Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2016-52-AC2, 2017

Earth System Dynamics
Discussions

Interactive comment on "Addressing the assumption of stationarityin statistical bias correction of temperature" *by* Manolis G. Grillakis et al.

Manolis G. Grillakis et al.

manolis@hydromech.gr

Received and published: 21 February 2017

Authors would like to thank Reviewer #2 for his valuable comments on the methodology and the structure of the manuscript. All the comments were taken into account to revise the manuscript. Each one of the R#2 comment is transferred (denoted as R2) while an answer is provided after each comment (denoted as A). The revised manuscript is better structured and was been language reviewed in order to better meet the requirements.

R2: The article tries to address the common assumption of stationarity in statistical bias correction of modeled temperature by separating the stationary and non-stationary signals in the time series and only correct the stationary part. The idea is novel but the

method is questionable, furthermore, the presentation of the paper is inadequate. It is poorly structured and the description of the method is unclear, which made it impossible for the audience to repeat the test. The results are not thoroughly discussed and conclusions are not well supported. Thus I recommend this paper to go through a major revision before it can be considered for publication. The authors assert that the difference between the original model data and the normalized data is the non-stationary component of the time series, which are subsequently added back in. The key assumptions here would be that i) the "non-stationary components" would contain trends as well as year to year fluctuations (and presumably even changes to seasonality and day to day fluctuations as well); and ii) these components are not subject to bias correction. In my opinion, both are questionable. What if the model get these things systematically wrong in the first place? The use of "stationary" is somewhat confusing here, since it's really an anomaly from resampled climatology. And it's totally dependent on the reference period selected.

A: Authors agree with reviewer #2 comment, however would like to make clear that the procedure of separation is performed on daily basis, but for each year's data explicitly. Hence it is indeed the anomaly from a reference period climatology as reviewer correctly indicated, but not from the "resampled" climatology, as it is performed in daily basis. Additionally, in order to avoid potential confusion, the revised manuscript the term normalization will be followed instead of the term "stationarization", and residuals instead of "non-stationary". Another point that has to be made clear in the revised manuscript is that the separated as non-stationary components are not non-stationary as a whole, however may potentially contain non-stationary components relatively to the annual basis normalization that is performed. Regarding the point (i), would like to mention that the "non-stationary components" (residuals) would contain trends as well as year to year fluctuations (and presumably even changes to seasonality and day to day fluctuations as well), relatively to the average reference period simulated climatology , and the each year separation that is performed. Changes in the considered reference period or the timescale in which the separation is performed would give different

results. Regarding the point (ii), the residual temperature signal is not bias corrected as it is stated in the abstract section, as “The methodology separates the stationary and the non-stationary components of a time series, in order to adjust the biases only for the former and preserve intact the signal of the later.” Additional clarification remarks will be added to end of the introduction section. To overcome any other potential misconceptions about the purpose of the methodology, the title of the manuscript will be changed to “Suppression of long term signal distortion during bias correction of climate model temperature”. Moreover, numerous changes have to be performed in the text to the direction that the presented methodology does not resolve the stationarity assumption by identifying and correcting the non-stationary components. Instead, an exemption is performed relatively to the reference period model climatology, which may also include nonstationary changes along with other changes. Regarding the presentation of the methodology, it has to be noted that a step by step example of the bias correction methodology that is applied along with NSM can be found in the Appendix A of (Grillakis et al., 2013).

R2: While the n-fold cross validation scheme has been used in similar research before, it is commonly recognized that at least 30 years of data should be used in the calibration of a bias correction method. Why not use a moving window of 30 years to do the calibration and validation? If you have to use this scheme, each of the 10-year period need to be analyzed (before the normalization) to show their characteristics and each pair of calibration-validation need to be studied separately to show the effect of NSM.

A: Authors agree with Reviewer #2. In the k-fold test, we actually used 50-years for each calibration, which are sufficient to describe a reference climatology and calibrate the correction process. The 10-year long periods were used for the validation. Regarding the moving 30-year window was an initial thought. However this approach would have the drawback of dependent validation periods among the replicates of the experiment. As a result, the estimates calculated in each cross-validation sample will be highly correlated with each other. As the time width of the data is 60 years time-

series, there would be just two truly independent 30-year validation periods. Hence we employed the k-fold approach which is based on the same principles to the sliding window, but offers a decent number of independent validation periods. The procedure has been proposed for evaluating the performance of bias correction procedures in (Maraun, 2016).

R2: Are Figures 1 and 2 a test performed on one point/grid cell in the study area? If so, the results should be discussed in the results and discussion section. This is not mentioned anywhere in the text. Such obscurities should be avoid in the manuscript. Also, the authors shouldn’t assume readers to have knowledge of their study area or data. The study area, including the model domain and its climate should be discussed in the data section.

A: Authors followed the recommendations of Reviewer #2. The Figure 2 discussion of the results is moved to the results and discussion section as indicated. Additionally, the description of the data and the study area were enhanced. “To examine the effect of NSM on the bias correction on a timeseries, the Hadley Center Central England Temperature (HadCET - Parker et al., 1992) observational dataset was considered to adjust the simulated output from the earth system model MIROC-ESM-CHEM (Hasumi and Emori, 2004) historical emissions run between 1850 and 2005 for Central England. This particular case study was chosen due to the large observational record (the longest instrumental record of temperature in the world) that is available for central England, i.e. the triangular area of the United Kingdom enclosed by Lancashire, London and Bristol. Discussion about dataset related uncertainties can be found in Parker and Horton (2005)”

Moreover, as Reviewer #2 indicates, the test conducted and presented in Figure 1 was indeed performed using grid-point data. Additional clarification was added to the footnote. However authors believe that the relocation in the results and discussion section would make it unnecessary as it was put in the introduction section as a indicative example of the time-dependent bias which partly motivated the research. “The Figure

1 data were obtained from RCM model ICHEC-EC-EARTH r12i1p1 SMHI-RCA4_v1 of Euro-CORDEX experiment (0.11degress resolution) simulation under the representative concentration pathway of RCP85, for the location Chania International Airport (lon=24.08 lat=35.54). Observational data were obtained from the E-OBS v14 dataset (Haylock et al., 2008) of 0.25degrees spatial resolution."

R2: What is the basis of selecting 5th and 95th percentiles in case study and 10th and 90th percentiles in results? Neither of them can be considered as extremes with respect to temperature.

A: Authors share Reviewer's #2 opinion that none of the above percentiles are considered as extremes, or are referred as extreme in the manuscript. Their purpose is to exhibit the methodology performance on a higher and a lower percentile, and not just mean statistics. Moreover, the 95th and 5th percentile used earlier in the timeseries example of the methodology, was changed to 90th and 10th for uniformity with the latter results of Figure 6.

R2: The captions and legends in Figures 3, 5 and 6 need to be rewritten in a more precise and descriptive way and need to be discussed thoroughly in the text to reflect the intention of these figures.

A: The captions were rewritten to describe better the information that they provide. Additionally, lettering that corresponds to the figure captions was added to Figure 5 (attached). "Figure 3: Mean temperature of the EOBS (first line) and for each RCM model (second line) for the reference period 1951-2005. The long term average difference (DIFF) between individual models and EOBS are shown in the third line. The last column shows the ensemble mean of each line. Different color maps are provided for the MEAN panels (1st and 2nd line) and the DIFF (3rd line). Lines 4, 5, 6 are similar to 1 2 and 3 but for standard deviation. Figure 5: Mean surface temperature of the cross validation test. Panels a and b show the ensemble mean of the 5 raw models data and the EOBS respectively. Panels c and d show the ensemble mean of the 5 RCM models

after the correction with and without the NSM module respectively, for the calibration periods' data. Panels e and f show the difference of the c and d panels for the EOBS, respectively, Panels g to j are the same as c to f but for the validation periods' data. Figure 6: Ensemble long-term linear trend of the 5 RCM models' data. The trend is estimated on the mean temperature (top) and the 10th (mid) and 90th (bottom) percentiles in annual basis. The change in the corrected data trend relatively to the raw data trend is provided for the BC (middle panels) and the BCNSM data (right panels). All values are expressed as degrees per century [oC/100 y]."

R2: There are grammatical mistakes and incomprehensible sentences in the manuscript. A few examples in the abstract: 1. Lines 26-27: change 'their majority assumes' to 'the majority of them assume';

A: Corrected according to the indication.

R2: 2. Line 29: change 'in the context of a climate' to 'in the context of climate research';

A: Corrected according to the indication.

R2: 3. Line 31: change "pre-post processing" to "pre- and post-processing"; A: Corrected according to the indication.

R2: 4. Line 36: change 'but also' to 'and'; The authors will benefit from using a language editor before resubmitting the manuscript.

A: Corrected according to the indication. Moreover the entire manuscript was reviewed for its language.

A: References Grillakis, M.G., Koutroulis, A.G., Tsanis, I.K., 2013. Multisegment statistical bias correction of daily GCM precipitation output. J. Geophys. Res. Atmos. 118. doi:10.1002/jgrd.50323 Hasumi, H., Emori, S., 2004. K-1 Coupled GCM (MIROC) Description K-1 model developers. Haylock, M.R., Hofstra, N., Klein Tank, A.M.G., Klok, E.J., Jones, P.D., New, M., 2008. A European daily high-resolution grid-

ded data set of surface temperature and precipitation for 1950–2006. J. Geophys. Res. 113, D20119. doi:10.1029/2008JD010201 Maraun, D., 2016. Bias Correcting Climate Change Simulations - a Critical Review. Curr. Clim. Chang. Reports 2, 211–220. doi:10.1007/s40641-016-0050-x Parker, D., Horton, B., 2005. UNCERTAINTIES IN CENTRAL ENGLAND TEMPERATURE 1878–2003 AND SOME IMPROVEMENTS TO THE MAXIMUM AND MINIMUM SERIES. Int. J. Climatol. Int. J. Clim. 25, 1173–1188. doi:10.1002/joc.1190 Parker, D.E., Legg, T.P., Folland, C.K., 1992. A new daily central England temperature series, 1772–1991. Int. J. Climatol. 12, 317–342. doi:10.1002/joc.3370120402

Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2016-52, 2016.

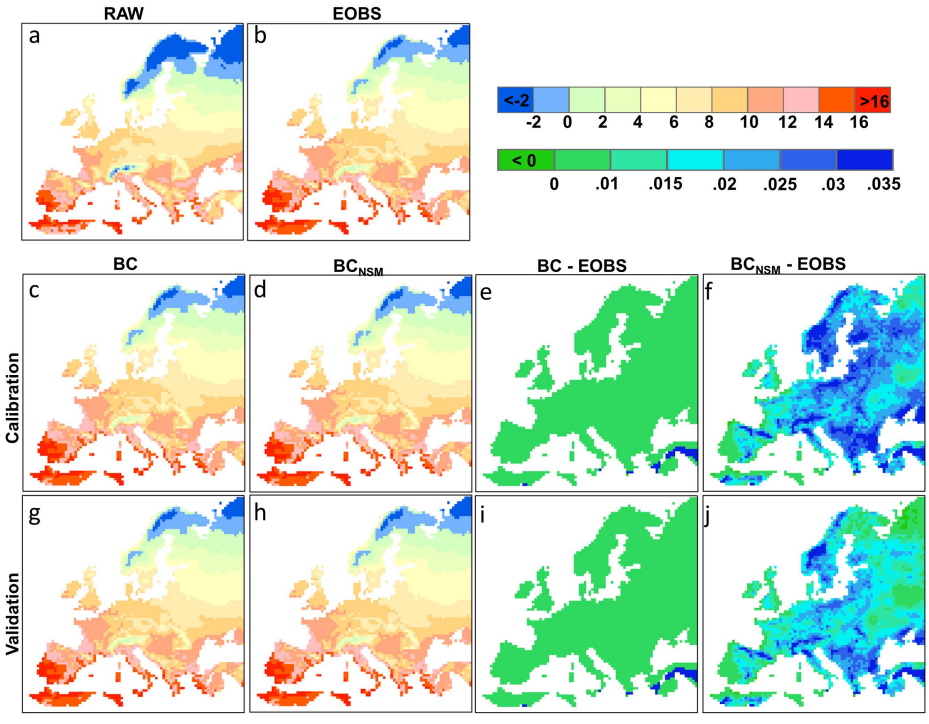

Fig. 1.