Hydrol. Earth Syst. Sci. Discuss., 7, C4288–C4295, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C4288/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Climate model bias correction and the role of timescales" *by* J. O. Haerter et al.

J. O. Haerter et al.

jan.haerter@zmaw.de

Received and published: 20 December 2010

Anonymous Referee 2 Received and published: 18 November 2010

We thank the reviewer for her/his comments. We believe that they have greatly helped improve the clarity of the manuscript.

Reviewer comments are indicated by **Rev 2**. Author responses are indicated by **Haerter et al.**.

1 General Comments

Rev 2: The manuscript "Climate model bias correction and the role of timescales" by

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

J.O. Haerter, S. Hagemann, C. Moseley and C. Piani discusses the influence of climate model bias corrections on processes living on different time scales. They introduce bias correction approaches, particularly one based on (affine) linear transfer functions and exemplify the problem on a global daily temperature data set. The pivotal finding for the bias corrected daily model data set is that the variability of the monthly means does not correspond to the observed variability of monthly means. They consequently suggest an augmented bias correction involving anomalies on different time scales, i.e. monthly means additionally to daily values, to overcome this problem. A generalised version of this approach has been exemplified for hourly model data for one station. The manuscript ends with a theoretical motivation for this approach based on a one-dimensional energy balance model. It is important to raise awareness that matching the variance of daily model values and observed daily values does not necessarily imply that the variances of the monthly means are equal. As the authors mention, the process governing the monthly means is certainly different from the one governing the fluctuations of daily values. The augmented bias correction algorithm presented here is certainly useful for those who want to perform one bias correction procedure and need to rely on the property that the variances of hourly, daily and monthly means match those of the observations. But a discussion what these bias corrected values actually mean should be included in the manuscript. The paper is understandable but extensive with some lengths here and there. I find the algorithm described in a reproducible way but the presentation of concepts and notations are in some cases not consistent or not presented in the proper order, see below. The title is adequate, the abstract, however, is not easy to understand beforehand. It would also be interesting to discuss some more general questions on bias correction and GCMs, see below.

2 Specific Comments

2.1 Abstract

Rev 2: You might consider to give an example, e.g. daily temperature, “time scale of the fluctuations” was too vague to grasp the idea of what is coming.

HESSD

7, C4288–C4295, 2010

Interactive Comment

Haerter et al.: In the revised version, we give the example of temperature.

Rev 2: The word "persistence" is used in a misleading way, the word "stationarity" might be mode adequate.

Haerter et al.: We change "persistence" to "stationarity".

2.2 Introduction

Rev 2: I think the introduction could be shortened and more focused. I was surprised by the concept "fitting probability density functions (pdfs) to the histograms". Usually pdfs are fitted to the data and not to histograms.

Haerter et al.: We shorten the introduction by removing the entire paragraph starting "While global climate models (GCMs) ... for saturation specific humidity.". This paragraph goes into some detail on precipitation which can be dropped to make the introduction more brief. We meant to say that the pdfs are fitted to the data, just as the reviewer points out, and we have removed the reference to histograms.

2.3 Statistical bias correction

Rev 2: There seems to be a back and forth between a general quantile mapping and a correction of the first two moments. A simple formula would also help to explain the quantile mapping: $TF(x_{mod}) = F_{obs}^{-1}(F_{mod}(x_{mod}))$.

Haerter et al.: We have intended to keep the discussion general. This is why we mention "quantile mapping" in the text. However, when a specific example is needed, we have occasionally chosen Gaussian distributions to facilitate the conceptual discussion. On p. 7867, l. 5 we now write: "To conceptually exemplify the procedure, in the following we repeatedly make reference to a bias correction of a given normally distributed climate variable x with mean μ and standard deviation σ." We also introduce the formula given by the reviewer on p. 7867, l. 4.

Rev 2: I find the presentation of the bias correction algorithms in Sec. 2.1. not very

HESSD

7, C4288–C4295, 2010

easy to understand. Subscripts are not explained or explained too late in the text. Furthermore, I have the impression that affine linear (Ax + b) and linear transformations (Ax) are mixed. The last but one paragraph of Sec.2.1 is hard to understand and should be revised.

Haerter et al.: We have moved the explanations of the subscripts to an earlier position in the text and now write "In this case, the control period (heavy lines) means and standard deviations are $\mu_{mod,con} = 1$, $\mu_{obs} = 4$, $\mu_{mod,sc} = 2$, $\sigma_{mod,con} = \sigma_{mod,sc} = 1$, $\sigma_{obs} = 2$ where the subscripts mod (obs) indicate model (observations), and con (sc) refer to the control (scenario) period." on p. 7867, l. 22. We have thoroughly revised the second to last paragraph and believe it is now more concise and understandable.

2.4 Bias correction with GCM data

Rev 2: I find the measure in Eq.3 not really intuitive. It would be good to motivate it a little more. Why not using the ratio instead of the difference?

Haerter et al.: We have used the difference, not the ratio, to avoid singularities or very large ratios. Such cases would be possible when the standard deviation of the modeled and observed data were identical or very similar. This is unlikely to occur but can not be excluded in numerical work. Therefore, we find the current measure to be more intuitive than giving the ratio. We add an explanation in the text to motivate our choice of measure (p. 7870, l. 24): "To examine this aspect, we investigate whether the bias correction improved on the discrepancy between the modeled and the observed standard deviation. In [former]Fig. 4a ([new] Fig. 3a) we first present the change in discrepancy of standard deviation of the daily values caused by the bias correction ..."

Rev 2: P. 7871, l. 6: Here you might add that the computation is repeated for the monthly mean values of temperature obtained from the bias correction based on daily values.

Haerter et al.: We add this to the text.

HESSD

7, C4288–C4295, 2010

Rev 2: P. 7871, last paragraph: you state “no systematic” pattern and say subsequently that ECHAM5 generally underestimates. The latter would be a systematic pattern for me.

Haerter et al.: This is correct. We now try to be more specific and write “In the low and mid latitudes, the difference between the modeled temperature fluctuations and the observed ([former] Fig. 5b, [new] Fig. 4b) shows no systematic pattern, neither for the daily nor the monthly mean standard deviation and there is no clear dominance of a positive or negative signal. However, the ECHAM5 model appears to generally underestimate day-to-day variability in the high latitudes while the bias is more mixed in the case of inter-annual fluctuations.”

Rev 2: P. 7871, l.28: Please check the sentence: “Clearly, the bias in the day-to-day ...”. Is that right?

Haerter et al.: Fig. 5c shows that the bias in the day-to-day fluctuations is now almost gone (compare the right panels of 5c and 5b). Hence, we believe the sentence is correct.

2.5 Improved statistical bias correction

Rev 2: This section might benefit from the use of the concept “anomalies”.

Haerter et al.: We have introduced the term anomaly in this section.

2.6 Discussion

Rev 2: Is the presentation of the energy balance model really necessary? I find it too long. Maybe it can be shortened?

Haerter et al.: We have substantially shortened the presentation by removing most of the formulas and explanations. The main point of this discussion should still be obvious to the reader in the current condensed form.

2.7 Further General Questions

HESSD

7, C4288–C4295, 2010

Rev 2: Reading the paper, I was surprised that it is actually expected, that a bias correction on the daily level should compensate also for a mismatch of variances on the level of monthly means. Is this really expected in the community?

Haerter et al.: It is customary to make one choice of timescale before performing a bias-correction. The use of daily data is very common in the community, mostly because daily resolution is usually the highest resolution available. The benefit of using the data at its highest temporal resolution – i. e. not re-arranging daily data to monthly means – is that the entire information contained in the data is preserved and statistics (such as the fits to the data) become more reliable. In the current work we point out the disadvantages of doing that, and we point to the alternative of using the statistics at different timescales.

Rev 2: Remember that only the first two moments are matched by the procedure you describe (or the affine linear TF in general). This is a quite good approximation for Gaussianlike data, e.g. for daily (and larger time scale) temperature. But might not help a lot for values with a distribution very different from normal.

Haerter et al.: Yes, this has to be kept in mind. In this paper, use is made of Gaussian distributions due the conceptual nature of the study. However, the cascade method that we describe should also work for more general distribution functions. We believe that this has become more clear in the revised version as we have made changes to sections 2 and 4 to motivate the use of the simple Gaussian distributions solely as an example.

Rev 2: Are GCMs really made to yield "realistic" daily values? Does it really help to scale the variance of daily GCM data such that it matches the observed daily variance? This is only one characteristic of daily values. I am asking that to encourage a discussion on that topic, not because I think it might not be helpful in some cases.

Haerter et al.: It is of course questionable whether GCMs really represent fluctuations in a realistic enough fashion and there is a plethora of studies trying to assess "similar-

HESSD

7, C4288–C4295, 2010

ity" between models and observations, e.g. in terms of skill measures. Such measures are necessarily subjective as there is no clear way to define a metric to gauge the similarity, especially when more than one climate variable is of interest. While GCMs do involve many processes of the climate system that enable them to generate rather "good" agreement with observations for different observables and on several timescales, they still have severe shortcomings, especially in the context of the generation of convective precipitation and precipitation intensity and diurnal timing more generally. As GCMs are further improved by the modeling centers, impact studies are being performed using their data already. These impact studies – such as hydrological applications - often rely on adequate input from GCMs and somewhat realistic representation of the day-to-day fluctuations. The question bias correction techniques are really trying to address is: What is best possible way to combine simulation and observed data to produce future scenario forcing fields for impact models. In the discussion section we have now introduced a paragraph on what types of biases can actually be corrected in a sensible way by a grid-based bias correction methodology. Many types of errors cannot be meaningfully removed by bias-correction and found it necessary to make this clear in the discussion.

3 Technical Corrections

Rev 2: I am surprised about the use of some English words. You might consider to let a native speaker check. Some examples are:

- detrimental
- couched
- "tier" cascade
- "Utility" of the statistical bias correction
- resort

HESSD

7, C4288–C4295, 2010

- We caution that . . .

Haerter et al.: One of the authors is a native speaker. We have double checked the language in the paper and could not find any improper terms. However, we believe that a replacement can be made to make use of a more common expression: We replace “couched” by “expressed”. We found the other terms listed by the reviewer to be more difficult to replace without changing the meaning and brevity of the text.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 7863, 2010.