Downscaling of GCM for prediction of regional climate change around Turkey

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1.Introduction

This study intends to provide the scenarios of likely climate change in precipitation, temperature and insolation in Turkey after the global warming. Climate change is estimated by a down-scaling technique using regional climate models from the global warming data estimated by GCMs. Regional climate models also allow to estimate the effects of land-surface conditions upon the regional climate system in Turkey. Before downscaling, we have to validate the method and clarify the uncertainty of the models.

2.Validation of RCM

Monthly precipitation was estimated by a regional climate mode, TERC-RAMS (Yoshikane et al., 2001), assuming the boundary condition given by NCEP/NCAR reanalysis data. Monthly mean precipitation was validated by rain gauge data in Turkey for four months, Jan, Apr, Jul and Oct, during seven years, in 1994-2000. Total precipitation was estimated in the entire Turkey by the double nested regional model¥ (grid interval is 25km, see Fig.2b).

Figure 1 indicates total observed(light blue) and simulated(blue) precipitation in April, during 1994 to 2000, although these in 1999 are omitted because of lack of observation data. The simulated precipitation is slightly overestimated, while the inter-annual variation is almost reproduced. Simulated precipitation of the other months also agree well to the observation, although the model underestimates monthly precipitation by 30% during October. Horizontal distribution of precipitation in Turkey has some difficulty to compare with the observation because of strong dependency on the orography. Figure 2 shows horizontal distribution of simulated(a) and observed(b) monthly precipitation in January, 1999. Both model and observation indicate the largest amount of precipitation along the southeastern coast to the Mediterranean Sea. The other part of Turkey seems to be underestimated by the model.

In order to validate frequency of heavy rain fall in the simulation, probability density functions of simulated hourly precipitation in each month are estimated and compared to observed one. The estimated probability density function agrees well with observation.

3.Downscaling of climate change

After the validation, the regional climate model was applied to the downscaling of the GCM products, which was obtained by MRI-CGCM-2. Downscaling were carried out for Jan, Apr, Jul and Oct during two decades: 1990's and 2070's. Predicted precipitation during 1990's are roughly agree with observation except for July. Range of inter-annual variation of the estimated precipitation also agrees with observation. In principal, predicted weather by GCM is different from that of the real earth, but the statistics of the weather (climate) must be similar to the real one. Inter-annual variation is not always agree to the real one even during past years.

Yellow and orange bars in Fig. 1 show estimated ten years mean monthly precipitation in April during 1990's and 2070's. Precipitation simulated during 1990's almost agree with observed one. The predicted precipitation during 2070's is about 30% smaller than that during 1990's.

However, predicted monthly mean precipitation during July is the level of only about 1/10 of the observation.

Turkey is covered by a too strong anti-cyclone during July in the GCM products. In generally, one of the largest difficulty in the downscale process using a nested regional climate model, is the bias of GCMs, especially shift of a regional scale climate system may gives serious error in the nested model (Wang,et al,2004).

4.Pseud warming

To avid this difficulty the boundary condition was assumed by a linear coupling of the re-analysis data (observation) and the trend component of the global warming estimated by GCMs. This assumption may valid when the trend of the global warming is small enough and allows to neglect the nonlinear interaction between the trend and the inter-annual variation of the climate systems. By this method, prediction will approach to the simulation using re-analysis data when the difference of the global warming is small and allow to estimation of the difference by smaller number of ensemble of run. Downscaling by this method gives similar results as the nested RCM directly driven by daily GCM products for monthly mean precipitation in January. Figure 3 shows precipitation difference between 1990's and 2070's estimated by the pseud warming method. Precipitation decreases in Blue areas. Figure 4 shows monthly precipitation of July: observation in 1998, simulation using NCEP/NCAR reanalysis data in 1998, pseud warming (2070's), simulated using GCM (1990's) and predicted using GCM(2070's), from left to right, respectively. The method of the pseud warming seems to give more reasonable precipitation in Turkey in July during 2070's.

5.Conclusion

Prediction estimated by the GCM has a bias, which prominently underestimates during summer. However, the model bias can be modified by the pseud global warming technique. The validity of the pseud warming can be assess by comparison between downscaling strait forward from GCM prediction and pseud warming from current simulation by GCM. Since pseud warming is based upon the analysis data obtained by observed data, we can expect better accuracy than the strait forward downscaling when the difference by global warming is not large.

RCM tends to underestimates the diurnal range of surface temperature. Main reason seems to be radiation parameters, which can be turned in the following versions. RCM underestimates extreme daily precipitation, this may came from the course grid interval, 25km, which is expected to be improved by the higher resolution version.

Reference

Yoshikane,T.Kimura,F and Emori, S (2001):Numerical study on the Baiu Front genesis by heating contrast between land and ocean.J.Meteoro.Soc.Japan,79,671-686.

Y.Wang,L.R.Leng,J.McGregor,D-K.Lee,W-C.Wang,Y.Ding and F.Kimura(2004): Regional Climate Modeling: Progress, Challenges, and Prospects, in press JMSJ.

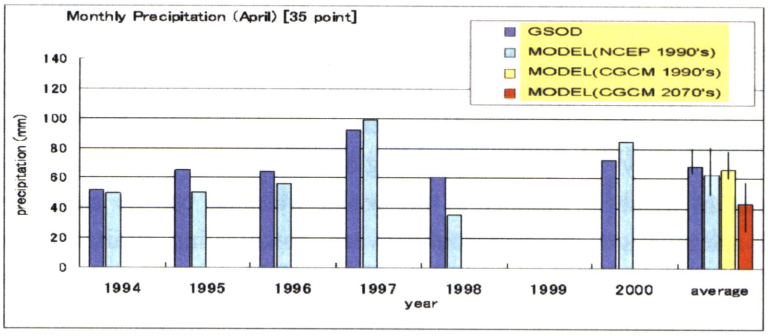

Fig.1 Total observed(blue) and simulated(blue) precipitation in April, during 1994 to 2000.
Yellow and orange bars indicate estimated ten years mean monthly precipitation in April during 1990's and 2070's.

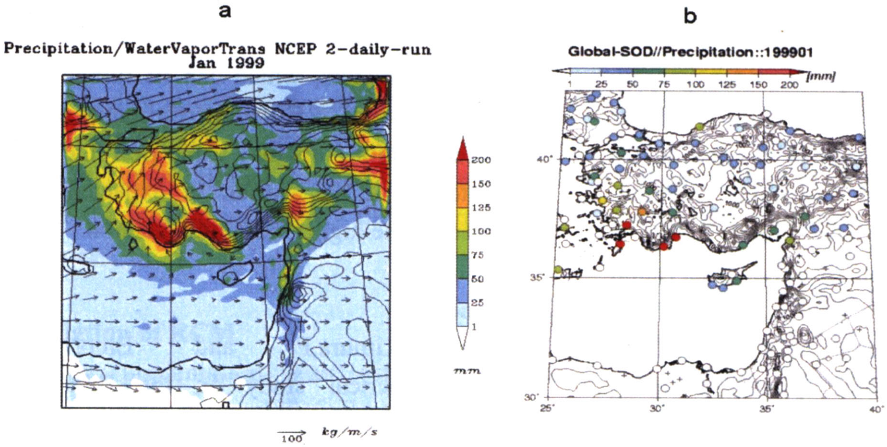

Fig. 2 horizontal distribution of simulated(a) and observed(b) monthly precipitation in January, 1999.

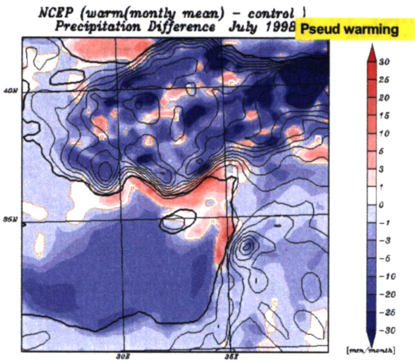

Fig.3 Difference in precipitation between 1990's and 2070's estimated by the pseud warming method.

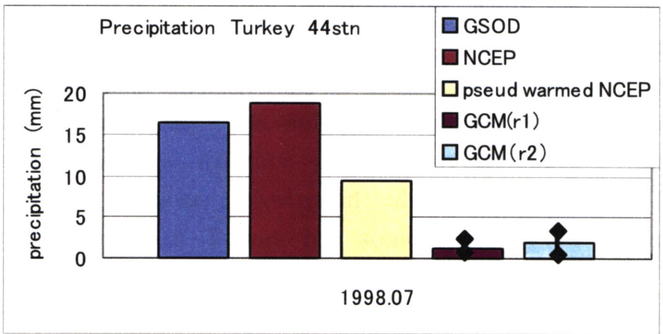

Fig. 4 Monthly precipitation of July: observation in 1998, simulation using NCEP/NCAR reanalysis data in 1998, pseud warming (2070's), simulated using GCM (1990's) and predicted using GCM(2070's), from left to right, respectively.