An Analysis of Precipitation for Assessing Global Warming Impacts on Hydrological Regime in Adana, Turkey

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1. Introduction

Recent climatological models project that the East Mediterranean/Mid-East will have less rainfall due to the global warming (Milly et al., 2005; Nohara et al., 2006). In terms of water resource management, it is important to have a long-term perspective of a future change of precipitation amount, especially over the mountains, because waters archived in the hydrological reservoirs are critically important for agricultural water resources.

Here the present and the future projection of precipitation pattern over Turkey derived from two types of high-resolution models (Kimura et al., 2006) are displayed. A reliable interpretation of the impact of global warming on local environments hinges on the availability to use a hi-resolution precipitation dataset as a validation tool. Therefore, it is also important to prepare a quantitative estimate long-term observational dataset (Yatagai et al., 2005). Efforts have been made to check daily/monthly precipitation data that ICCAP obtained from Turkish State Meteorological Service for making grid analysis precipitation (Yatagai, 2004).

Here, the temporal and spatial patterns of the observation derived from this preliminary analysis are also displayed together with those patterns derived from models. Then simulated changes in precipitation are displayed.

2. Results

2.1 Seasonal Change

Figure 1 shows the time series of seasonal change of precipitation those are derived from control (present climate) run experiments, future scenario experiments and observation. All time series are chosen from the nearest grid to Adana (35.2E, 37.0 N). Maximum precipitation is observed in December. So here we mainly show the results for December.

The NCEP downscaling precipitation (Fig.1 left panel, blue) is unexpectedly showing different seasonal pattern with the observation, and it overestimate precipitation. The climatological annual precipitation of the rain gauge analysis, NCEP downscaling and pseudo warming experiment are 687 mm, 1261 mm, and 697 mm, respectively. One of this discrepancy is considered to be attributed that model overestimates precipitation in the mountainous regions but underestimates in the plain region (Kimura et al., 2006). The pseudo-warming experiment projects future decrease in precipitation throughout a year.

The MRI 20km model simulates present precipitation change at Adana well, although it shows precipitation maximum in January. According to this model simulation, it is projected that Adana has less precipitation in winter season (November to February) after global warming. The climatological annual total precipitation of the analysis (observation), present climate, and future

experiment is 687 mm, 850 mm and 727 mm, respectively. Simulated difference, 123 mm/year of decrease corresponds to 18% decrease of total precipitation compared to the observation.

2.2 Spatial Patterns of the Present Climate Simulations

Figure 2 shows December climatology from (a) observation, (b) NCEP/RAMS and (c) MRI-20km AGCM. Locations of rain gauges those are used for creating (a) are also displayed in (b). Here, we only show 2nd nesting downscaling results of 25 km resolution, although 3rd nesting results are also available in 8.3km resolution around Adana.

The models simulate overall precipitation pattern quite well. The NCEP/RAMS tends to overestimate precipitation around the coastal lines. It may correspond that the TEAC/RAMS model used here overestimates precipitation in the mountainous regions. While, the gauge precipitation analysis used here does not explicitly express orographic effect. Generally, there is more precipitation over the mountainous regions, while less rain gauges are located such region, we need to check the distribution of the rain gauges and to express orographic enhancement of observation in the grid precipitation analysis.

2.3 Spatial Patterns of the Future Climate Simulations

Figure 3 shows the difference in December precipitation between the future precipitation pattern and that of present condition. Pseudo warming results project decrease in precipitation overall Turkey, and the south part of Turkey shows strong decreasing trend. The MRI-20.km model projects decreasing precipitation in the southeast part of Turkey, and slightly increasing in the rest part of the country.

Grid precipitation dataset is useful not only for validation purpose but also it enables us to project present and future hydrological budget more quantitatively. Figure 4 shows an example of adding GCM bias to the present precipitation climatology. As annual total precipitation, MRI 20km model projects decreasing precipitation in the southern part of Turkey, and increasing trend in the northern part. By taking the grid of rain gauge dataset with GCM grid points, we can easily add the difference of the future and present precipitation to our analysis (Fig.4b). Then, we can project how much (which percent) of precipitation, i.e. hydrological resources will change with respect to the current quantitative estimation.

3. Conclusion and Remarks

The TEAC-RAMS RCM and the MRI 20km mesh GCM successfully simulate precipitation patterns over Turkey presented in our grid precipitation data. The both two models project decrease of precipitation in 2070s (based on SRES A2 or A1B scenario) over the southern part of Turkey including Chukurova basin. According to the MRI 20km AGCM, which simulates precipitation amount and its seasonal change around Adana better, average annual precipitation change for Adana -123 mm/year, which corresponds to around 18% of the present total precipitation. It is inevitably important for projecting the future change of the water resources over a basin to estimate daily precipitation accurately. Representation of precipitation around mountaineous region is one of the challenging subjects for climate system modeling. It is warranted to further development of daily grid precipitation for the past several decades by taking into account of orographic enhancements.

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4. References

Kimura, F., A. Kitoh, A. Sumi, J. Asanuma and A. Yatagai, 2006: An assessment for downscaling methods for global warming in Turkey, ICCAP Publication 8, Proceedings of the International Workshop for the research project on the ICCAP, Kyoto, March 2006 (this volume).

Milly, P.C.D., K.A. Dunne, and A.V. Vecchia, 2005. Global pattern of trends in streamflow and water availability in a changing climate. Nature, 438, 347-350.

Nohara, D., A. Kitoh, M. Hosaka, and T. Oki, 2006. Impact of climate change on river discharge projected by multi-model ensemble. J. Hydromet. (in press).

Yatagai, 2004: Precipitation data availability over the East Mediterranean and their preliminary analysis, Interim report of the ICCAP project.

Yatagai, A., P.. Xie and A. Kitoh, 2005: Utilization of a new gauge-based daily precipitation dataset over monsoon Asia for validation of the daily precipitation climatology simulated by the MRI/JMA 20-km-mesh AGCM, SOLA, 1, 193-196, doi:10.2151/sola.2005-050.

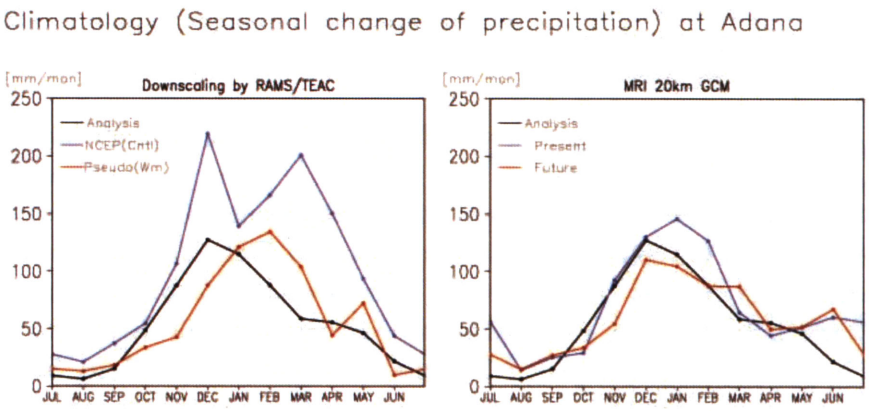

Fig.1 Comparison of the monthly precipitation climatology at Adana. Left Panel: NCEP downscaling (1994-2003, blue), Pseudo warming (red) and rain-gauge based precipitation climatology (observation, black). Right: MRI TL959 (20km mesh GCM) present climate (blue), 2070's scenario A1B experiment (red) and observation (black).

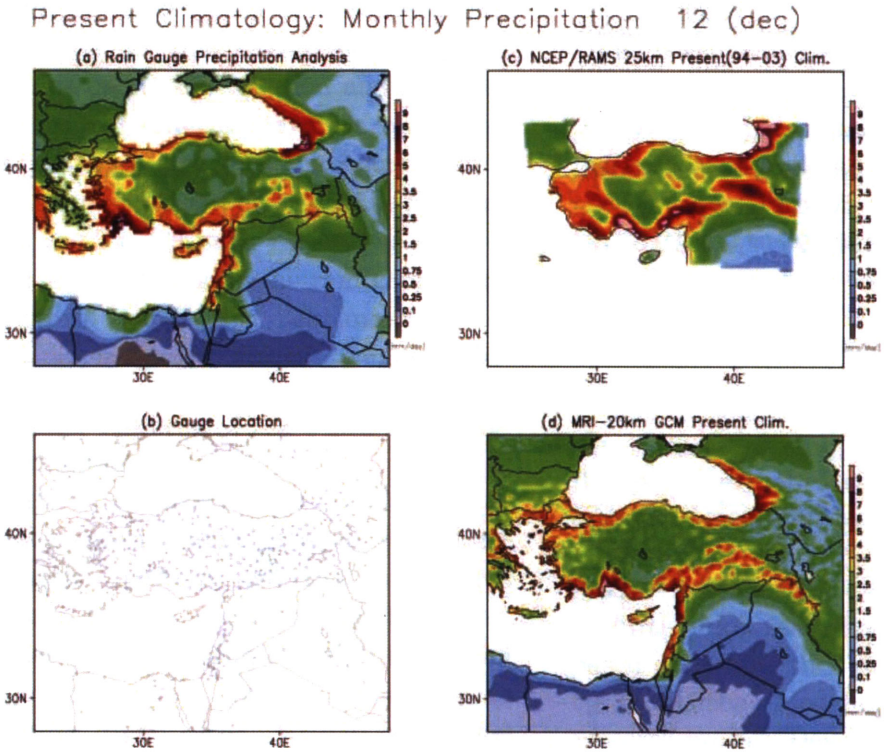

Fig. 2(a) Distribution of December climatology (1975-2004) of precipitation interpolated by Shehard (1965) algorithm. Inside Turkey: about 300 stable stations are used. Outside of Turkey: Stable stations from GTS are used. (b) Gauge location used for the rain gauge data analysis. (c) December precipitation averaged from 1994 to 2003 simulated by TEAC/RAMS with NCEP/NCAR reanalysis. Only land area is shown. (d) 10 year average of December precipitation simulated by the MRI TL959 (20km AGCM).

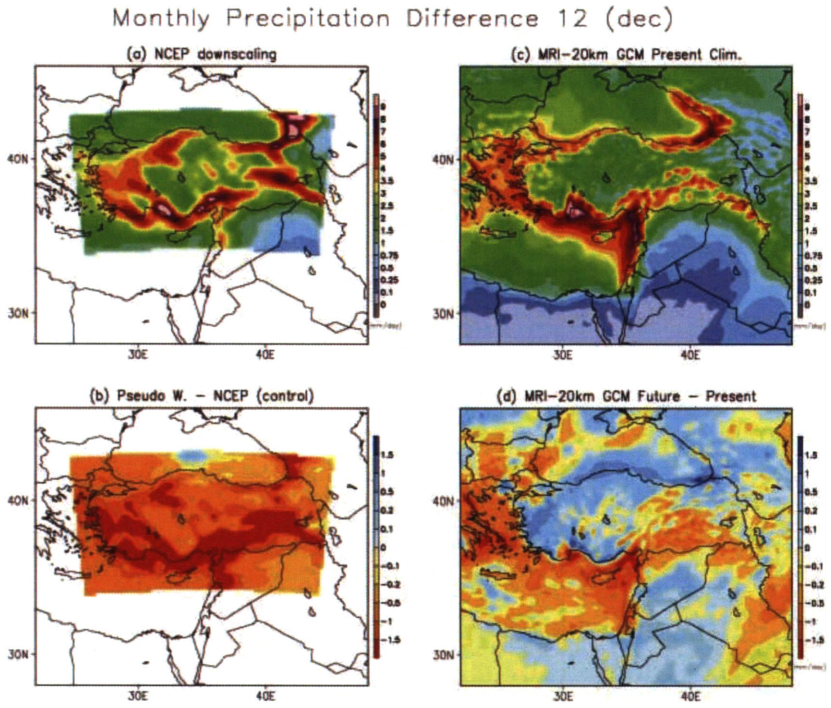

Fig.3 (a) December precipitation of 10 year average from NCEP downscaling. (b) Difference between Pseudo warming experiment and NCEP downscaling (a). (c) December precipitation of 10 year average from MRI 20km model (present). (d) Difference between future experiment and control experiment (present.) of MRI 20km model.

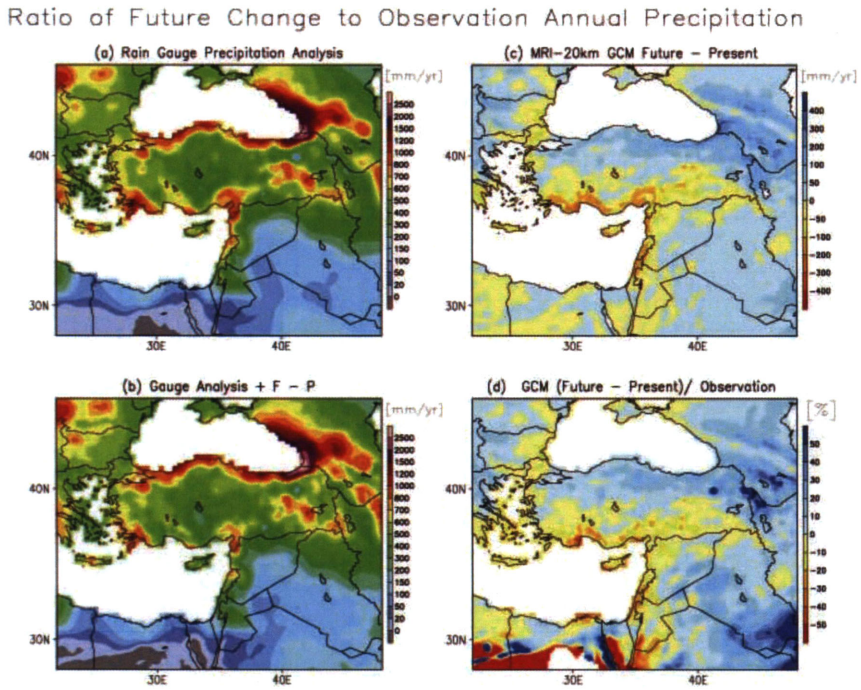

Fig.4 (a) Analysis of annual climate normal precipitation (observation). (b) Projected annual precipitation by summing (a) and difference between future and present precipitation projected by MRI 20km GCM (c). (c) Difference between future experiment and control experiment (present.) of MRI 20km model. (d) Ratio of change in future compared to the observation (a).