Hydrol. Earth Syst. Sci. Discuss., 7, C4296–C4301, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C4296/2010/

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 3 Received and published: 3 December 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 3**. Author responses are indicated by **Haerter et al.**

1 GENERAL COMMENTS

Rev 3:

The paper "Climate model bias correction and the role of timescales" submitted by J. O. Haerter, S. Hagemann, C. Moseley, and C. Piani presents the impact onto different time scale statistics as a consequence of unbiasing model outputs. They show that this impact is likely to be negative. They consequently propose a correction methodology working simultaneously on several time scales, namely the "cascade bias correction". They apply it on two different time scales, monthly-daily, and on three different time scales (three tier cascade), monthly-daily-hourly. In the context of a more and more extended use of climate projections, the question of model output correction is of prime interest. Seasonal, monthly or daily time scale fluctuations are generally not governed by the same process and therefore not solved in the same way by models. Thus, the manuscript reviewed here is undoubtedly of scientific significance and the methodology proposed to address the problem, despite some limitations, an interesting step forward. Reading this manuscript I however have some important concerns that drive me to ask the paper to be reconsidered after major revisions detailed in the Specific comments section. I qualify the revisions of major since they imply (i) some restructuring of the paper, essentially due to its length, and (ii) some necessary clarifications : discussion about extremes, qualification of the method ("bias correction"?), relation between time scales.

2 SPECIFIC COMMENTS

2.1 **Rev 3**: Is it "bias correction"?

I would say "not only".The correction method does unbias the model but it also works on fitting the whole distribution. It is in fact a "quantile-matching" methodology such as in Deque (2007) that would be added in the reference. The method should then be qualified as model output statistical correction or statistical downscaling.

Haerter et al.: We use the term "statistical bias correction", which we have coined in the earlier publications Piani et al. (2010a) and Piani et al. (2010b). We have chosen this term to distinguish our method from statistical downscaling and from standard bias

corrections, where only one aspect of the distribution is corrected. We believe that this term should be similarly understandable as “model output statistical correction” as suggested by the reviewer and we would be pleased to further use this terminology to be consistent with the earlier work by Piani et al. We add the reference to Deque (2007) in order to make reference to “quantile-matching” in the introduction (section 1).

2.2 **Rev 3**: Length

The paper could benefit of shortening/removing some sections. Since the method is based on Piani et al. (2010), it is not necessary to explain it again (ch. 2) but to refer to this paper and to shorten the section.

Haerter et al.: We shorten this section by removing text and Fig. 1 and make reference to Piani et al. (2010b). We also shorten the discussion on the energy balance model in section 5.

Rev 3: This paper is submitted in an hydrological review, why not focus on precipitation only (even if temperature is of importance) and on non-gaussian distributions? Moreover, one doesn’t need quantile matching to fit two gaussian CDFs (mean + standard deviation are enough).

Haerter et al.: The reason for choosing temperature instead of precipitation is explored within the text in section 3.2 and Fig. 7. We show that the monthly fluctuations of precipitation are generally dominated by a small number of daily records, hence monthly mean and day-to-day statistics are much more strongly coupled in the case of precipitation than temperature. We mention quantile-matching to keep the discussion general. For the more conceptual aspects of the paper, simple Gaussian distributions are sufficient.

Rev 3: I am not sure that the presentation of the energy balance in the Discussion section is necessary. I would remove this section and say a few words about it in the conclusion.

Haerter et al.: We have greatly shortened the section on the energy balance and now present it in a much more condensed form. We believe that the presentation now takes a much less prominent role in the discussion part of the paper.

2.3 **Rev 3**: Extremes

As written in the first sentence of the introduction: "One of the greatest challenges facing modern society in a changing climate is the management of risk associated with hydrological extremes, namely floods and droughts". But, even if the correction method presented here can deal with any distribution (non-parametric method), it works with the entire distribution. Hence, it is certainly not suited for extremes (focus on distribution tail, use of GPD...). It is important to stress that point.

Haerter et al.: We find that our text can be made more clear. We have changed the manuscript to make obvious that we are referring to extreme hydrological events, not extreme daily precipitation events. Only flash floods are associated with extreme daily precipitation values (associated with the tail of the distribution function) and we do not consider such events in our paper. Most floods are caused by persistent strong precipitation over several days, not single days of extreme precipitation. This leads to extremes in the accumulated precipitation amount. Droughts are not associated with the tails of the daily precipitation intensity distribution but the number of dry days, which are corrected independently in the method described in Piani et al. (2010b). To clarify this point, we reword the introduction: "Hydrological processes depend on the entire distribution function of precipitation intensity and temperature. For example, extreme hydrological conditions are often caused by unusual precipitation amounts or high temperatures. Persistent heavy precipitation over several days can lead to floods while the absence of precipitation along with high temperatures is often the cause of drought. Hence, improvements on simple bias correction methods can be made when adjusting the entire probability density function (pdf) of the simulated fields to that of the observations. Consequently, adjusting the likelihood of the occurrence of a given magnitude of daily precipitation or temperature, allows a more adequate representa-

tion of the risk of flood and drought by the corrected data. (Wood et al., 2002; Hay and Clark, 2003; Dobler and Ahrens, 2008; Piani et al., 2010b,a) These methods are also sometimes referred to as "quantile mapping" (Deque, 2007), "histogram equalization" and/or "rank matching". A related technique is "statistical downscaling" (Widmann et al., 2003; Schmidli et al., 2006), where large-scale synoptic variables are related statistically - for example in terms of correlation functions - to local weather characteristics. "

2.4 **Rev 3**: Relation between scales

The correction method works separately on the different time scales, but phenomenons of different time scales are often closely related: e.g no rain events (short range time scale) over northern europe during strong euro-atlantic blocking regimes (medium range time scale). A short discussion on this topic and how to deal with it should be interesting.

Haerter et al.: We thank the reviewer for raising this point. In section 3.2 we add this point in the text: “On the other hand, the monthly precipitation mean is not the average of 30 values of the random variable as is the case for temperature. For precipitation, non-zero measurements are recorded only on a few days of the month. Hence, the monthly mean value is often dominated by only a small number of daily precipitation records and hence is often rather well approximated by one or two large events. Furthermore, precipitation processes on the daily and monthly timescales are often closely related, e.g. no rain events (short range time scale) over northern Europe during strong Euro-Atlantic blocking regimes (medium range time scale).”

2.5 **Rev 3**: Other comments

p.7875, l.5: replace "relative variables" by "anomalies".

Haerter et al.: We have made this replacement.

Rev 3: p.7875, l.17: authors switch from subscript i,j to l,k. Why ?

Haerter et al.: This appears to be unnecessary. We have switched to subscripts i, j as the reviewer points out, and we use k as the hourly index.

Rev 3: p.7876, eq(6): replace $T'^{cor}_{l,k,h}$ by $T''^{cor}_{l,k,h}$.

Haerter et al.: We have replaced $T'^{cor}_{l,k,h}$ by $T''^{cor}_{l,k,h}$ as noted by the reviewer.

Rev 3: Deque, M., 2007: Frequency of precipitation and temperature extremes over France in an anthropogenic scenario: Model results and statistical correction according to observed values, Global Planet. Change, 57, 16–26.

Haerter et al.: This reference has been added as suggested by the reviewer.

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