Earth System Dynamics Discussions

Earth Syst. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/esd-2022-12-RC2, 2022

Comment on esd-2022-12

Anonymous Referee #2

Referee comment on "Contrasting projections of the ENSO-driven CO_2 flux variability in the equatorial Pacific under high-warming scenario" by Pradeebane Vaittinada Ayar et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2022-12-RC2, 2022

Firstly, Vaittinada Ayar et al. evaluated the skill of 16 ESMs from CMIP6 to reproduce the ENSO-CO2 flux relationship in the Pacific Equatorial. For this, model outputs of chemical, physical and biological variables were compared to observational datasets. Secondly, they analysed how the simulated ENSO-CO2 flux relationship evolved in the future (i.e., 2071-2100) using model projections under the SSP5-8.5 scenario. They found that half of the ESMs projected a positive correlation between ENSO-associated warming and sea-air CO2 flux anomalies, instead of the current negative correlation. According to their findings, the future reversal of the ENSO-CO2 flux relationship is induced by the thermal component of pCO2 becoming more important than the non-thermal components. However, they concluded that this reversal is unlikely because it could be related to model biases in the historical period.

Such comparative study of CMIP6 models improve our understanding of the influence of climate modes on the carbon cycle and could provide useful metrics to evaluate ESMs. The manuscript is clear and well written. However, I have some questions about the evolution of the simulated CO2 flux anomaly variability which is different between ESMs identified as "reversed" or "preserved". Therefore, the paper will likely be a significant scientific contribution with minor revisions.

General comments:

1) Figure 5 and Line 206: "This reversal is thus independent on the performance of the model over the contemporary period, though the models in the first row tend to simulate lower than observed CO2 flux anomaly variability."

Firstly, after reading the manuscript, the results suggested that the reversal behavior was indeed induced by the model performance in the contemporary period. Authors should modify or clarify this sentence.

Secondly, when looking at figure 5, the lower CO2 flux variability in the "reversed" ESMs than in the "preserved" ESMs is a striking feature. I would like to see some discussion about the influence (or the relationship) of this feature with the conclusions. For example, could the historical low CO2 flux variability in the "reversed" ESMs be related to their higher carbon uptake than in the "preserved" ESMs? Authors focused on the understanding of the correlation between the annual CO2 flux and the ENSO index, but could some of their findings explain the variability in the amplitude of the simulated CO2 flux anomalies? As a reminder, most models underestimated the CO2 flux variability (line 197 and Table 3) and according to the figure 5 this is more visible in the "reversed" ESMs.

2) Authors estimated the depth of the thermocline (line 105) but their discussion and conclusions focused on the stratification (or the vertical gradient), which are two different concepts. Although there is no difference between the two ESM groups in term of "thermocline depth" (line 306) the vertical stratification might be different. Therefore, could authors replace their "thermocline depth" estimate with a stratification estimate.

Minor comments:

3) Line 28: "…the Equatorial Pacific CO2 flux represents the dominant mode of variability of the global oceanic CO2 flux variations (Wetzel et al., 2005; Resplandy et al., 2015…". According to Resplandy et al. (2015), for some ESMs, the Southern Ocean can also be the dominant mode of variability of the global oceanic CO2 flux variations.

4) Line 110 – At which temporal resolution is the thermocline depth estimated? Monthly?

5) Line 175: "Note that the observed average is the result of the climatology over the 2004-2017 period while the average for CMIP6 is computed over 30 years (1985-2014)." Could authors calculate the CMIP6 climatology using the same period (i.e., 2004-2017)? If not, this information should be included in Figure 3.

6) Line 188: "The correlation between annual CO2 flux anomaly and annual ENSO index is given for the models for each 30-year sliding window over the 1850-2100 period." Why did author choose a 30-year sliding window? Is it the observational period? This information needs to be added.