P1.42 A MESOSCALE CLIMATE MODEL FOR THE TROPICS

Edward K. Vizy, Brian N. Belcher, and Kerry H. Cook*
Cornell University, Ithaca, New York

1. INTRODUCTION

The PSU/NCAR mesoscale model 5 (MM5) is developed for use as a tool to support studies of the physical processes that determine climate and variability over the monsoon regions of Africa and India. Motivation behind this development is to capture smaller-scale features within the atmosphere (e.g., African wave disturbances and the low-level Turkana Jet), and at the surface (e.g., East African topography, cold sea surface temperatures (SSTs) associated with upwelling, and tight meridional temperature gradients of the Sahel).

The purpose of this paper is to discuss the modifications made to MM5 to develop the tropical mesoscale climate model (TMCM) and to explore the model's sensitivity to horizontal resolution and the choice of boundary conditions.

2. TMCM EXPERIMENTAL SET-UP

The TMCM and MM5 designs differ in that the TMCM simulations are performed in climate mode, as opposed to synoptic mode used in MM5. The model is initialized at 00Z on the 15th of May using climatological May conditions from either the NCEP (Kalnay et al. 1996) or ECMWF reanalysis (Gibson et al. 1997). Lateral boundary conditions are generated from the reanalysis monthly means by assigning the monthly mean to represent conditions for the middle of the month, and linearly interpolating in time to determine boundary conditions for every 12 hours for the duration of the simulation. Likewise, surface boundary conditions, such as SSTs and moisture availability, are generated from monthly climatological means of Shea et al. (1990) and Willmott et al. (1985). Seasonal simulations are run from May 15th through September 30th (139 days). The first 17 days are used as a spin-up period and discarded. Output is averaged to form monthly and seasonal climatologies. Other options chosen include:

- 120-km, 60-km, or 30-km Resolution
- 24 vertical levels
- Fixed pressure at top of the atmosphere at 50 mb
- Grell or Kain-Fritsch Cumulus Convection scheme
- CCM2 or RRTM radiation scheme
- Inclusion/exclusion of simple ice cloud physics

For further discussion, see Vizy and Cook (2002).

3. RESULTS

The TMCM can capture the summer monsoon climate of Africa (Vizy and Cook 2002) and India, including features such as the African easterly jet, Somali jet, and tropical easterly jet. In general, the TMCM climatology is more similar to the observations than GCM climatologies.

Producing such a good simulation using the TMCM required many validation runs with various choices in boundary conditions and physical parameterizations, and modification of the original MM5 code. This raises concerns about the robustness of the simulation, so we performed an extensive series of sensitivity simulations to characterize and better understand the model's behavior for our application. Highlights are summarized below.

(a) 120 km vs. 60 km Resolution

Two summer seasonal simulations were run over Africa at resolutions of 120-km and 60-km. Both simulations capture key features of the West African summer monsoon (e.g., the monsoon inflow, AEJ, and TEJ). For example, Fig 1 shows a comparison of June-August rainfall for the GPCP satellite-gauge climatology from Huffman et al. (1995) (Fig. 1a), and the 120-km (Fig. 1b) and 60-km (Fig. 1c) TMCM simulations. Note the TMCM simulation results have been interpolated to the $2.5° \times 2.5°$ resolution of the GPCP. Both TMCM simulations capture the rainfall maxima over Africa. While the 120-km simulation produces unrealistic rainfall over the east-central Sahara, the higher resolution simulation does not have this difficulty. Furthermore, the 60-km simulation produces a more realistic rainfall maxima over West Africa than the 120-km simulation. Both simulations produce large rainfall maxima in the vicinity of Lake Victoria due to strong evaporation off the lake. This is not noticeable in the GPCP.

(b) Domain Boundary Conditions

Two 120-km climatological simulations are run to investigate the sensitivity to the lateral boundary conditions. These simulations are identical except one has climatological conditions determined from the 1983-1992 ECMWF reanalysis climatology specified on the lateral boundaries, and the other uses the 1949-2000 NCAR/NCEP reanalysis climatology.

These two simulations produce significantly different climatologies. For example, Fig. 2 shows the June-September rainfall from the GPCP satellite-gauge climatology and the two TMCM simulations. Rainfall rates are low over India and larger than observed over Malaysia in the ECMWF simulation. This is associated with a diversion of the Somali jet southward around India. Westerlies transporting drier air from the Arabian Peninsula over India replace the moist flow associated with the Somali jet. Unlike the ECMWF simulation, the NCEP simulation captures the expected summer rainfall over India and Malaysia, but it tends to produce too much

---

* *Corresponding author address:* Edward K. Vizy, Cornell University, Dept. of Earth and Atmospheric Sciences, 3152 Snee Hall, Ithaca, NY 14853; e-mail: ekv3@cornell.edu.

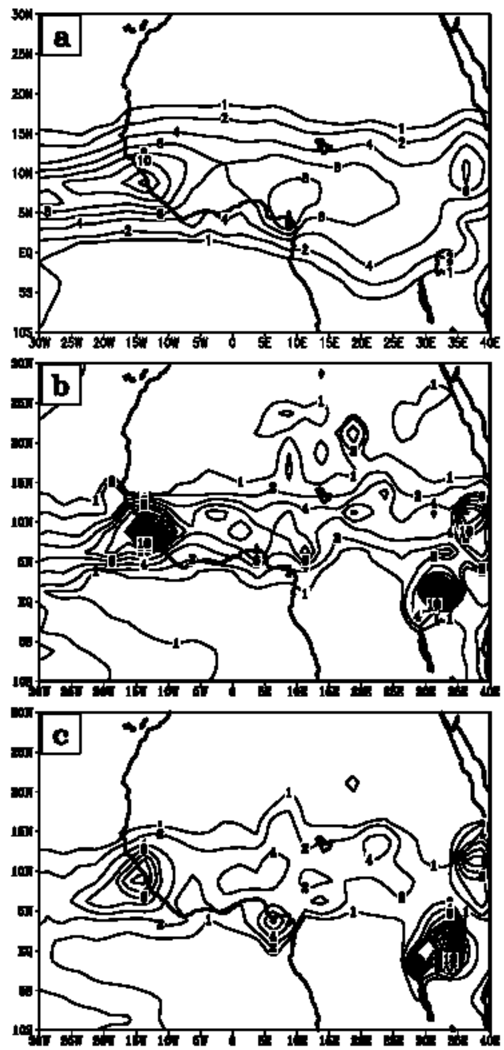

Fig. 1 June-August precipitation for (a) 1979-2000 GPCP satellite-gauge precipitation climatology, (b) TMCM 120-km run, and (c) TMCM 60-km run. Rates are mm day^{-1}.

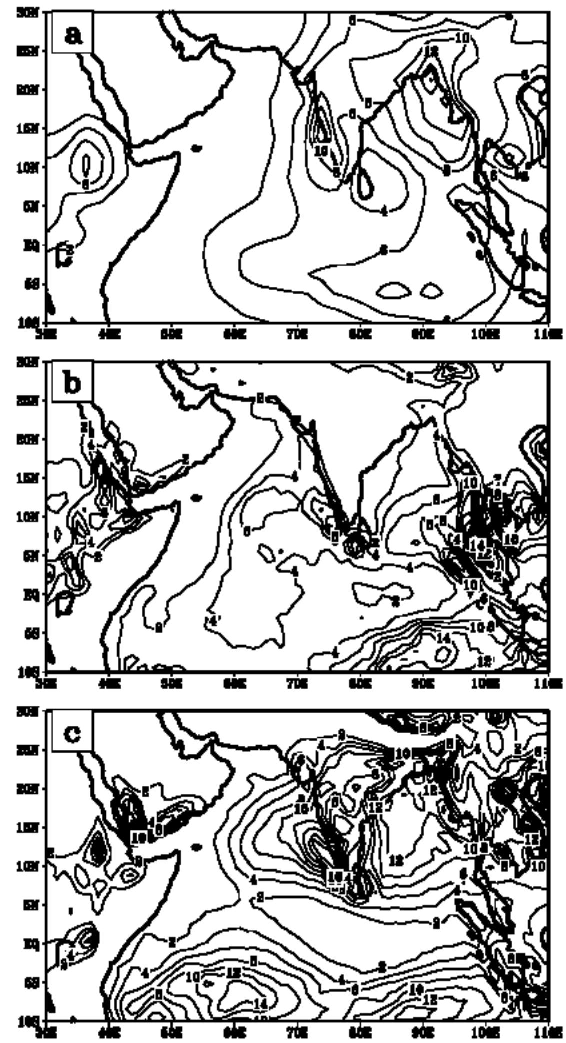

Fig. 2 June-August precipitation for (a) 1979-2000 GPCP satellite-gauge precipitation climatology, (b) TMCM ECMWF boundary condition run, and (c) TMCM NCEP boundary condition run. Rates are mm day^{-1}.

Rainfall over the southwestern tropical Indian Ocean. This increase in rainfall is associated with stronger wind convergence over the region.

4. CONCLUSIONS

The TMCM captures the summer climate over Africa and India, and can be a useful tool for further climate studies. However, as this study points out, caution needs to be taken in designing experiments.

5. ACKNOWLEDGMENTS

This research was supported by NASA Grant NA16GP1621 and NSF Grant ATM-9815419.

6. REFERENCES

Gibson, J. K., P. Kallberg, S. Uppala, A. Hernandez, A. Nomura, and E. Serrano, 1997: ECMWF Reanalysis Project Report Series: 1. ERA description. 72 pp.

Huffman, G. J., R. F. Alder, B. Rudolf, U. Schneider, and P. R. Keehn, 1995: Global precipitation estimates based on a technique for combining satellite-based estimates, rain gauge analysis, and NWP model precipitation information. *J. Climate*, **8**, 1284-1295.

Kalnay, E., M., and co-authors, 1996: The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Meteor. Soc.*, **77**, 437-471.

Shea, D. J., K. E. Trenberth, and R. W. Reynolds, 1990: A global monthly sea surface temperature climatology. NCAR Tech. Note NCAR/TN-345 + STR, XX pp. [Available from National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000.]

Vizy, E.K., and K. H. Cook, 2002: Development and application of a mesoscale climate model for the tropics: Influence of sea surface temperature anomalies on the West African monsoon. *Accepted by J. Geophys. Res. Atmos*.

Willmott, C. J., C. M. Rowe, and Y. Mintz, 1985. Climatology of the Terrestrial Seasonal Water Cycle. *J. Climatology*, **5**, 589-606.