

Nonlin. Processes Geophys. Discuss., author comment AC1  
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## Reply on RC1

Clara Deser and Adam S. Phillips

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Author comment on "A range of outcomes: the combined effects of internal variability and anthropogenic forcing on regional climate trends over Europe" by Clara Deser and Adam S. Phillips, Nonlin. Processes Geophys. Discuss.,  
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The original comments are included in plain black text, and our response is given in *italicized text* beneath each one.

RC1: Tamas Bodai

This paper is very nicely written, with abundant information on its subject.

I would like to raise a caution about taking it for granted that any ensemble-statistics (E-stat') (even with a hypothetical infinite initial condition ensemble of a model) represents a forced response of the model climate. The following lines of the paper seem to have no such concern:

Because the temporal sequences of internal variability unfold differently in the  
96 various ensemble members once the memory of the initial conditions is lost, one can  
estimate the  
97 forced component at each time step (at each location) by averaging the members  
together, provided  
98 the ensemble size is sufficiently large. The internal component in each ensemble  
member is then  
99 obtained as a residual from the ensemble-mean.

However, Gabor Drotos and I (see reference below) worked out the conditions when we  
can regard an E-stat' (change) a sound quantifier of climate (change). This is a conditional  
definition of climate and it requires — for one thing — a time scale separation bw. certain  
fast and slow processes. Such a sound conditional climate change, however, might not be  
entirely forced, but the evolution of the slow system could introduce an unforced  
component. Thus, the concepts of climate change and forced change decouple. The  
following lines from the paper could be interpreted in our sense (not considering the  
citations), but then they would contradict the above quotation (I65-99):

In some  
58 areas, climate trends driven by internal processes may even outweigh those due to  
anthropogenic  
59 influences over the past 30-60 years (Deser et al., 2012, 2016 and 2017; Wallace et  
al., 2013; Swart

60 et al. 2015; Lehner et al. 2017).

*Thank you Tamas for alerting us to your new paper with Gabor Drobos, which we were not aware of. You raise an important point, which we shall address in our revised version by adding the following sentence after lines 96-99 above: "This definition of forced and internal components assumes that there are no slow internal variations that may confound identification of the forced response as the ensemble-mean change (Drobos and Bodai, 2022)."*

On the subject of "...a larger ensemble may be needed for some aspects of the forced response than others" (I99-100), maybe you wish to cite my papers that advocate that cross-correlations of TWO quantities as opposed to some E-stat' of ONE observable quantity tend to show much smaller SNR. So, forced changes of teleconnections can be difficult to detect even in an ensemble. Also, typically the higher the statistical momentum/quantile, the smaller the SNR.

*Thank you. In our revised version, we shall cite your papers regarding the need for larger ensemble sizes for quantities with lower SNR such as higher statistical moments/quantiles and teleconnections (cross correlations between two quantities).*

I didn't quite understand how the obs ensemble can help in re-assessing the detectability of trends in single observed realisations (paragraph starting with line 376). The model ensemble can have a bias in the forced trend because of model error (or changes of the slow system, as mentioned above, or numerical model drift, being an artefact). Isn't the forced trend of the OBS ensemble the same as that of the model ensemble by construction, i.e., possibly biased? I don't see a solution for this problem.

*Yes, in the case of Fig. 8 to which this paragraph pertains, the forced trends are the same as that of the model ensemble by construction. Our point here is to quantify model biases in the noise (internal variability of trends as measured by the standard deviation of trends across ensemble members) and how they affect the SNR. In our revised manuscript, we shall add the following text in bold italics to the sentence in lines 377-378: "We address this question by using the OBS LE  $\sigma$  values in place of the model's  $\sigma$  values in the signal-to-noise calculation (**note that the "signal" in the two LEs is identical by construction**)."*

I553 this is the first time?

*Yes, this is the first time to the best of our knowledge. I (Clara Deser) have been wanting to take this step for a long time!*

I581 "wet" and "dry" — check for the consistency of the directionality of double quotation marks

*Thank you, corrected.*

I605 combined the internal variability?

*Thank you, changed as suggested.*

Note: I do not make recommendation to editors for or against publishing a paper. I selected "minor revision" only to be able to submit my review; please consider it void.

Tamas Bodai

References

Gabor Drotos, Tamas Bodai 2022. On defining climate by means of an ensemble [Preprint]. <https://essoar.org> (2022) <https://doi.org/10.1002/essoar.10510833.2>  
Tamás Bódai, June-Yi Lee, Aneesh Sundaresan.(2022) Sources of Nonergodicity for Teleconnections as Cross-Correlations, *Geophysical Research Letters*, 49, 8, e2021GL096587, doi: 10.1029/2021GL096587

Bódai, T., G. Drótos, M. Herein, F. Lunkeit, and V. Lucarini (2020) The Forced Response of the El Niño–Southern Oscillation–Indian Monsoon Teleconnection in Ensembles of Earth System Models. *J. Climate*, 33, 2163–2182, <https://doi.org/10.1175/JCLI-D-19-0341.1>