Text S1.

We construct the full pCO_2 Taylor expansion decomposition starting with the carbonate chemistry definitions of DIC and TA as in *Egleston et al.* (2010):

$$DIC = [CO_2] + \frac{K_1[CO_2]}{[H^+]} + \frac{K_1K_2[CO_2]}{[H^+]^2} \tag{1}$$

$$TA = \frac{K_1[CO_2]}{[H^+]} + 2\frac{K_1K_2[CO_2]}{[H^+]^2} + \frac{B_{tot}K_b}{(K_b+[H^+])} - [H^+] + \frac{K_w}{[H^+]} \tag{2}$$

Where K_1 and K_2 are defined as *Millero et al.* (2006), K_w as *Millero* (1995) and K_b according to *Dickson* (1990). From Eq.(1) we can obtain $[H^+]$ and from Eq.(2) we get $[CO_2]$ respectively as:

$$[H^+] = \frac{K_1[CO_2] + \sqrt{K_1^2[CO_2]^2 + 4K_1K_2[CO_2](DIC-[CO_2])}}{2(DIC-[CO_2])} \tag{3}$$

$$[CO_2] = \frac{[H^+]^2}{K_1[H^+]+2K_1K_2}\left(TA - \frac{B_{tot}K_b}{(K_b+[H^+])} + [H^+] - \frac{K_w}{[H^+]}\right) \tag{4}$$

For $[H^+]$ the positive solution was chosen; the negative root gives a result far from real values. From Eq.(3) and Eq.(4) we can make a Talyor's expansion of $[H^+]$ and $[CO_2]$ respectively as:

$$\delta[H^+] = \left.\frac{\partial[H^+]}{\partial DIC}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\delta DIC + \left.\frac{\partial[H^+]}{\partial[CO_2]}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\delta[CO_2] + \left.\frac{\partial[H^+]}{\partial T}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\delta T + \left.\frac{\partial[H^+]}{\partial S}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\delta S \tag{5}$$

$$\delta[CO_2] = \left.\frac{\partial[CO_2]}{\partial TA}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\delta TA + \left.\frac{\partial[CO_2]}{\partial[H^+]}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\delta[H^+] + \left.\frac{\partial[CO_2]}{\partial T}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\delta T + \left.\frac{\partial[CO_2]}{\partial S}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\delta S \tag{6}$$

The over bars indicate the mean values of the variables in which the derivatives are evaluated. Finally, we replace $\delta[H^+]$ from Eq.(5) into Eq.(6), to get $[CO_2]$ in terms of DIC, TA, T and S:

$$\begin{aligned}
\delta[CO_2] = {} & \left[1 - \left.\frac{\partial[CO_2]}{\partial[H^+]}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\left.\frac{\partial[H^+]}{\partial[CO_2]}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\right]^{-1} \cdot \left[\left.\frac{\partial[CO_2]}{\partial TA}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\delta TA\right. \\
& + \left.\frac{\partial[CO_2]}{\partial[H^+]}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\left.\frac{\partial[H^+]}{\partial DIC}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\delta DIC \\
& + \left(\left.\frac{\partial[CO_2]}{\partial T}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}} + \left.\frac{\partial[CO_2]}{\partial[H^+]}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\left.\frac{\partial[H^+]}{\partial T}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\right)\delta T \\
& \left. + \left(\left.\frac{\partial[CO_2]}{\partial S}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}} + \left.\frac{\partial[CO_2]}{\partial[H^+]}\right|_{\substack{\overline{TA},\overline{H}\\ \overline{T},\overline{S}}}\left.\frac{\partial[H^+]}{\partial S}\right|_{\substack{\overline{CO_2},\overline{DIC}\\ \overline{T},\overline{S}}}\right)\delta S\right]
\end{aligned} \tag{7}$$

Comparing the terms from Eq.(7) to the desired Taylor's expansion:

$$\delta pCO_2 \approx \left.\frac{\partial pCO_2}{\partial DIC}\right|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}}\delta DIC + \left.\frac{\partial pCO_2}{\partial TA}\right|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}}\delta TA + \left.\frac{\partial pCO_2}{\partial T}\right|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}}\delta T + \left.\frac{\partial pCO_2}{\partial S}\right|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}}\delta S \tag{8}$$

We can identify the derivatives from Eq.(8), as follows:

$$
\begin{aligned}
\frac{\partial pCO_2}{\partial TA}\Big|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}} &= \overline{pCO}_2 \cdot \frac{-\overline{TA}_c}{\overline{DIC}\cdot\Theta - \overline{TA}_c^2} \\
\frac{\partial pCO_2}{\partial DIC}\Big|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}} &= \overline{pCO}_2 \cdot \frac{\Theta}{\overline{DIC}\cdot\Theta - \overline{TA}_c^2} \\
\frac{\partial pCO_2}{\partial T}\Big|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}} &= \overline{pCO}_2 \cdot \frac{1}{\overline{DIC}\cdot\Theta - \overline{TA}_c^2}\left[\overline{TA}_c \cdot \Big(\frac{\partial Alk_c}{\partial T} + \frac{\partial [B(OH)_4^-]}{\partial T} + \frac{\partial [OH^-]}{\partial T}\Big) - \Theta \cdot \frac{\partial (DIC - [CO_2])}{\partial T}\right] - \frac{\overline{pCO}_2 \cdot}{\overline{K_0}(T,S)}\frac{\partial K_0(T,S)}{\partial T} \\
\frac{\partial pCO_2}{\partial S}\Big|_{\substack{\overline{TA},\overline{DIC}\\ \overline{T},\overline{S}}} &= \overline{pCO}_2 \cdot \frac{1}{\overline{DIC}\cdot\Theta - \overline{TA}_c^2}\left[\overline{TA}_c \cdot \Big(\frac{\partial \overline{TA}_c}{\partial S} + \frac{\partial [B(OH)_4^-]}{\partial S} + \frac{\partial [OH^-]}{\partial S}\Big) - \Theta \cdot \frac{\partial (DIC - [CO_2])}{\partial S}\right] - \frac{\overline{pCO}_2 \cdot}{\overline{K_0}(T,S)}\frac{\partial K_0(T,S)}{\partial S}
\end{aligned}
\tag{9}
$$

where $\Theta = [\mathrm{HCO_3^-}] + 4[\mathrm{CO_3^{2-}}] + \frac{[\mathrm{B(OH)_4^-}][\mathrm{H^+}]}{(\mathrm{k_b} + [\mathrm{H^+}])} + [\mathrm{H^+}] + [\mathrm{OH^-}]$ and $\overline{\mathrm{Alk}}_\mathrm{c} = [\mathrm{HCO_3^-}] + 2[\mathrm{CO_3^{2-}}]$. Below are some details of the specific concentrations derivatives.

$$
\begin{aligned}
\frac{\partial Alk_c}{\partial T,S} &= \frac{[CO_2]}{[H^+]^2}\Big(\frac{\partial k_1}{\partial T,S}[H^+] + 2k_1\frac{\partial k_2}{\partial T,S} + 2k_2\frac{\partial k_1}{\partial T,S}\Big) \\
\frac{\partial (DIC - [CO_2])}{\partial T,S} &= \frac{[CO_2]}{[H^+]^2}\Big(\frac{\partial k_1}{\partial T,S}[H^+] + k_1\frac{\partial k_2}{\partial T,S} + k_2\frac{\partial k_1}{\partial T,S}\Big) \\
\frac{\partial [B(OH)_4^-]}{\partial T} &= \frac{B_{tot}[H^+]}{(k_b + [H^+])^2}\frac{\partial k_b}{\partial T} \\
\frac{\partial [B(OH)_4^-]}{\partial S} &= \frac{B_{tot}[H^+]}{(k_b + [H^+])^2}\frac{\partial k_b}{\partial S} + \frac{k_b}{(kb + [H^+])}\frac{\partial B_{tot}}{\partial S} \\
\frac{\partial [OH^-]}{\partial T,S} &= \frac{1}{[H^+]}\frac{\partial k_w}{\partial T,S}
\end{aligned}
\tag{10}
$$

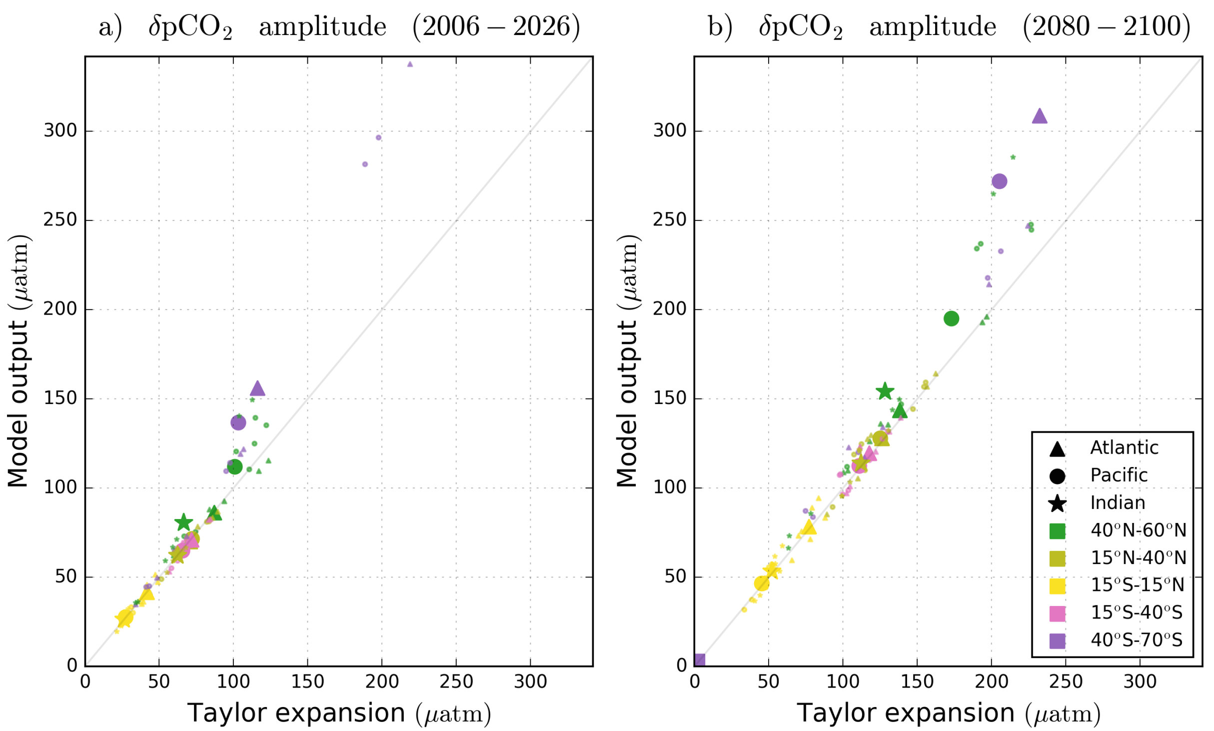

Figure S1. pCO_2 seasonal cycle amplitude calculated from models outputs compared to its Taylor's expansion reconstruction in a) 2006-2026 and b) 2080-2100. Different colors indicate latitudinal ranges of zonal means, for the Atlantic (triangles), Pacific (circles) and Indian (stars) ocean basins. Large symbols represent the ensemble mean, and small symbols are the result for each model separately.

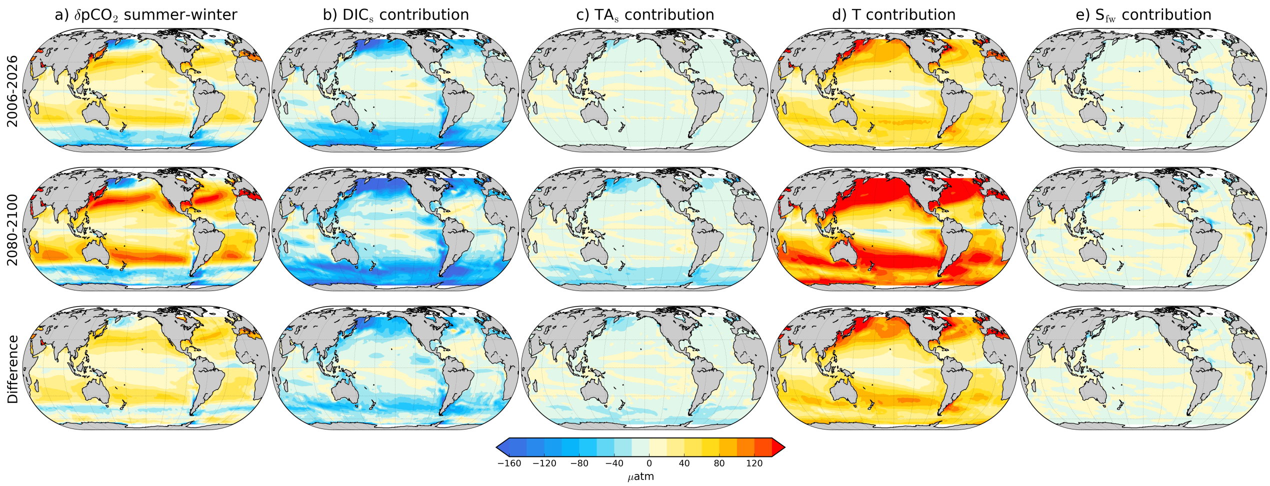

Figure S2. a) pCO_2 seasonal amplitude calculated as summer minus winter for each hemisphere respectively. b)- e) show DIC, T, TA and S contributions to the pCO_2 summer minus winter amplitude. First and second rows represent 2006-2026 and 2080-2100 periods respectively. Third row shows the difference between second and first rows.

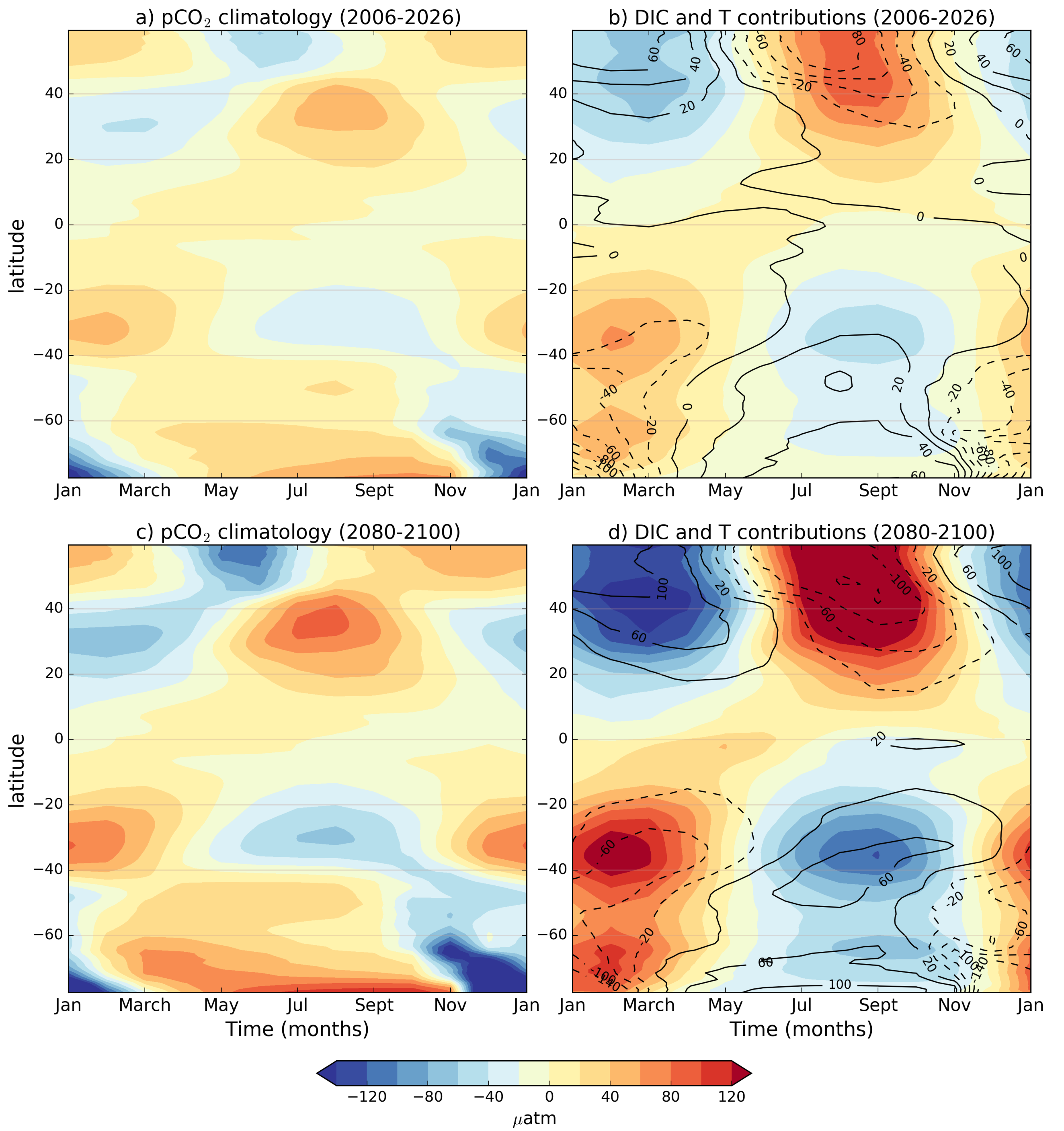

Figure S3. a) Ensemble zonal mean pCO_2 climatology and b) DIC contribution in color with overlying black contours of T contribution for 2006-2026 period. c) and d) same as a) and b) but for the 2080-2100 period.

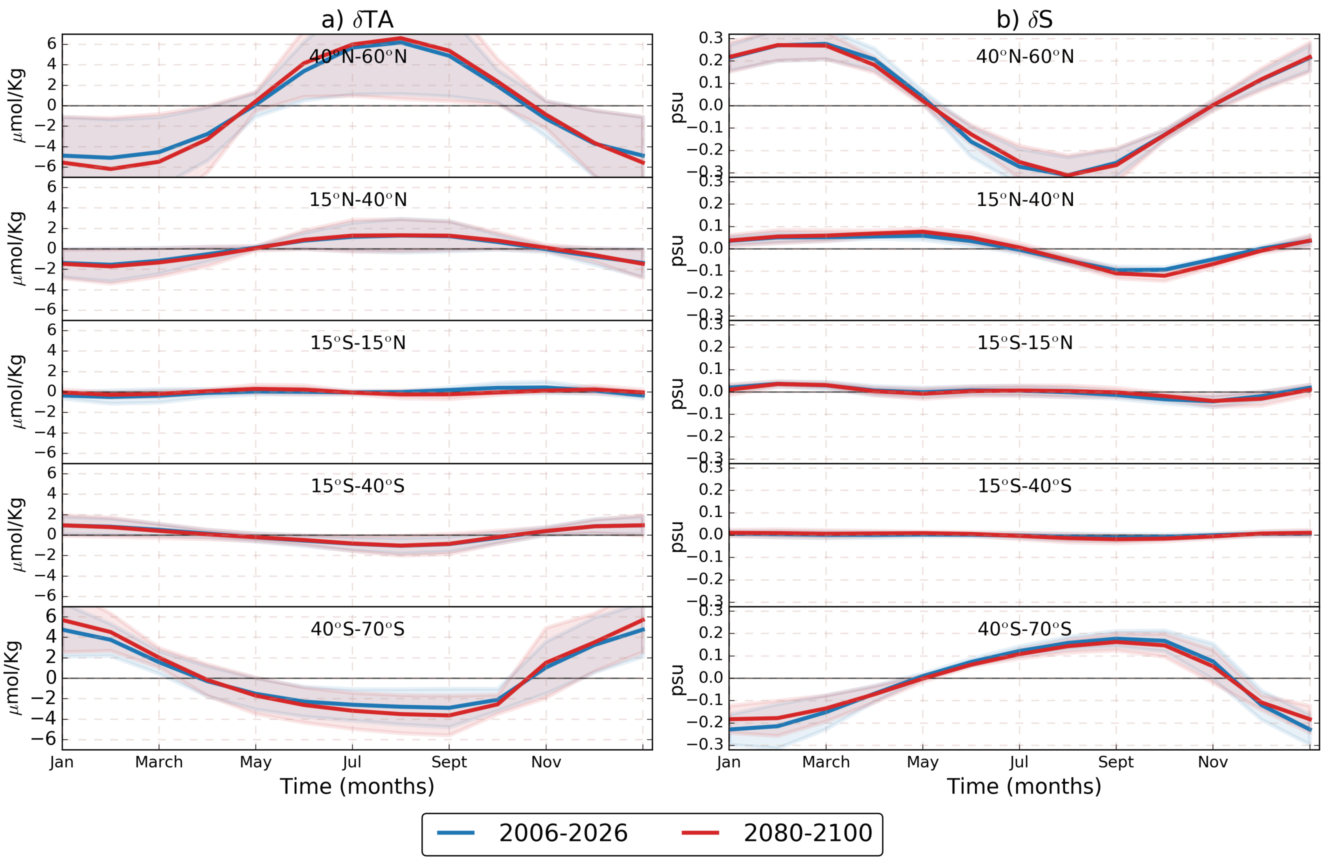

Figure S4. RCP8.5 ensemble zonal mean seasonal cycles: a) δTA_s and b) δS, for different latitudinal bands. Blue lines represent the 2006-2026 period, depicted for comparison with the 2080-2100 period shown by red lines. Different panels represent different latitudinal sections. δTA_s is projected to slightly increase in all the bands, while δS is projected to slightly decrease. The shading represents one standard deviation across the models.

References

Dickson, A. G.: Thermodynamics of the dissociation of boric acid in synthetic seawater from 273.15 to 318.15 K, Deep-Sea Research Part A. Oceanographic Research Papers, 37: 755-766, 1990.

Egleston, E. S., Sabine, C. L. and Morel, F. M. M.: Revelle revisited: Buffer factors that quantify the response of ocean chemistry to changes in DIC and alkalinity, Glob. Biogeochem. Cycles. 24, GB1002, 2010.

Millero, F. J.: Thermodynamics of the carbon dioxide system in the oceans, Geochemica et Cosmochemica Acta, 59, 661-677, 1995.

Millero, F. J., Graham, T. B., Huang, F., Bustos-Serrano, H., and Pierrot, D.: Dissociation constants of carbonic acid in seawater as a function of salinity and temperature, Marine Chemistry, 100(1-2), 80-94, 2006.

Weiss, R. F.: Carbon dioxide in water and seawater: The solubility of non-ideal gas, Marine Chem., 2, 203-215, 1974.