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The Cryosphere
Discussions

Interactive comment on "Significant additional Antarctic warming in atmospheric bias-corrected ARPEGE projections" *by* Julien Beaumet et al.

Anonymous Referee #1

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General comment:

This study consists of two parts: implementation of simulated bias correction (with respect to a reanalysis dataset) in an atmospheric general circulation model (AGCM) and the effect of bias correction on assessing the future climate change in the Antarctica. The use of the AGCM with refined resolution near the Antarctica allows one to acquire detailed, useful information with only prescribed lower (oceanic) boundary conditions and without lateral (regional) boundary conditions. It can be seen as a type of dynamical downscaling. The authors implemented a method of correcting biases in the model, and their approach is, I think, unique for this context, and potentially very practical. The description of the methodology (Sect. 2) is clearly given and it is easy to follow the text throughout. The authors demonstrated that the result differs significantly with and

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Discussion paper

without the bias correction. I found that the first part of the study (implementation of the bias correction) (Sects. 3.1 and 4.1) is nicely done but the second part (Sect 4.2) needs significant improvement as argued below.

Major comment:

1. As in the title, abstract, and conclusion, the most important scientific finding in this study is that the climate change signal is assessed differently with and without the bias correction. The heart of the discussion should then be placed on whether the bias-corrected climate change simulations are more reliable or not compared to the uncorrected climate change simulations. It is not trivial because the addition of extra terms to the tendency equations violates the conservation laws of physics and may distort the processes operating in the model. There are at least two ways to check the validity of the approach. The first method is a perfect model study in which the bias in a model with respect to the simulated present-day climate by another model is to be corrected and one can investigate whether the climate change signal simulated by the second model is better reproduced by the bias-corrected first model. The second method is to provide a physically persuasive mechanism/rationale why the bias-corrected simulations are more reliable. Now, the first approach requires two models and too much extra work, and still the result may depend on the reference models used. The second approach is, on the other hand, feasible and essential.

In Sect. 4.2.1, the authors describe how the changes in atmospheric circulation and sea level pressure are different with and without the bias correction, but they do not discuss the reason and mechanism. It is, thus, difficult to assess which result is more reliable. Before discussing the difference from previous studies, they should investigate and explain the mechanism in their own model. In Sect. 4.2.2, it is stated that the difference in summer SAM change has large impact on the surface warming, but again they do not investigate why the summer SAM is different and which dynamical mechanism responsible for it is affected by the imposed bias correction. Moreover, they cite PSA1, PSA2, and Amundsen Sea Low differences as potentially important to understand the temperature difference with and without the bias correction, but they do not explain the link of these differences to the background climate state. In Sect. 4.2.3, the difference in precipitation change is attributed to the atmospheric circulation difference, but the link between the unperturbed climate state and the circulation difference is not explained. To my view, these are the most important scientific points of the paper, and the necessary data to explore are all at the authors' hands. Without these explanations, one may see the paper as simply demonstrating how the present-day simulation becomes close to the reanalysis dataset after the correcting terms are added (as implemented), and the simulated future climate change signal are affected by the bias correction for unknown reasons. As it is unclear which one (bias-corrected or uncorrected) is more realistic in the climate change simulations, one could argue that the main conclusion is not convincingly established.

2. As the tendency terms are corrected at each time step so that it should reproduce the reanalysis datasets, it is not surprising that the simulated result shows better agreement with the targeted dataset. I would not describe it as "improvement" as the authors claim. It only demonstrates that the implementation worked as designed. I do not at all mean that it is easy to achieve it (indeed I appreciate the effort and see that the approach has a great potential), but this part of the study is more a technical advancement, rather than a scientific one. Please highlight which results are unexpected (or surprising) in simulating the present-day climate with the bias correction and implication of those unexpected results. The climate modelling community had taken the similar approach of so-called flux adjustments decades ago and virtually abandoned it by now due to various side effect. I am a bit surprised that the authors do not touch upon such a historical path in the model development and not discuss why the authors consider it worth to be revived.

Minor comment:

1. In Fig. 1-(b)-left, is there explanation why the SLP bias in the vicinity of Antarctica does not disappear after the bias correction?

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