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Supporting Information for "Immediate and long-lasting impacts of the Mt. Pinatubo eruption on ocean oxygen and carbon inventories"

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Contents of this file

1. Figures S1 to S11

Introduction This supporting information provides additional figures to support the findings presented in the manuscript. We show the complete time series (1990-2025) for most of the main figures as well as additional information related to climate indices which help with the interpretation of the results.

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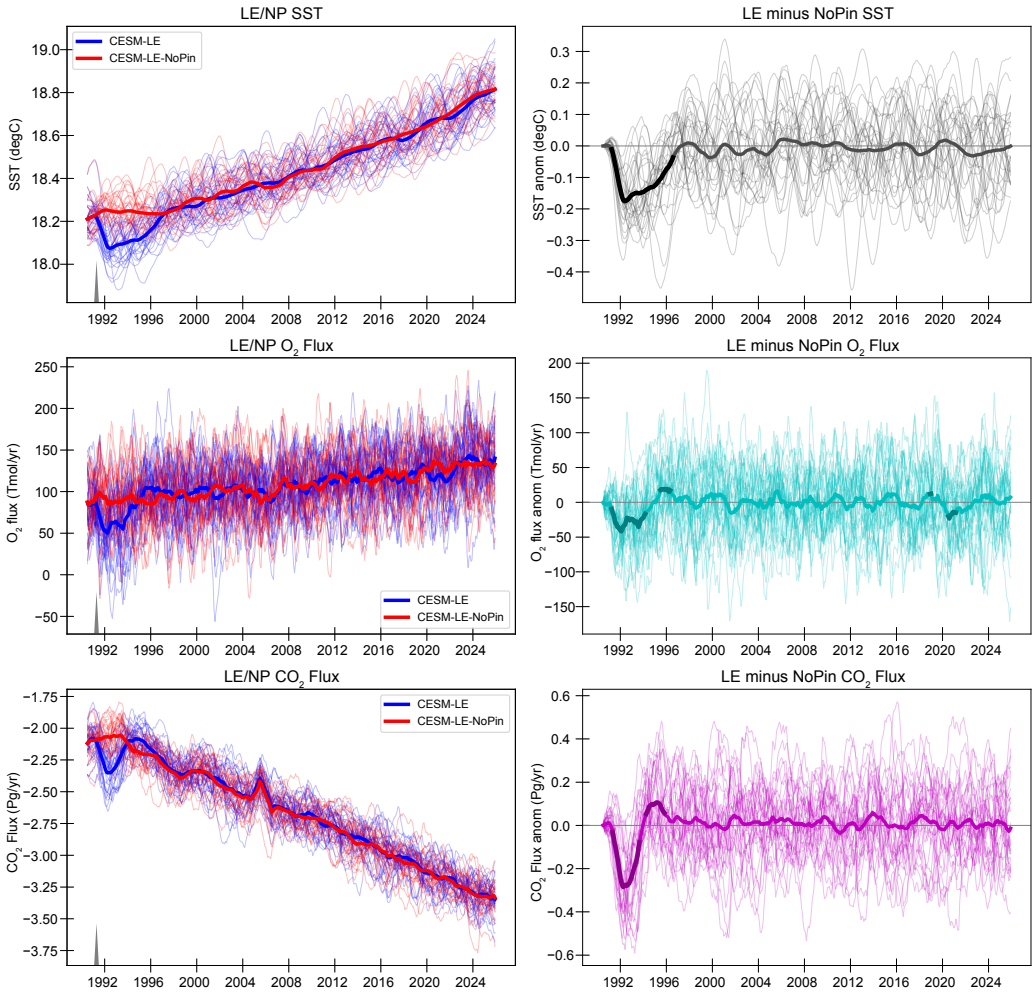

Figure S1. Left column: CESM-LE (blue) and CESM-LE-NoPin (red) individual members (thin lines) and ensemble mean (thick line) time series for global mean SST (black, degC), Oxygen flux (teal, Tmol/yr), and CO_2 Flux (magenta, Pg/yr) for full model time series (1990-2025). Right column: CESM-LE minus CESM-LE-NoPin difference for each variable with thicker line indicating significant difference between two ensembles at 2σ Deser:2012a. Time series are seasonally detrended, smoothed with a 12-month running mean. Gray triangle marks timing of eruption.

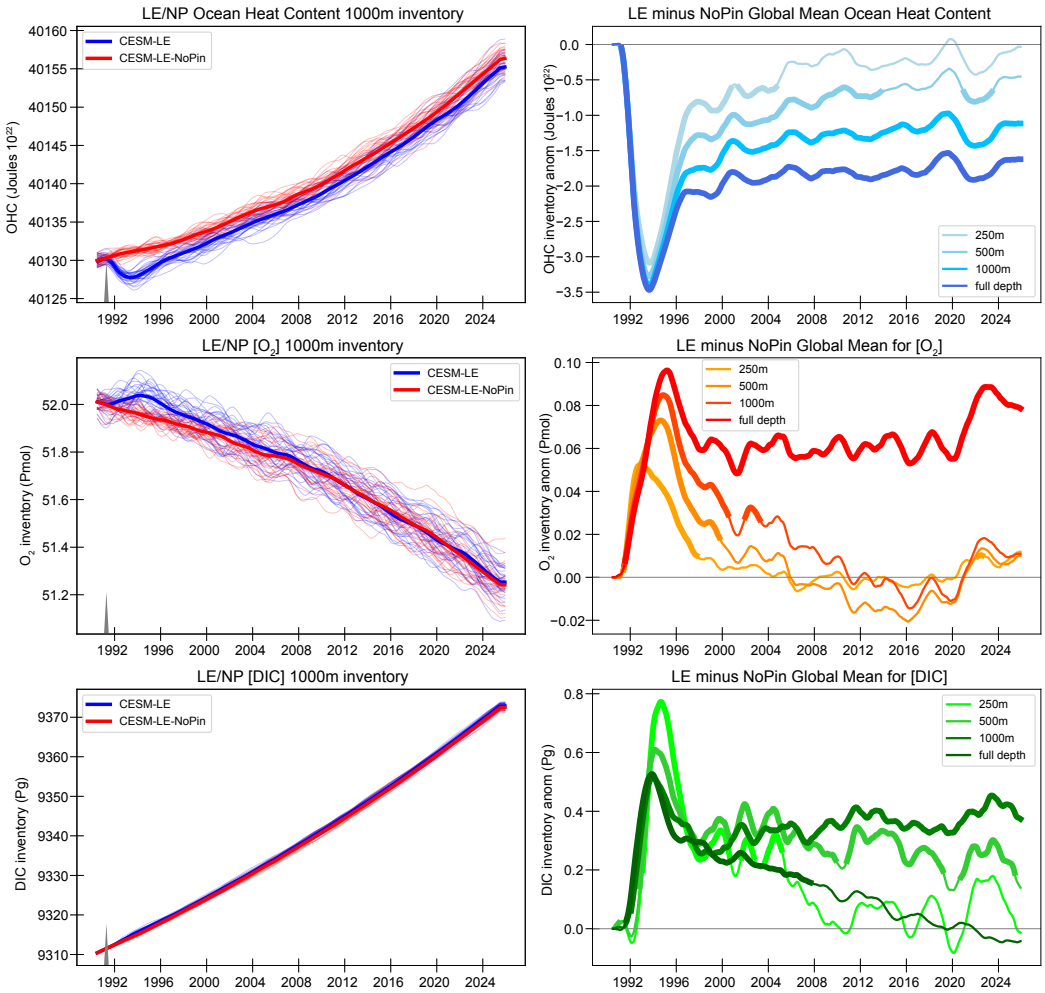

Figure S2. Left column: CESM-LE (blue) and CESM-LE-NoPin (red) individual members (thin lines) and ensemble mean (thick line) time series for global mean Ocean Heat Content (blue, Joules 10^{22}), Oxygen inventory (orange, Pmol), and Dissolved Inorganic Carbon inventory (green, Pg) for top 1000m for full model time series (1990-2025). Right column: CESM-LE minus CESM-LE-NoPin inventory difference for each variable with thicker line indicating significant difference between two ensembles at 2σ Deser:2012a. Inventory plots include lines for depths 250m, 500m, 1000m and full depth. Time series are seasonally detrended, smoothed with a 12-month running mean. Gray triangle marks timing of eruption.

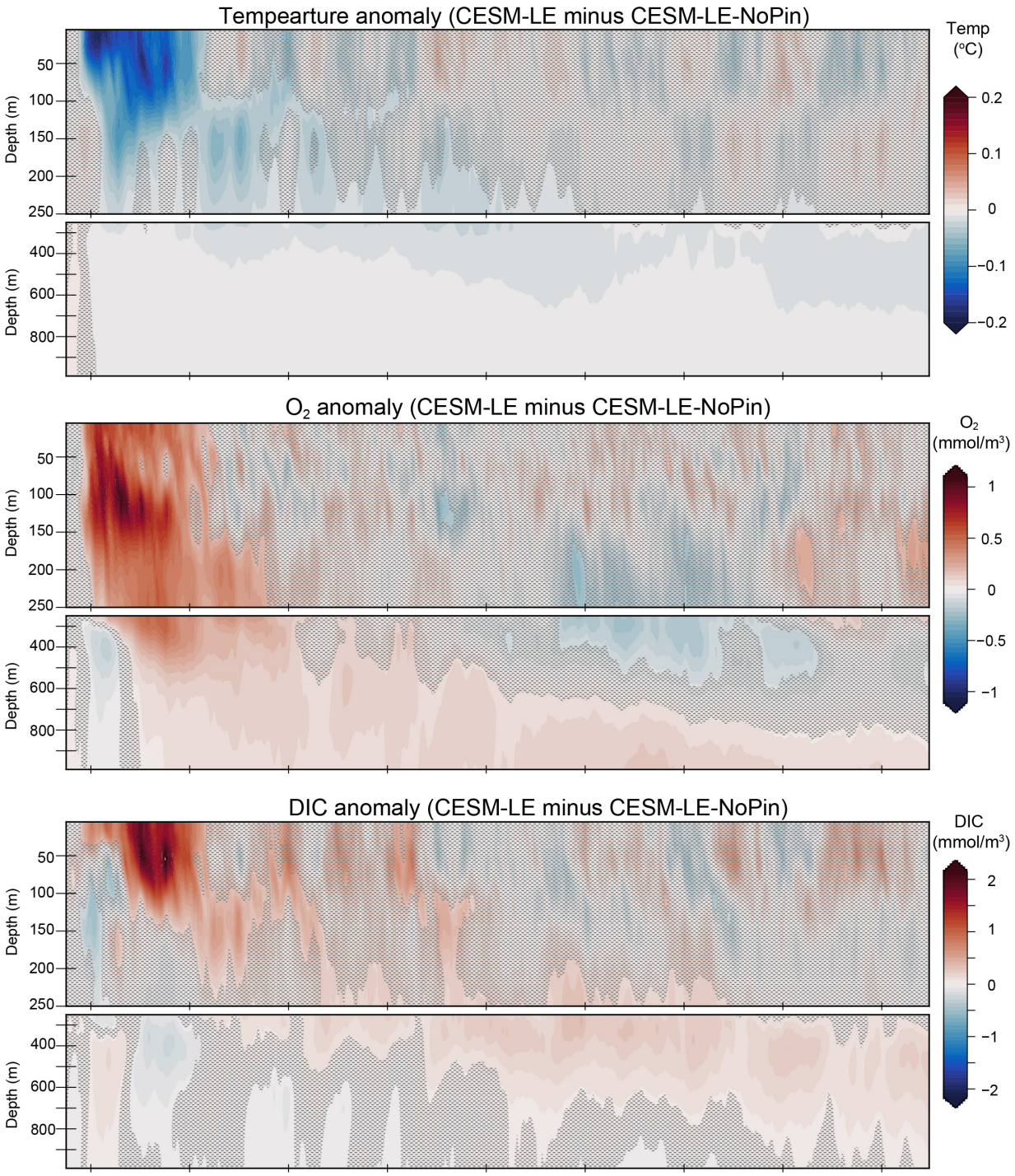

Figure S3. Globally averaged vertical profile of difference plots (CESM-LE minus CESM-LE-NoPin) for ensemble mean in a) temperature (°C) b) [O_2] (mmol/m^3), and c) [DIC] (mmol/mm^3) for full model time period (1990-2025). Stippling indicates time/depth where differences are not significant at the 95% confidence level Deser:2012a. Positive anomalies (warm colors) indicate greater values with the eruption of Pinatubo while negative anomalies (cool colors) indicate lower values with the eruption.

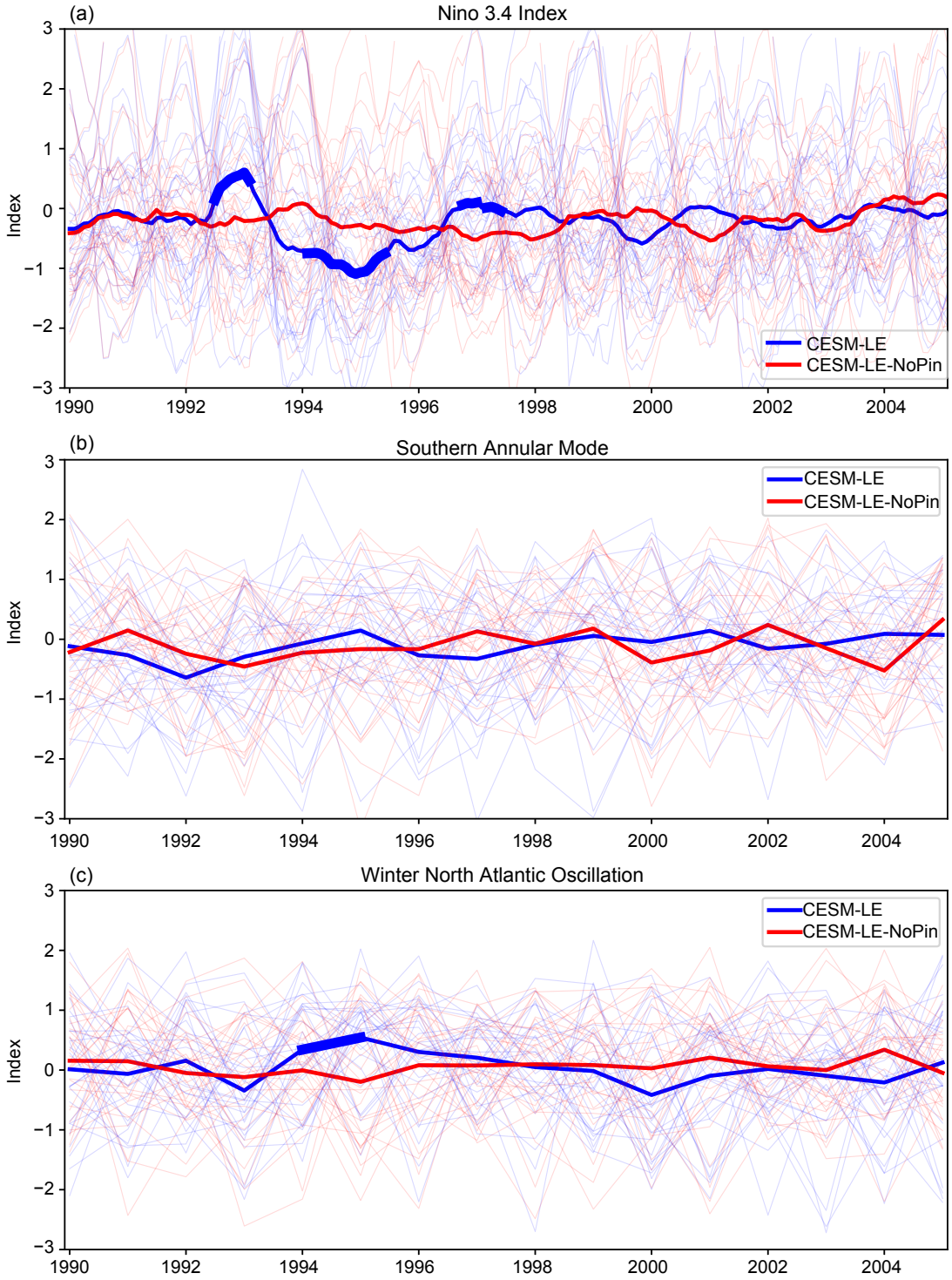

Figure S4. CESM-LE (blue) and CESM-LE-NoPin (red) individual members (thin lines) and ensemble mean (thick line) time series of pertinent climate indices: (a) monthly mean Niño 3.4 index (b) Southern Annual Mode (SAM), and (c) winter (DJF) North Atlantic Oscillation (NAO). Thicker line segments on ensemble means indicate significant difference between two ensembles at 2σ Deser:2012a.

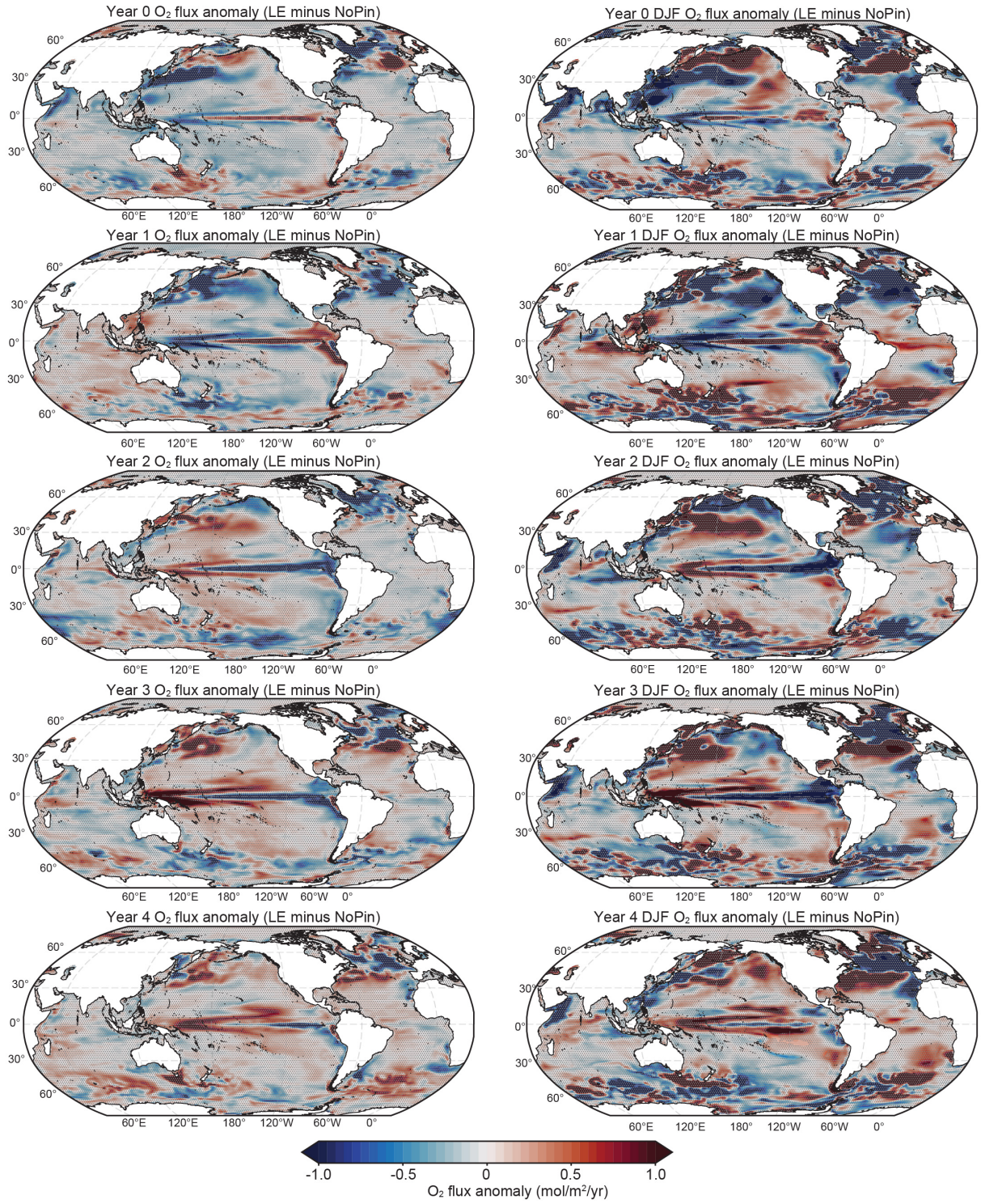

Figure S5. Evolution of annual mean anomalies (CESM-LE minus CESM-LE-NoPin) of oxygen fluxes during the first five years following the June 1991 eruption of Pinatubo: Year 0 (July 1991-June 1992), Year 1 (July 1992-June 1993); Year 2 (July 1993-June 1994); Year 3 (July 1994-June 1995); Year 4 (July 1995-June 1996). Anomalies are calculated by removing the seasonal cycle and annually averaging over respective months. Positive flux anomalies (warm colors) indicate increased efflux of O_2 in ocean efflux regions or less uptake with the eruption of Pinatubo. Negative flux anomalies (cool colors) indicate less efflux or increased uptake with the eruption of Pinatubo. Stippling indicates areas without significant difference between the two

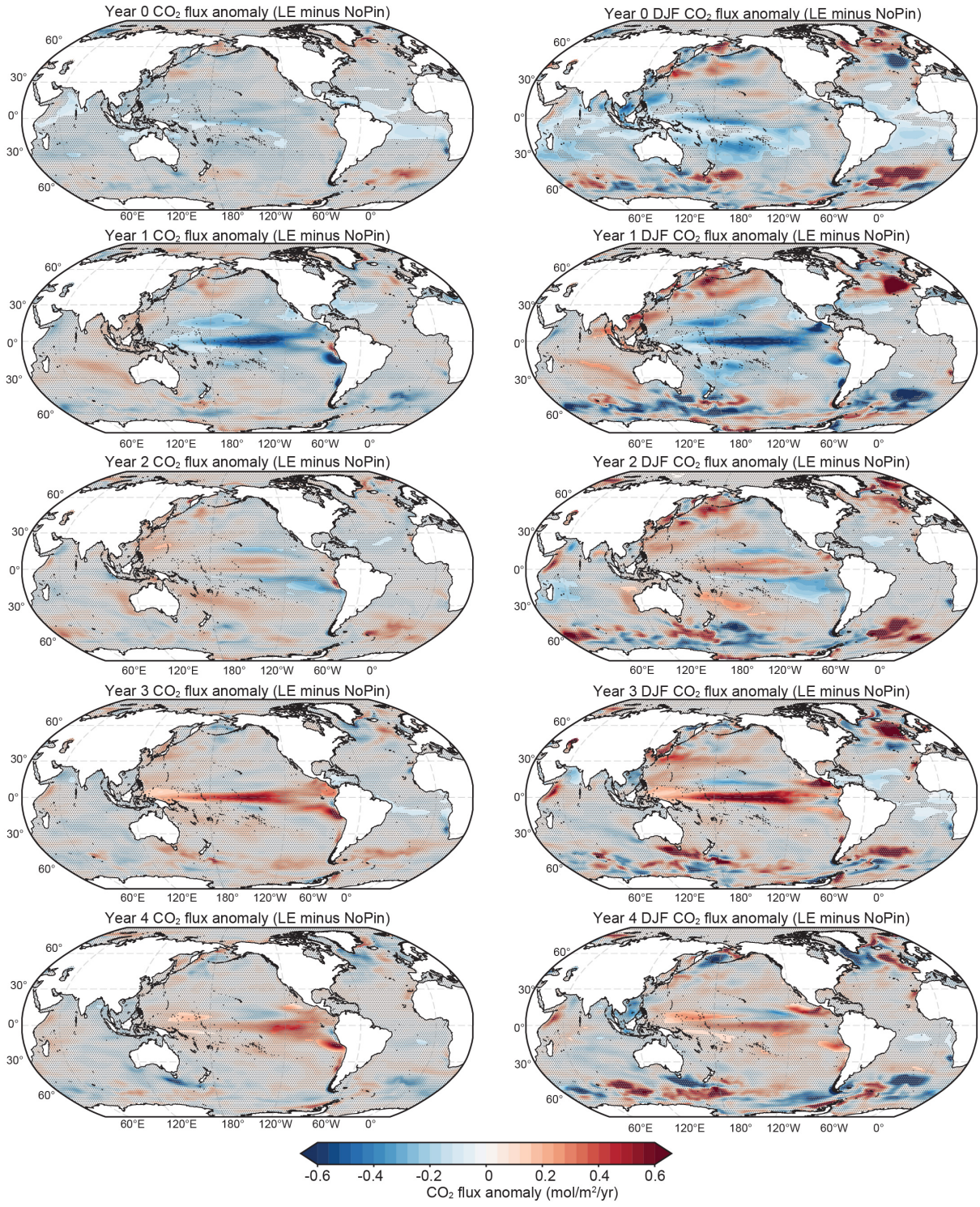

Figure S6. Evolution of annual mean anomalies (CESM-LE minus CESM-LE-NoPin) of carbon fluxes during the first five years following the June 1991 eruption of Pinatubo: Year 0 (July 1991-June 1992), Year 1 (July 1992-June 1993); Year 2 (July 1993-June 1994); Year 3 (July 1994-June 1995); Year 4 (July 1995-June 1996). Anomalies are calculated by removing the seasonal cycle and annually averaging over respective months. Positive flux anomalies (warm colors) indicate increased efflux of CO_2 in ocean efflux regions (e.g. equatorial Pacific) or less uptake with the eruption of Pinatubo. Negative flux anomalies (cool colors) indicate less efflux or increased uptake with the eruption of Pinatubo. Stippling indicates areas without significant

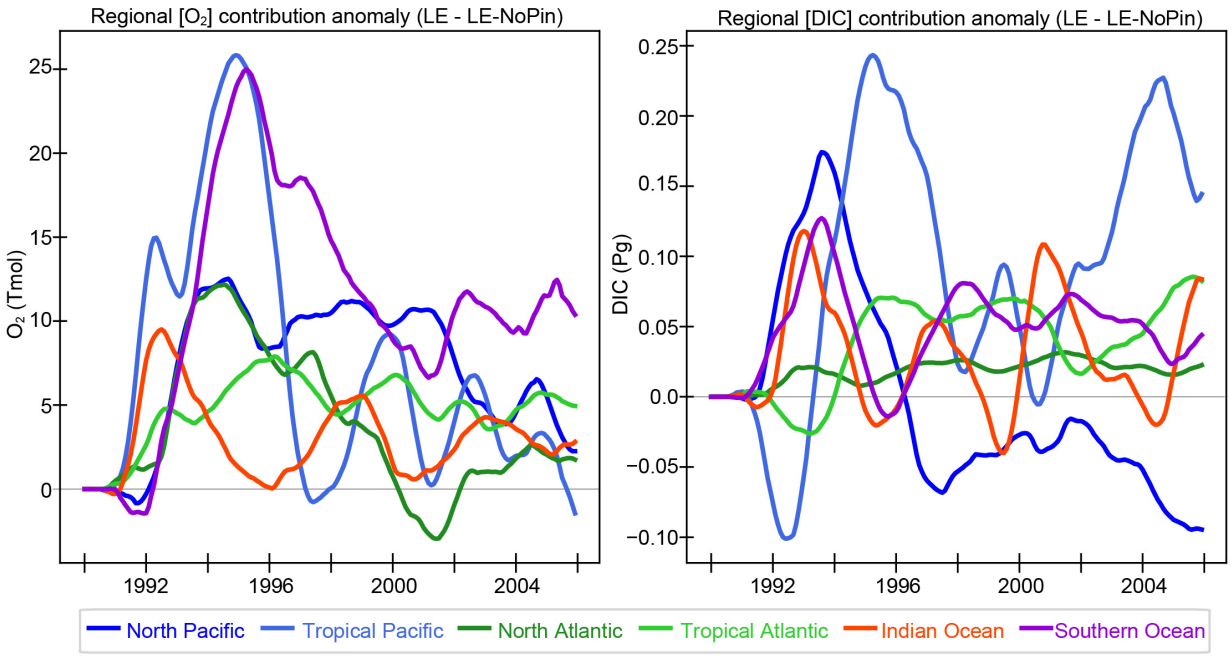

Figure S7. Regional contributions to O_2 (left) and DIC (right) 1000m concentrations anomalies (CESM-LE minus CESM-LE-NoPin). Ensemble mean time series, with 12-month running mean, for the North Pacific and Atlantic (¿30°N), Tropical Pacific and Atlantic (30°N - 30°S), Indian Ocean, and Southern Ocean. Can be compared to global values in Figure 2b.

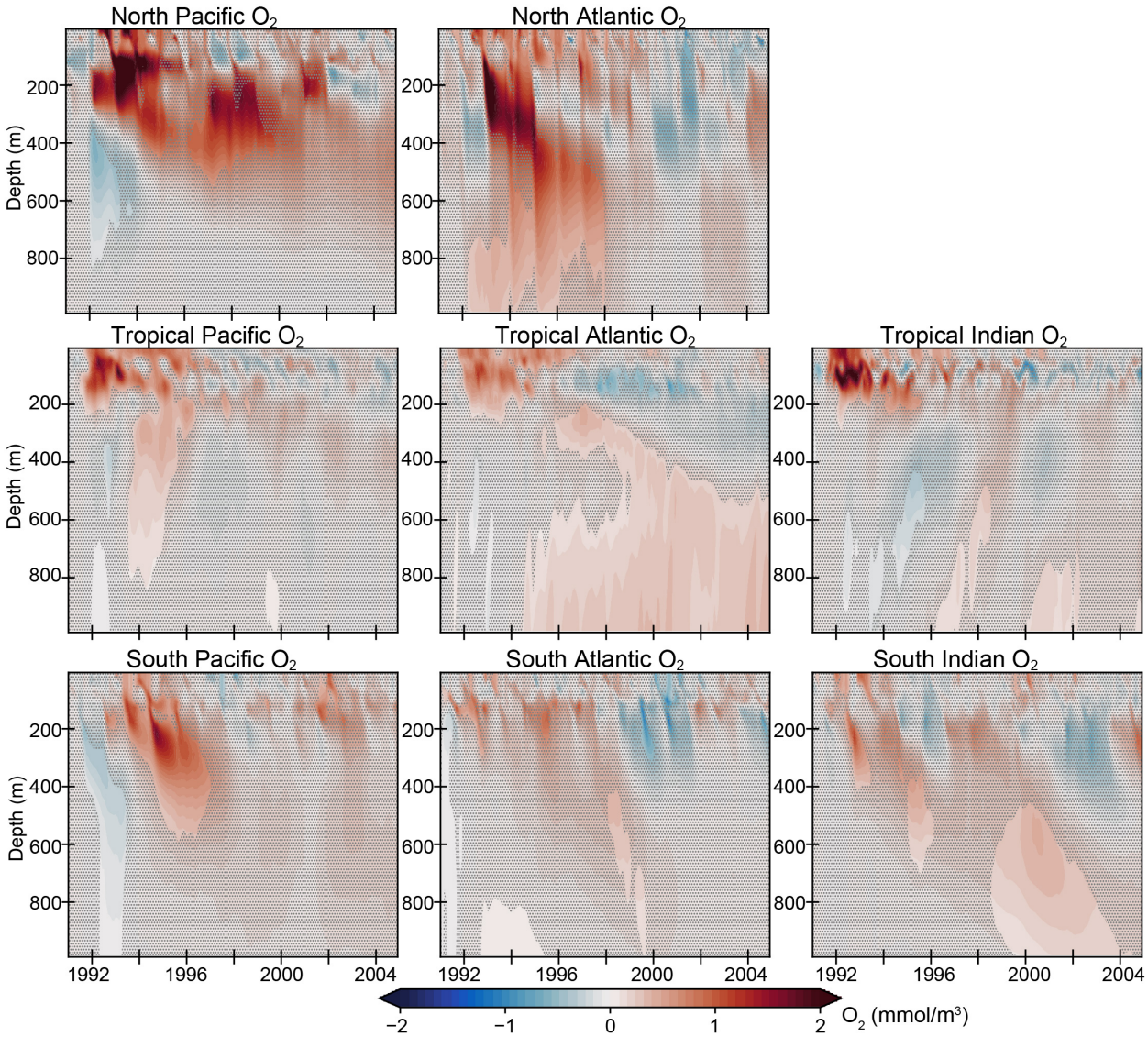

Figure S8. Regionally averaged vertical profile of difference (CESM-LE minus CESM-LE-NoPin) plots for ensemble mean O_2 inventory (mmol/m^3) for full model time period (1990-2025). Separations are made for the Pacific, Atlantic, and Indian basins into northern (¿30°N), tropical (30°N-30°S), and southern sections (¡30°S). Stippling indicates time/depth where differences are not significant at the 95% confidence level Deser:2012a. Positive anomalies (warm colors) indicate greater oxygen inventory values with the eruption of Pinatubo while negative anomalies (cool colors) indicate lower oxygen with the eruption.

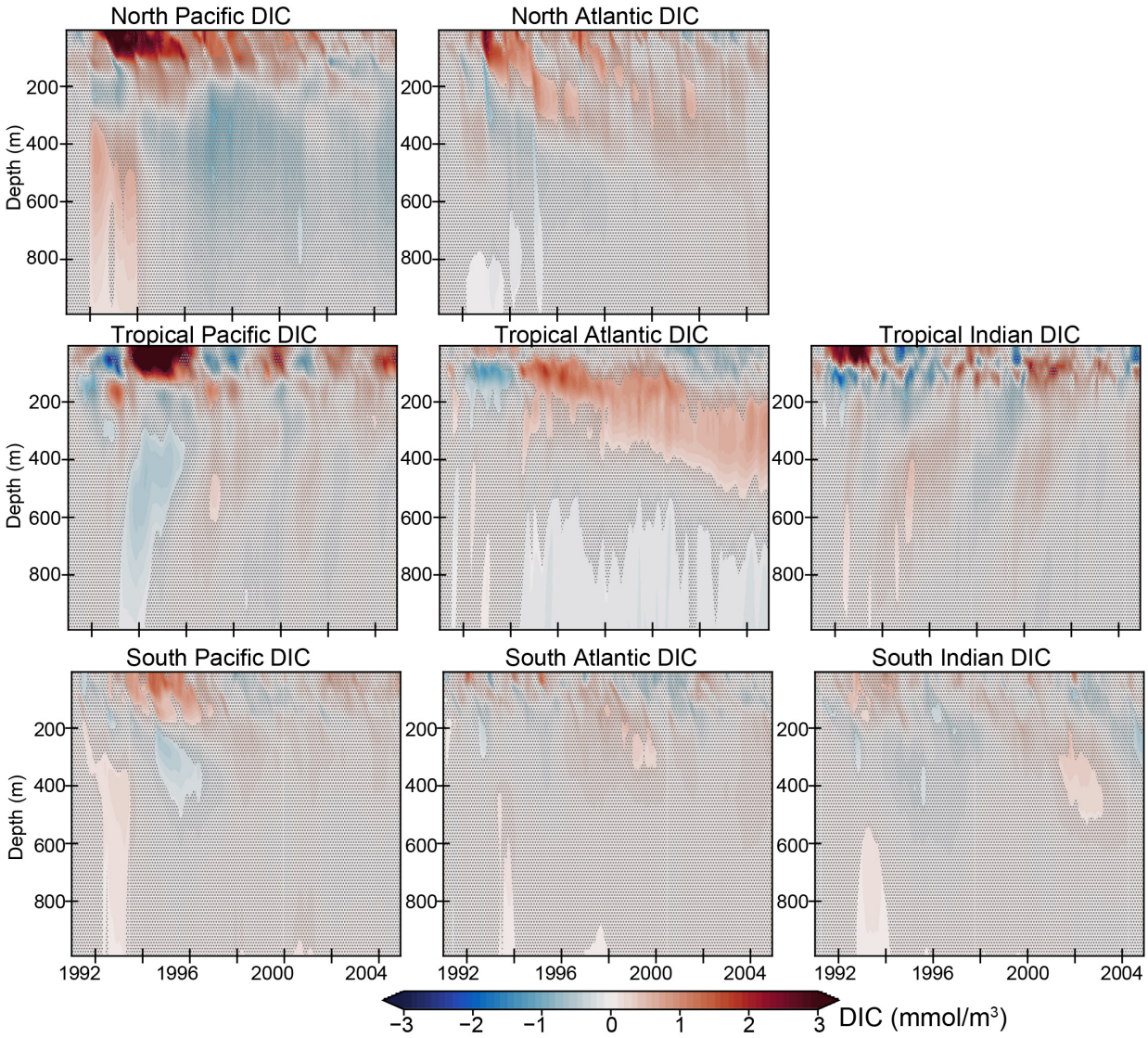

Figure S9. Regionally averaged vertical profile of difference (CESM-LE minus CESM-LE-NoPin) plots for ensemble mean DIC inventory (mmol/m^3) for full model time period (1990-2025). Separations are made for the Pacific, Atlantic, and Indian basins into northern (¿30°N), tropical (30°N-30°S), and southern sections (¡30°S). Stippling indicates time/depth where differences are not significant at the 95% confidence level Deser:2012a. Positive anomalies (warm colors) indicate greater DIC inventory values with the eruption of Pinatubo while negative anomalies (cool colors) indicate lower DIC levels with the eruption.

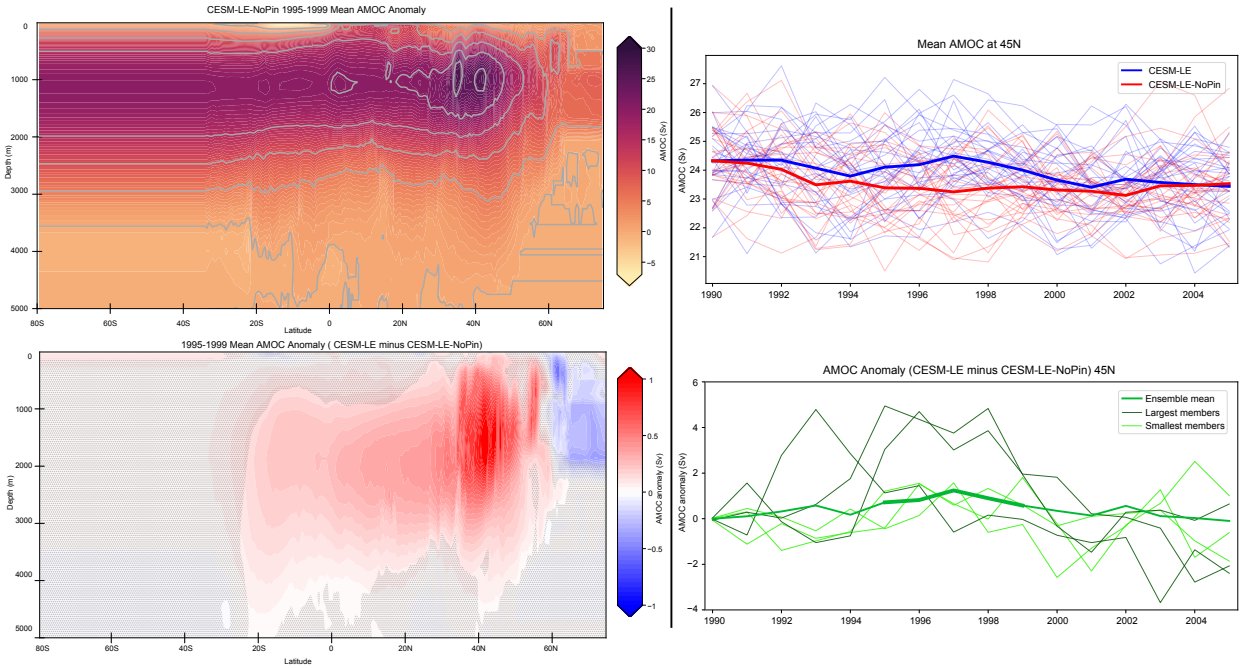

Figure S10. Time-mean Atlantic Meridional Overturning Circulation (AMOC) from (a) the "control" CESM-LE-NoPin ensemble mean (yrs 1995-99 mean) and (b) CESM-LE minus CESM-LE-NoPin ensemble mean anomaly (yrs 1995-99 mean). The contour interval in (a) is 5 Sv. Stippling on (b) indicates depth/latitude where ensemble mean differences are not significant at the 95% confidence level Deser:2012a. Positive anomalies (warm colors) indicate stronger AMOC values with the eruption of Pinatubo while negative anomalies (cool colors) indicate weaker AMOC values with the eruption. (c) shows a time series of the maximum AMOC at 45°N in CESM-LE (blue) and CESM-LE-NoPin (red) individual members (thin lines) and ensemble mean (thick lines). CESM-LE minus CESM-LE-NoPin anomalies (d) for the ensemble mean (thick line) along with individual ensembles representing the three largest (dark green thin lines) and three smallest (light green thin lines) changes for the time period. Thicker line segments on ensemble means (d) indicate significant difference between two ensembles at 2σ Deser:2012a.

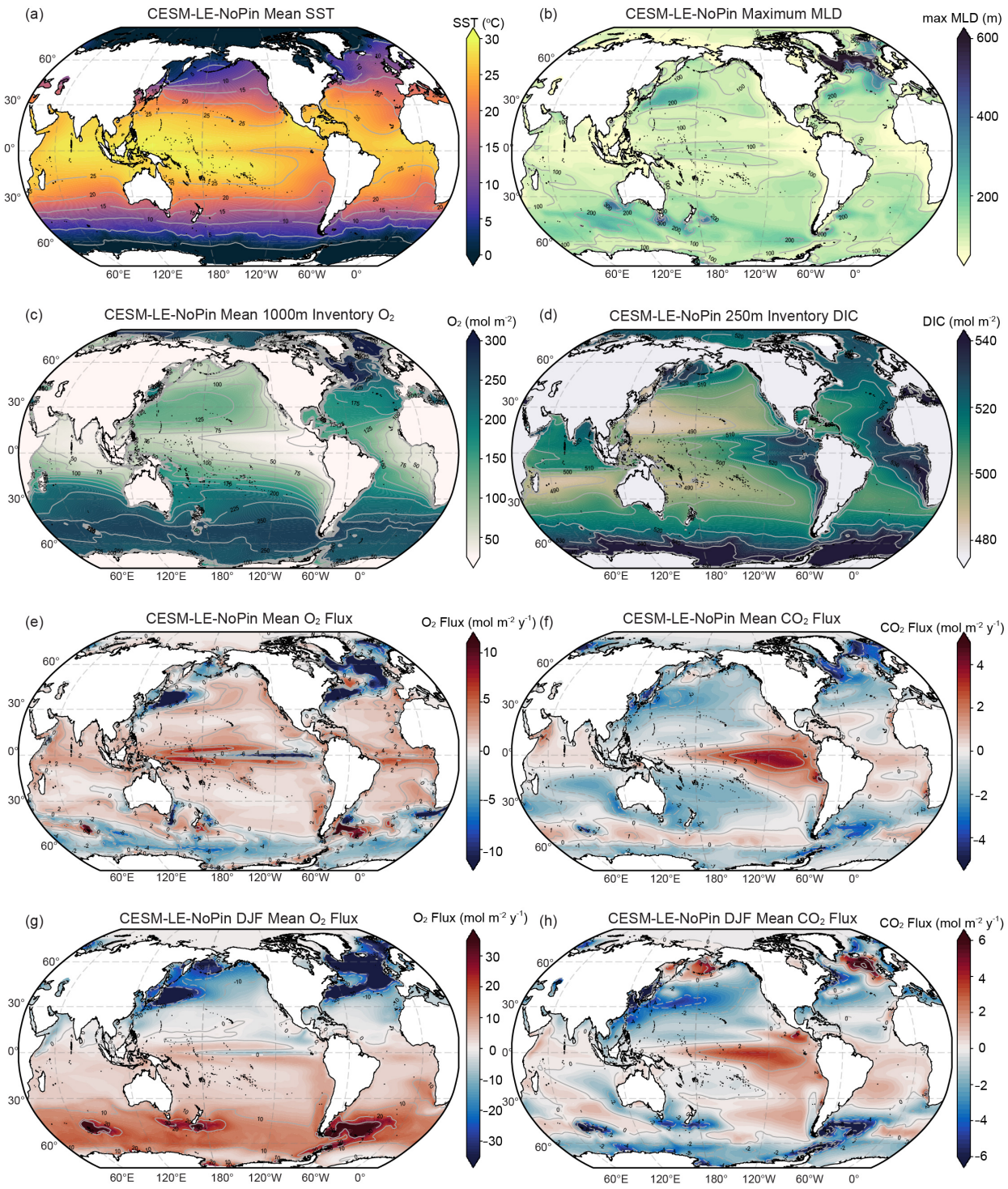

Figure S11. Mean state maps of 1990s CESM-LE-NoPin ensemble mean for (a) SST (contour interval 5°) , (b) maximum MLD (contour interval 100m) (c) 1000m O_2 inventory (contour interval 25 mol/m^2) , (d) 250m DIC inventory (contour interval 10 mol/m^2), (e) O_2 flux (contour interval 2 mol/m^2/yr), (f) CO_2 flux (contour interval 1 mol/m^2/yr), (g) DJF O_2 flux (contour interval 10 mol/m^2/yr), (h) DJF CO_2 flux (contour interval 2 mol/m^2/yr).