# A Regional climate simulation over Japan nested with JRA-25

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## INTRODUCTION

Global warming affects not only on long range environment but also on short timescale phenomena such as exterme events and their frequency (Boo ,2004,, Kamiguchi et al., 2006). Although reanalysis data is quite useful for large scale investigations, higher resolution data is required in order to investigate regional extreme climate change. Our aim is to obtain more detailed dynamical data over Japan from reanalysis data using a regional climate model. We performed a 26-year continuous integration from January 1979 using a 20km resolution Regional Climate Model (Meteorological Research Institute RCM, MRI-RCM20) with initial and boundary conditions provided by JRA-25. In this study, we especially focus on precipitation and evaluate the results by comparing with observations.

## MODEL DESCRIPTION AND EXPERIMENT

The regional climate model used in this study is Meteorological Research Institute Regional Climate Model (MRI-RCM20) described by Sasaki et al. (2006). It is based on a regional spectral model, which had been originally developed by Japan Meteorological Agency as short range forecast model (NPD/JMA 1997). The model resolution used in this study is approximately 20km with 36 hybrid vertical levels. It uses vertical diffusion scheme of level2 model by Mellor and Yamada (1982), the cumulus convection schemes of Arakawa-Shubert (1974) and convective adjustment, the shortwave radiation scheme by Lacis and Hansen (1974), the longwave radiation scheme by Sugi et al. (1990), grand surface process by Takayabu (2003). For a long term simulations, the model is adopted a Spectral Boundary Coupling (SBC) method, proposed by Kida et el.(1991). In this method the large-scale component of reanalysis data and the small-scale component of inner nested model results are joined in wave number space. It has the advantage of long-term integration smoothly because that there are no contradiction between an outer coarse-mesh reanalysis data and a nested model in respect of large-scale fields. Figure 1 depicts 6-hourly wind and temperature and specific humidity data in JRA-25 around Japan are used as lateral boundary condition s and daily SST and ice data are used as lower boundary conditions. In addition to that, the RCM20 uses SBC method regarding wind and temperature field over 500hPa level.

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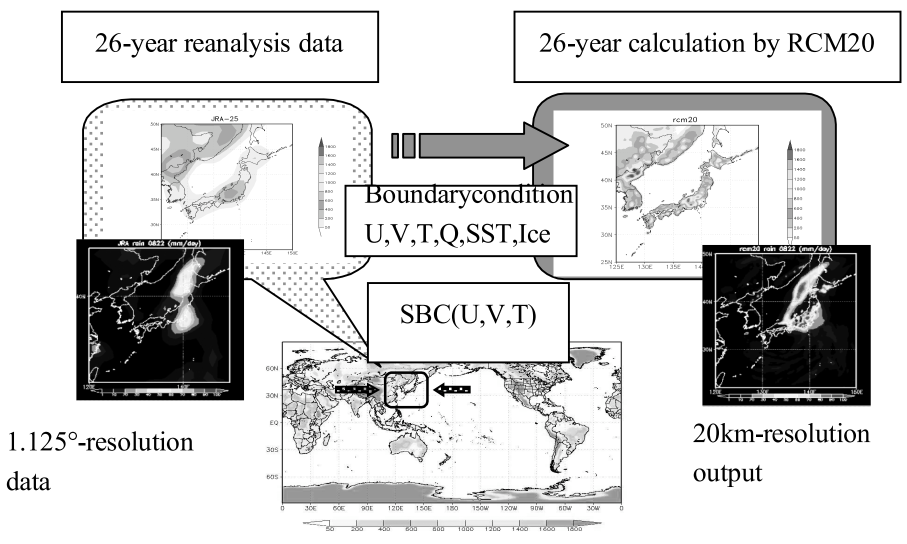

Figure 1 Schematic figure of how to downscale JRA-25.

**RESULTS**

A continuous 26-year calculation has been performed from 1 Jan 1979 to 31 Dec 2004. In this study, AMeDAS (Automated Meteorological Data Acquisition System) and radar-AMeDAS are used for the model evaluation. Figure 2 displays differences in monthly precipitation averaged over Japan between models and observation. JRA-25 underestimates monthly precipitation especially in warm season and the RCM20 improves dramatically. It can be explained as due to more realistic topography and improved reproducibility of cyclonic disturbance in Meso-β scale.

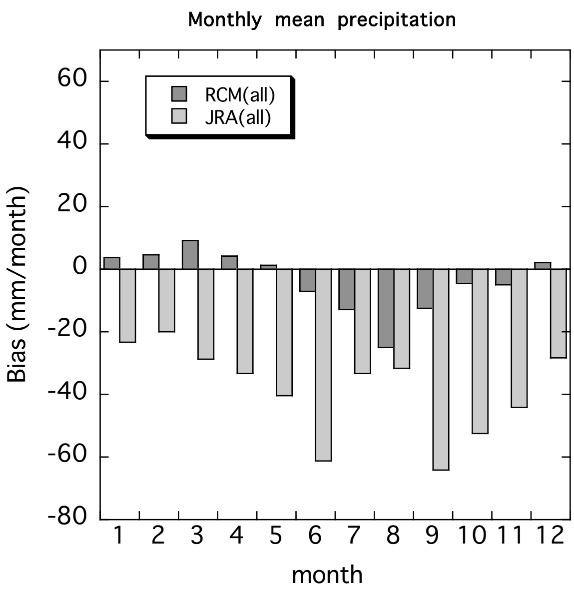


Fig.2 Biases of 26-yr mean monthly precipitation of the RCM (deep shaded column) and JRA-25 (light shaded column).

Figure 3 shows daily precipitation averaged over Japan plot during 26 years. Total number of plot is 9497 and the correlation coefficient of daily precipitation between observation and simulation is 0.84.

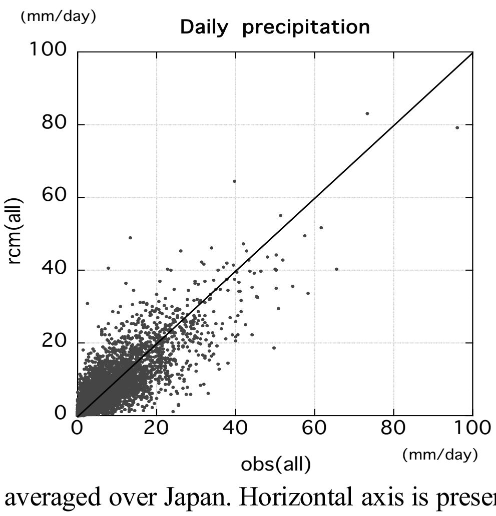


Fig.3 Scatter plot of daily precipitation averaged over Japan. Horizontal axis is presents observation and vertical axis represents RCM results.

Figure 4 presents the observed and simulated daily precipitation over Japan during last 6 months of the integration. Despite about 26years of progress since the model started the calculation, the RCM reproduces the variation of daily events well. These results indicate the model reproduces precipitation well not only at monthly time scale but also at daily scale. For example, Figures 5 show 3-day accumulated precipitation distribution from July 12 to 14, 2004. During this period, there was a heavy rainfall in Niigata and Fukushima area (as shown in Figure5a). The result shows that the large-scale characteristics are quite similar to JRA-25 but the RCM represents more realistic precipitation distribution due to the topography of Japan.

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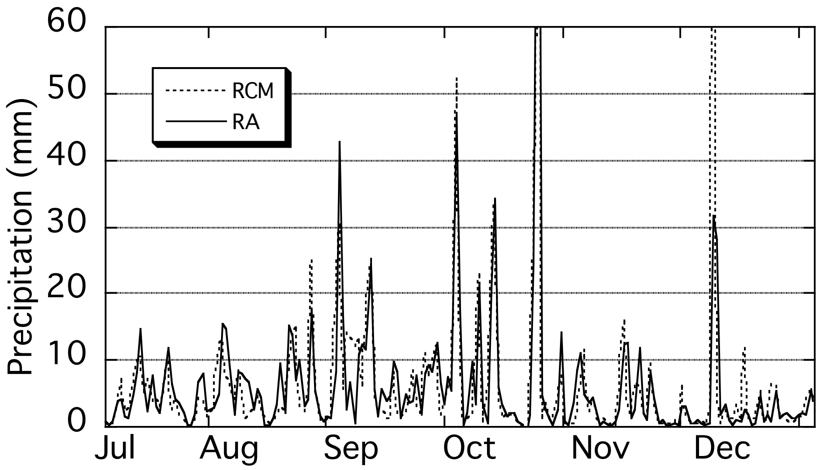


Figure 4 Time series of daily precipitation (mm) as simulated (dashed line) and observed (solid line) averaged over Japan area from July to December 2004.

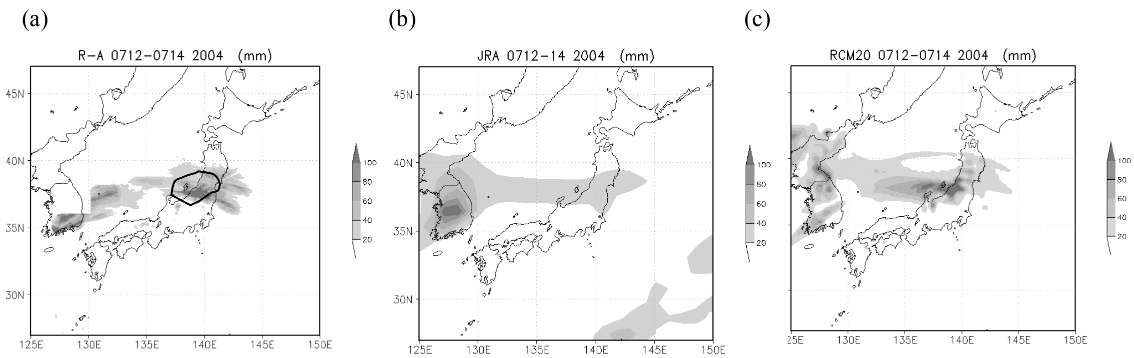


Figure 5 3-day accumulated precipitation (mm) from July 12 to 14, 2004
(a) observation, (b) JRA-25 and (c) RCM20.

Finally, averaged precipitation in 1 degree in latitude by 1 degree in longitude grid box are used for evaluation of interannual variability of heavy precipitation or dry weather. The grid boxes that have more than 5 stations and more than 5 grid points of the RCM are taken into account the evaluation.

PrecipitationCoverage Rate (PCR) is defined as

$$PCR(y)=\frac{\sum_{i=Nstart}^{Nend} OR(i,y)}{\sum_{i=Nstart}^{Nend} TR(i,y)}$$

where OR(i,y) is the number of grid boxes in which box-averaged daily precipitation that meets the criteria, TR(i,y) is the total number of the grid boxes over Japan on day “i” in year “y”. Nstart and Nend indicate start and last date of statistics respectively.

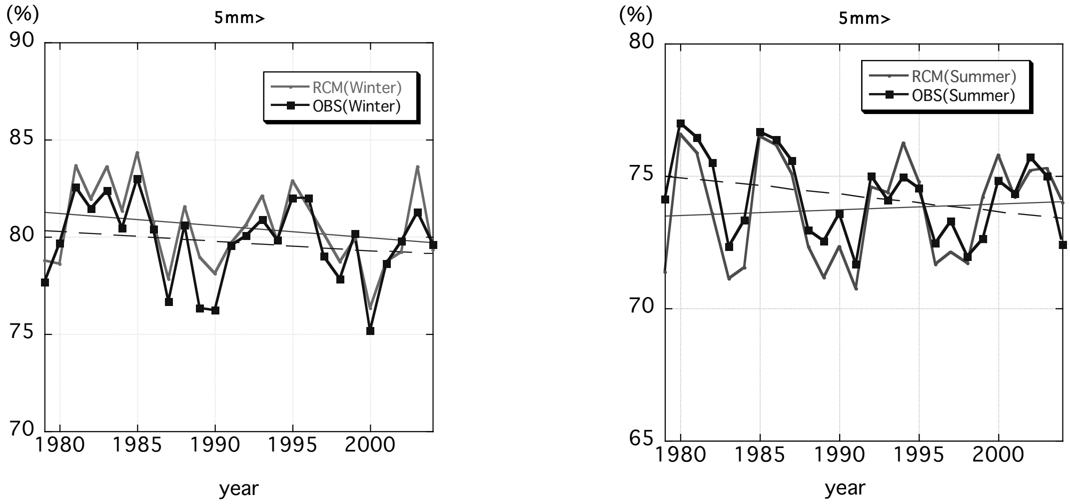


Fig.6 Time series of PCR(precipitation coverage rate) (%) less than 5mm/day for daily precipitation and its trend (solid line: RCM20, broken line; ovserbation) in (a) winter and (b) summer.

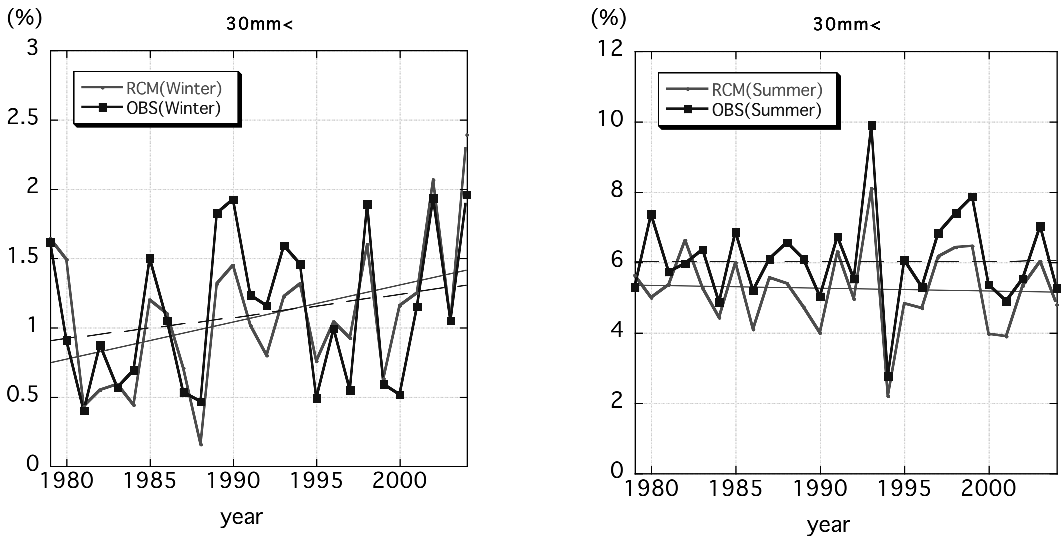


Fig.7 Same as Figure 6 except for more than 30 mm/day for daily precipitation.

As shown in Figure 6, interannual variability of PCR is quite good agreement for the dry weather case especially in winter. The correlation coefficients in winter and summer case are 0.91 and 0.84 respectively. The trend line presents opposite gradient in summer case. However, the tendency difference is relatively small. Figure 7 shows heavy rain case, which is more than 30 mm/day for daily precipitation. These results also quite well. The correlation coefficients in winter and summer case are 0.82 and 0.88 respectively. It can be seen that the RCM20 reproduces upward trend in winter well.

**CONCLUSIONS**

We performed a continuous 26-yr simulation over Japan by the MRI-RCM20 nested with JRA-25. The MRI-RCM20 improved underestimation of precipitation over Japan in JRA-25. The results of the MRI-RCM20 are quite similar to JRA-25 in large-scale daily precipitation characteristics but the MRI-RCM20 represents more realistic distribution due to higher resolution. Moreover, the model captured interannual variability of daily precipitation coverage rate for dry and heavy rain cases. Correlation coefficients between the model and observation are quite good (0.82-0.91). These results suggest that the MRI-RCM20 is quite useful tool for downscaling to investigate regional extreme climate changes.

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**REFERENCES**

Arakawa, A., and W. H. Schubert, 1974: Interaction of a cumulus cloud ensemble with the large scale environment, Part I, J. Atmos. Sci., **31**, 674-701

Boo, K. O., W-T. Kwon, J-H. Oh, and H.-J. Baek 2004: Response of global warming on regional climate change over Korea: An experiment with the MM5 model, Geophys. Res. Lett., **31**,21, L2126, doi:10.1029/2004GL021171.

Kamiguchi, K., A. Kitoh, T. Uchiyama, R. Mizuta, and A. Noda 2006: Changes in precipitation-based extremes indices due to global warming projected by a Global 20-km-mesh Atmospheric model. SOLA, **2**, 064-067

Kida, H., T. Koide, H. Sasaki and M. Chiba 1991: A new approach to coupling a limited area model with a GCM for regional climate simulations, J. Meteor. Soc. Japan, **69**, 723-728

Lacis, A. A., and J. E. Hansen 1974: A parameterization for the absorption of solar radiation in the Earth's atmosphere, J. Atmos. Sci., **31**, 118-133

Mellor, G. L., And T. Yamada, 1982: Development of a turbulence closure model for geophysical fluid problems. Rev. Geophys. Space Phys., **20**, 851-875

Numerical Prediction Division/Japan Meteorological Agency 1997: Outline of the operational numerical weather prediction of the Japan Meteorological Agency. 126pp.

Sasaki, H., K. Kurihara, I. Takayabu, K. Murazaki, Y. Sato, and H. Tsujino 2006: Preliminary results from the coupled atmosphere-ocean Regional Climate Model at the Meteorological Research Institute. J. Meteor. Soc. Japan, **84**, 2, 389-403

Sugi, M., K. Kuma, K.Tada., K.Tamiya, N. Hasegawa, T. Iwasaki, S. Yamada, and T. Kitade, 1990: Description and performance of the JMA operational global spectral model (JMA-GSM88). Geophys. Mag., **43**, 3, 105–130.

Takayabu, I., H. Kato, K. Nishizawa, S. Emori, K. Dairaku, Y. Sato, H. Sasaki, and K. Kurihara 2004: Simulation of Asian climate by using regional climate models nested in global circulation models, Proc.2004 Symposium on water resource and Its Variability in Asia in the 21st Century. 94-97