P3.14 CHARACTERISTICS OF THE SIMULATIED EAST-ASIAN SUMMER MONSOON CIRCULATION IN THE RegCM3

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1. INTRODUCTION

During the past decades, the skill of seasonal climate prediction has improved substantially with dynamical model. It has become clear that there exists the potential for making skillful seasonal and even inter-annual predictions well beyond traditional predictability limits for numerical weather prediction (Palmer and Anderson 1994).

Dynamical downscaling is essentially forced by a General Circulation Model(GCM) through boundary conditions at the boundary of a Regional Climate Model(RCM) domain, which allows the RCM to develop its own climate within the domain. In statistical downscaling, the reliability of the results depends on, for example, how well the predictors are simulated by GCM (Palutikof et al. 1997; Winkler et al. 1997) and how stable the connections between predictors and predictands are. The statistical downscaling can easily handle a variety of scales including the station scale.

Both dynamical and statistical downscalings have their own advantages and disadvantages. The RCMs cannot be expected to improve the finescale if the driving GCM provides poor lateral boundary conditions (Noguer et al. 1998). Especially, Noguer et al. (1998) showed that a GCM forced RCM simulation had large errors which was related to the systematic errors of the GCM. RCM is influenced by the size of the regional domain, season of the year, the region, and the RCM physics and dynamics. Statistical downscaling approaches have subsequently emerged to satisfy the need to interpolate regional-scale atmospheric predictor variables to station-scale meteorological series (Kim et al., 1984).

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The objective of this paper is to produce a RCM climate over East Asia for summer season and to demonstrate the ability of the regional climate model (RegCM3) in reproducing inter annual, intra seasonal, daily, and diurnal variability during the summer. The downscaled climatology from the RegCM3 is compared with that with a statistical method.

2. EXPERIMENT DESIGN

In this study, we investigate the characteristics of the simulated regional climate over East Asia during the summertime using a RegCM3. RegCM3 has been run for the period of June-July-August for 1982-2003, creating three-month long simulations from initial and boundary conditions provided by the NCEP/NCAR Reanalysis II datasets, which are available at 6-h intervals with a resolution of 2.5° × 2.5°. The RegCM3 is configured at a 60-km grid resolution with dimension of 109 (Zonal) × 86 (Meridional) centered at 38.6°N and 127.50°E. A 23 vertical layer with the model top of 74.08 hPa is used. The time step of the integration is 180 s. The information of experiments summarized in Table 1.

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

Contents	RegCM3
Resolution	60km
Projection	Polar stereographic
Horizontal dimension	109×86
Center of model	38.6°N, 127.50°E
Vertical layer / Top	23 layers / 74.08 hPa
Cumulus parameterization	Grell
PBL	Holtslag
Microphysics	SUBEX
LSM	BATS
Radiation	CCM3

The ability of the model performance from diurnal to inter-annual variation is accessed. Model precipitation was compared with the Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) (Xie and Arkin 1996). These global monthly precipitation fields are on a 2.5°×2.5° grid and are obtained by merging gauges and satellite estimates.

For the statistical downscaling method the data used in this study are the monthly precipitation for 22-years from June 1982 to August 2003, observed at 73 stations in South Korea. The station dataset was interpolated to grid data. The corresponding observed monthly mean SLP was obtained from reanalysis II data. The data for the GCMs are the monthly mean SLP over the monsoon region (15 °N–70 °N, 60 °E–150 °W) in East Asia.

In this study, SVDA with EOF truncation is used to obtain the coupled mode between the large scale and regional scale. Before obtaining the transfer function between the two fields, EOF analysis is applied to the simulated and the observed fields, separately, to reduce the spatial dimensions. After that, SVDA is used to extract coupled modes between the two fields. The covariance matrix in SVDA is constructed by using the normalized time coefficients of EOF analysis in both sides. The downscaling transfer function was constructed as follows:

$$E(x^*,t)=\sum_{i=1}^{p}\alpha_i S_i(t)R_i(x^*) \qquad (1)$$

where $E(x^*,t)$ indicates the downscaling prediction, $S_i(t)$ is the time coefficient of the SVD mode for the large-scale predictor, and $R_i(x^*)$ represents the covariance map between regional precipitation and the time coefficients of the SVD mode for the regional-scale predictand. If regional precipitation data are normalized and in addition the expansion coefficients have a variance of one, $R_i(x^*)$ is identical to the correlation map. α_i is the correlation coefficient between the time series of the SVD mode of the large-scale predictor and the corresponding SVD time series of the predictand. n is the total number of SVD modes retained. Refer to the Kim (2005) for a more detailed information.

Resulting climatology with the dynamic model is discussed in comparison with that using a statistical method combining the EOF (empirical orthogonal function) and SVD (singular value decomposition).

3. RESULTS AND DISCUSSION

Figure 1 show the distribution of the 22-year-mean monthly precipitation over East Asia. The monthly precipitation over southern China, Korea, and Japan reasonably are well reproduced (Figs. 1ab). Compared with the corresponding observation, the RegCM3 well captures the location and amount of precipitation (Figs. 1cd). However, the model underestimates the amount of precipitation over the Korean peninsula, whereas precipitation over the ocean is underestimated (Figs. 1ef).

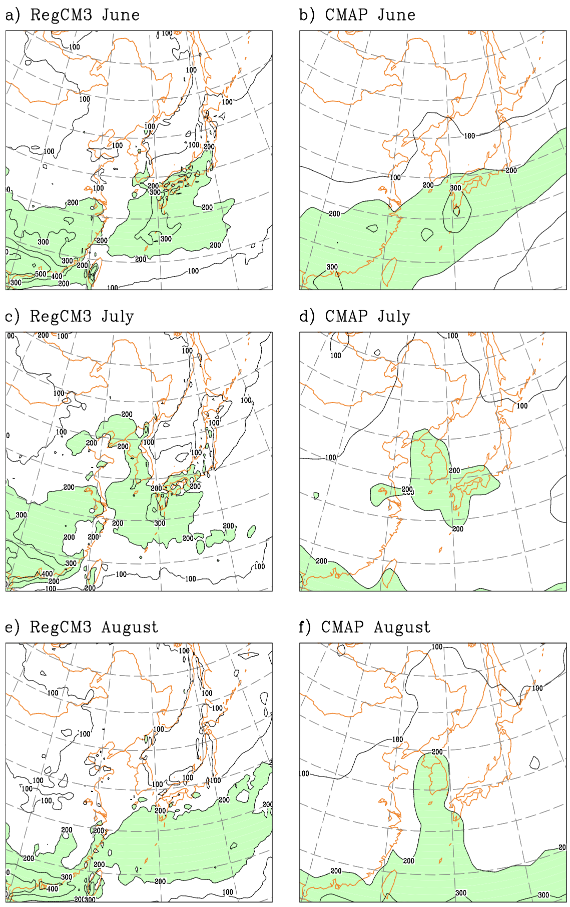

Figure 1. The distribution of 22-year averaged monthly precipitation (mm) over East Asia, (a) June, (c) July, and (e) August from the RegCM3 simulation, and (b) June, (d) July, and (f) August from CMAP data. Contour intervals are 100 mm and shaded areas are over 200 mm.

Table 2 shows the statistics of the bias, RMSE, and pattern correlation for 22-year summer climatology over the whole domain. The summer mean precipitation is overestimated with a bias greater than 0.54 mm/day. The 500 hPa geopotential heights are underestimated with a bias lesser than -26.90 gpm. The systematic error represents 0.53 m/s in 850 hPa wind field and the 200 hPa wind bias in the whole domain is -0.34 m/s (Table 2).

Table 2. Statistics of the bias, RMSE, and pattern correlation for 22-year summer climatology over the whole domain.

Variable	Bias	RMSE	P-Corr.
Precipitation (mm/d)	0.54	1.72	0.66
850 hPa Temp. (K)	-1.80	1.95	0.97
500 hPa Temp. (K)	0.57	0.64	0.99
300 hPa Temp. (K)	0.42	0.55	0.99
850 hPa Wind (m/s)	0.53	0.90	0.88
200 hPa Wind (m/s)	-0.34	1.47	0.99
500 hPa Height (gpm)	-26.90	27.37	0.99

Figure 2 shows the first SVD mode between observed SLP and observed temperature. Here, the first 10 EOFs of SLP and temperature have been retained for the subsequent SVDA. The SLP pattern shows an east–west pattern around the Korean peninsula and the temperature pattern has the same sign over the entire area (Figs 2ab). The correlation coefficient between the expansion coefficients is 0.66 for the first SVD mode (Fig. 2c).

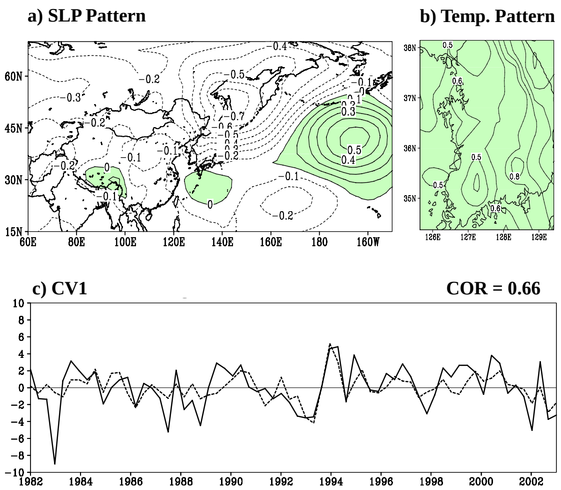

Figure 2. The first coupled pattern between (a) sea level pressure and (b) temperature in summer. (c) is associated time series. The solid and dashed lines indicate time series of SLP and temperature, respectively.

Figure 3 shows the first SVD mode between observed SLP and observed precipitation. Here, the first 10 EOFs of SLP and precipitation have been retained for the subsequent SVDA. The SLP pattern shows an east–west and north-south dipole pattern around the Korean peninsula and the precipitation pattern has the same sign over the entire area (Figs 3ab). The correlation coefficient between the expansion coefficients is 0.53 for the first SVD mode (Fig. 3c).

lower skill for precipitation with the dynamical method may be due to the fact that summer precipitation over South Korea is highly localized, which is difficult to be correctly captured by the numerical model.

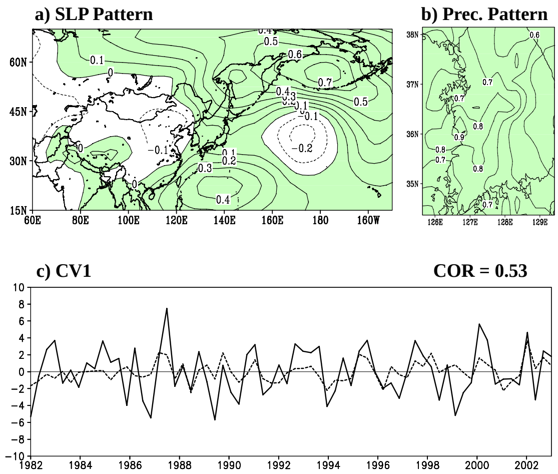

Figure 3. The first coupled pattern between (a) sea level pressure and (b) precipitation in summer. (c) is associated time series. The solid and dashed lines indicate time series of SLP and temperature, respectively.

Figure 4 shows the temporal evolution of spatial averages of the estimates obtained from statistical downscaling, dynamical downscaling, and observed summer anomaly temperature and precipitation for year-to-year time scale (Figs. 4ab). The correlation coefficient between the observed and the statistical downscaling is about 0.64 in temperature (Fig. 4a), whereas, the correlation coefficient between the observed and the dynamical downscaling is about 0.71 in temperature (Fig. 4a). The correlation coefficient with the dynamical downscaling is larger than that with the statistical downscaling. However, the correlation coefficient with the statistical downscaling is larger than that with the dynamical downscaling (Fig. 4b). A relatively

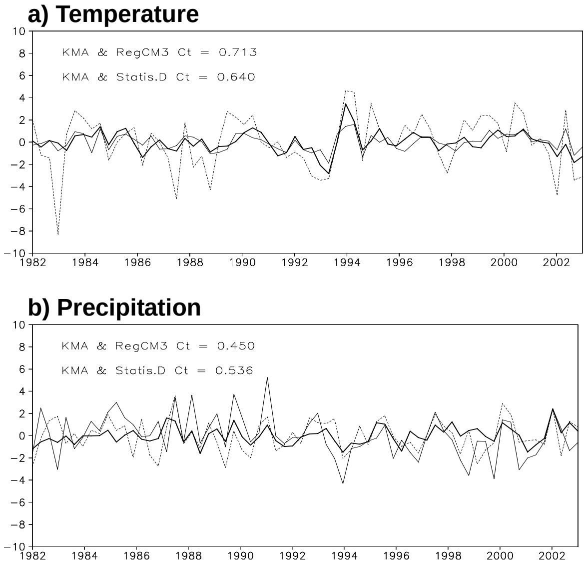

Figure 4. Observed (heavy solid line), the predicted (dashed line), and model simulated (solid line) time series anomalies of summer temperature (upper panel) and precipitation (lower panel).

4. SUMMARY AND CONCLUDING REMARK

The RegCM3 reproduces relatively well the regional climatology of the East Asian Monsoon System. The general patterns of the interannual variations of temperature, height, and wind are well simulated. The 22-year summer mean precipitation simulated over the East Asia reveals the major monsoonal rain bands over southern China, Korea, and Japan. Compared to reanalysis II data, the model improves the deficiency of precipitation over Korea and Japan, surplus over southern China.

The statistical downscaling method based on the SVD with the EOF truncation is applied to downscale the regional information from the observed fields. The relationship between the large scale and regional scale parameters is high. The observed variability of precipitation over South Korea is associated with the first mode of SLP with the east-west and north-south pattern. The temperature has the same pattern.

In the comparison of the downscaled temperature and precipitation over South Korea with the statistical and dynamical methods, it is found that the correlation coefficient with the dynamical downscaling is larger than that with the statistical downscaling, whereas in precipitation the skill with the statistical downscaling is higher than that with dynamical downscaling.

ACKNOWLEDGEMENTS

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