An Assessment for Downscaling Methods for Global Warming in Turkey

Fujio KIMURA [1], Akio KITOH [2], Akimasa SUMI [3], Jun ASANUMA [4] and Akiyo YATAGAI [5]
[1] *Terrestrial Environment Research Center, University of Tsukuba*
[2] *Meteorological Research Institute, Japan Meteorological Agency*
[3] *Center for Climate System Research, University of Tokyo*
[4] *Terrestrial Environment Research Center, University of Tsukuba*
[5] *Research Institute for Humanity and Nature (RIHN)*

1. Objectives

Climate change by increasing of greenhouse gas is estimated by General Circulation Model (GCM). However, horizontal resolution of the ordinary GCM is quite low, i.e., grid interval is about 100-300km, although these are being improving much with the computer power day by day. The resolution is still not enough to estimate the climate change in a basin, such as Seyhan river basin in Turkey. Downscaling of GCM using Regional Climate Model (RCM) may allow to estimate climate and provides scenarios of the likely climate change in a basin, although GCMs and methods of downscaling still have many problems for the reliability of the prediction. In this report, the reliability of the prediction methods is discussed by the comparison between several methods.

2. Models

For the downscaling to Seyhan basin by RCM, the forcing data for the boundary condition of RCM are given by MRI-CGCM2 (Yukimoto et al., 2001; Kitoh et al., 2005) with T42 in wave truncation, which approximately corresponds to 2.5 degree horizontal resolution. Control run of MRI-CGCM2 simulates the current climate condition, while global warming run is performed based on A2 scenario in Special Report on Emission Scenarios (SRES) (IPCC, 2000). Meteorological data for both integrations are recorded in every six hours during 1991 to 2000 for the control run and 2071 to 2080 for the A2 scenario run. Beside MRI-CGCM2, products of the different CGCM which is provided by CCSR-NIES are applied to the downscaling, in order to assess the model dependency in the Climate projection.

3. Simple downscaling by RCM

RCM-GCM run calculates Turkish climate with grid interval of 25km and 8.3km using products by MRI-CGCM2 whose grid interval is about 250km. RCM-GCM-CNTL run estimates regional climate in the period from 1997 to 2001. RCM-GCM-A2 run is carried out corresponding five years in 2070s using the products by MRI-CGCM2 SRES-A2 scenario run. The difference between RCM-GCM-A2 and RCM-GCM-CNTL is the component of the global warming during 1990s and 2070s. This method has been widely attempted to study regional impact of the global warming (e.g. Kato et al., 2001; Leung and Ghan, 1999). We have also tested the downscaling from the product of CGCM by CCSR-NIES after the SRES A2 scenario for only several months.

4. Pseud worming

Pseudo worming method is attempted to prevent bias in GCMs that is biggest concern to evaluate regional climate prediction. The NCEP/NCAR reanalysis data is used as a RCM forcing in RCM-NCEP-CNTL run for the period during 1997 to 2001, which is a hindcast experiment to demonstrate the ability of TERC-RAMS to reproduce the regional climate. In RCM-NCEP-PWM run, new forcing dataset as mentioned below is prepared to simulate the regional climate influenced by the global warming. Monthly mean difference between control run (corresponding to 1990s) and A2 scenario run is calculated for each 2.5 degree grid from GCM products (hereafter GWMD: Global

Warming Monthly mean Difference), which indicates the change of spatial structure induced by the global warming. The GWMD in wind speed, temperature, geopotential height specific humidity, and sea surface temperature are time-independently superimposed on each variable of six-hourly NCEP/NCAR reanalysis data as a perturbation from the current weather condition during 1990s. RCM-NCEP-PWM is expected to simulate cyclones and troughs with basically same structures during 1997 to 2001 except for that time-independent GWMD are added representing the perturbation induced by global warming. Generally, the precipitation difference caused by global warming is smaller than the bias of GCMs that is the difference in precipitation between observation and GCMs. The model bias should be reduced in RCM-NCEP-CNTL rather than in RCM-GCM-CNTL for the current regional climate simulation. Difference between RCM-GCM-CNTL and RCM-GCM-A2 gives the change of precipitation after global warming by method-G, which seems to be much smaller than the model bias, i.e., difference between observed precipitation and estimated one by RCM-GCM-CNTL. On the other hand, RCM-NCEP-PWM is expected to give more reasonable prediction than RCM-GCM-A2.

High resolution GCM on the Earth Simulator (Kitoh,2005) presented Turkish climate simulated by MRI/JMS A-GCM TL959L60. The global model framework is designed to become a next generation numerical weather prediction model of the Japan Meteorological Agency in this resolution (global 20-km mesh). The Earth Simulator makes possible to run this huge numerical mode. 10-year control simulation was done with the climatological observed sea surface temperature (SST) corresponding to the 1982-1999 period (TL959-CNTL). Then, another 10-year global warming simulation (time-slice experiment) was performed by adding the SST anomalies derived from the MRI-CGCM T42L30 assuming SRES A1B (TL959-A1B) scenario experiment corresponding to the end of the 21st century (2081-2100 mean). The scenario is different from the downscaling and the averaging period is also different (3 month mean), comparing with results are useful for evaluate the reliability.

5. Summary of comparison

Figure 1(top) indicates monthly precipitation during January in five years of 1997-2001 and simulated (hindcasted) five years precipitation (bottom) for January. Precipitation pattern can be simulated quite well. However, horizontal distribution of precipitation in Seyhan basin shows some discrepancy between observation and simulation (Fig.2 left and right). Model overestimates precipitation in the mountainous regions but under estimates in the plain. This means that the downscaling with very small grid interval to the basin scale still has some difficulty.

Figure 3 shows monthly mean precipitation in the entire Turkey, observation (red), simulation (blue) and after pseudo warming (white). Hindcasts simulate well not only seasonal variation but also year to year variation in precipitation. The model also predicts that precipitation will decrease almost in every month.

Estimated precipitation patterns in current years agree better in the order of RCM-NCEP-CNTL, TL959-CNTL and RCM-GCM-CNTL. The accuracy of current simulation almost does not depend on the reanalysis data, NCEP/NCAR or ERA40. The difference in precipitation between 1990s and 2070s depends on the models. In the most months, precipitation estimated to be decrease, but TL959 predict increase in precipitation in spring and autumn as well as RCM-GCM-CNTL in January.

Mean temperature at ADANA, KONYA and SINOP estimated by RCM-NCEP-CNTL agrees well to the observation, while it has cold bias, especially at ADANA in January. Temperature by RCM-GCM-CNTL has almost always cold bias. Temperature change between 1990s and 2070s is predicted to increase by about 2 to 3 degree in these stations by both RCM-NCEP-PWM and RCM-GCM-A2.

RCM-NCEP-CNTL simulate most accurately current climate in Turkey for precipitation and also temperature. This is quite reasonable because of using observational boundary forcing. Precipitation change between 1990s and 2070s are predicted to have decreasing tendency. However, the tendency strongly depends on the methods and it implies that the reliability is not high.

On the other hand, both of the predictions by RCM-NCEP-PWM and RCM-GCM-A2 are quite similar each other for temperature change between 1990s and 2070s, although the temperate along the coast line has stronger dependency on the method. The reliability for the temperature change is higher than that for precipitation, while it may have larger bias along the coastline. We cannot say yet that the reliability of prediction for the difference between current climate and the future climate is very high for the both method of simple downscaling and pseudo warming. However, the method of Pseudo warming (RCM-NCEP-PWM) may more useful to apply to the quantitative estimation of the effects of climate change to agriculture, because of better estimation for the current climate (RCM-NCEP-CNTL).

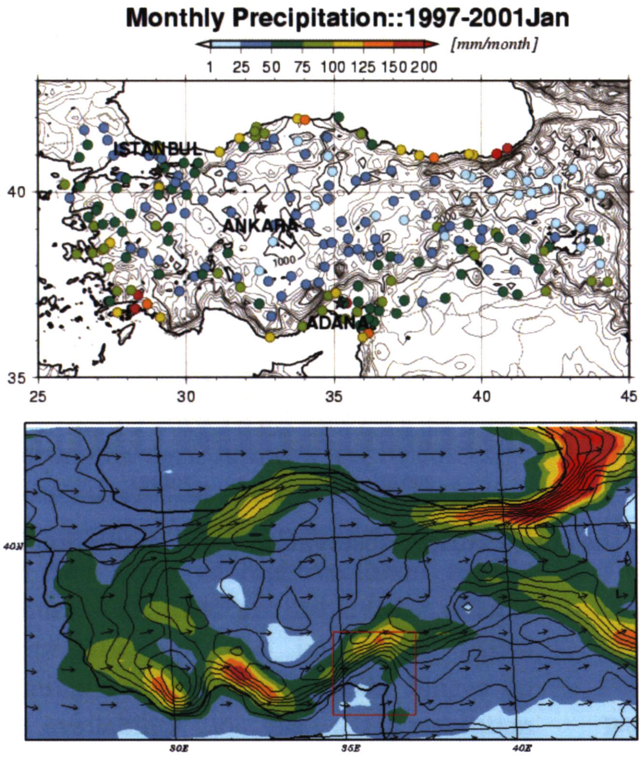

Figure 1: Monthly precipitation during January in five years of 1997-2001.Top panel: observation, Bottom panel: Simulation (hindcast)

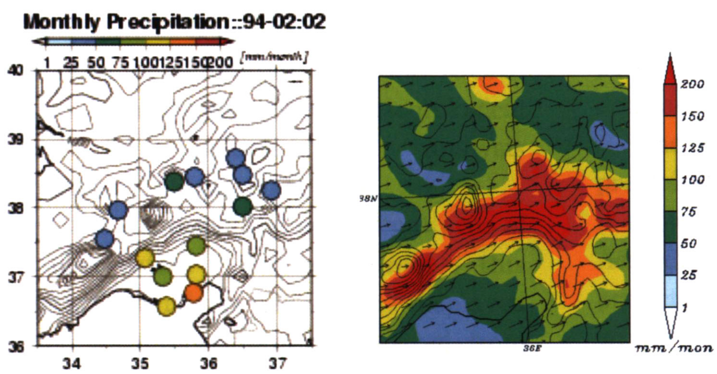

Figure 2: Horizontal distribution of precipitation in Seyhan basin, Left: observation, Right: Simulation.

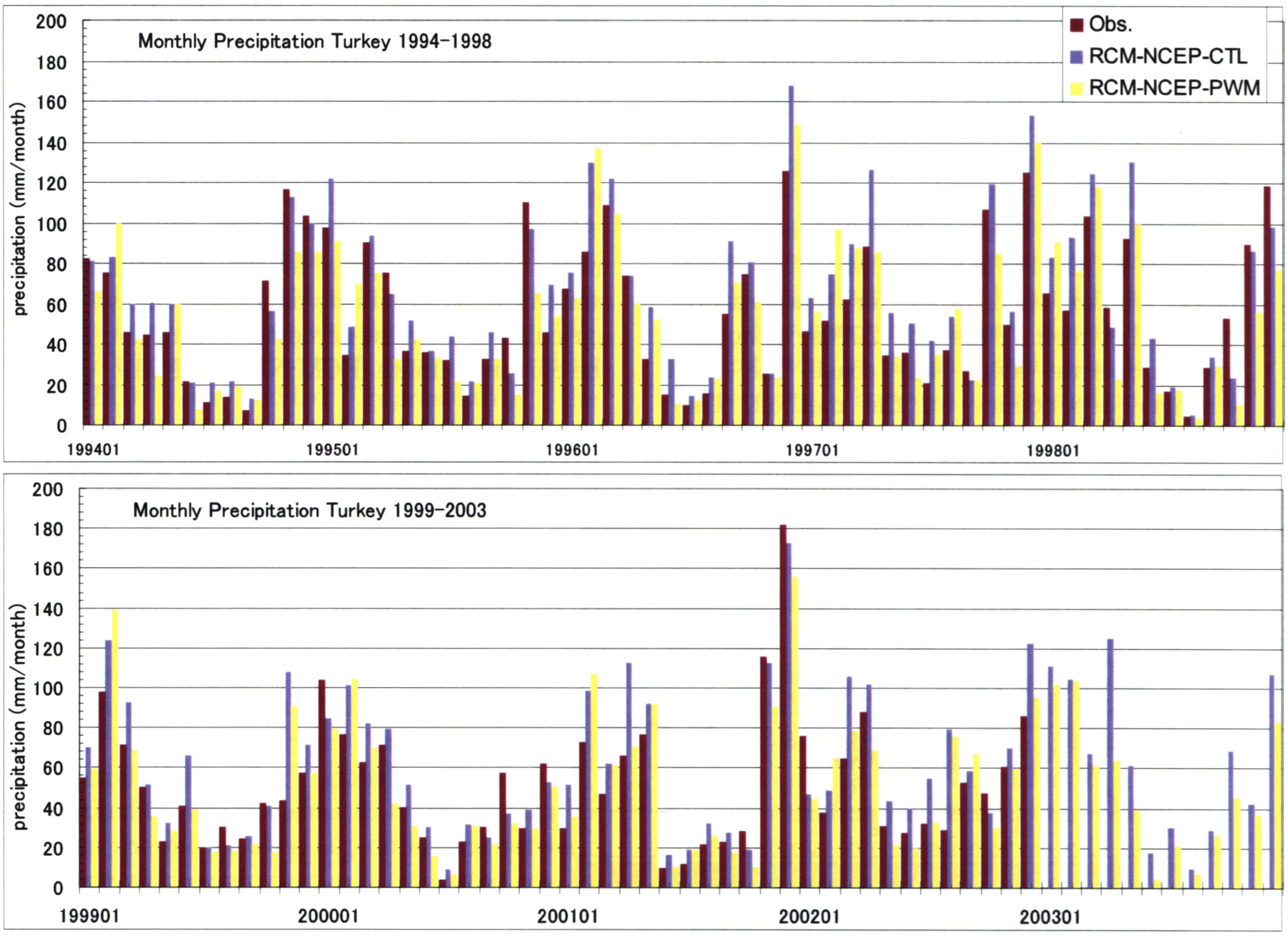

Figure 3: Monthly mean precipitation in the entire Turkey, observation (red), simulation (blue) and after pseudo warming (white).