Geoscientific Model Development Discussions

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Comment on gmd-2022-167

Anonymous Referee #1

Referee comment on "The pseudo-global-warming (PGW) approach: methodology, software package PGW4ERA5 v1.1, validation, and sensitivity analyses" by Roman Brogli et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-167-RC1, 2022

General comments:

This paper presents a detailed description of the methodology in the preparation of the boundary conditions for PGW simulations, provided in the companion software PGW4ERA5. As the authors have said, the PGW approach offers several benefits, so it will be attractive not only for climatologists but also for the groups who are not familiar with atmospheric dynamics and have interest in impact assessment of future climate change in a certain field. The proposed software and this description paper must support such groups.

This paper basically includes sufficient information as a description paper of PGW4ERA5. This paper is also worthy in that the several specific considerations when preparing boundary conditions for PGW simulations are described based on the authors' knowledge and results of sensitivity experiments. On the other hand, there are somewhat insufficient points in terms of discussing how appropriate it is to create boundary conditions for PGW experiments. Whether those insufficient points should be included or not may be a matter of opinion. However, since this paper is expected to be useful to readers who want to know the specific procedures of the PGW method, and not just a description paper, it is suggested the authors revise the manuscript following the comments below prior to publication.

Specific comments:

[1]

The method presented in this paper to create the lateral boundary data for a PGW experiment is one of several options; the procedure in this paper uses ERA data on the

original (hybrid) coordinate as a base climate and the changes in geopotential at the reference level obtained from pressure level GCM data. On the other hand, the simplest and easiest option may be the case of using pressure level data both for reanalysis (base climate) and GCM (climate change) data. In this case, one can simply add $\Delta\varphi$ given from the GCM to the reanalysis data without pressure adjustment. The impacts on the RCM (PGW) results of using reanalysis data on pressure level instead of the original ERA-coordinate as a base climate should be mentioned, because many RCM users usually use pressure level data for boundary conditions.

The boundary conditions are further converted to the RCM coordinate for calculation because the coordinate of a GCM or reanalysis providing boundary conditions usually differs from that of the RCM. At that time, the bias in pressure adjustment generated in the conversion procedure to the RCM coordinate will be more significant in the case of using pressure level data than the original coordinate data. Therefore, it is also important to evaluate the magnitude of the bias and to indicate the authors' opinion on the use of pressure level data for base climate.

[2] Sec. 2.6 (L. 246): How do you determine the convergence of iterations? Please describe the definition of convergence determination.

[3] L.267-271 and Figure 4

How were "errors in the integration of φ'_{ref} and in the adjusted surface pressure" obtained? Please describe more in detail. For example, does it mean that the error in $\Delta\varphi_{ref}$ in Figure 4 is $\Delta\varphi'^{N}_{ref} - \Delta\varphi^{GCM}_{ref}$? Note that, $\Delta\varphi'^{N}_{ref} = \varphi'^{N}_{ref} - \varphi_{ref}$ and *N* is the number of *n* when iteration is converged, and $\Delta\varphi^{GCM}_{ref}$ is climate change of φ at the reference level obtained from GCM. However, the iteration should be performed until $\Delta\varphi'^{N}_{ref}$ agrees with $\Delta\varphi^{GCM}_{ref}$, as described in L.229-231. Why are there large differences as shown in Figure 4? Alternatively, does Figure 4 show the results of the difference between $\Delta\varphi^{GCM}$ recalculated by Eq. (7) using only AMON/EMON data and $\Delta\varphi$ directly provided in the AMON/EMON data, which is calculated using the native grid data? Either way, a more careful description is needed.

[4] Section 4.3

There are other ways to treat humidity changes in PGW methods; for example, there is the idea of not considering the change in RH (as introduced in Sec. 4.5.2 of Adachi and Tomita, (2020)). It is better to mention those other methods. In addition, when the temperature is below 0°C (upper atmospheric level), there are two definitions of RH. It is possible that the definitions may differ between the reanalysis data and a GCM. In such cases, simply summing them is undesirable.

Technical corrections:

[1] L.50-54: What is described here is correct, however, this explanation may lead readers to misunderstand that this paper focuses on the preservation of the hydrostatic balance when converting from the driving reanalysis/PGW coordinate (i.e., boundary conditions) to the RCM coordinate, for instance, $HIST_{ERA}$ to $HIST_{LBC}$ or PGW_{ERA} to PGW_{LBC} in Figure 2. In fact, the paper explains how to maintain the hydrostatic balance when adding the climate change Δ in the GCM coordinate system to the base climate (i.e., reanalysis data), although the concept is the same in either case. In other words, the treatment of hydrostatic balance when converting boundary conditions with the driving reanalysis/PGW coordinate to the RCM coordinate depends on a used RCM's internal procedure.

[2] L.70: "Figures 1 and 6" --- "Figure 1 and Figures 6e and f, respectively" will be better.

[3] L.93-95: While it may be difficult to refer to all the studies using the PGW method, it is suggested to cite several pioneering studies. For example, there are studies that investigated changes in precipitation (Sato et al., 2007; Kawase et al., 2009), temperature changes (Adachi et al., 2012), and snow changes (Hara et al., 2008).

- Sato et al., 2007, Journal of Hydrology, https://doi.org/10.1016/j.jhydrol.2006.07.023
- Kawase et al., 2009, JGR, https://doi.org/10.1029/2009JD011803
- Adachi et al., 2012, JAMC, https://doi.org/10.1175/JAMC-D-11-0137.1
- Hara et al., 2008, Hydrological Research Letter, https://doi.org/10.3178/hrl.2.61

[4] L.115-122: The difference between "Complete GCM output" and "CFDAY data" is not clear. Both data have the same category on a temporal resolution, i.e., daily, and a spatial resolution, i.e., the original/native (GCM) grid.

[5] L.161-162: Please add a reference related to "nonlinear heuristic procedures", if possible.

[6] L.202-204: If my understanding is correct, the description here is not accurate. Δ in the GCM coordinate system is interpolated to the ERA grid to add it to ERA reanalysis, and then the merged data (Δ+ERA) is regridded from the ERA grid to the coordinate of the target RCM.

[7] L.252: It would be better to add "Eq.(7)" such as "(see Subsection 2.5 and Eq. (7))"

[8] L.266: Does it mean "on the native vertical grid *of the GCM*"?

[9] Caption of Figure 4: What is the P_s in the caption? Does it mean P_{sfc}?

[10] L.322: The definition of EKE would be better moved to L.291, where EKE first appears.