Supplementary Material for

Atmospheric and Oceanic Origins of Tropical Precipitation Variability

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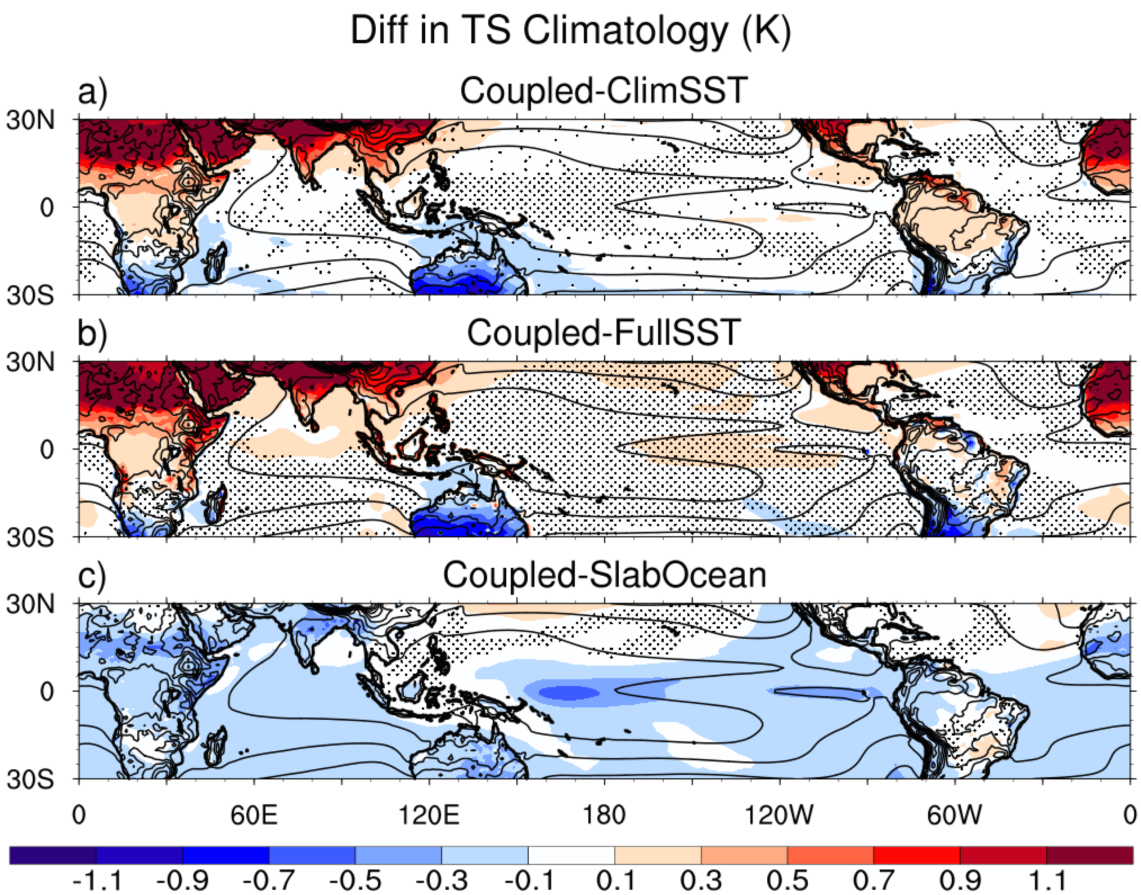

Figure S1. Differences in annual mean surface temperature climatology between (a) Coupled and ClimSST, (b) Coupled and FullSST and (c) Coupled and SlabOcean. Contours show the climatological surface temperature climatology with an interval of 3K. Differences in DJF and JJA climatologies show similar patterns. Areas where the difference in variance is not significant at the 99% level based on the student t-test are stippled.

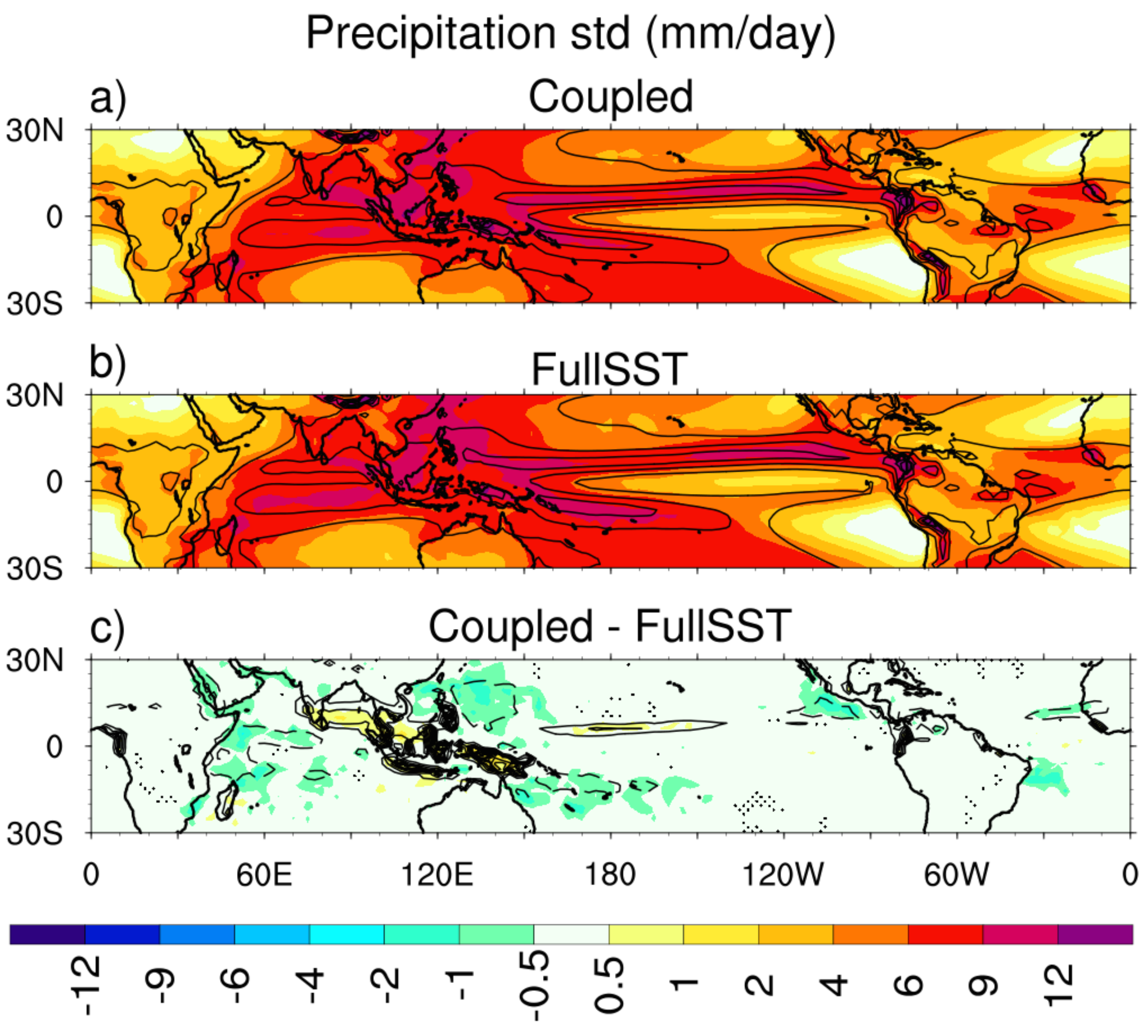

Figure S2. Mean (contours) and standard deviation (color shading) of daily precipitation anomalies from (a) the Coupled run, (b) the FullSST run and (c) their difference. Results from the Coupled run are calculated as the average of 18 non-overlapping 100-year segments, whereas results for the FullSST run are calculated using the available 100 years. Contour interval is 3 mm/day starting at 3 mm/day in (a) and (b), and 0.3 mm/day in (c) with dashed lines indicating negative values. Stippling in (c) indicates that the difference in variance does not pass the 99% significance level based on the f-test. Note that the FullSST run is forced with monthly mean SST anomalies. The small difference in variance between the two runs (which matches the difference in climatology) indicates that the lack of two-way coupling and the lack of sub-monthly SST variability do not substantially affect the simulation of precipitation variance.

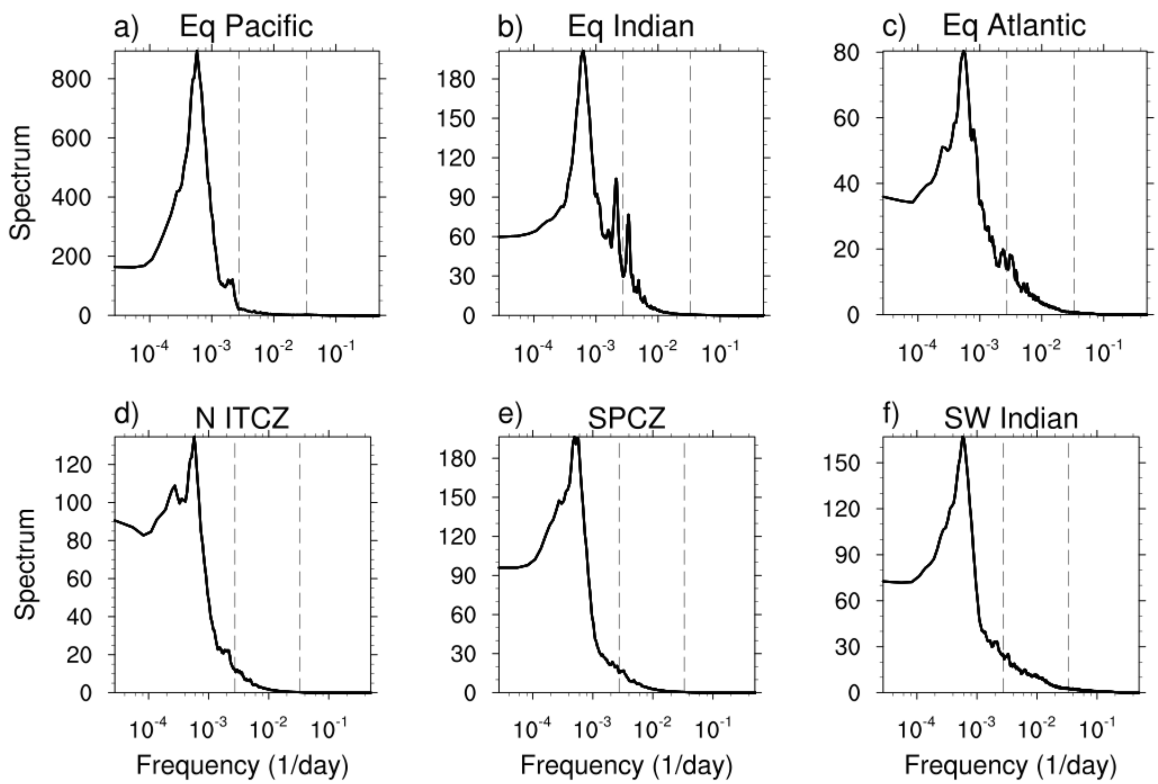

Figure S3. Regional average surface temperature power spectra from the Coupled run. The location of the regions is shown as the purple boxes in Figure 2g in the main text. The spectra are calculated as the average of partially overlapping 100-year segments from the daily output.

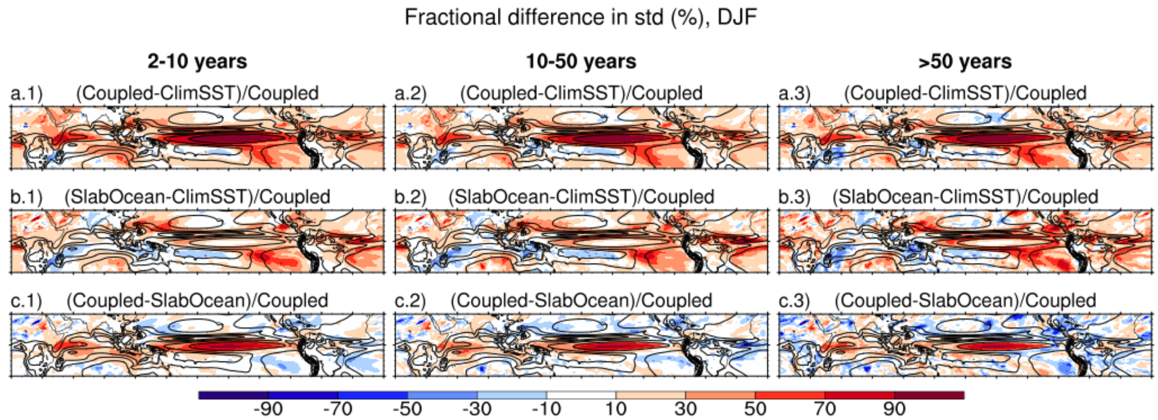

Figure S4. Fractional difference in precipitation standard deviation (color shading) between (a) Coupled and ClimSST, (b) SlabOcean and ClimSST and (c) Coupled and SlabOcean, using (left) 10-year high pass, (middle) 10 to 50-year band pass and (right) 50-year low pass yearly DJF precipitation anomalies. The fractional difference is shown as a percentage relative to the Coupled standard deviation. DJF mean precipitation climatology from the Coupled run is plotted as contours. Contour interval is 3 mm/day starting at 3 mm/day.

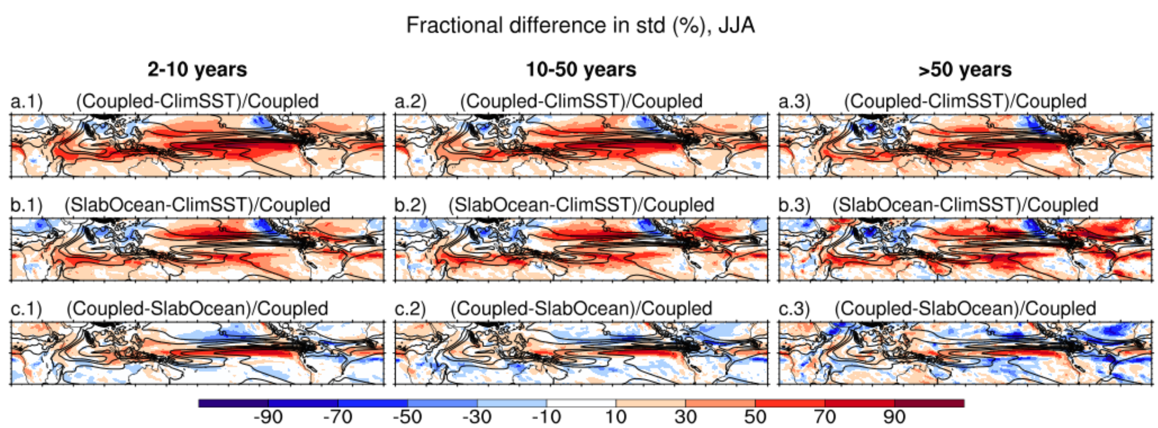

Figure S5. The same as Figure S4, except for JJA.

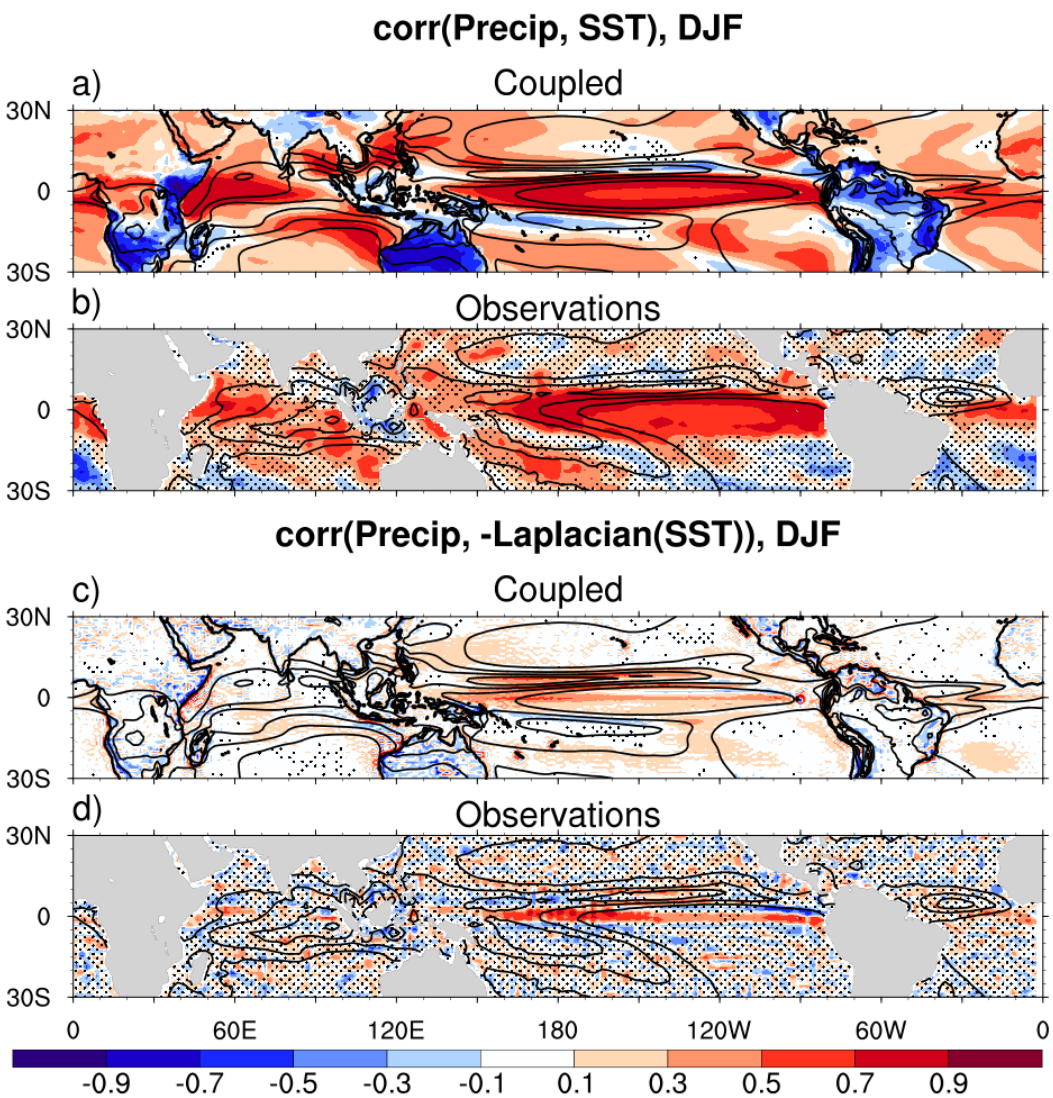

Figure S6. Pointwise correlation between DJF anomalies of precipitation and surface temperature in (a) the Coupled run and (b) observations and between DJF anomalies of precipitation and the negative of the Laplacian of surface temperature in (c) the Coupled run and (d) observations. The observed surface temperature is taken from the merged Hadley-NOAA/Optimal Interpolation SST (Hurrell et al. 2008) instead of GISS because the latter only provides surface temperature anomalies, which alone does not yield the Laplacian of surface temperature without information about the mean climatology. The observations span 1979/02 to 2012/01. The Laplacian is calculated using spherical harmonics, and all observations are interpolated to the CAM model grid before calculating the Laplacian. The DJF mean precipitation climatology is plotted as contours. Contour interval is 3 mm/day starting at 3 mm/day. Stippling indicates that the linear correlation between precipitation and surface temperature or between precipitation and the Laplacian of surface temperature is not significant at the 99% level based on the two-sided t-test. A comparison between (a, b) and (c, d) indicates that monthly precipitation anomalies are more closely related to local SST rather than local SST gradient.

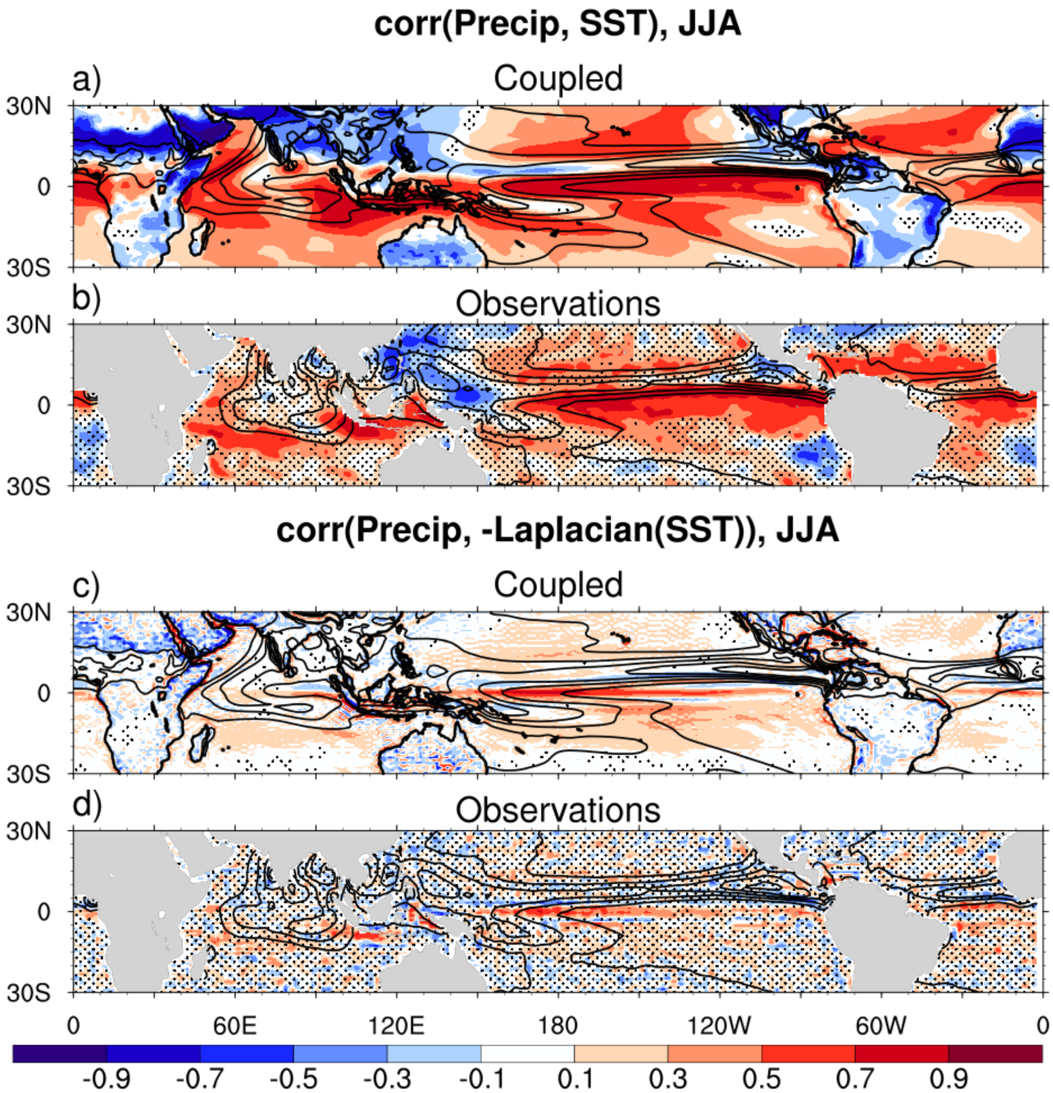

Figure S7. The same as Fig. S6, except for JJA.

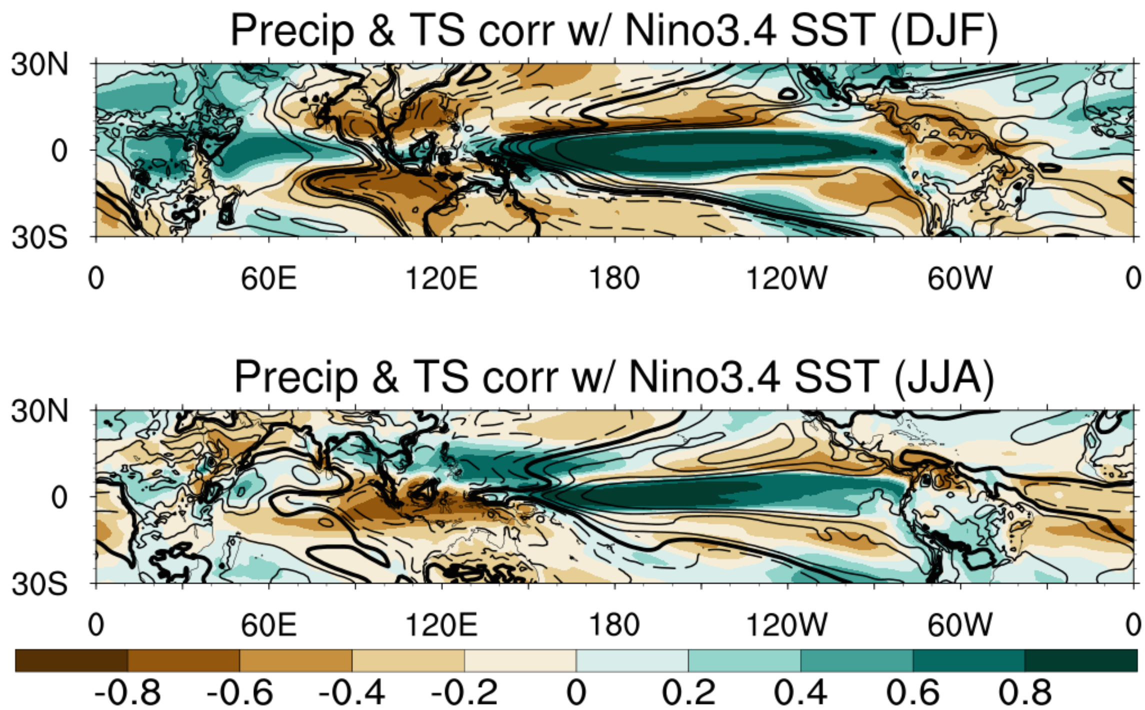

Figure S8. Precipitation (shading) and surface temperature (contour) correlation with Nino 3.4 SST anomaly using yearly DJF (top) and JJA (bottom) output from the Coupled run. The Nino 3.4 region is defined as the area from 5S-5N and 170-120W. Contour interval is 0.2. Dashed contours represent negative values. The zero contour is thickened.

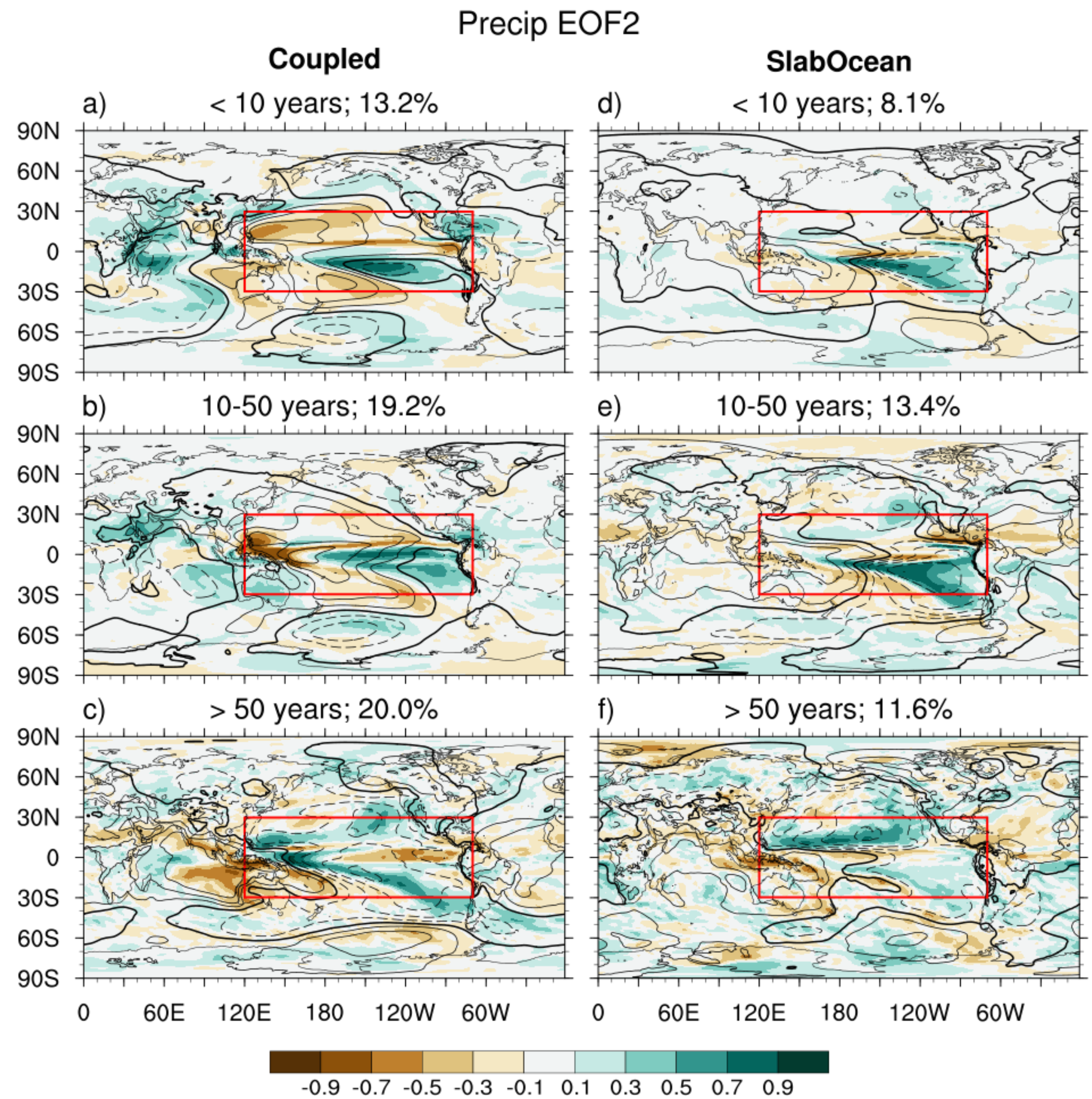

Figure S9. The same as Figure 12 in the main text, except for EOF2 instead of EOF1.

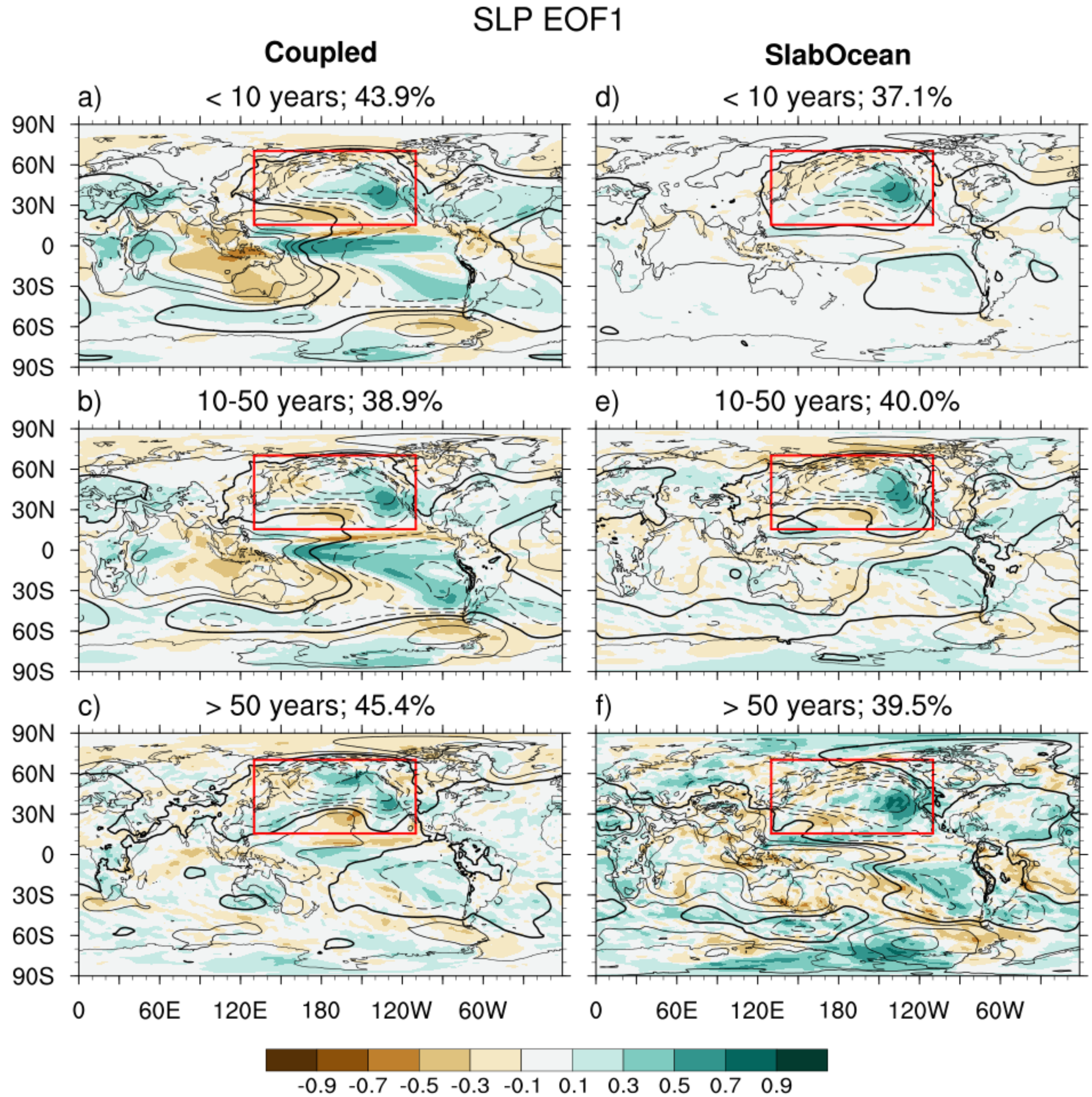

Figure S10. The same as Figure 14 in the main text, except for North Pacific (outlined by the red box) instead of South Pacific.

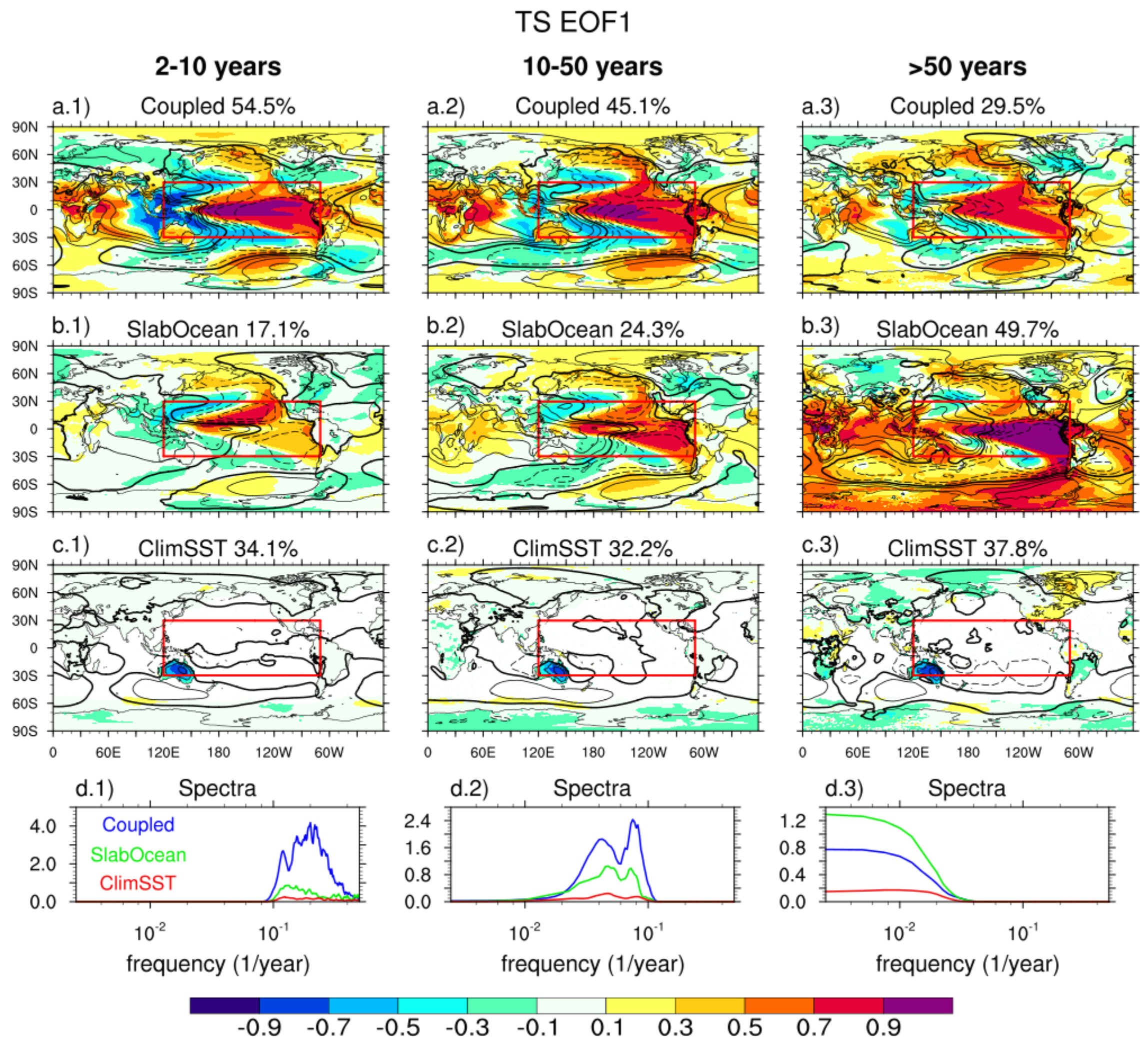

Figure S11. Linear correlation of surface temperature (shading) and SLP (contour) anomalies with the leading PC of surface temperature anomalies in the tropical Pacific region, which is marked by the red boxes. Data are the annual mean output filtered by (left column) 10-year high pass, (middle column) 10-year to 50-year band pass and (right column) 50-year low pass. (a), (b) and (c) are results from the Coupled, SlabOcean and ClimSST simulations, respectively. Contour interval is 0.2. Dashed contours represent negative values. The zero contour is thickened. Variance explained by the first EOF is shown in the title of each panel. (d) shows the power spectra of the first PC (scaled by a factor of 1/1000) for the corresponding timescales. It can be seen from (d.3) that the multi-decadal "ENSO-like" variability in the SlabOcean run is stronger than that in the Coupled run.

Reference

Hurrell, J. W., J. J. Hack, D. Shea, J. M. Caron, and J. Rosinski, 2008: A new sea surface temperature and sea Ice boundary dataset for the community atmosphere model. *J. Clim.*, **21**, 5145–5153, doi:10.1175/2008JCLI2292.1.