Response to RC1:

In general, I would not recommend this manuscript for publication as-is. A lot of the claims made in the text are not supported by the data presented in the figures (more details in the major comments). I also have a few minor comments on typos and clarifications. I would gladly review a revision of the manuscript.

Reply: We sincerely appreciate your effort and time in reviewing our manuscript as well as constructive comments/suggestions, and grammar corrections. We have attempted to revise the manuscript in the light of your suggestions/comments. The following is also the point–point response to all the comments (comments are rewritten in black color and their corresponding replies in red).

Major comments:

- L.295-7 The data shown in figure 6 does not support the conclusion that there is an increase in the peak interval, height, and width with SAI relative to GHG only. For CESM1, there is virtually no difference between the two. For CESM2, there are modest increases in the median value for some of the measures, but if you consider the upper and lower quantiles, the values are not that different. I would include more caveats in your statement. And unless there is in fact a significant difference, I would remove the arrows between the medians as I find some slightly misleading.

Reply: Agreed. We have rewritten this part as follows:

"Nonetheless, for the CESM2 SAI experiment, there are modest increases in the median values for peak intervals, height (i.e., intensity), and width (i.e., duration) of both the El Niño and La Niña episodes relative to the global warming SSP5-8.5 scenario without SAI, except for peak interval during El Niño which shows no differences between the two (Fig. 6g). In contrast, for CESM1, there are no remarkable differences between the results from RCP8.5 and GLENS-SAI scenarios. However, while CESM2 provides more ensemble members over the historical period, SAI tends to compensate for the changes in frequency, intensity, and duration of the El Niño and La Niña episodes."

Furthermore, the red arrows have been removed from the new Fig. 6 as follows:
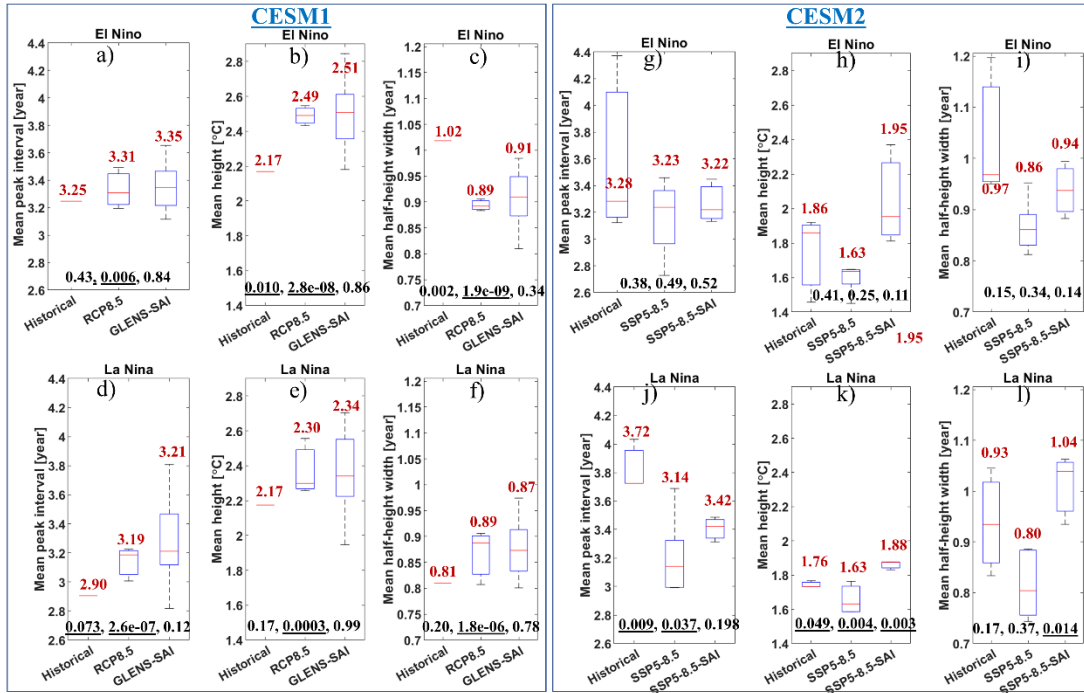
Figure 6. The projected changes in the mean peak interval, height, and half-height width of El Niño and La Niña events for global warming (RCP8.5 and SSP5-8.5) and SAI (GLENS-SAI and SSP5-8.5-SAI) scenarios simulated by CESM1 (left panel) and CESM2 (right panel). The median for each experiment is denoted by the red line, the upper (75th) and lower (25th) quartiles by the top and bottom of the box and ensemble limits by the whisker extents. The values labeled in red on each box show their median. The p-values shown at the bottom of each box in black are obtained from the t-test where the underlined values are significant (p<0.05).

- L.320-3 The evidence for these claims do not seem very robust, given that the historical simulation has only one ensemble member. Is there a better way of quantifying the importance of the differences between the green and blue/red lines?

Reply: We have added two new Figures S4 and S5 to the Supplementary Information to show the wavelet power spectrum diagrams at periodicity-time space for the ENSO and PDO, respectively obtained from historical, RCP8.5, and GLENS-SAI scenarios. For ENSO, Figure S4 illustrates the dominant historical inter-annual modes show no significant change under both global warming and SAI at the periodicity-time space. For PDO, the historical time series has two clear dominant modes, at inter-annual (i.e., 3 to 4.5 years)

and near decadal (6 to 10 years) scales (Figs. S5a and S5b), of which the inter-annual is relatively preserved under both global warming and SAI, but the near decadal mode is largely weakened and shifted to longer modes under global warming (Figs. S5c and S5d) and SAI does not effectively restore it (Figs. S5e and S5f). However, this part has been rewritten as follows:

"For ENSO, the dominant historical inter-annual modes show no significant change under both global warming and SAI (Fig. S4). Historical PDO also has two clear dominant modes, at inter-annual (i.e., 3 to 4.5 years) and near decadal (6 to 10 years) scales, of which the inter-annual is relatively preserved under both global warming and SAI, but the near decadal mode is greatly weakened under global warming and SAI does not effectively restore it (Figs. 7 and S5). PDO dominant modes have lower powers under both RCP8.5 and GLENS-SAI climate changes scenarios compared with the historical PDO signal."

About a single ensemble member for the historical period under CESM1, you are right; that is why we further focused on the CESM2 results having three ensemble members for the historical simulations as shown in Fig. 8. As we further discussed in the paper "Model-observation differences are larger in the earlier CESM1 version than in CESM2."
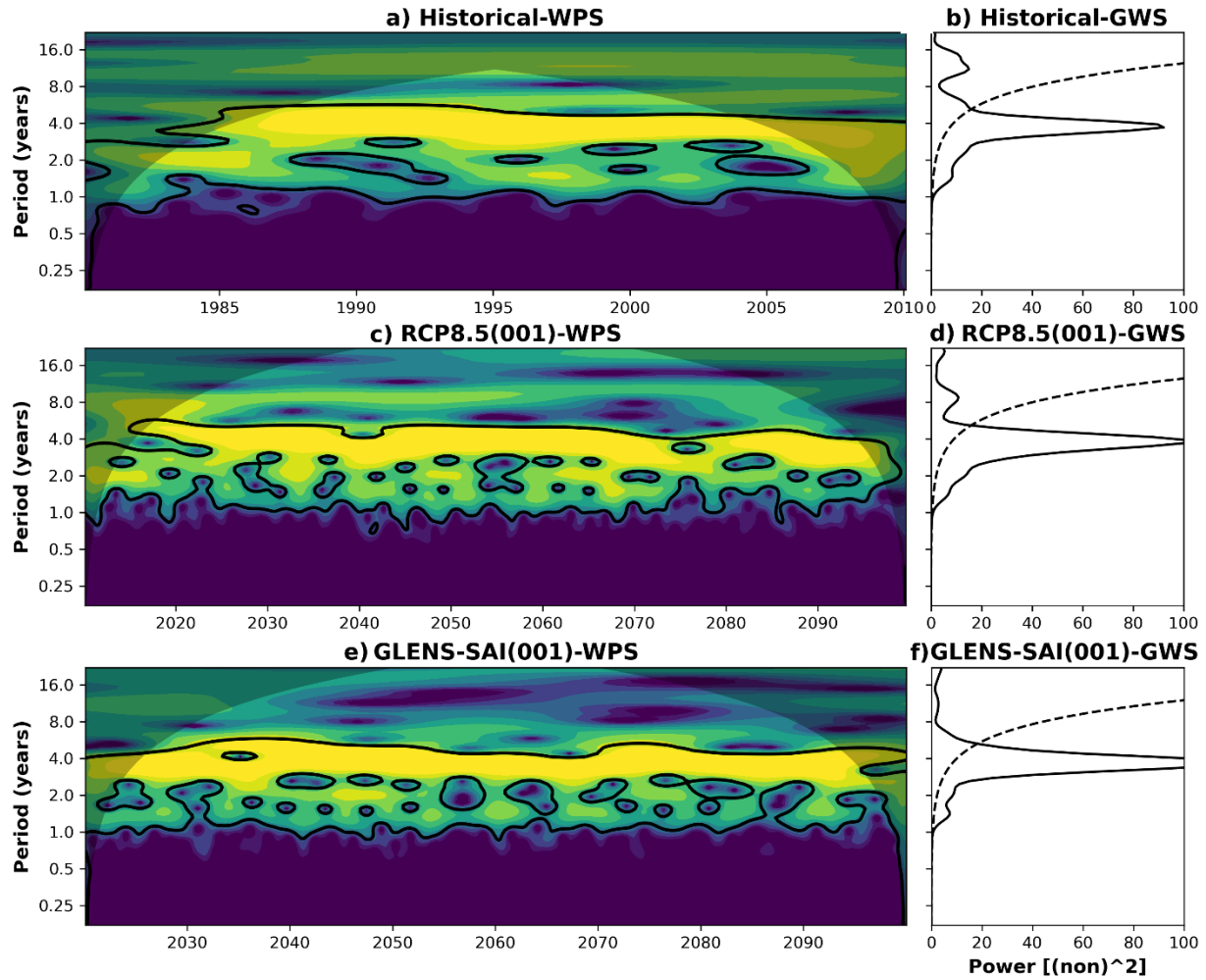
Figure S4. The wavelet power spectrum WPS (left column) and global wavelet spectrum GWS (right column) of ENSO obtained from CWT for the (a and b) historical, (c and d) RCP8.5, and (e and f) GLENS-SAI scenarios.
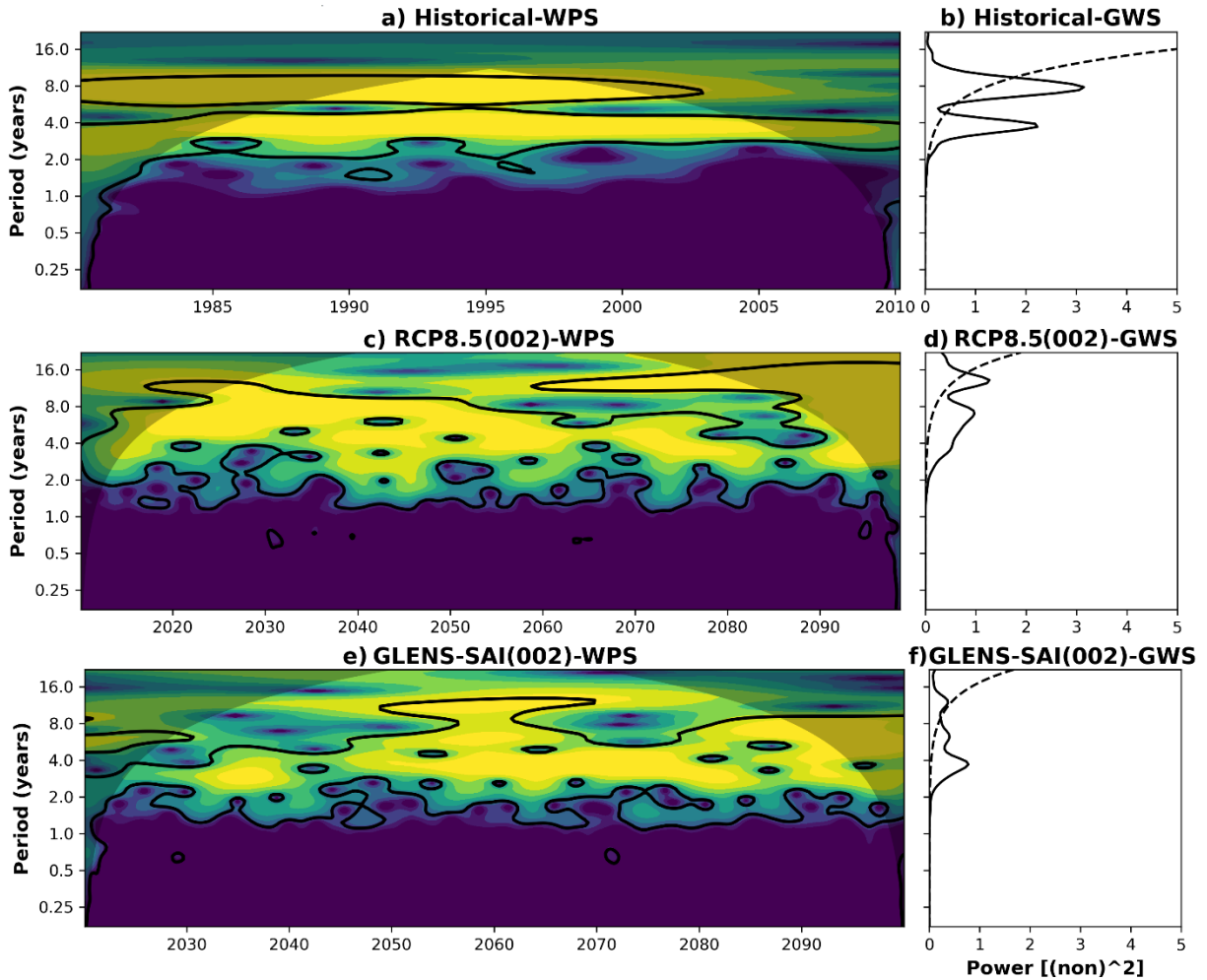
Figure S5. The wavelet power spectrum WPS (left column) and global wavelet spectrum GWS (right column) of PDO obtained from CWT for the (a and b) historical, (c and d) historical, (c and d) RCP8.5, and (e and f) GLENS-SAI scenarios.

- L. 338 Why is the power of the historical NAO considerably smaller than that of the SSP585 and SAI runs?

Reply: We have re-checked all the steps and the codes from scratch, it was due to a small error in the code we wrote to compute the historical NAO from CESM2 PSL data. After correction, the power of the historical NAO in the new Fig. 8 is similar to the future simulations:
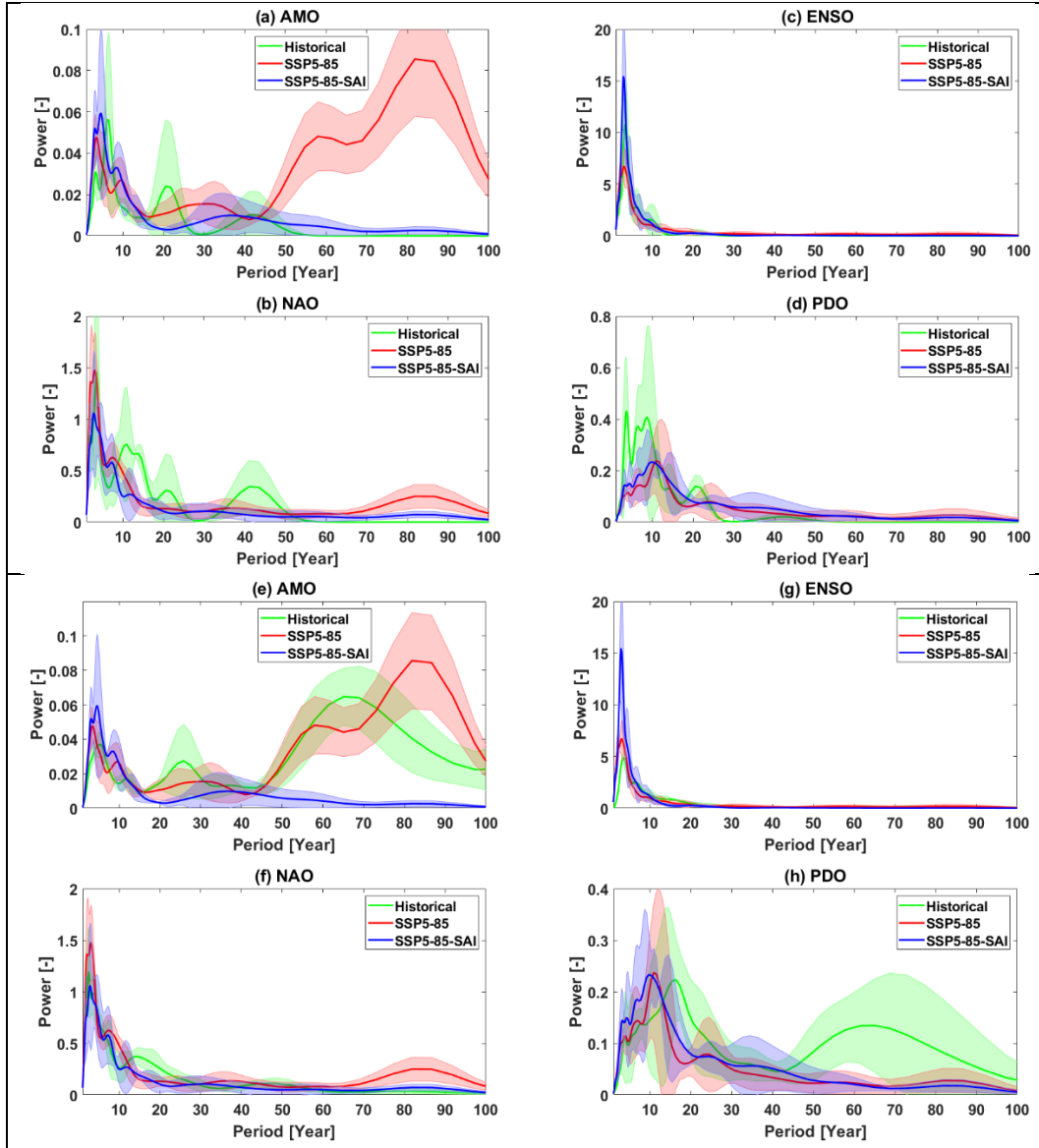
Figure 8. As Fig. 7 but for CESM2 under SSP5-8.5 and SSP5-8.5-SAI relative to the historical results for the periods of 1980-2009 (upper panel; a to d) and 1850-2014 (lower panel; e to h). Shading in each curve shows the across-ensemble range.

- L. 344 Confused by the use of "counter-productive" here. It seems like the AMO in SSP585 is closer to historical than the SAI simulations (fig. 8e), but that is not the case for the NAO (fig. 8f).

Reply: We have revised this part as follows:

"For the decadal and longer periodicities, SAI accentuates AMO changes induced by greenhouse gases (Figs. 8e). For example, the dominant modes at 20-30- and 55-85-year of the AMO,

observed during the historical period, show no significant changes under global warming; however, they vanish under SAI (Fig. 8e). The decadal 10-20-years mode of the historical NAO is not preserved in the global warming scenario nor with SAI (Fig. 8f)."

- L.348 I am a little confused about how to interpret "the dominant 35-55 year mode in historical NAO" in fig 8f, given that its power is so much smaller than that of the SSP585 and SAI simulations.

Reply: We have completely removed this sentence from new Fig. 8f it is clear that the 35-55 year mode in historical NAO is roughly in the same power range of the SSP5-85 and SAI simulation's results.

- L.349-351, Maybe it is clearer to say that the 10-20 and 50-70 year modes present in the historical simulations are not present in both the SSP585 and SAI simulations, and the latter two are similar to eachother.

Reply: We have rewritten it as follows:

"The dominant modes at 10-20- and 50-70-years, observed in historical PDO (consistent with the real PDO's dominant modes (Mantua et al., 1997)), are not present in both the SSP5-8.5 and SAI simulations, and the latter two are similar to each other (Fig. 8h)."

Minor comments:

Typo "relatted" figure 1.
Reply: It has been corrected (Please 1).

L.238-240 "broaden" typo?
Reply: It has been replaced by "broadens".

L.290-1 With increases in greenhouse gases.
Reply: Implemented.

L.298 CESM

Reply: Implemented.

Figure 6 CESM2 panel, 1.95 between panel h and k.

Reply: It has been removed (Please see new Figure 6).

Figure 6, add in the title what the red line, box, and whiskers represent.

Reply: We have added the following sentences to the caption:

"The median for each experiment is denoted by the red line, the upper (75th) and lower (25th) quartiles by the top and bottom of the box and ensemble limits by the whisker extents."

L.366 use 2xCO2 and 0.5xCO2.

Reply: Implemented.

L.400 rephrase: how good each model's simulations are?

Reply: Implemented.

L.422 usual -> more likely?

Reply: Implemented.

L.424 Explain "devil's staircase" or remove.

Reply: It has been removed.

L.442-3 Models are different from obs, but they are not "simulating a different system".

Reply: We do not mean the models simulate different systems, just the models are not perfect. However, for clarification we have rewritten it as follows:

"As noted in Section 4.1 both CESM versions do present differences from observations, so they are not perfect. All climate models are unavoidably uncertain (Knutti et al., 2002), mostly because of the imperfect understanding of many of the interplays and feedbacks within the climate system (Jun et al., 2008)."

L.445 actuality -> observations.

Reply: Implemented.

L.447-8 rephrase, I am confused. Remove "that is … response of the system"?

Reply: Implemented.

L.468-9 I would remove the last sentence.

Reply: Implemented.

L.475 Some historical data cover more years than that.

Reply: It has been re-written to add the requested point: "The impacts of these interventions are assessed against historical (1980-2009 for both the models and 1850-2014 for CESM2 in some analyses) and projections under RCP8.5 and SSP5-85 (for the GLENS-SAI and SSP5-8.5-SAI, respectively)."

L.489 impact them -> restore them?

Reply: Implemented.

L.498 Caution is warranted due to …

Reply: Implemented.