Earth System Dynamics Discussions

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Comment on esd-2022-14

Anonymous Referee #1

Referee comment on "STITCHES: creating new scenarios of climate model output by stitching together pieces of existing simulations" by Claudia Tebaldi et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2022-14-RC1, 2022

The STITCHES algorithm presents a unique time-sampling based approach that enables exploration of different, arbitrary climate scenarios. Its added benefit of not being limited to specific climate variables or spatial/temporal scales makes it a powerful tool in comparison to existing simple climate models/emulators. Overall, it is extremely relevant to the climate modelling and impact/integrated assessment societies and suitable for the Earth System Dynamics journal. Some comments are as follows:

High-level comments:

- The "outside the lower-end emission scenario bracket" application of STITCHES should be clarified, there is discussion surrounding overshoot however not for low-emission scenarios with near equilibrated climate by 2100.
- Some discussion on choice of tuning parameters (X and Z) for different temporal scales (annual vs monthly) should also be given. Since non-linear warming could manifest more strongly at monthly timescales (due to e.g. snow-albedo feedbacks), this could limit the values of X or Z to be used (or otherwise the fineness of temporal resolution). Given that decadal oscillatory patterns such as El-Nino are aimed to be conserved, implications of having X>9 and the compromise this has on fidelity of representation for finer temporal resolutions should furthermore be explored (e.g. looking at performance on monthly timescales with different X values).
- Although discussion of application of STITCHES is given, readers would be curious for more discussion on future developments and improvements that could be made.

Below are more specific comments

Specific comments:

L4: the link between emulators and computational demand should be clarified

L19: This may be confusing to readers: the use of GSAT to create the pointers from which all other climate variables at different spatial and temporal scales will be stitched together should be clarified (i.e. pointer is not climate variable specific).

L113: This suggestion is a bit strong given that emulators already mentioned (Link et al. 2019, Beusch et al. 2020,2021) circumvent the need for initial condition ensembles by providing stochastically generated imitations of the expected internal variability. Furthermore, scenario exploration to look at climate under equilibrated or overshoot state is still extremely important and this should be clarified.

L115-L135: Very well explained background to the rationale!

L146: what about scenarios lower than the lowest emission scenarios or overshoot scenarios?

L197-L205: Z is dependent on X which is also a tuning parameter, this may introduce additional caveats in choosing X so as to avoid "jumps" between the seams. Have sensitivity tests been performed on this? Some explanation on how to jointly pick the optimal combination of X and Z should be provided.

L211: Is the ensemble size the sole thing considered when choosing which ESMs to display? Looking at ESMs of different genealogies would also be interesting especially for the (T, XdT) space (if not that is also O.K., just curious about why the above criteria).

Figure 1: it seems that for most models around -0.01degC the rate of historical warming is higher than that at 0-0.01 degC, is there a reason for this? It also raises the question of the genearlisability of this approach for time windows with major volcanic events (e,g, Mt Pinatubo which has a distinct fingerprint in the GMT trajectory) and some elaboration on this may be required.

L227-L230: Great that this is elaborated upon here! Providing this elaboration earlier could benefit and provide more structure to the text however.

Figure 2: It seems that all ESMs in this figure have a mismatch in the GSAT trajectories after 2050 for ssp 2-4.5 (and also BSS-CSM2-MR and CMCC-ESM2 in Figure 4), some elaboration on this may be needed e.g. transient vs equilibrated state. In general some consideration of how to stitch together cases where X*dT ~ 0 should be elaborated as nearest neighbors could have both a positive or a negative trend.

L306: It would be interesting to see month specific trends (e.g. the decadal trend for Jan and Jul). It seems here it is only the decadal trend of the whole monthly time series, if not this should be clarified as well.

Figure 6: There seems to be systematic overestimation of monthly variance around central Africa (also for models in the appendix), are there reasons for this (e.g. vegetation/land cover changes where SSP 5-8.5 imposes quite high deforestation which may lead to spurious variabilities)

L321: The argument that internal variability explains the mismatch in the Arctic is not so convincing. It could for instance be due to the AMOC or otherwise due to a non-linear increase in summer time temperatures during ice-free arctic summers.

L346: Figure 7, it may be difficult to visually gauge similarity in magnitude and oscillatory behaviour. Although this is made more obvious in Figure 8, it may be a good idea to apply a power spectral decomposition instead and show their results for a clearer overview. Very good idea to look at SOI within the analysis otherwise!

L400: Does the Z_cutoff value generalize to all values of X? The calculation of Z_cutoff is already a very useful exercise so this is a minor detail, just curious.

L438: The term envelope collapse should be clarified and how it related to the Z value as well (i.e. how best to know at which Z envelope collapse has been approached?

Table 5: Is there a relationship (e.g. linear) between between E_r and Z_cutoff, or are they stable and then jump to above 10% after a certain cutoff?

Table E1: The E_1 and E_2 values for CanESM5 tend to be higher for 20 archive members and then drop lower at 25 archive members. More so for SSP 3-7.0 the E_1 values are 0 at 25 archive members for both 2010 and 2050. Is there a reason for this?

Conclusion and Discussion: the recommendation for looking at less scenarios and focusing on more initial condition ensembles may be quite strong: perhaps there should be elaboration on which scenarios are more useful to explore (i.e. ones where interpolation becomes difficult such as overshoot or equilibrated climate). The applicability of STITCHES across different temporal scales should also be clarified (i.e. limitations when applying it to annual vs monthly vs subdaily timescales).

Editorial comments:

L35: support the *climate information needs of the* impact research community

L44: bias-correcting *them.* Alternatively just *bias-correction* could also work

L120: perhaps “scenario-independence” would be a term more consistent with the terms already introduced

L147: “the STITCHES algorithm”

Figure 1: Lovely plots, very informative! Font size needs to be increased however.