

Review of « Ubiquity of human-induced changes in climate variability »

The authors present a new dataset consisting in a large-ensemble simulation from an Earth system model with a relatively fine atmospheric resolution over a relatively long period (1850-2100) and representing a significant computational effort. They use this product to rather systematically describe changes in climate variability in the model, moving beyond analyses of climate change in terms of means. Variability is considered in terms of probability, distribution, amplitude, frequency, phasing, and patterns. Moreover, they study a large spectrum of patterns of climate variability, including the continuous part of the spectrum, rather than solely focusing on leading modes of climate variability such as El Nino-Southern Oscillation. The dataset and the systematic study of changes in climate variability on a broad range of time scales makes this study original. Moreover, its main conclusion that “the ubiquity of such changes in variability also points to the importance of moving beyond the assumption of stationary variability in detection and attribution studies of climate change” is timely.

This is why I recommend this article to ESD once the following minor comments have been addressed.

Minor comments :

Abstract :

l. 19 To emphasize the originality of the dataset, I would also mention the simulation period and the model resolution like at l. 333

l.23 « Greenhouse warming will in particular alter... ». I would rather write « Greenhouse warming in the model in particular alters... » and mention that model uncertainty is not considered here, as explained in the paragraph of l. 356.

Introduction :

l. 33 « spectral variance peaks ». The « peaks » are also relatively broad for different reasons contrary to spikes (Dirac's). I would write « relatively sharp peaks ».

l. 53 « variance » is repeated

l. 59 Explain why the the results of the CMIP6 version of CESM2 is expected to be conclusive compared to “earlier studies” (l. 46). Perhaps based on what is explained in Section 2.

Method :

l. 78 Missing punctuation

l. 81 Is the resolution for the POP ocean model also 1 degree ? It is important to know if it is eddy-resolving since this might also affect the atmospheric variability.

L. 91 – paragraph : How are these improvements measured ? To which extent does the land model (fire model and agricultural management in particular) rely on assumptions regarding human behavior in the future (for instance in response to climate change) ?

Results :

l. 169 Could you explain what motivated the choice of these observables ? I guess one factor is the relationship between these observables and climate-change impacts, but this is not obvious.

l. 169 Instead of the Fourier transform of the observable, why not use an estimate (e.g. periodogram) of the power spectrum which can be directly related to the variance that you use in Figure 1 (as the integral of an adequately normalized power spectrum) ? The variance is also used in Figure 3. If this is in fact what you are doing, please make it clearer.

l. 169 To avoid spectral leakage, a window should be applied before the FFT. Is this the case ?

l. 171 and l. 172 Why 35 years and not 30 years (2070-2099 and 1960-1989) ?

l. 173 If the power spectrum is computed, an alternative would be to first compute correlation functions for each member, average over the members and then do the FFT. I do not know which estimation method has the best properties, but could you explain why you made this choice ?

Figure 2 What are the units of the spectral amplitudes given the observable ?

l. 183 Even if I do not think that it is necessary to add confidence intervals to all panels and for all frequencies or to test the significance of the differences between spectra, could you give an estimate of what would be the width of these confidence intervals given the data that you use (in the supplementary material for instance) ? This would also make this section more coherent with the part on wavelets.

l. 200 and l. 208 Although a scalar observable can technically be seen as a bilinear form, I would reserve the term positive definite for non-trivial bilinear forms (e.g. represented by non-scalar matrices) and simply write “positive variables”.

l. 202 This is not true for all stochastic processes. I guess you mean for a Brownian motion ?

l. 251 Could you clarify what is meant by “cross-ensemble” everywhere this expression is used ?

l. 256 “minimum n” → “minimum in”

l. 265 Same as for l. 251. “cross-ensemble calculations applied for identical time records for each ensemble member” is not clear to me. The standard deviation is computed from a sample combining all members and all years for a given period (historic or future) ? Based on the caption, I guess not, the standard deviation is computed over the ensemble and then time averaged over the period. Could you clarify and explain why you made this choice and not the other ?

l. 310 “and” → “an” I guess

Figure 5 : Do the histograms aggregate ensemble members for a single year only or is their also an aggregation of the 20 years in the interval (in which case the histograms would include the 20y-trend) ?

Figure 5 : How are the histograms estimated ? Using a grid ? Which interval length(s) ?

l. 318 Since the spacing between to vertical grid lines in Figure 5 represent an interval of 10 days, it seems to me that the shift in the onset is closer to 3 weeks or even 4 weeks than 2 weeks. Am I wrong ?

l. 322 How do you “measure” the interannual variability ? Even if you read the histograms with the eyes, I guess that you have some metric representation of the spread in mind, such as the standard deviation. In fact, if you use the distance between the minima and the maxima, the interannual variability appears comparable to the trend to me.

l. 325 Same question as for l. 322. Which measure do you use to obtain these percentages ?

Discussion :

l. 331 I would call this section “Summary and Discussion”, but that’s a detail.

l. 335 English is not my mother tong, so I may be wrong, but shouldn’t “affords” be replaced by “offers” ?

References are hard to read because entries are not visually separated.