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Comment on esd-2022-26

Anonymous Referee #1

Referee comment on "The future of the El Niño-Southern Oscillation: Using large ensembles to illuminate time-varying responses and inter-model differences" by Nicola Maher et al., Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2022-26-RC1>, 2022

Review of "The future of the El Niño-Southern Oscillation: Using large ensembles to illuminate time-varying responses and inter-model differences"

I find the paper to be informative and I believe that the community would be interested in this work. The paper is generally well written. My detailed comments are listed below.

- Line 19 P2, add Cai et 2012 Nature <https://www.nature.com/articles/nature11358>; 2014 NCC <https://www.nature.com/articles/nclimate2100#citeas>, as these are among the earliest papers on the topics?
- Line 23, the difference between Cai et al., 2022 and [Wengel et al., 202, Callahan et al., 2021] lies in that one is transient and the others are stabilised CO₂. This should be clarified so as not to create further confusion. Line 45 seems to reinforce the confusion.
- Lines 55-60, paleoclimatic proxy suggests that there is no relationship between mean zonal SST gradient and ENSO variability (Cai et al 2021).
- Line 93, please cite a butterfly effect paper <https://www.nature.com/articles/s41586-020-2641-x> as it is easy to understand. I think the paper also suggests that there is an effect on future ENSO evolution from the initial period.
- Line 155 onward, it is not clear if anomalies are constructed referenced to climatology of individual experiment or the ensemble mean. It should be the former. By definition, a climatology is the average of all years that contribute, such that the anomalies sum to zero. If it is the latter, then the inter-experiment difference in climatology needs to be assessed, and the anomalies might not sum to zero.
- Lines 166-167, "CESM2 is an exception that has opposite changes in El Niño SST amplitude and La Niña duration between the two periods." The Cai et al. 2020 seems to provide a mechanism for this?

- Figure 1, it is interesting that for a SMILE, most experiments behave in a similar way, either unidirectional or reversing, suggesting that it is strongly model dependent. What causes the dependence?
- Line 175, what is the dynamics for increased ENSO seasonality?
- Line 220, are you able to further test the idea of nonlinearity controlling mean state change by relating them in an inter-model/experiment relationship?
- Lines 229 and 289, what is the dynamics for increasing aerosols to drive an increase in ENSO variability? One would expect increasing aerosols to have an opposite impact to that of increasing CO₂. Is it possible that internal variability plays a role in the result?