Trend in Precipitation during the next 80 years in Turkey estimated by Pseud warming experiment

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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.

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 triple nested regional model (grid interval is 25km for entire Turkey and 8.3km for Cukurova area). Simulated precipitation is slightly overestimated, while the inter-annual variation is almost reproduced. Simulated precipitation 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 1 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.

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 (Kitoh,2002). 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 the past years.

Downscaled monthly precipitation on January during 1990's almost agree with observed one. The model indicats that precipitation during 2070's is about 30% smaller than that during 1990's. However, monthly mean precipitation during July is estimated to be only the level about 1/10 of the observation. During July, Turkey is covered by a too strong anti-cyclone in the GCM. Figure 2 indicates monthly mean precipitation at 44 observation stations. From the left, the first is estimated by RCM using NCEP/NCAR global data, the second shows pseud warming run (will be mentioned latter), the third is downscaled by RCM using GCM run (current) and the most right one indicates precipitation estimated by RCM using GCM run during 2070s. The precipitation downscaled from GCM seem to be too small. 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.

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 estimate the difference by smaller number of ensemble of runs. Some comparative numerical experiments show that downscaling by this method gives similar results as

the nested RCM directly driven by daily GCM products for monthly mean precipitation in January.

The third bar in Fig 2 shows monthly mean precipitation on July estimated by the pseud warming run based up on 1998, but the global condition is corresponding to 2070s. The estimated precipitation seems to be much more reasonable than the directory downscaled precipitation downscaled form GCMs, although the model predicted monthly precipitation will decrease to about 60% of 1998. Figure 3 shows precipitation difference between 1990's and 2070's estimated by the pseud warming method. Precipitation will decrease in the blown area.

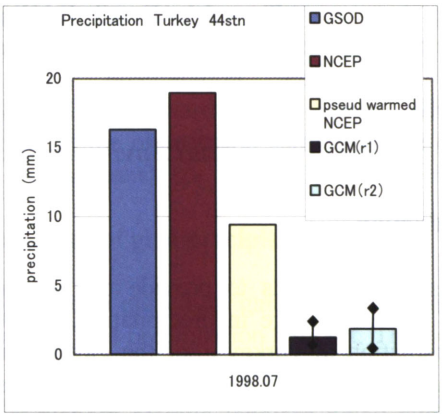

Figure 2 indicates monthly mean precipitation at 44 observation stations. See the text.

Conclusion

Prediction estimated by the GCM has a bias, which prominently underestimates during summer. However, the model bias can be reduced 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.

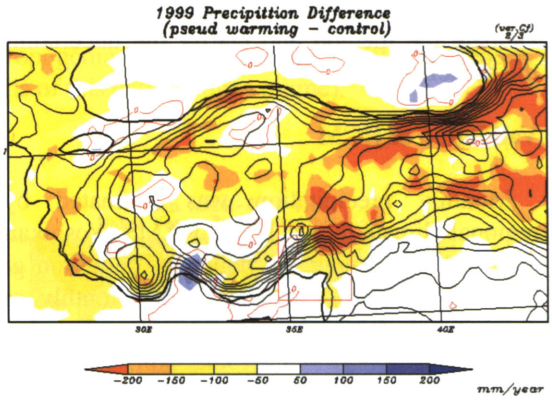

Figure 3: Precipitation difference between 1990's and 2070's estimated by the pseud warming method

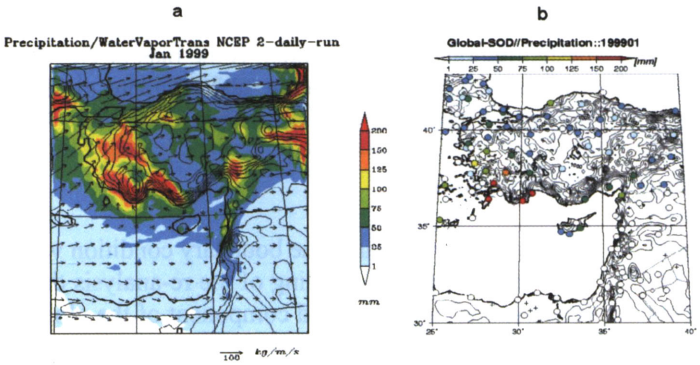

Figure 1 Monthly precipitation in January, 1999. (a) simulated by the RCM. (b) rain gauge dara.