Bias correction of the meteorological variables from RCM for hydrological application

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1. Introduction

Physically based (or dynamic) downscaling is an appropriate method when the density of surface station is not so high like in Seyhan River Basin. Regional Climate Model (RCM) provides us the detailed spatial and temporal structure of meteorological field. By the way, it is usually very difficult to directly utilize the products of RCM to hydrological applications since the accuracy needed by hydrological side is usually higher than that achieved by RCM. In this report, the characteristics of model biases provided by RCM are investigated and the method for bias correction is developed making the best use of currently available meteorological data in this project.

2. Precipitation

There are 13 stations which have more than 90% (108 month) measurement during 10 years (1994 to 2003). Total precipitation is calculated to see the mean bias which is defined as RCM precipitation divided by observed precipitation. Here, this mean bias is called as 'ratio', and it is ranging from 0.59 to 2.47. Generally, ratio is small in plane area and large in mountainous area. **Fig.1** is a comparison of 10-year average seasonal cycle of monthly precipitation at six stations (Blue: observation, Red: RCM). As can be seen from each panel of this figure, model bias varies from station by station, and it also varies each month. This nature requires the bias correction to vary both in space and time. Although the rain gauge density is not high enough, grid precipitation dataset is produced by spatial interpolation to calculate the monthly precipitation bias. **Fig.2** shows the spatial distribution of precipitation bias with upper (1.500) and lower (0.667) limits. Here, observation based grid precipitation dataset does not include the topographic dependency in its spatial interpolation process, and it should not be relied on too much (too much reliance of grid precipitation dataset might erase the structure of precipitation distribution well captured by RCM). That is why upper and lower limits are applied in bias calculation. Anyway, RCM precipitation at each grid was divided by the values shown in **Fig.2** to get bias corrected precipitation. **Fig.3** shows the comparison of the inter-annual variability of basin average annual precipitation (upper panel) and the basin average seasonal cycle (lower panel). Due to the upper and lower limits, corrected values (Green) are located in between observation (Blue) and RCM (Red).

3. Downward Shortwave Radiation

There are 9* stations which have more than 90% (108 month) measurement during the analysis period. Average shortwave radiation is calculated to see the mean bias (ratio). Ratio is ranging from 0.44 to 0.70. Generally, ratio becomes smaller in inner region. 9 stations' average monthly radiation is compared by a scatter diagram in **Fig.4**. Firstly, monthly mean biases were applied to get bias corrected radiation. And this simple

*Goksun was questionable and excluded from analysis since observed value was too small comparing from surrounding stations.

method seemed to be successful on a monthly basis (see the green dots in **Fig.4**). **Fig.5** shows the time series of daily mean radiation at Adana. As can be seen from this figure, RCM radiation (blue) is much smaller than observation (black), and there is high variability within short period. The simple correction method with monthly mean bias sometime gives unrealistic value (even larger than theoretically maximum value at the top of atmosphere (S_{0top})) if the original value is close to observation (see the green dots in **Fig.5**). Looking at this daily time series, it was found that the radiation bias has dependency on weather (sunny or cloudy) and season. Thus, model biases are calculated for each weather class which is classified by the ratio of RCM radiation to S_{0top} and for each month. Disaggregating all stations' data into 120 (10 class times 12 month) categories, mean bias for each category (radiation bias matrix) was calculated. The red dots in **Fig.5** are the result of this correction method, and they coincide with observation (black dots).

4. Air Temperature

There are 16 stations which have more than 90% (108 month) measurement during the analysis period. **Fig.6** shows the time series of diurnal range (left), maximum (center), and minimum (right) temperature at Pinarbasi (upper) and Adana (lower). **Fig.7** shows the time series of hourly air temperature in January (left) and July (right) of 2000 at Adana (Black:observation, Blue:RCM). Lower temperature bias was reported from climate group, and the correction method was provided. Although this method was effective to get better daily mean temperature, the diurnal range was not improved so much. As can be seen from the left panel of **Fig.6** and **Fig.7**, diurnal range of RCM temperature (blue) is much smaller than observation (black). To get better diurnal cycle, temperature bias correction requires the amplification of the diurnal range. As is the case for radiation, amplification according to monthly mean bias sometimes produces unrealistically large diurnal variation. Thus, model biases are calculated for each weather class which is classified by the value of RCM temperature range and for each month. Disaggregating all stations' data into 120 (10 class times 12 month) categories, mean bias for each category (temperature bias matrix) was calculated. The red dots in **Fig.6** and red lines in **Fig.7** are the result of this correction method, and they coincide with observation (black dots and black lines).

5. Humidity (Water Vapor Pressure)

Available information is daily maximum and minimum relative humidity. Relative humidity is highly dependent upon air temperature, and it is not a good measure to know the humidity bias. Since the information on the time when the relative humidity had its maximum and minimum is not available, new index on water vapor pressure which is calculated from mean temperature and mean humidity is defined. This new index (E_{ave}) can be a measure for daily mean vapor pressure. **Fig.8** shows monthly average daily maximum and minimum temperature, relative humidity, and E_{ave} at Gemerek (upper) and Karaisali (lower). As for relative humidity, both panels show higher biases. By the way, as for absolute value of E_{ave}, bias is very small at Gemerek, and significantly lower bias exists at Karaisali as a result of lower temperature biases. Humidity bias, which is defined by the ratio of RCM E_{ave} to observed E_{ave}, is calculated at each station for each month, and these values are spatially interpolated to get grid humidity bias information.

6. Bias corrected RCM product (ver.2.5)

Bias correction was applied to precipitation, shortwave radiation, air temperature and humidity, and this dataset is ver.2.5 product.

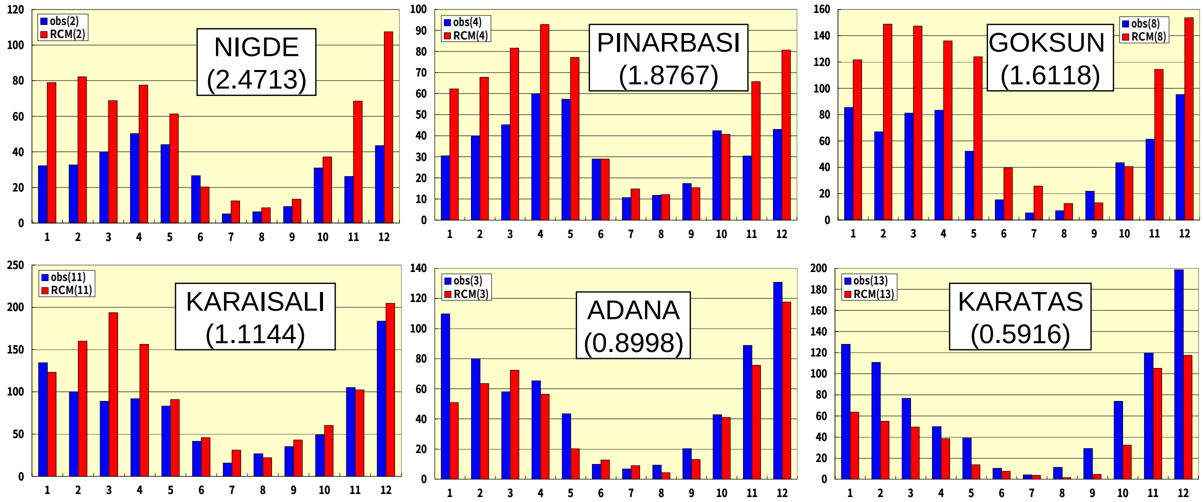

Fig.1 Comparison of monthly precipitation at each station (Blue:Observation, Red:RCM ver.2)

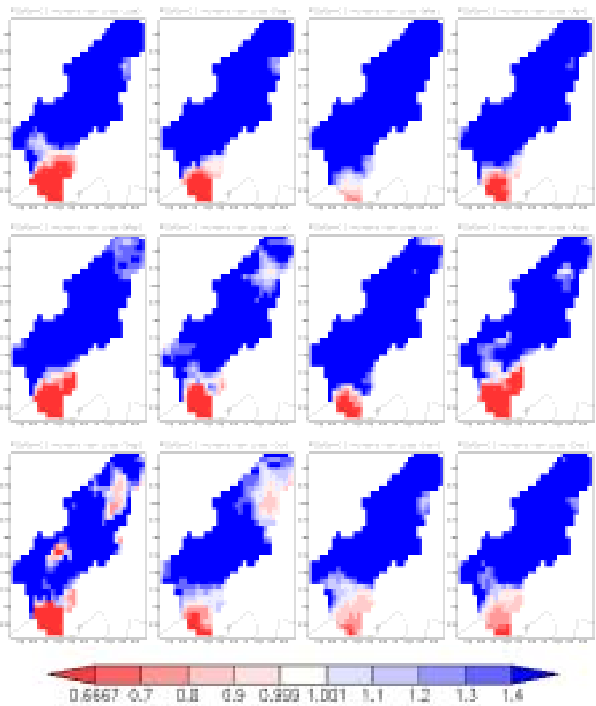

Fig.2 Spatial distribution of precipitation bias (upper limit: 1.5, lower limit: 0.667)

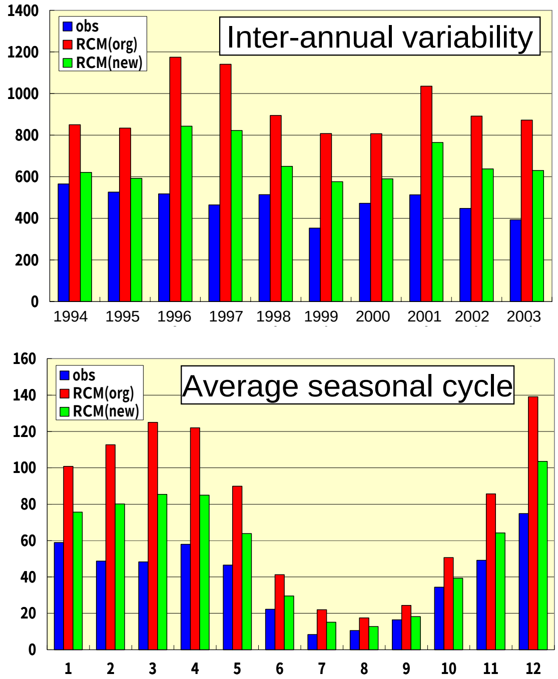

Fig.3 Comparison of average precipitation (Blue:Obs, Red: RCM, Green:Corrected)

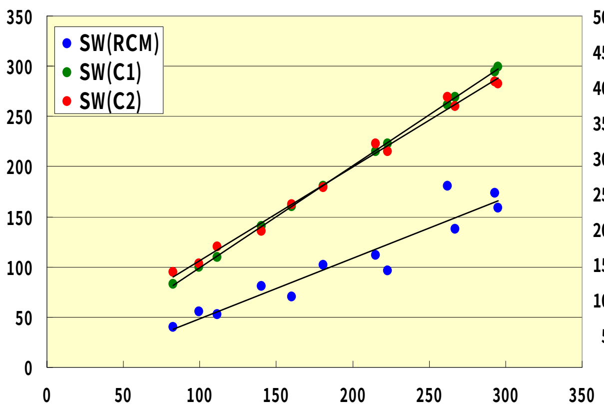

Fig.4 Comparison of monthly solar radiation (Blue:RCM, Red: Corrected)

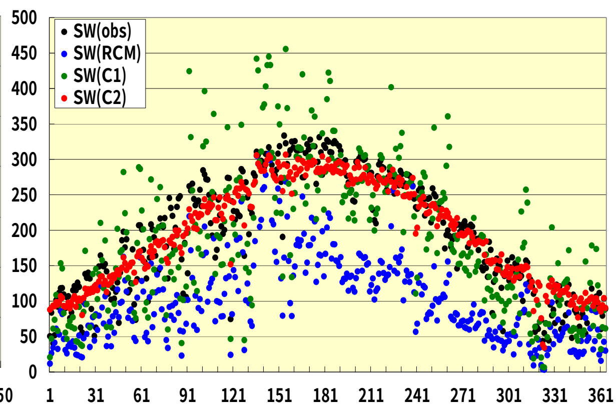

Fig.5 Comparison of daily solar radiation (Black:Obs, Blue:RCM, Red:Corrected)

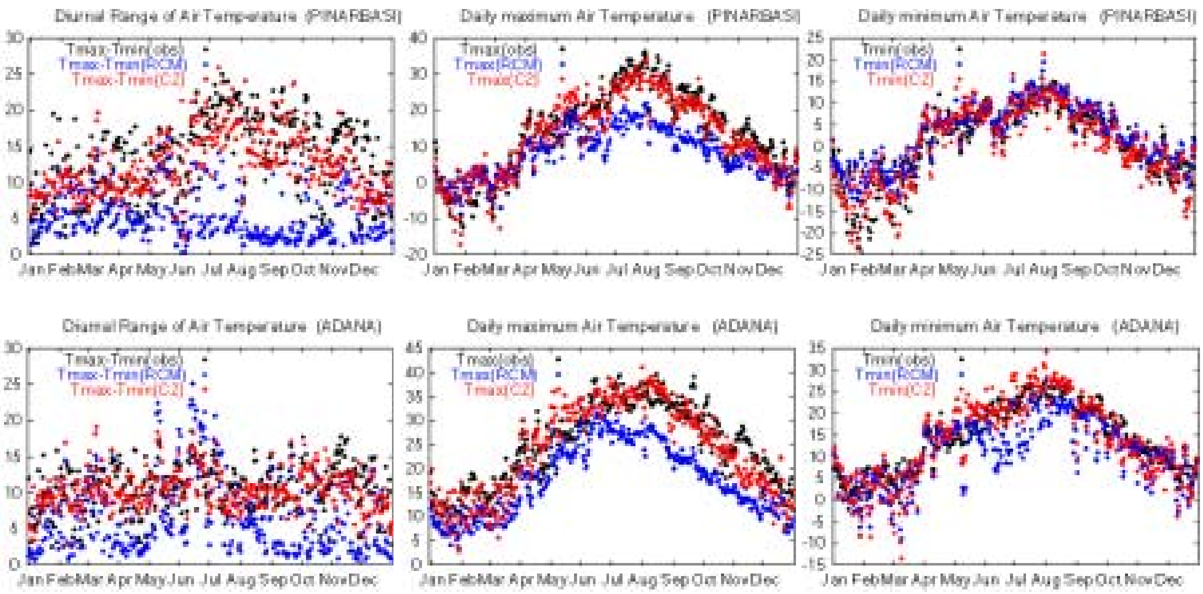

Fig.6 Diurnal range, daily maximum, and daily minimum temperature at Pinarbasi(upper) and Adana (lower). (Black:observation, Blue:RCM, Red:corrected)

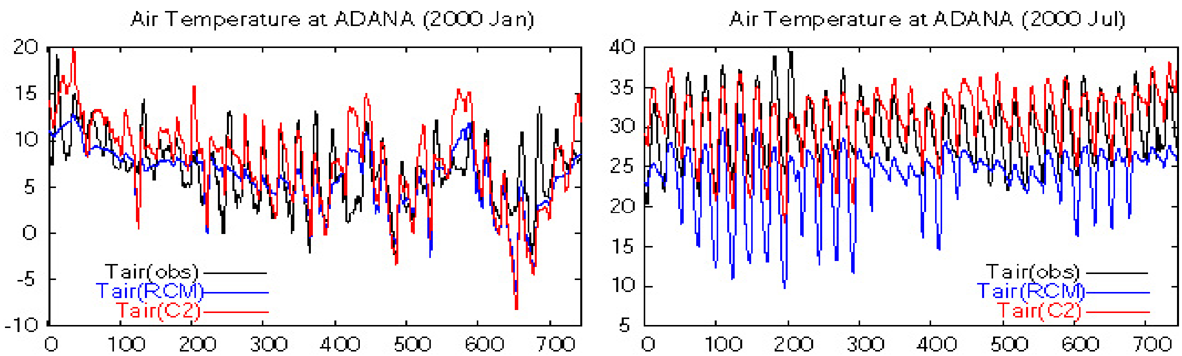

Fig.7 Time series of hourly air temperature in January (left) and July (right) of 2000 at Adana. (Black:observation, Blue:RCM, Red:corrected)

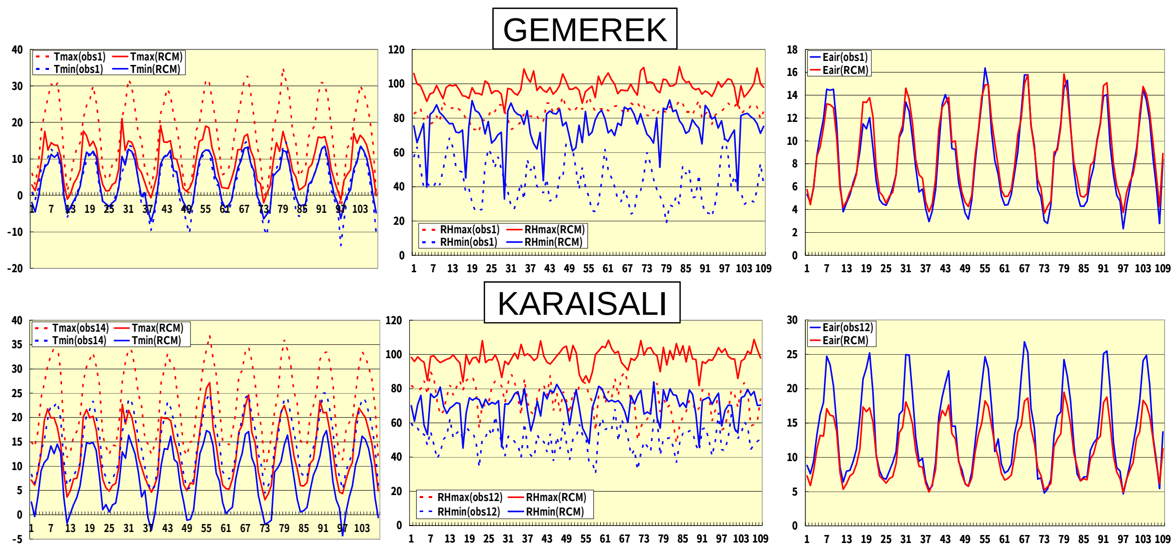

Fig.8 Monthly average daily maximum and minimum temperature (left), relative humidity (center), and daily mean vapor pressure at Gemerek (upper) and Karaisali (lower). Left, Center (broken line: observation, solid line: RCM, Red: maximum, Blue: minimum) Right (Blue: observation, Red: RCM)