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Hydrology and Earth System Sciences Discussions

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

Anonymous Referee #1

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In the manuscript a new bias correction method is suggested that corrects biases with respect to different time scales using what the authors call a cascade bias correction. The manuscript looked interesting, initially, but after carefully thinking about the main ideas, the assumptions, and in particular the setting, I am convinced that the idea of cascade bias correction is fundamentally flawed, based on a misunderstanding of what bias correction can actually correct in principle. I regret that I have to suggest to reject the manuscript.

The key section demonstrating this misunderstanding is the introductory paragraph of section 4 (p 7874). The authors discuss different mechanisms responsible for variability on different time scales, and therefore potential sources of biases on different

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time scales. As examples for causes of interannual variability, they list (among others) ENSO and changes in storm tracks. Misrepresentation of these processes in GCMs can indeed cause local temperature and precipitation biases, but such biases cannot sensibly be corrected by bias correction! In fact, the whole manuscript lacks a discussion of which biases can be corrected by bias correction and which cannot, and naively applies a correction to all different types of biases (even though considering different time scales).

Related to this problem is the naive bias correction based on a GCM control run. I would like to illustrate this point with two examples, one unrealistic, and one realistic: First, consider that someone has misinterpreted the model grid, and basically swapped Northern and Southern Hemisphere (because the Latitudes where mirrored). Now a grid box corresponding to, say, Sicilly in the observations would be falsly related to a GCM grid box in South Africa. A bias correction applied to this grid box would of course be able to correct the modelled distribution of any climate variable to perfectly match the observed one. Yet this correction would obviously be meaningless. Everybody will probably agree that bias correction could not solve the problem. As a second example consider a GCM that systematically shifts North Atlantic storm tracks by, say, 1000km to the South. Instead of crossing Scotland, most storm tracks would cross France. Here, one might be tempted to say that bias correction could help, but in fact, even though the example is much more realistic, its nature is still the same as that of the previous unrealistic example. Also here bias correction cannot help. The model would produce too low rainfall amounts over Scotland and too high rainfall amounts over France. After a bias correction, storm tracks will still move across France in the model, but now without producing rain, and Scotland will experience rain without strom tracks crossing. In both examples, bias correction does not work because the dynamics at the point of interest in the model are not at all related to the real dynamics. In other words, bias correction cannot correct errors related to wrong model dynamics but only errors related to wrong (or too simple) model parameterisations and orography.

The influence of model parameterisations and orography on model bias, however, are scale independent. For a convective parameterisation bias or an orography bias it doesn't make a difference whether ENSO or other processes showing interannual variability influence the probability of related rainfall events. One might think of biases related to interannual (or longer scale) variability such as precipitation biases caused by the Clausius Clapeyron relation, i.e. changes in precipitation intensity on long scales, because temperature might show long term fluctuations. Such biases, of course, can be correct by bias correction, but again, they are independent of time scale, as they are only related to the amount of rainfall given a particular temperature, no matter whether the temperature is fluctuating on short or long time scales.

To summarise, the authors attempt to correct biases which are related to misrepresentation of large scale dynamical processes such as ENSO or the North Atlantic Oscillation in a GCM. These biases indeed affect precipitation on different time scales. Yet these biases are caused by misrepresented dynamics, which are not local. Bias correction, however, can only correct local biases caused by wrong parameterisations or orography. Consequently, the whole issue of downscaling directly from a GCM control run does not make sense as well as a bias correction method that works on different time scales. Application of the suggested method will most likely lead to physically inconsistent, strongly biased and thus meaningless future scenarios.

Selection of other issues: -the authors do not cite state of the art literature. E.g., the papers by Widmann et al and Schmidli, 2006, using scaling for precipitation bias correction have not been mentioned at all.

-the authors should state whether they apply the so-called delta method (corrected scenario = scenario transformation of the observations) or the direct method (corrected scenario = corrected model scenario). As the authors only discuss mean values but never state how a single corrected value is calculated, this is not clear at all.

-if I am not completely wrong, the first term in equation (3) should be exactly zero by construction. Also the explanation of the equation is wrong: it is not giving the change in standard deviation, but the change in deviation of standard deviations.

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