"Is time a variable like the others in multivariate statistical downscaling and bias correction?", reviewer 1-2

Yoann Robin & Mathieu Vrac, https://doi.org/10.5194/esd-2021-12

Reviewer 1

General comments

The paper presents an original approach to deal with temporal correlation during multivariate bias adjustment of climate variables.

I have 2 main questions:

1. Don't you think that an initial study of the autocorrelation of the variables of interest could guide the choice of the lag?

2. How is the occurrence of rainfall dealt with? Maybe this is the process which bears most of the autocorrelation?

First, we would like to thank this anonymous reviewer for her/his thorough reading and interesting comments. We tried to take them into account and we provide point-by-point responses below in blue.

1. Regarding an initial study of the autocorrelation: In the present article, we have investigated TSMBC for a "fixed lag", but it would be indeed quite relevant to choose the lag according to the specific temporal properties of the variables and the area of interest. As variables like temperature and pressure have a much longer memory than precipitation, the choice of lag should be based on this type of information, as well as on the analysis of the data to be corrected. The following sentence has then been added into the conclusion:

   "*Note also that the chosen lag in TSMBC should be adapted to the type of variable and the area of interest. For example, taking 3 days ($s=3$) for precipitation in Europe seems reasonable, while pressure or temperature could require a week ($s\geq7$). Hence, a preliminary analysis of the autocorrelation or temporal properties of the variables to be corrected should be performed to decide about the relevant lag to use.*"

2. Regarding the occurrence of rainfall: In the TSMBC approach proposed here (i.e., using dOTC as underlying MBC method), the occurrence of rainfall is not treated differently from the non-occurrence. However, it is true that the sequences of dry days and wet days can bear a major part of the autocorrelation information. Hence, it could be interesting to account for this specific aspect of precipitation when performing the underlying MBC method. This is now clarified in the "Conclusion and discussion" section:

"In addition, when dealing with precipitation, the rainfall occurrence is not treated differently from the non-occurrence (dry days) by the TSMBC approach proposed here (i.e., using dOTC as underlying MBC method). However, the sequences of dry days and wet days can bear a major part of the autocorrelation information. Hence, it could be interesting to account for this specific aspect of precipitation when performing the underlying MBC method."

Minor comments:

- P8 line 210: time is written twice in "time series"
- P9 line 237: "This generates the corrections"
- P14 line 396: "single" instead of "singles"
- P15 line 427: "has" is written twice in "has been"
- P15 line 430: was then applied or has then been applied

All these technical comments have been corrected. Thank you for pointing them out.

Reviewer 2

General comments

The manuscript describes an approach to correcting biases in future climate projections based on 'time shifted multivariate bias correction' and the dynamical Optimal Transport Correction (dOTC). I think the overall manuscript is carefully written and the authors examined various aspects of their method to test its robustness and performance.

1. The only issue that I am concerned about is that the current description on 'tas/pr', 'pr/tas', 'pr/pr', and 'tas/tas' pairs are somewhat messed up. These abbreviations for the pairs suddenly show up in Line 330 for the first time in the manuscript without much explanation. The readers may be able to figure out their meanings much later in Lines 425-428, but the difference between 'tas/pr' and 'pr/tas' still remains unclear. How are they exactly different? Does 'tas/pr' mean the lagged cross-correlation between the past temperature and the current precipitation?

2. This suggestion is largely optional: Perhaps a similar approach to the one proposed here can be applicable to a delta change method, which will be particularly useful when high-quality observational data are available and the model fails to capture some important features of the observations. Perhaps authors can comment on this point?

First, we would like to thank this anonymous reviewer for her/his thorough reading and interesting comments. We tried to take them into account and we provide point-by-point responses below in blue.

1. Regarding the "couples" tas/pr, pr/tas, tas/tas and pr/pr: The reviewer is right. The couples tas/pr and pr/tas are respectively the lagged cross-correlations between tas and past pr, and between pr and past tas. We have added the sentence "*The couples tas/tas, pr/pr, tas/pr and pr/tas are, respectively, the correlations between temperature and lagged (in past) temperature, precipitation and lagged precipitation, temperature and lagged precipitation, and precipitation and lagged temperature.*" at the first occurence of the "couples" term (section 4.1, paragraph 4).

2. Regarding the delta change method: This suggestion is not really clear to us. It is not clear at all how a delta change method could be inserted into a TSMBC approach. Indeed, one main issue is that the delta change method is a univariate method while TSMBC requires a multivariate bias correction method. Hence, a delta change does not sound to be appropriate within a TSMBC approach.