Does the Lack of Coupling in SST-Forced Atmosphere-Only Models Limit Their Usefulness for Climate Change Studies?

Supplementary Material

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The main article examined the impact of lack of coupling with an underlying ocean by using AMIP simulations forced with daily mean SST and sea ice. The daily mean input was used instead of the monthly mean in order to maximize the similarity of SST between the coupled and AMIP simulations so that the difference between the coupled and AMIP simulations only results from the lack of two-way coupling. However, in common procedures of AMIP simulations, the monthly mean input is used most of the time. This supplementary material offers an investigation on the impact of the temporal resolution of the boundary condition on AMIP-type simulations of anthropogenic climate change.

Figure S1 shows the change in precipitation at $4xCO_2$ from the monthly-SST forced AMIP simulation. Overall, the monthly-SST forced AMIP simulation shows the same level of performance as the daily-SST forced AMIP simulation. The change of the temporal resolution of the boundary conditions from daily to monthly mean does not change the overall magnitude of error, which can also be seen in other variables (Fig. S2). Although the spatial structure of error changes, it is most likely due to the randomness of error, which is only associated with internal variability (also seen in the bottom 3 panels of Fig. 1).

To further investigate the impact of the temporal resolution of the input data, we increase the integration time step of the idealized atmospheric model by 100 times (i.e., from 6 days to 20 months). As shown in Fig. S3, the increase of the time step smoothens the time series of the temperature anomaly but the long-term trend is unaffected. This indicates that changes in the temporal resolution of the boundary condition should not impact AMIP-type simulations of anthropogenic climate change.

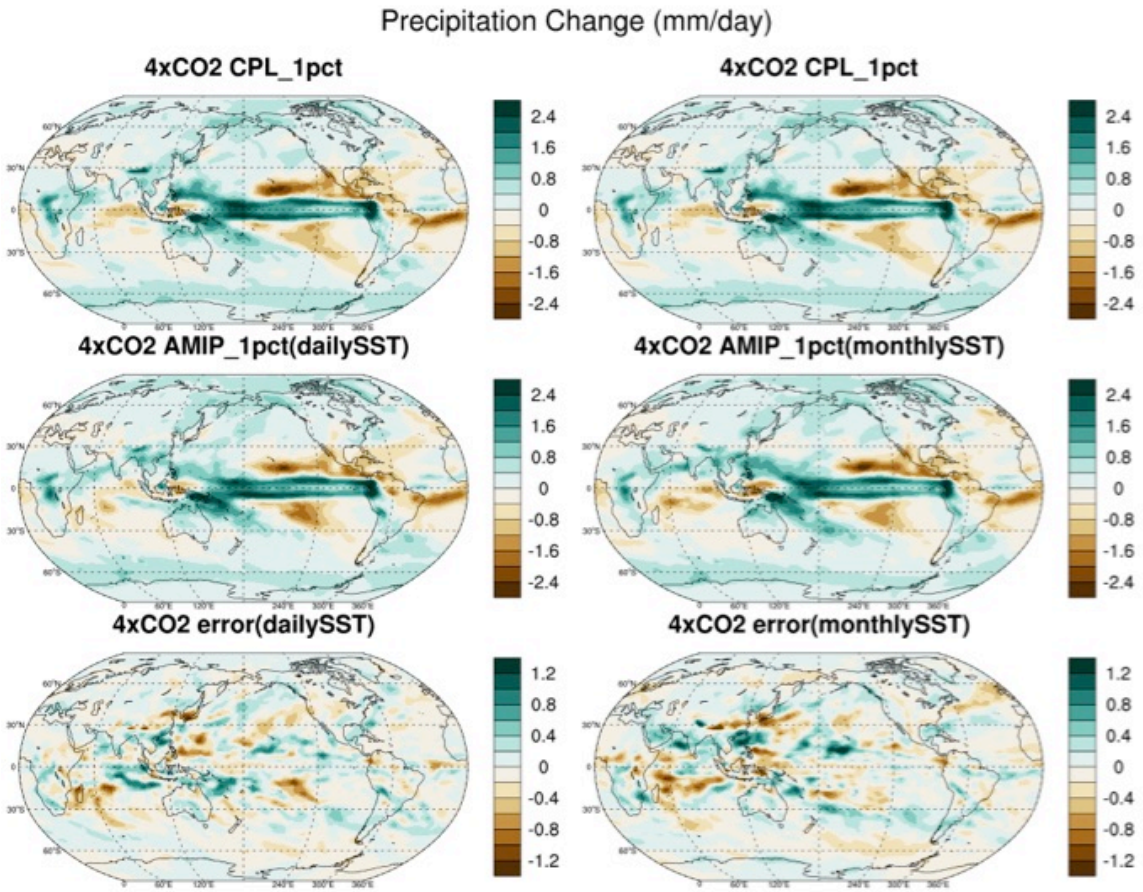

Figure S1. Precipitation change at $4xCO_2$ from (top) coupled, (center) AMIP simulations and (bottom) error defined as the difference between the AMIP and coupled simulations. The right column shows the results from the daily-SST forced AMIP simulation, whereas the left column shows the monthly-SST forced AMIP simulation.

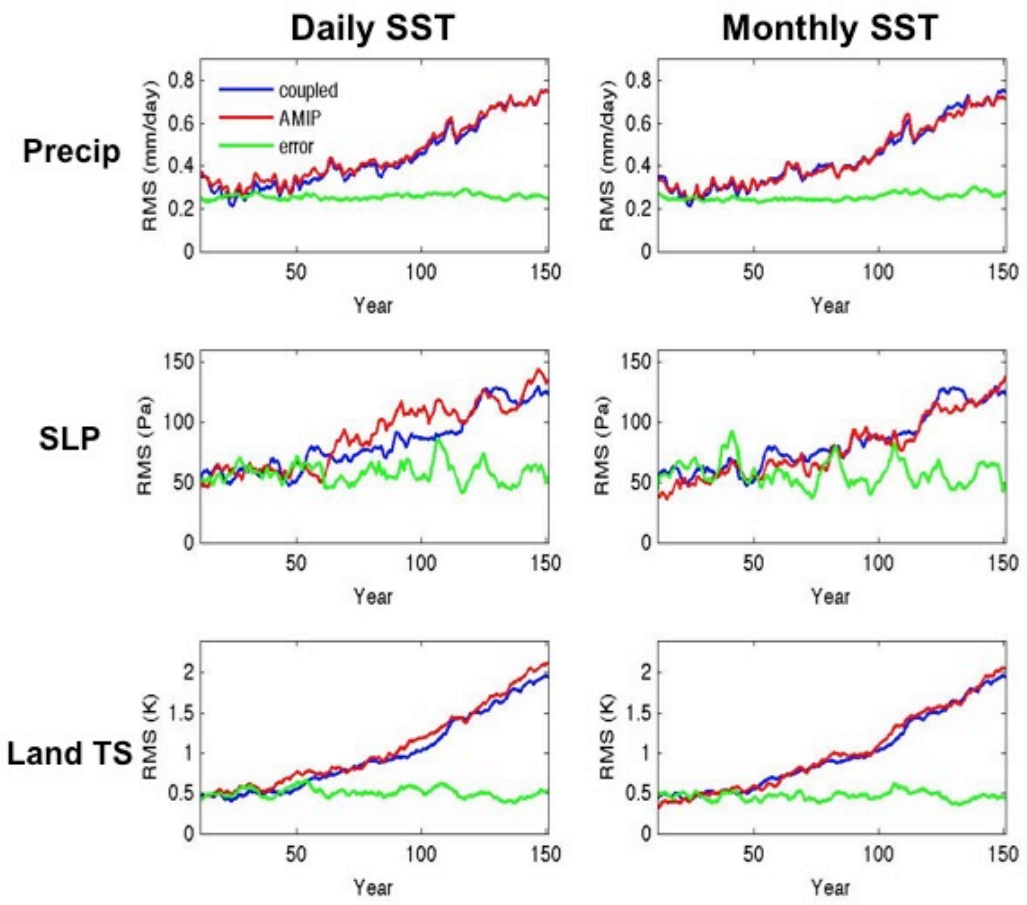

Figure S2. Moving RMS of changes in the 10-year mean (top) global precipitation, (middle) global SLP and (bottom) relative land surface temperature calculated the same way as Fig. 2. Numbers on the x-axis represent the first year of the moving epoch. Blue and red represent the moving RMS from the coupled and AMIP simulations, respectively. The right column shows the results from the daily-SST forced AMIP simulation, whereas the left column shows the monthly-SST forced AMIP simulation. Green represents the moving RMS of errors, which is the difference between the climate change in the AMIP simulations and that in the coupled simulations.

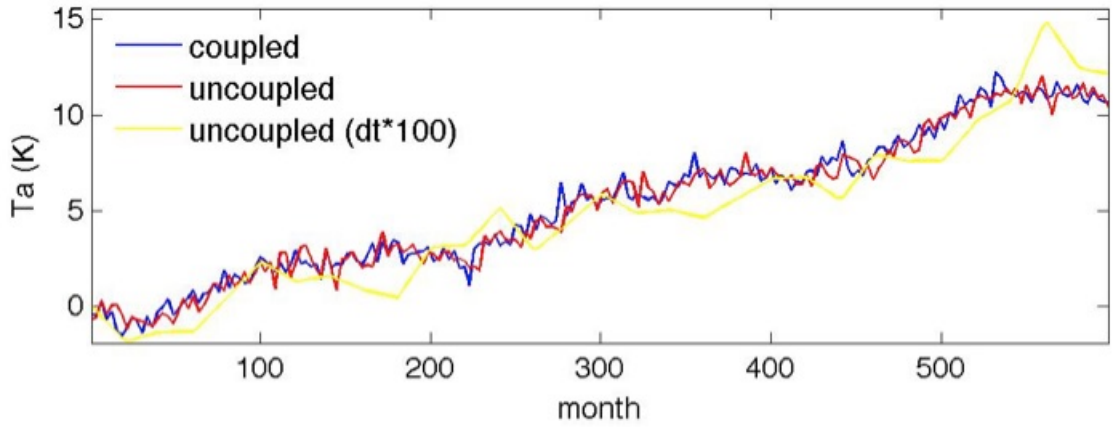

Figure S3. Time series of 3-month mean atmospheric temperature anomaly from the one-dimensional stochastic model for the (blue) coupled integration, (red) uncoupled integration and (yellow) uncoupled integration in which the time step was increased by 100 times. SST is the same in all three integrations.