Hydrol. Earth Syst. Sci. Discuss., 11, C5852–C5859, 2014
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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Comparing bias correction methods in downscaling meteorological variables for hydrologic impact study in an arid area in China" *by* G. H. Fang et al.

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Dear Reviewer,

First of all, we would like to thank you for the instructive comments. These comments will be very valuable to improve the manuscript. Below is the point to point reply and the revised manuscript is uploaded as supplement.

1. Since the raw RCM simulation is greatly biases, it is necessary to give some explanation on the data reliability.

Our reply: Firstly, It has shown that GCM or RCM outputs are generally biased

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(Ahmed et al., 2013;Teutschbein and Seibert, 2012;Mehrotra and Sharma, 2012), which demonstrates the need for bias correction before their use in regional impact studies. Secondly, though the biases in the raw RCM simulation are large, the RCM outputs show reasonable simulation of temperature and precipitation over China especially when compared with its driving GCM BCC_CSM1.1, which is validated by Gao et al (2013) using the observational dataset (CN05.1).

We have incorporated the explanation in the revised manuscript.

Line 121 $\sim$ 131:

GCM or RCM outputs are generally biased (Ahmed et al., 2013; Teutschbein and Seibert, 2012; Mehrotra and Sharma, 2012), which demonstrates the need for bias correction before their use in regional impact studies. The RCM outputs used in this study are based on the work done by Gao et al (2013). In Gao et al. (2013), the RCM model (RegCM, Giorgi and Mearns, 1999) was driven by a global climate model BCC_CSM1.1 (Beijing Climate Center Climate System Model; Wu et al., 2013; Xin et al., 2013) at a horizontal resolution of 50 km over China. The RCM outputs were validated with the observational dataset (CN05.1) over China for the period from 1961 to 2005. The RCM outputs show reasonable simulation of temperature and precipitation over China especially when compared with its driving GCM BCC_CSM1.1 (more details refer to Gao et al., 2013).

2. P12666 Line 16: what do you mean by "bias correction methods were conducted on a monthly basis", since the inputs required for SWAT is normally daily climate data.

Our reply: The time step of climate variables is daily. We altered the sentence into "bias correction methods were conducted on a daily basis" in the revised manuscript (Line 183).

3. Table 6 could be improved if you provide the MAE (mean absolute error) or RMSE value, so the readers could quickly acquire the relative errors that are still existed in the

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corrected meteorological data and can compare with other studies easily.

Our reply: That is a good point. We added the MAE values in Table 6 and Table 3. The equation of MAE has also been added in the revised manuscript.

In addition, the corresponding analysis has been replaced.

Line 418 $\sim$ 425:

For precipitation, the performance of the raw RCM simulated precipitation is very poor with NS=-6.78, PBIAS=293.28% and MAE=64.40 for monthly statistics, and the improvements of correction are obvious. The"PBIAS"s of the corrected precipitation are within $\pm$5% and "NS"s approach 0.64. It is worth noting that LS and LOCI methods perform better than PT and QM methods in terms of time series performances. For temperature, although the raw RCM simulation obtains an acceptable NS value (0.84), it severely overestimates the observation (PBIAS= 15.78% and MAE=4.31 °C).

4. P12663 line 24: The "precipitation falls as rain from May to September", therefore, the hydrological regime is different among seasons. It is advisable to alter Figure 5 and Figure 6 to demonstrate the differences of performances.

Our reply: In order to investigate the performances of bias correction methods for different hydrological regimes, we divided the streamflow into two different periods according to the hydrograph (Fig. 2): wet period is from April to September and dry period is from October to March of next year. Streamflow statistics for each simulation scenarios are shown in Fig. S1 and Fig. S2.

In Fig. S1, except for magnitudes, the results are similar for both wet and dry period. Therefore, there is no need to demonstrate the streamflow distribution in wet period and dry period separately, since the aim of this study is comparing the performances of bias correction methods. In Fig. S2, the exceedance probability curves can represent streamflow data for each frequency, therefore, there is no need to display separately. The similar performance of bias correction methods for the wet and dry periods in term

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of simulated streamflow confirms that evaluation of bias correction is robust and can provide useful information for both wet and dry climate.

We incorporated the following discussion in the revised manuscript.

Line 443 $\sim$ 449:

To investigate the performances of bias correction methods for different hydrological regimes, we divided the streamflow into two different periods according to the hydrograph (Fig. 2): wet period is from April to September and dry period is from October to March of next year. It is indicated that the performances of bias correction methods are, except for magnitudes, similar for both wet and dry period (not shown), which demonstrates that the evaluation is robust and can proved useful information for both dry and wet season."

5. Present some discussion on the differences of bias correction method applied in the arid area and humid area.

Our reply: We agree and added some discussions on the performances of bias correction methods based on previous studies.

Line 363 $\sim$ 368:

These results are consistent with previous studies (e.g., Themeßl et al., 2011, 2012; Wilcke et al., 2013; Graham et al., 2007) , but are different from the research by Piani et al. (2010) who found that performance of DM method is unexpectedly well for the humid Europe region. This non-uniformity can be partly attributed to the precipitation regime for different regions: better fit of the assumed distribution lead to better performance of DM.

Line 501 $\sim$504:

Results show slightly better performance of PT, DM and QM methods than LOCI in predicting extreme flood, which is consistent with previous study, e.g., Chen et al. (2013)

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and Teutschbein and Seibert (2012), who validated the effectiveness of bias correction methods for un-stationary conditions.

Technical corrections:

6. Some expressions should stay consistent throughout the paper, e.g., P12667 line18 Capital the first letter “Transformation”. Also, some items are confusing, e.g., RCM simulations, RCM outputs, climate variables from the RCMs, RCM output. I think they all indicate the RCM simulated climate variables, why not use one expression?

Our reply: We corrected them in the revised version.

References

Ahmed, K. F., Wang, G., Silander, J., Wilson, A. M., Allen, J. M., Horton, R., and Anyah, R.: Statistical downscaling and bias correction of climate model outputs for climate change impact assessment in the US northeast, Global Planet Change, 100, 320-332, 2013.

Chen, J., Brissette, F. P., Chaumont, D., and Braun, M.: Performance and uncertainty evaluation of empirical downscaling methods in quantifying the climate change impacts on hydrology over two North American river basins, J Hydrol, 479, 200-214, 10.1016/j.jhydrol.2012.11.062, 2013.

Mehrotra, R., and Sharma, A.: An improved standardization procedure to remove systematic low frequency variability biases in GCM simulations, Water Resour Res, 48, W12601, 10.1029/2012WR012446, 2012.

Piani, C., Haerter, J. O., and Coppola, E.: Statistical bias correction for daily precipitation in regional climate models over Europe, Theoretical and Applied Climatology, 99, 187-192, 10.1007/s00704-009-0134-9, 2010.

Teutschbein, C., and Seibert, J.: Is bias correction of Regional Climate Model (RCM) simulations possible for non-stationary conditions?, Hydrology and Earth System

Sciences Discussions, 9, 12765-12795, 2012.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C5852/2014/hessd-11-C5852-2014-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 12659, 2014.

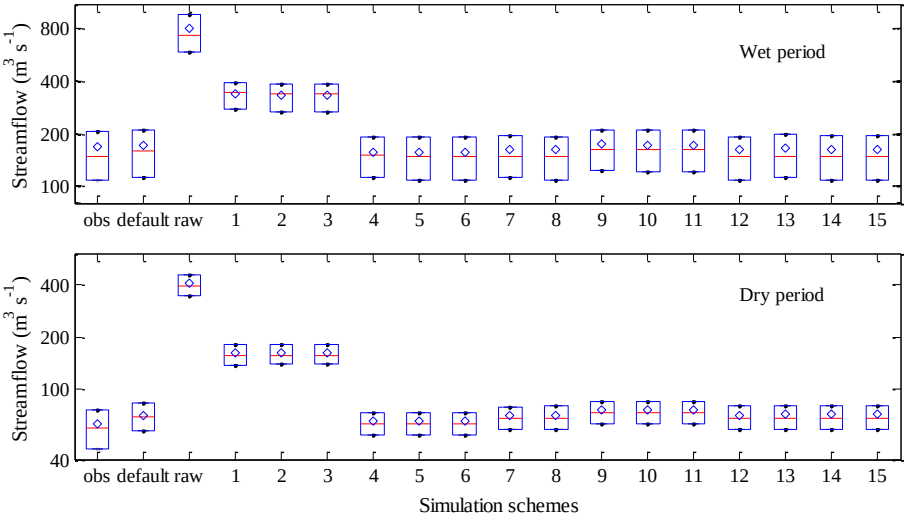

Fig. S1 Same as Fig. 5 but for the wet period and dry period.

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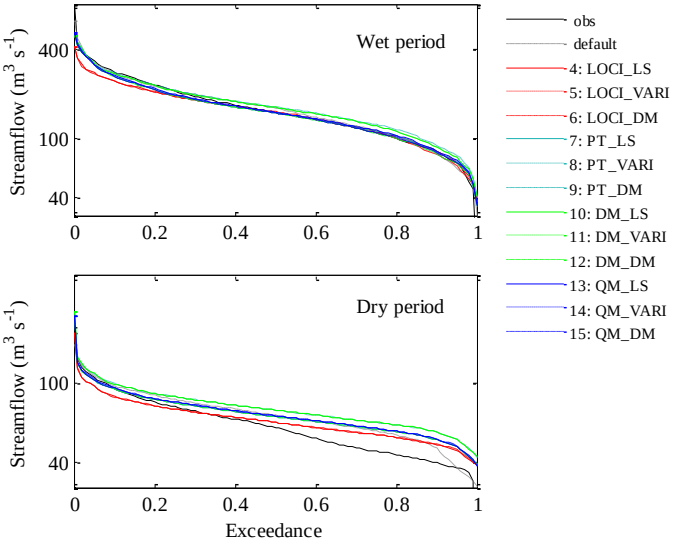

Fig. S2 Same as Fig. 6 but for the wet period and dry period.

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