JP2.3 DOWNSCALED 1997/1998 SUMMER OVER EAST ASIA USING THE REGIONAL SPECTRAL MODEL

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1. INTRODUCTION

Due to computational constraints, Atmospheric General Circulation Model (AGCMs) are typically run at a resolution far too course to provide information (e.g., precipitation, temperature) at spatial and temporal resolutions useful for direct application. One remedy for this is the adoption of a dynamical downscaling approach. A high-resolution limited-area model is run for the region of interest, forced by the large-scale circulation prescribed from a lower-resolution AGCMs. Several studies already examined this approach for particular areas such as the Asian monsoon region (Ji and Vernekar 1997) and North America (Fennessy and Shukla 1998).

A number of research efforts are currently in progress to test and evaluate dynamical methods, using Regional Climate Model (RCM), for downscaling AGCM results on seasonal and interannual timescales (Nobre et al. 2001; Chou et al. 2000; Sun et al. 1999; and others). There is an expectation that higher-resolution regional climate models can "add value" to the seasonal climate prediction of a AGCM by improving the spatial and temporal patterns of regional rainfall resulting from complex topography and/or land use, as well as from improved resolution of mesoscale circulation systems.

East Asia is characterized with unique topography, landscape, and monsoon climate compared to other regions of the world. East Asia is surrounded by the high Tibetan Plateau in the west and the western Pacific Ocean in the east as well as complex topographical land in the north and tropical ocean in the south. In this study, the 1997 and 1998 summer (JJA) has been selected. East Asia drought and heat waves during the summer of 1997, and flooding in Korea, Japan, and the Yangtze and Songhua River valleys of China, during the summer of 1998.

In this study, the RCM ability to simulate circulation and rainfall observed in the two extreme seasons (1997/1998 summer) was demonstrated when driven at the lateral boundaries by AGCM forcing.

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2. MODEL DESCRIPTION

a. AGCM Description

ECHAM5 is the fifth generation version of the Hamburg atmospheric general circulation model ECHAM, which was modified from ECMWF AGCM for the use of long-term climate simulations (Roeckner et al 2003). The T63 (Gaussian grid 192×96) and 19 hybrid sigma-pressure levels are used.

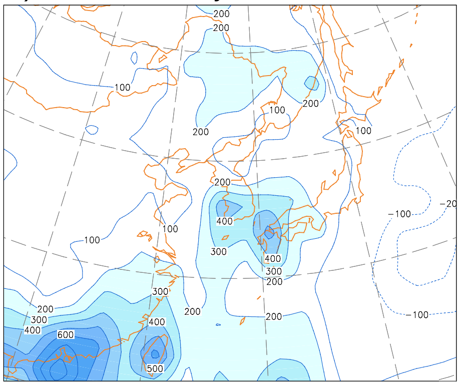
b. RCM Description

The National Centers for Environmental Prediction (NCEP) Regional Spectral Model (RSM) (Juang et al. 1997) is used in this study. The RSM is a primitive equation model using the sigma-vertical coordinate. The model includes parameterizations of surface, boundary layer (BL), and moist processes that account for the physical exchanges between the land surface, the boundary layer, and the free atmosphere.

b. Description of Selected Seasons

A typical summer over Korea is characterized by heavy rainfall, which can mainly be attributed to the Changma front in June and July and a hot spell from late July to mid-August. However, there was an abnormally heavy spell of rain in the summer of 1998 (Fig. 1a). On the other hand, areas with monsoonal precipitation are displaced southward during the summer of 1997 (Fig. 2b)

a) CMAP Anomaly 1997 summer



b) CMAP Anomaly 1998 summer

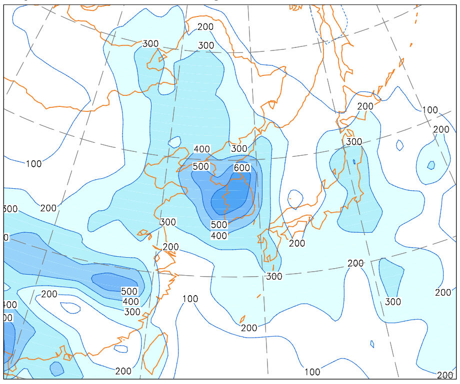


Figure 1. Observed precipitation anomaly field for the 1997(upper panel) and 1998(lower panel) summer over the East Asia from Xie and Arkin (1996). Contour intervals are 150 mm and shaded areas are over 200 mm

3. EXPERIMENTAL DESIGN

RSM has been run for the period of June-July-August for 1997(dry) and 1998(wet), creating three-month long simulations from initial and boundary conditions provided by the ECHAM5 datasets, which are available at 6-h intervals with a resolution of T63 (Gaussian grid 192×96).

RSM domain covers East Asian monsoon region centered over the Korean Peninsula. The number of grid points in Cartesian coordinates is 109 (west-east) by 86 (north-south). A 50-km resolution is chosen. The RSM vertical resolution employed is 28 layers.

Model precipitation was compared with the Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP). These global monthly precipitation fields are on a 2.5°×2.5° grid and are obtained by merging gauges and satellite estimates (Xie and Arkin 1996). The information of experiments summarized in Table 1.

Table 1. Summary of numerical experiments used in this study.

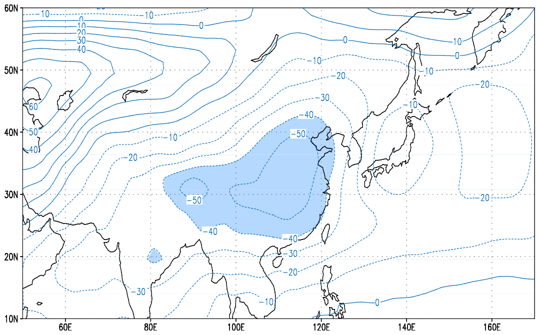
Contents	RSM
Resolution	50km
Projection	Polar stereographic
Horizontal dimension	109×86
Center of model	38.6°N, 127.50°E
Vertical layer / Top	28 layers / 74.08 hPa
Cumulus parameterization	SAS
PBL	YSUPBL
LSM	OSU
Radiation	LWRMDC

4. RESULTS

a. AGCM Result

The 500 hPa eddy height from the AGCMs are compare with the reanalysis in Figure 2 and Figure 3. The quasi-stationary wave component at a grid point is defined as the time-averaged departure of the value from zonal me at the same latitude. Compare with the RA2, the AGCM is not fairly well simulated in location and intensity. Furthermore, the inter-annual variability of quasi-stationary wave is not appeared (Figure 2 ab).

a) 1997 summer 500hPa Z* AGCM



b) 1998 summer 500hPa Z* AGCM

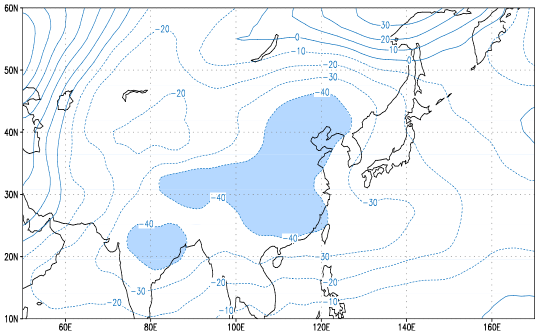
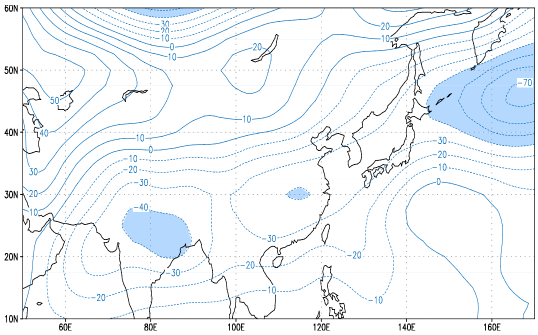


Figure 2. Seasonal mean 500 hPa quasi-stationary waves for 1997(upper panel) and 1998(lower panel) from AGCM data. Contour interval is 10 m, negative values lesser than -40 m are shaded.

a) 1997 summer 500hPa Z* RA2



b) 1997 summer 500hPa Z* RA2

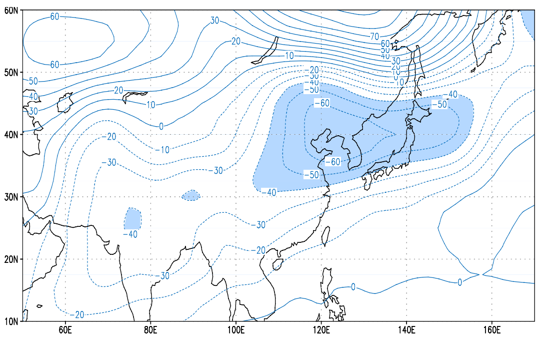
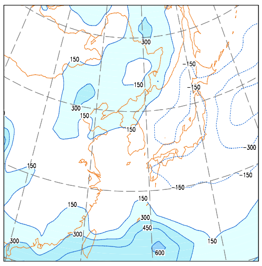


Figure 3. Same as Figure 2 except for RA2 data.

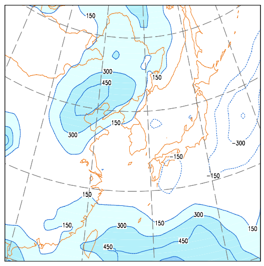
b. RCM Results

Figure 4 presents the distribution of the precipitation anomaly over the East Asia from AGCM data (Figure 4 ac) and RCM results (Figure 4bd). In Figure 4 ac, the precipitation deficit appears over East China, Korea, and Japan regions. Also, we can find that the RCM can not reproduce the precipitation in northern China and central region (Figure 4 bd). However, precipitation over South China, Japan and Ocean regions is overestimated.

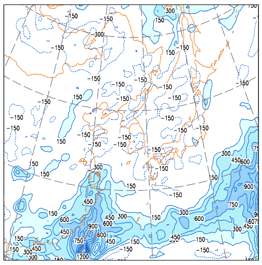
a) GCM 1997



c) GCM 1998



b) RCM 1997



c) RCM 1998

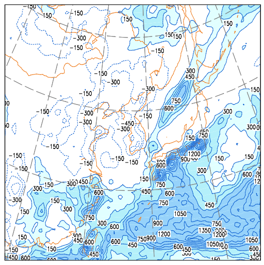


Figure 4. Seasonal mean precipitation (mm) anomalies from a), c) AGCM and b), d) RA. Climatology is the average for 1987-2000. Contour interval is 150 mm, positive values greater than 150 mm are shaded.

Figure 5 shows the vertical profiles of temperature and specific humidity. The ECHAM5 temperature has a cold bias at the whole level. The RSM reduced cold bias significantly especially near the surface both in 1997 and 1998 (Figure 5 ac). The domain averaged specific humidity analysis shows wet bias more than RA2 (Figure 5bd). However, the RSM results show that the moisture slightly decreases.

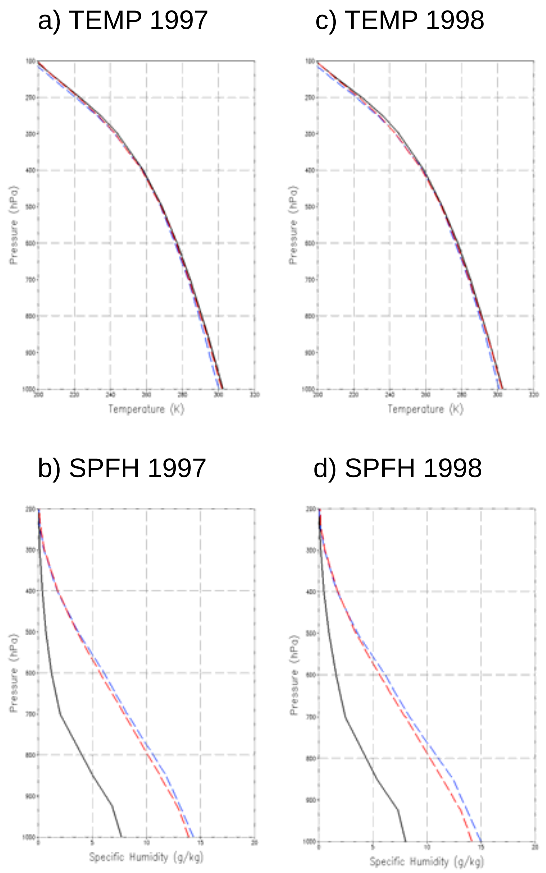


Figure 5. Vertical profiles of domain averaged temperature (K) and specific humidity (g/kg). Black solid line, red dashed line and blue dashed line indicate observation, RCM and AGCM, respectively.

5. CONCLUSION

In this study, the sever drought (1997 summer) and flood (1998 summer) case over East Asia was simulated using a RSM, initial and boundary conditions provided by the AGCM datasets, and the model performance in reproducing the extreme climate events was evaluated.

The AGCM is able to produce large-scale atmospheric response, and it gives a temperature pattern similar to that observed. However, the AGCM is not fairly well simulated in location and intensity in quasi-stationary wave over East Asia regions. A lower amount for precipitation may be due to the fact that AGCM is not fairly well simulated in location and intensity of quasi-stationary wave.

The RCM is nested in the AGCM outputs to enhance rainfall. In comparison to the observation the RCM underestimate the rainfall in central region. However, the RCM overestimate the precipitation over northern China and Ocean regions. The RSM had significant biases in simulated precipitation over some areas. The upper level temperature is also realistic. The RSM reduced cold bias significantly especially near the surface both in 1997 and 1998. The RSM results show that the moisture slightly decreases.

ACKNOWLEDGEMENTS

This research was supported by the Climate Environment System Research Center sponsored by the SRC program of Korea Science and Engineering Foundation.

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