Electronic Supplementary Materials for Pacific Meridional Mode over the last millennium

Sara C. Sanchez[1], Dillon J. Amaya[1], Arthur J. Miller[1], Shang-Ping Xie[1], Christopher D. Charles[1], Scripps Institution of Oceanography, San Diego, CA 92037

Corresponding author: sasanch@uw.edu

Introduction

This appendix contains supplementary information for (1.) An evaluation of the role of the Samalas eruption on the average moving standard deviation of the Pacific Meridional Mode (Figure S1); (2.) composites of the extremes in the PMM variance (Figure S2); (3.) Observed DJF wind anomalies associated with the North Pacific Oscillation and the Pacific Meridional Mode Index (Figure S3); (4.) an evaluation of the diversity in the response to volcanic eruptions within single ensemble members (Figure S4); (5.) and a least squares linear regression plot of surface temperatures on the standard deviation of the PMM in the CESM-LE Slab Ocean Control simulation (Figure S5).

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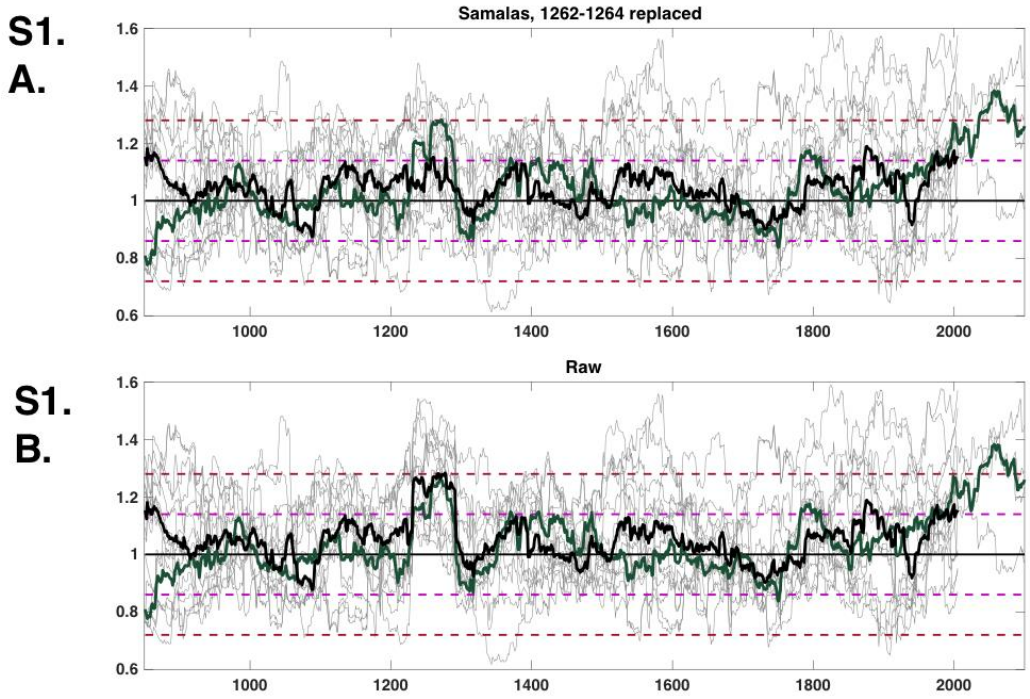

Figure S1 Evaluation of 30 year moving standard deviation of PMM index (using the SST expansion coefficient) over the Samalas Volcanic eruption. Figure (**A)** shows that when the three eruption response years (1261-1263) are replaced with random values within one sigma of the mean, there is no notable increase in variance during the 1230 to 1290 period. (**B),** same as A, but calculated using all years highlights that the Samalas Volcanic eruption of 1258 creates an extremely short-lived anomaly that overwhelms the 30 year moving standard deviation methodology.

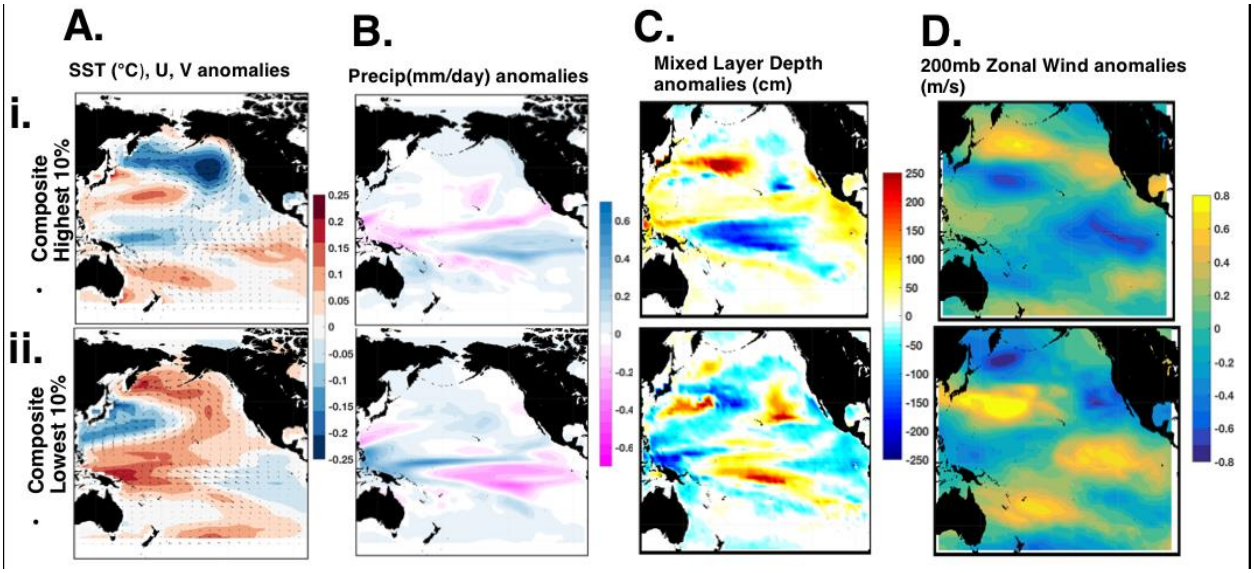

Figure S2 The composite of the highest 10% and lowest 10% of PMM variance years in each of the 12 "All Forcing" ensemble members (12 ensemble members of 1156 years. Similar and physically consistent patterns emerge between this and the linear regression approach in Figure 3.4. It should also be noted that the middle 80% of events from the composites average out to roughly zero anomaly. (**A)** SST and wind vector composites (**B)** Precipitation composites (**C)** Mixed layer depth composites. (**D)** 200mb zonal wind composites.

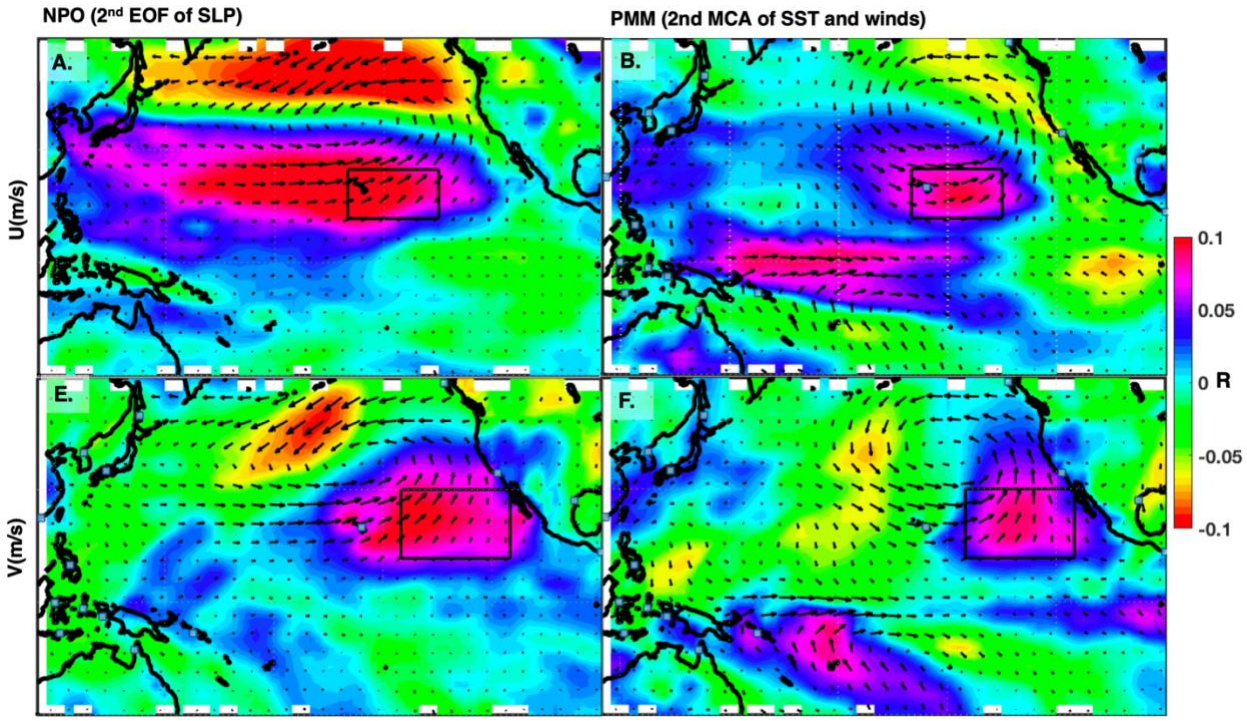

Figure S3. Observed DJF wind anomalies associated with the North Pacific Oscillation (A, E) and the Pacific Meridional Mode Index (B, F). Same procedure as Figure 6, except the analysis only considers data from the NCEP NCAR Reanalysis version 1 over the years 1948-2016. The exact location of the bolded boxes are further westward in the CESM-LME, illustrated in the corresponding panels of Figure 6. In the reanalysis, zonal winds are particularly influential over the 10-25°N, 200-225°E region, while meridional winds are influential over the 10-30°N, 215-245°E region. The magnitude of the correlation coefficients are reduced, yet still illustrate that the DJF NPO variability has a role in generating MAM PMM variability.

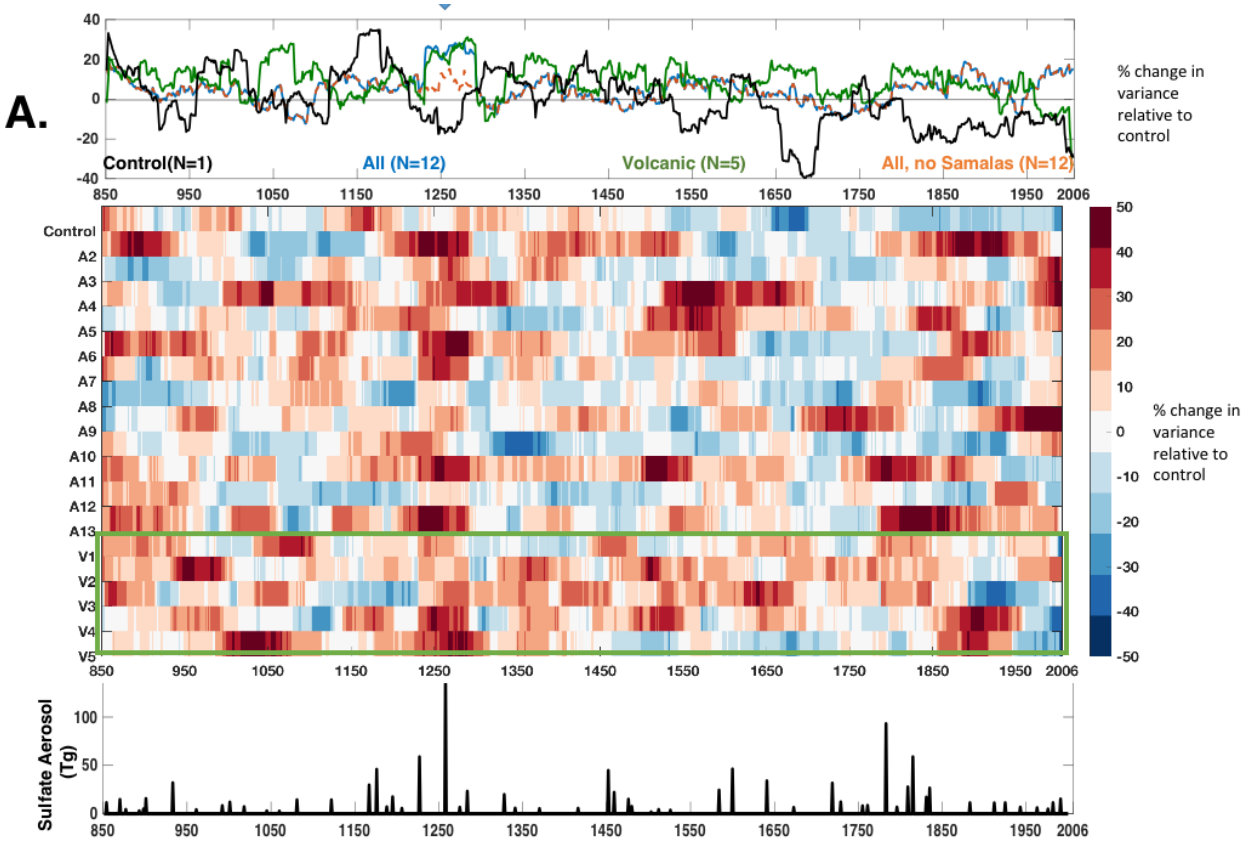

Figure S4. Illustration of the diversity within ensemble members in response to volcanic eruptions. (**A)** The first portion features the timeseries of the 30 year moving standard deviation of the control run (black, single ensemble member), the All Forcing experiment (blue, 12 ensemble members), the Volcanic-Only experiments (green, 5 ensemble members), and the All Forcing experiment, excluding the 3 years of extreme variance post Samalas eruption (orange, 12 ensemble members). The Y axis of this plot is slightly different from Figure 3. To convert the previous plots into this scale, merely subtract 1 and multiply by 100% to get a change in variance relative to the control. (**B)** The middle plot shows the relative increase or decrease in variance (relative to the control run) in each ensemble member. 18 Ensemble members are shown here; the Control at the top, the 12 All Forcing experiments, and 5 Volcanic-Only experiments. (**C)** The bottom plot shows the volcanic eruptions used in this model from the Gao 2008 study. With the exception of the enormous Samalas eruption, no consistent PMM response to volcanoes is observed in the LME.

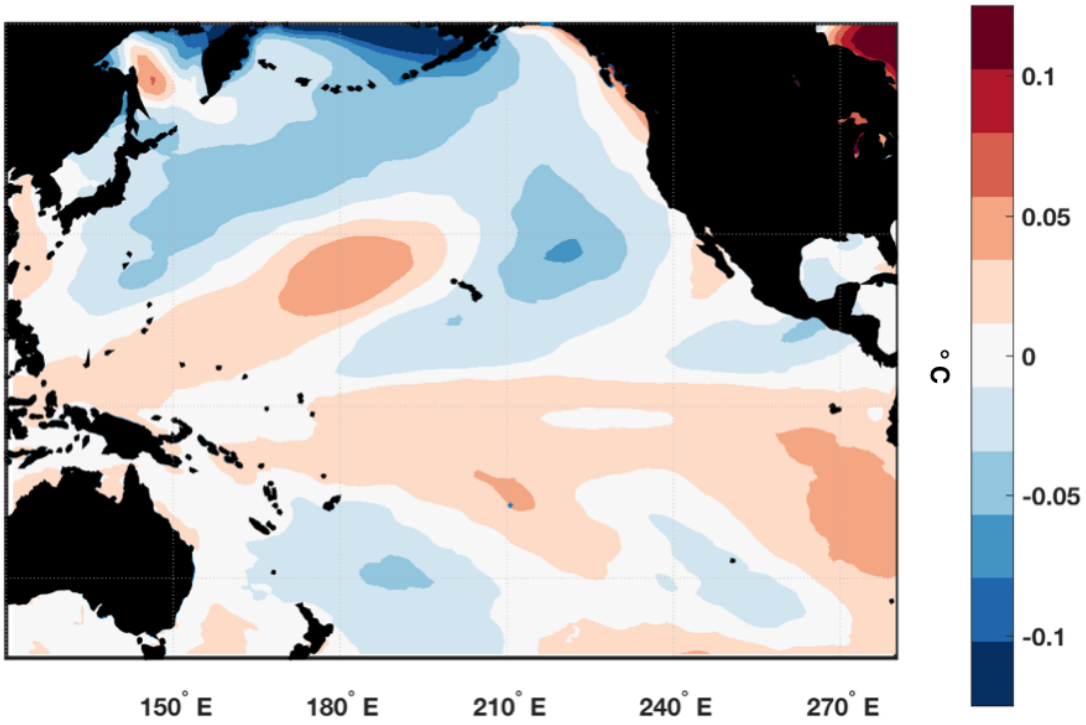

Figure S5 Least squares linear regression of DJF (+1) surface temperature on the 30-year moving standard deviation of the PMM index in CESM-LE Slab Ocean Control simulation. Same procedure as Figure 4A, except the slab ocean control simulation encompasses 900 years instead of 1156 years. In this figure, the anomalies of the equatorial Pacific stand in sharp contrast to the fully coupled experiment (Figure 4A).

Electronic Supplementary Materials References

Gao, C., Robock, A. and Ammann, C., 2008. Volcanic forcing of climate over the past 1500 years: An improved ice core-based index for climate models. *Journal of Geophysical Research: Atmospheres*, *113*(D23).