Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2017-247-AC2, 2018

Geoscientific Model Development Discussions

Interactive comment on "Assessing bias-corrections of oceanic surface conditions for atmospheric models" *by* Julien Beaumet et al.

Julien Beaumet et al.

julien.beaumet@univ-grenoble-alpes.fr

Received and published: 2 March 2018

The authors thank the referee for accepting to review the paper and for the generally constructive remarks aiming at the improvement of the quality of the paper. The responses to the different comments are below:

This manuscript discusses bias correction of sea-surface temperature using the anomaly method and the quantile-quantile method, and bias correction of sea ice concentration using the look-up table method, the iterative relative anomaly method, and the analog method. These bias correction methodologies are evaluated using a perfect model test (i.e. evaluated using the given model as "observations") and a real-case application in which the bias correction methods are compared to observations.

It is assumed that ideal bias correction will reproduce changes in the mean and variance between observations and projected climate as between historical simulations and projected climate. The authors determine that the presented methods for bias correcting SST are reliable. The methods presented for sea-ice concentration are less reliable, however, the analog method showed promising results and improvement over other bias correction methods. Additionally, the authors provide an appendix with a proposed method to parameterize sea-ice thickness, with potential for use in climate modeling applications. I have a number of major and minor comments for the authors to address. Some of the manuscript was unclearly written, making the arguments difficult to follow. I also question the inclusion of SST bias correction evaluation. In regards to the review criteria, the manuscript does present relevant information that is related to modeling questions, particularly for sea-ice concentration, rendering it suitable for publication. However, much of the methodology for sea-surface temperature bias correction has been noted in other manuscripts.

My comments are below. General Comments: 1. While the presented results for SIC are novel and will be very helpful for future modeling studies, the presented results for SST are somewhat less of an advancement. SST bias correction has been studied previously. In fact, there is much less discussion surrounding SST bias correction, and the results are almost glossed over by the authors in comparison. While the results are helpful in a summary sense for an interested reader, the concept seems less novel. This section may be able to be reduced even more, or eliminated completely.

Authors response: "We agree that this part of the paper is less novel and that these issues have been addressed in previous papers. Its presence in the manuscript is justified by the need to highlight the consistency with the work done for sea-ice, and the consistency between the response for the two variables, and to show the possibility to generalize the evaluation methods. However, in order to avoid redundant results, and emphasize the parts of the paper that are innovative, some parts of the result section were cut and the presentation of the methods have been mostly sent to the

Appendix section".

2. The Appendix describes a methodology for parameterizing sea-ice thickness, which was noted in Section 4.3 as a strong influence. While you state that an in-detail evaluation of sea ice thickness prescription is beyond the scope of this paper, you evaluate and further refine one of the methods for parameterization in the Appendix. This seems like an important contribution to the field that has been studied comparatively less than, for example, SST bias correction methodologies. I'm concerned that this contribution will be lost due to its presence in supplementary material, and would potentially warrant a separate manuscript that delves more deeply into the topic.

Authors response: "In some way, the work done on sea-ice thickness is not entirely innovative either, as it was already presented by one of the author (Krinner, 1997) and used in another study (Krinner, 2010). The innovation here is that the parameterization is further refined with parameters set for the Arctic and the Antarctic and that the results are objectively evaluated with sea-ice thickness measurements which so far were seldom, particularly in the Southern Ocean. However, we think that the current material on this topic is not sufficient to deserve a separate manuscript and it seems complicated to delves more deeply into the topic far enough to be able to produce a second manuscript. However, in order to avoid this contribution to be lost and in order to improve the manuscript consistency, we introduced the work on sea-ice thickness in the main part of the paper."

3. I am curious why the CNRM-CM5, IPSL-CM5A-LR, and HadGEM-ES coupled GCM data were explicitly chosen for this study. In addition, you note that HadGEM-ES was used in Section 2.1 near line 25, but never mention results from this model.

Authors response: "The search for suitable bias-corrections methods and their use was first motivated by the need to drive future scenarios climate experiments with atmosphere-only GCMs ARPEGE and LMDZ. Therefore, the work was started with SST and SIC coming from the corresponding coupled model of the latter two

atmosphere-only GCMs. HadGEM-ES was added later, in order to verify if the results obtained were reproduced with this model, but we acknowledge that criterion based on model performances was used to select this model rather than another one. However, the fact that the results are very close for the three models investigated gives us some confidence in the fact that they are robust and independent from the AOGCM chosen as initial material. Results/figures with HadGEM-ES are not presented in order to limit the length of the paper, nevertheless some of the results with HadGEM-ES could be included in the appendix section for some transparency purposes."

4. I am also curious why you selected the given bias correction methods for SST and SIC, are these arguably the most popular methods in use? If so, it would be helpful to note this as a motivation for the work.

Authors response: "Absolute anomaly and quantile-quantile methods are likely amongst the most popular methods for bias-corrections, especially for SST. Absolute anomaly for SST and iterative relative anomaly method for SIC have been introduced and used by one of the co-author in a previous work (Krinner et al., 2008). Evaluating the Look-Up Table method was motivated by the fact that this method is, so far, the method recommended in the frame of the HighResMIP for the production of bias-corrected SIC boundary conditions for atmospheric models. In the light of our results, this should be changed in favour of the analog method in a near future. We developed and introduced the analog method as we weren't satisfied by the results for the bias correction of SIC with the first two methods."

5. Because you are using a perfect model test, can these results be generalized to other models, or are these results specific to the models used?

Authors response: "We applied the perfect model test to rcp4.5 and rcp8.5 scenarios from three AOGCM of the CMIP5 experiments, and the results are very similar for each scenarios .From the perfect model test perspective, the results are not dependent on the models used. Relative performances of the three bias correction methods in the “real-case” application also corroborate the results from the perfect model experiment which gives us confidence in the fact that results are essentially not model-dependent."

6. The introduction could benefit from additional discussion on SST biases, as it is written the focus is on SIC biases.

Authors response: "Some additional references were add as examples of the considerable literature on the bias of CMIP5 models, especially on SST. References demonstrating the added value of bias-corrected SST have been included as well in the introduction : “The absence of the Pacific cold tongue bias and the reduction of the double ITCZ problem in AMIP experiments with respect to the CMIP5 model experiments (Li et al., 2014) shows the importance of forcing atmospheric model by SST close to the observations. For instance, improvements in the modelling of the tropical cyclone activity in the Gulf of Mexico (Holland et al., 2010) and of summer precipitation in Mongolia (Sato et al., 2007) were obtained by bias-correcting SST and other AOGCM outputs before using them as forcing for RCMs.”

7. Figure 6 and resulting discussion: How does one determine what is a “reasonable” and “very small” error? To me, these look like large errors overall, but perhaps they are reasonable and very small with respect to the relative anomaly method?

Authors response: "The use of terms such as "reasonable" or "very small" has been reduced. Now, mean errors and root mean square errors for each graph were added on the plots. In the text, we now discuss the average mean error or average RMSE for every scenarios and for the Arctic and Antarctic combined in order to quantify and compare more objectively the errors between the three methods."

8. In Section 4.2, page 18, last sentence on the page: Preferentially selecting output of reasonably “well behaving” AOGCMs is perhaps too simplistically stated here. There are a variety of issues in selecting which models are “well behaving”. Though the following reference focuses on selecting models for regional hydrological studies, some of the general comments will still hold true for model selection: Brekke LD, Dettinger

MD, Maurer EP, Anderson M (2008) Significance of model credibility in estimating climate projection distributions for regional hydroclimatological risk assessments. Clim Change 89:371–394 . doi: 10.1007/s10584-007-9388-3

Authors response: "Indeed, the selection of “well behaving” models for climate change applications is a complex issue extremely dependent on the processes and the region of interest. Further in the general discussion, we highlight this issue and add two references dealing with it : “The selection of climate models based on their credibility for climate change scenario is a complex issue (Brekke et al, 2008; Baumberger et al., 2017), dependent on the purposes, the processes and the region of study. Whether the climate change signal should be corrected remains on open question (Ehret, 2012), even though there are good reasons to believe that model biases are time invariant (Maurer et al., 2013).". In the discussion for the bias correction of SIC, we make clear that in the light of our results, it is preferable to avoid to use AOGCMs that have large or persistent negative bias on sea-ice in present climate as initial material for the analog or the iterative, relative anomaly method."

9. Is the main result for SST bias correction that either method is appropriate for use due to your evaluation of the reliability of these methods? How does this result differ from other work on SST bias correction?

Authors response: "Following our evaluation, this is indeed the main result for SST bias correction methods. This can be a little surprising as one can expect that the quantile-quantile method is more appropriate to reproduce change in variance and correct biases that are quantile-specifics. For the absolute anomaly, the fact that we use the complete time series of the AOGCM scenario rather than the climatological mean allows for taking into account the projected change in variance present in this scenario. However, given the fact that the quantile-quantile method is widely applied for bias correction of climate variables and has proven to be appropriate, at least for variables that have no skewed distribution such as temperatures, we would recommend the use of the quantile-quantile method. This is however not the main point of the paper."

Technical Comments: The following comments should be easy to address, but will substantially improve the readability of the manuscript.

1. Please confirm that all acronyms are clearly defined, I have not listed all instances, but a few examples follow: CMIP5, AOGCM, AMIP, PCDMI, AGCM, etc.

Authors response: "Ok, comment taken into account."

2. Please confirm that all acronyms are consistent throughout the manuscript. I have not listed all instance, but a few examples follow: a. You define sea-ice concentration (SIC) in the beginning of the abstract, but spell it out in other places. b. You defined sea-ice area (SIA) twice.

Authors response: "Ok, comment taken into account"

3. Some of your terminology is inconsistent throughout the manuscript. For example, sometimes you say “future SST and SIC”, other times you say “projected SST and SIC”, etc., which makes the manuscript difficult to follow.

Authors response: "Ok, comment taken into account"

4. There are a number of grammatical and spelling errors, for example “The presence of SIC maps from futures AOGCM projections. . .” should read “The presence of SIC maps from future AOGCM projections. . .”, please double-check the manuscript for grammar and spelling.

Authors response: "Comment taken into account, we had the manuscript read by a native speaker."

5. Figure 1 (right): It is difficult to determine which line is thick and which is thin, I suggest using a dashed line or adding more thickness.

Author response: "Ok, comment taken into account”

6. Figure 3 caption: Where should the reader go to “see text”?

Authors response: "Comment taken into account, there is now reference towards the corresponding section."

7. Figure 7: Including a key for the lines such as in Figure 4 would be helpful for clarity

Authors response: "Ok, comment taken into account"

8. Figure 8 and 9: The text refers to specific regions, for example the Weddell sea, but I’m not sure how to determine the regions from this Figure.

Authors response: "We changed the legend of the figure so that we can now distinguish the different regions with the help of different colors. Different signs (crosses and circles) are used to distinguish scenarios from CNRM-CM5 from IPSL-CM5A-LR. The more important for these figures is first to distinguish the regions, then the models. The distinction between rcp4.5 and rcp8.5 is less essential for the interpretation of the results and the connections with the text."

9. Figure A2 and A5: Including a key for the lines such as in Figure 4 would be helpful for clarity

Authors response: "Ok, comment taken into account."

10.Equation 1: As some of the parts of the equation refer to a climatological mean, and some to monthly data, adding in summations or “bar” notation would be very helpful.

Authors response : "Ok, comment taken into account."

11. Table 1 and resulting discussion: I may have missed something, but the labeling of this table confuses me, as well as the discussion in the text. In Section 3, below line 25, you that when comparing corrected RCP SST using the perfect model test and original SST from CNRM-CM5 RCP8.5 you obtain a null bias for the entire globe. Yet in this table you show CNRM-CM5 rcp8.5 – CNRM-CM5 hist has a mean difference of +3.04 degrees C. I assume something is written incorrectly here, but I’m not sure

what. In addition, this table is referenced in only in Section 3.1.2, which references the IPSL-CM5A-LR data. I'm confused why you're changing models here.

Authors response: "The goal of the real case application is to show that the mean and standard deviation shift due to the climate change is similar between the observations in the historical periods and the bias corrected scenario than between the historical simulation and the original scenario of the AOGCM used as initial material. Perhaps, the term mean difference was confusing here, we propose to replace it by change in mean and change in standard deviation."

12. As SIC is bias corrected independently of SSTA as noted in the first sentence of Section 3.3, this should also be mentioned somewhere in the methods section, providing context for the examination of physical consistency in Section 3.3.

Authors response: "We now refer to the examination of the physical consistency analysis in the introduction and the method section of the paper : "As SST and SIC are bias-corrected separately, section∼\ref{sec3.3} presents a few considerations about SST and SIC consistency after performing bias corrections. The effects of the corrections applied \textit{a posteriori} in order to ensure the physical consistency between the two variables are evaluated within the framework of the perfect model test."

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-247, 2017.