model. Comparisons will be made between the hourly

forecast surface parameters and the hourly observations at the conventional surface airways observing (SAO) sites. Statistics from New Jersey SAO sites and its surrounding locations will be shown here.

2. Model Configuration

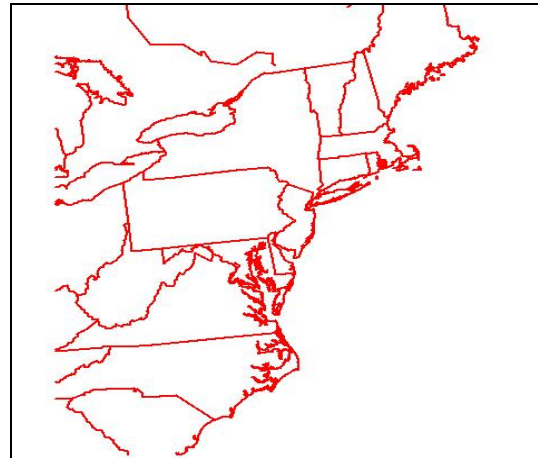


Figure 1 : Locally configured WRF domain for real time forecast

The domain of the current operational real time WRF runs at Kean University is mainly over northeastern United States and centered over New Jersey (Figure 1). But the domain can easily be shifted to any region of the U.S. according to the occurrence of interesting weather. The model is configured with 100x100x31 grid points and the grid spacing is close to 15 km. Model forecast starts at 00 UTC and uses the NCEP 00 UTC NAM run for initial condition. The boundary conditions are generated for every 6 hours up to 36 hours from the same 00 UTC NAM run. WRF Model physics includes Ferrier microphysics, RRTM longwave scheme, Dudhia shortwave scheme, Monin-Obukhov (Janjic Eta) surface layer, thermal diffusion land surface, YSU boundary layer and explicit Kain-Fritsch cumulus scheme. Using a Dell Dimension 8300 2.8 GHz computer with 2 GB of memory, the 36 hour forecast typically takes 6 hours to complete and hence the forecast from 00Z will be available in the morning for faculty and students to use. The post analysis

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is done by using Unidata GEMPAK analysis program, after the WRF netcdf output files are converted to GEMPAK format via the wrf2gem program developed by Steve Decker from the University of Wisconsin

(<http://speedy.aos.wisc.edu/~sgdecker/wrf2gem>).

The WRF output is available online at <http://hurri.kean.edu/nwpmoel>.

3. Results

For WRF model surface forecast verification, GEMPAK “gdgsfc” program is used to interpolate model grid data to SAO stations. Statistics can then be generated by comparing model forecasts and observations. Figure 2 shows the monthly mean bias (forecast – observed) and mean absolute error (MAE, absolute of mean bias) of forecast 2m temperature, 2m dew point temperature, sea level pressure, 10m wind speed and direction. For surface temperature, during the months of August to October, the WRF model exhibits a slight positive bias but the winter cool season shows a consistent cold bias with magnitude close to 1.5C. The WRF temperature MAE for this period is about 2.0C, which is close to the MAE for various MOS verification (Vislocky and Fritsch, 1995; Baars and Mass, 2005). This is encouraging since the raw WRF forecast output compared well with MOS without additional complexity of multiple regressions. From Figure 2b, it shows that the WRF model forecast surface dew point temperature is consistently higher (about 3C positive bias and MAE). Further investigation is necessary to understand WRF land-surface physics in order to account for this persistent high bias in dew point temperature. The bias of sea level pressure in the WRF forecast is small; while the MAE for sea level pressure is about 1mb. For wind verification, statistics is calculated only when the observed wind speed is greater than 1 m s^{-1} and wind direction is not reported as variable. The forecast MAE in scalar wind speed is close to 1.5 m s^{-1} and the magnitude of the average vector wind difference between the forecast and observed wind is much smaller.

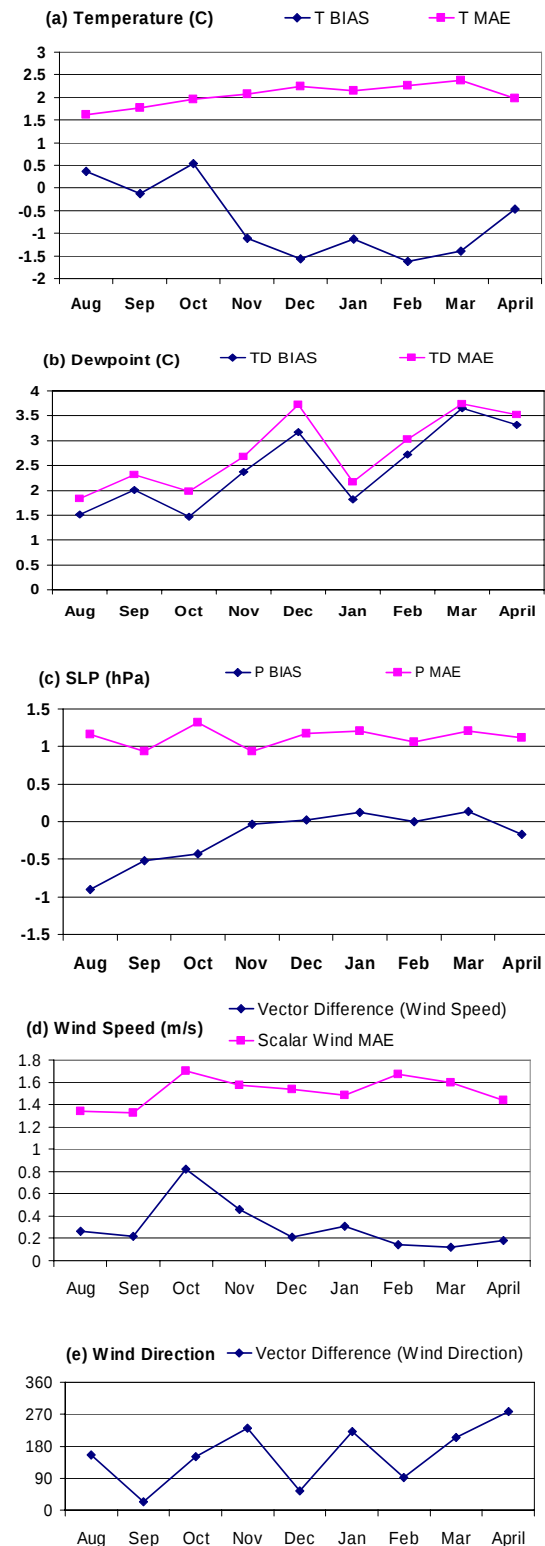


Figure 2 : Monthly (2005 August to 2006 April) average surface biases and mean absolute error (MAE) for (a) temperature, (b) dew point temperature (c) sea level pressure (d) wind speed for vector and scalar differences (e) wind direction for vector difference.

Figure 3 examines mean temperature bias and temperature MAE as function of forecast hour, averaged from all SAO stations in New Jersey. With lateral boundary condition from NAM every 6 hours, the WRF forecast surface temperature bias and MAE seem to remain steady throughout the 36 hour forecast period. This is also true for WRF surface dew point temperature, sea level pressure and wind forecasts. It will be interesting to experiment the WRF model forecast accuracy if the lateral boundary condition is imposed every 12 hours or 18 hours instead. Also, Figure 3 shows that both warm season (August) and cold season (December) months have similar temperature MAE (close to 2C); despite that the temperature bias in August is more positive and temperature bias in December is predominantly negative. In terms of spatial distribution, Figure 4 plots distribution of temperature and dew point temperature bias for the month of August in New Jersey. While the dew point temperature bias is more uniformly throughout the state, temperature bias is low or negative at region with high population (close to New York City in Northern Jersey and close to Philadelphia in Southern Jersey). This suggests that the heat-island effect might affect the observed temperature at these locations.

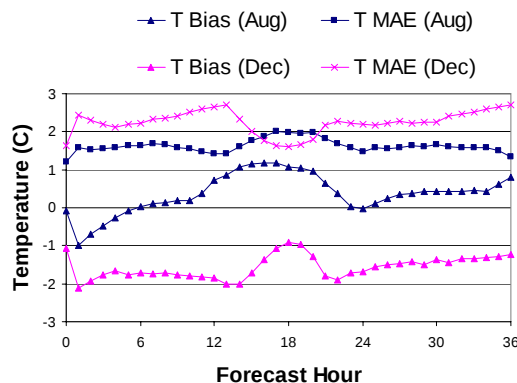


Figure 3 : Surface temperature bias and MAE vs Forecast hour for August 2005 and December 2005.

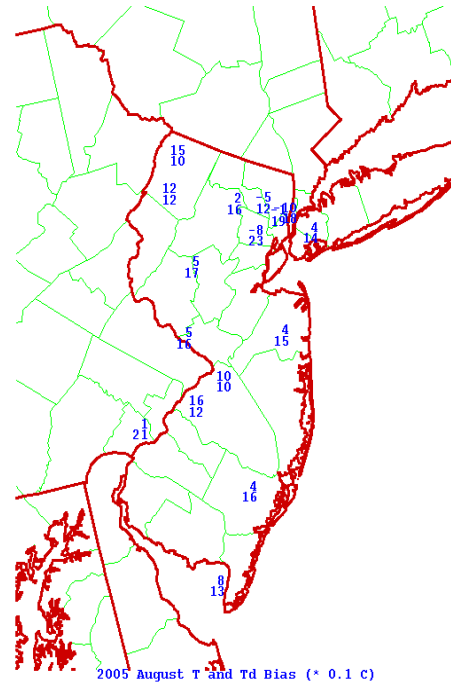


Figure 4 : Mean temperature bias (top number) and dew point temperature bias (bottom number) for August 2005. The unit is in 0.1 C.

4. Discussion and Summary

The WRF model can easily be tailored to local needs and interests. At Kean University, using a single processor PC from student computer lab, a WRF 36 hour forecast with about 15 km grid spacing for Northeast region of the U.S. can be completed in less than 6 hours. With NAM model provides the initial and lateral boundary conditions, the WRF 36 hour forecast does not show any obvious deteriorations in forecasting skills. The current WRF configuration tends to produce positive surface dew point temperature bias, negative temperature bias in the cool season, and only small bias in the sea level pressure. With a locally running WRF model, numerical weather forecast modeling can be better integrated into undergraduate curriculum and other outreach activities.

5. Acknowledgments

This research was supported by Kean University Office of Research and Sponsored Programs and the Department of Geology & Meteorology.

6. References

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