A note on horizontal resolution dependence for monsoon rainfall simulations

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With 4 Figures

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Summary

The motivation for this study came from recent results of an Atmospheric Model Inter-comparison Project (AMIP) coordinated by the Lawrence Livermore Laboratory at Livermore, California. That project included a review of seasonal monsoon simulations from 13 different atmospheric models over the world. Most of the models used a horizontal resolution of roughly 300 km. The seasonal monsoon simulations from these models varied significantly. The poor performance by these models stems in part from the use of the coarse resolution. The purpose of this note is to show that by using the same model physics and lower boundary conditions, such as snow/ice cover and sea surface temperatures, the use of the higher horizontal resolution does have a stronger positive impact on the skill of monthly rainfall when compared to a lower horizontal resolution. In this note we present the results of such a comparison between the horizontal resolutions of T42 and T170. These studies are carried out for the prescribed lower boundary specification of sea surface temperatures and snow/ice cover with the help of an Atmospheric General Circulation Model.

1. Introduction

In recent years precipitation climatology has been improved from the use of rainfall estimates from microwave radiometers and radar from satellites such as the Defense Meteorological Satellite Program (DMSP) and Tropical Rainfall Measurement Missions (TRMM). Outgoing long-wave radiation (OLR) has also been used to estimate rain rates. These types of data sets have been used to validate seasonal or monthly rainfall climatology of climate models.

This short contribution is intended to describe a comparison of monthly mean monsoon rainfall simulation at two different horizontal resolutions from an Atmospheric General Circulation Model (AGCM). The results of seasonal monsoon simulations for the Atmospheric Model Inter-comparison Project (AMIP) were reported by Sperber and Palmer (1996), and Gadgil and Sajani (1998). Most of the models used in this intercomparison employed horizontal resolutions of roughly 300 kilometers. Seasonal monsoon simulations have been a very difficult issue for modelers. The slow varying forcing from such surface parameter as sea surface temperatures (SST) and snow/ice cover are some of the most important factors for seasonal monsoon simulations. We have developed a method called physical initialization for the incorporation of “observed” rain rates to improve the initial states of weather and seasonal simulation in global models (Krishnamurti et al., 1991, 1999). This physical initialization is invoked within the data assimilation phase of the model forecast, and by using reverse algorithms, it entails the restructuring of the vertical distribution of humidity for given estimates of the observed rainfall rates. A reverse similarity theory restructures the humidity in the surface layer (the constant flux layer)
such that the surface evaporation and the prescribed precipitation are in close balance within the assimilation. This component provides a balance among the vertically integrated evaporation, precipitation and the substantial derivative of the specific humidity following Yanai et al. (1973) definition of the apparent moisture sink. In addition to these, a restructuring of the specific humidity of the upper troposphere provides a matching of the forecast model-based OLR with that obtained from satellite estimates. All of the aforementioned components of physical initialization are contained within the model’s data assimilation.

The purpose of this note is to illustrate that a higher horizontal resolution model provides a better definition of the initial rainfall and that this information helps the one-month lead simulation of rainfall especially over the monsoon environment.

The scope of this study is however fairly limited; it shows a comparison of monthly monsoon rainfall simulations for two horizontal resolutions at triangular truncations 42 and 170 waves for a global spectral model. These correspond to roughly 300 km and 70 km, respectively.

2. Design of model run and data assimilation

The results shown here are based on a multi-level Florida State University (FSU) global spectral model, which is described in Krishnamurti et al. (1991). The FSU spectral model is outlined in the Appendix of this note. The start date of the experiment is June 1, 1993, for both the T42 and T170 experiments. The initial data for June 1, 1993, 00UTC are obtained from ECMWF analyses. The initial data sets also include a 10 day average SST for the period June 1, 1993 through June 30, 1993. The orographies for the respective horizontal resolutions are obtained from the U.S. Navy’s global 10-minute tabulation. The snow and ice cover for the initial states is also obtained from ECMWF daily analyses. Furthermore, physical initialization following Krishnamurti et al. (1991, 1993) is invoked within a data assimilation phase of the model forecast. This provides a better coupling between the large-scale circulation and the meso-convective systems at the horizontal resolution T170 compared to that at T42. This is followed by integration for the period June 1 to June 30, 1993, at the respective horizontal resolutions.

3. Comparison of the T170 and T42 rainfall

Here we shall show correlations between the observed and the simulated monthly rainfall

![Graphs showing rainfall comparisons](image-url)