Supplementary information for

Unveiling ongoing biogeochemical dynamics of CDOM from surface to deep ocean

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Figs. S1-S10

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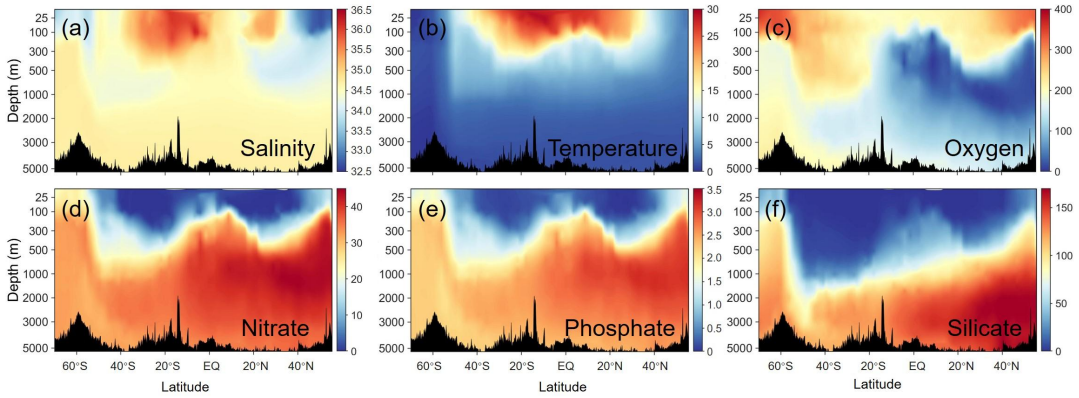
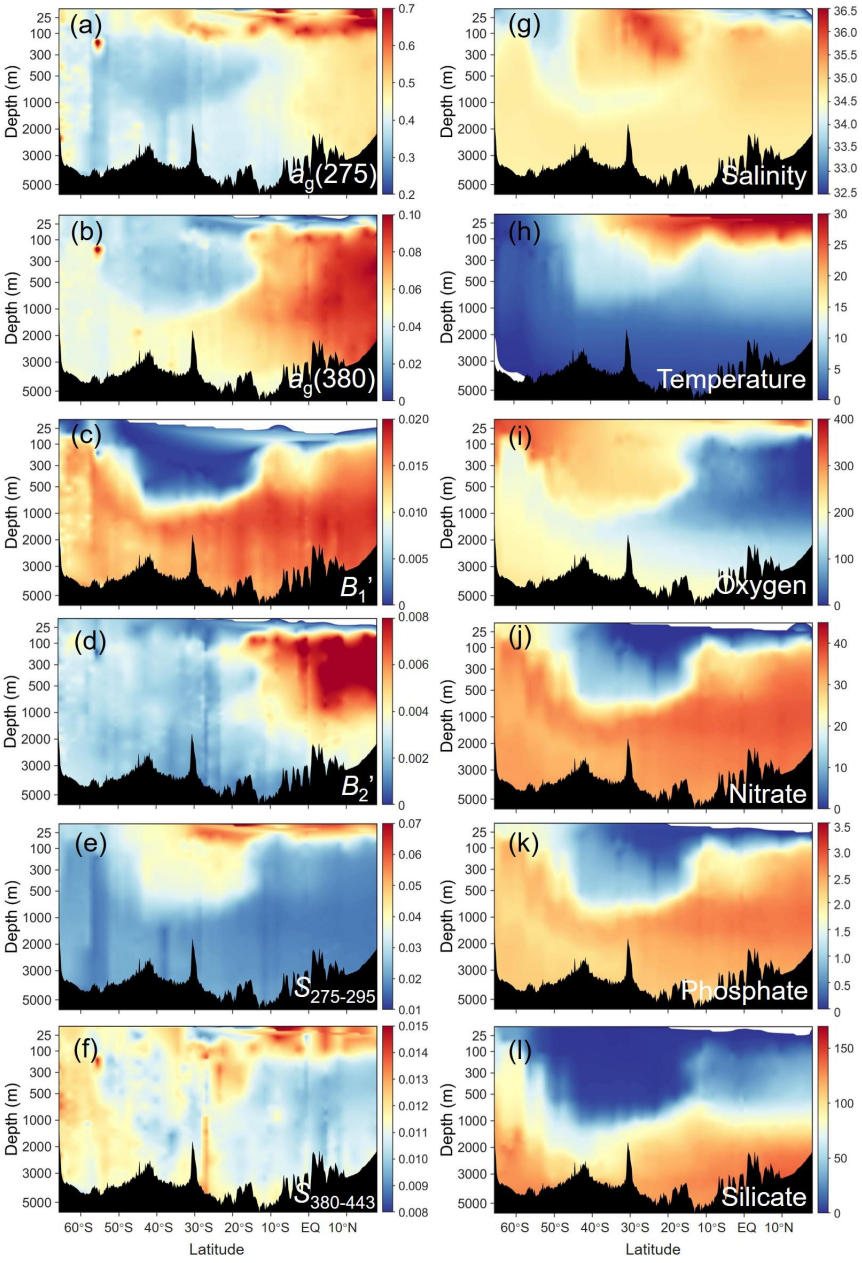


Fig. S1. The distribution of physicochemical parameters in the central Pacific Ocean. (a) Salinity (PSU). (b) Temperature (°C). (c) Dissolved oxygen (μmol kg^{-1}). (d) Nitrate (μmol kg^{-1}). (e) Phosphate (μmol kg^{-1}). (f) Silicate (μmol kg^{-1}).



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26 **Fig. S2. The distribution of physicochemical and spectroscopic parameters in the**

27 **eastern Indian Ocean.** (a) $a_g(275)$ (m^{-1}). (b) $a_g(380)$ (m^{-1}). (c) B_1' (m^{-1}). (d) B_2' (m^{-1}).

28 (e) $S_{275-295}$ (nm^{-1}). (f) $S_{380-443}$ (nm^{-1}). (g) Salinity (PSU). (h) Temperature (°C). (i)

29 Dissolved oxygen (μmol kg^{-1}). (j) Nitrate (μmol kg^{-1}). (k) Phosphate (μmol kg^{-1}). (l)

30 Silicate (μmol kg^{-1}).

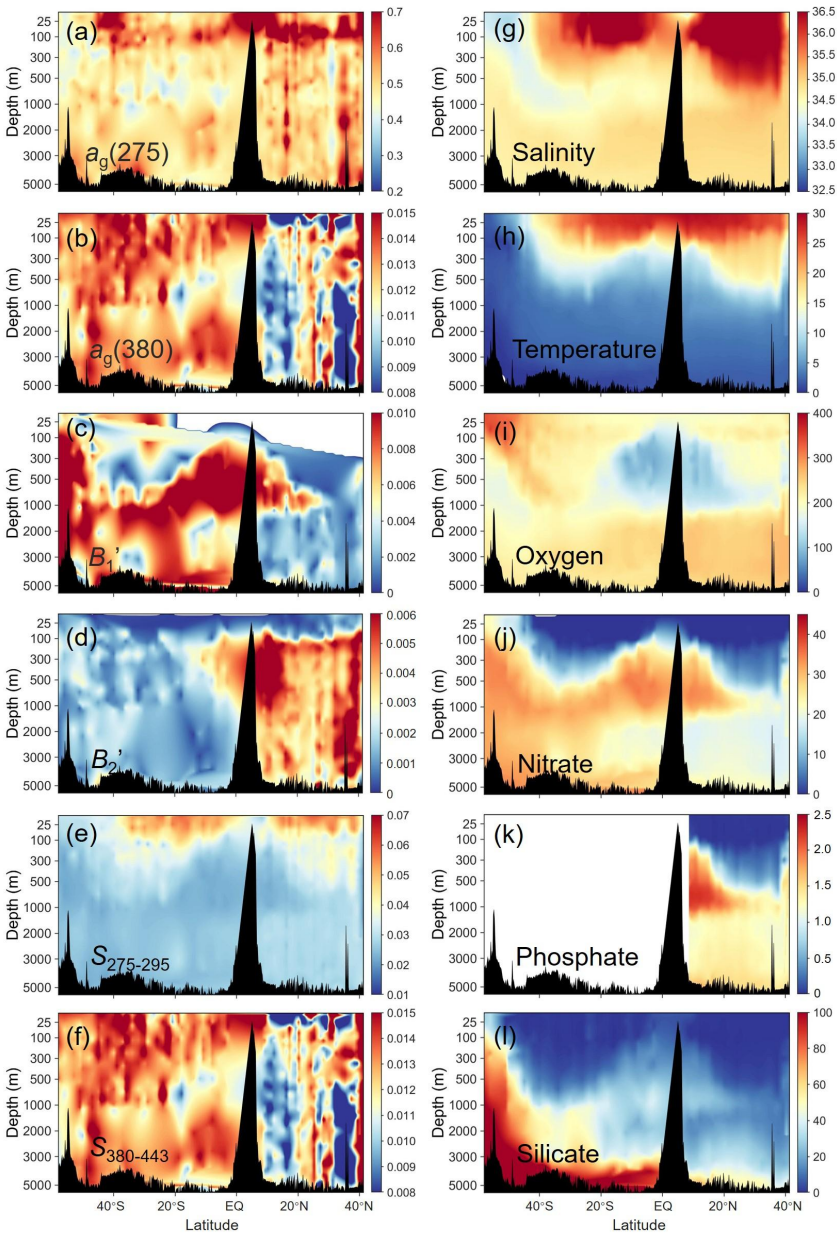


Fig. S3. The distribution of physicochemical and spectroscopic parameters in the central Atlantic Ocean. (a) $a_g(275)$ (m^{-1}). (b) $a_g(380)$ (m^{-1}). (c) B_1' (m^{-1}). (d) B_2' (m^{-1}). (e) $S_{275\text{-}295}$ (nm^{-1}). (f) $S_{380\text{-}443}$ (nm^{-1}). (g) Salinity (PSU). (h) Temperature (°C). (i) Dissolved oxygen (μmol kg^{-1}). (j) Nitrate (μmol kg^{-1}). (k) Phosphate (μmol kg^{-1}). (l) Silicate (μmol kg^{-1}). The phosphate measurements in panel f of the southern hemisphere were not successfully matched with spectral records in climate variability and predictability (CLIVAR) line A16-A20/A22.

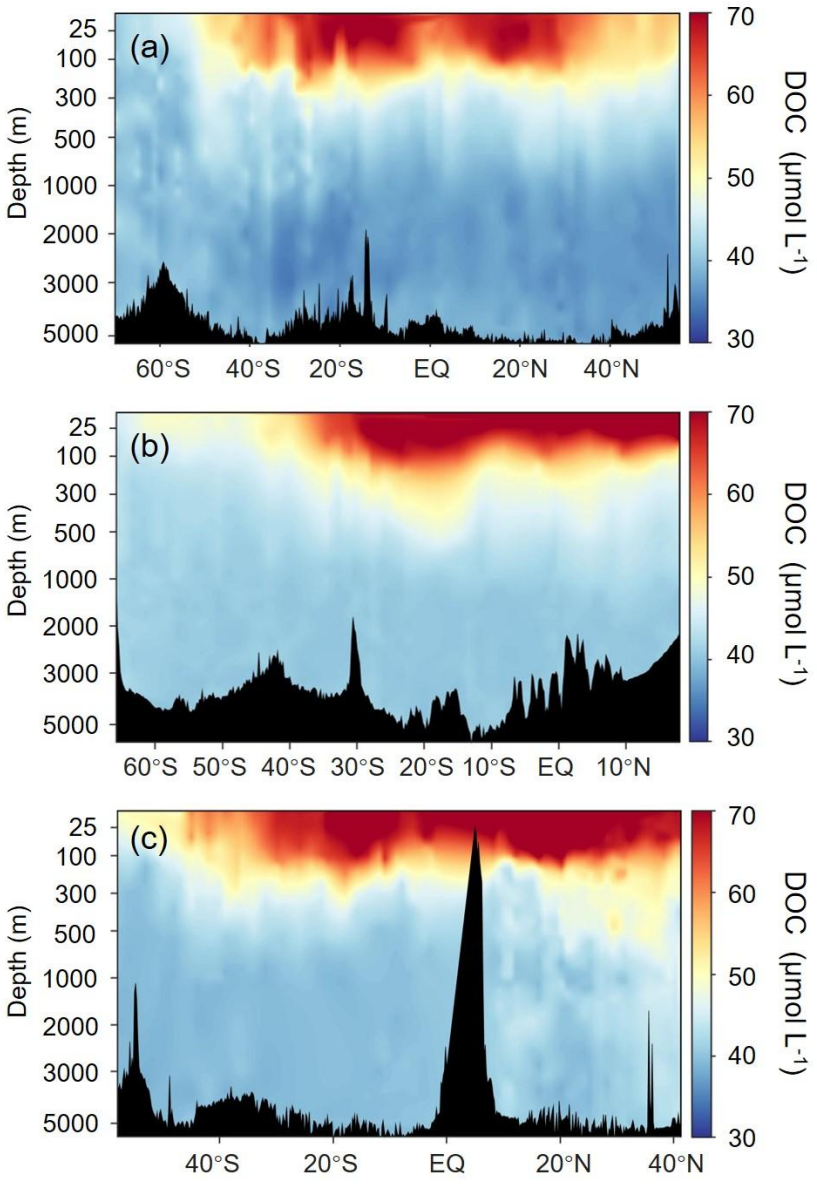


Fig. S4. Distributions of dissolved organic carbon (DOC) obtained for the central Pacific (a), eastern Indian oceans (b), and central Atlantic (c) on climate variability and predictability (CLIVAR) lines P16, I8/I9, and A20/A22-A16, respectively.

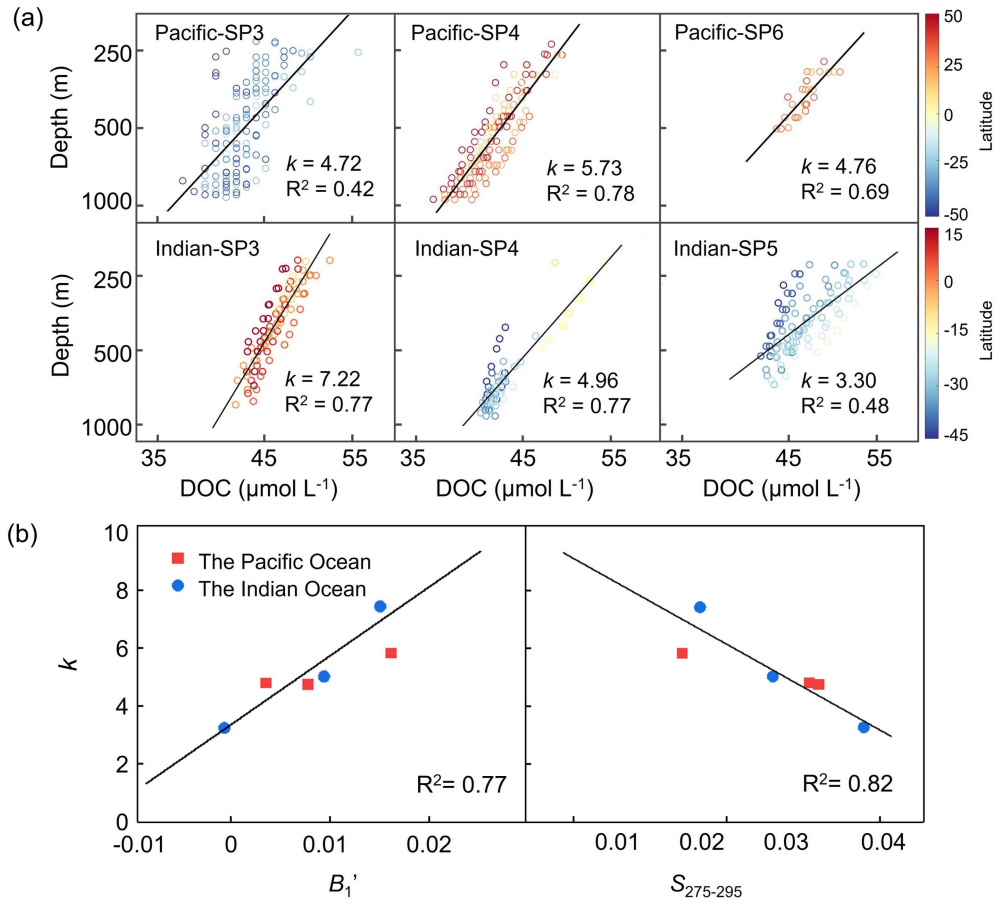


Fig. S5. Vertical distribution of dissolved organic carbon (DOC) sinks. (a) Distribution of DOC sinks across different spectral provinces, ranging from 200 m to 1000 m in the Pacific Ocean and Indian Ocean, with color bars representing latitudes (positive values for northern latitudes and negative values for southern latitudes). The Pacific-SPx denotes the SPx located in the Pacific Ocean, while Indian-SPx refers to the SPx situated in the Indian Ocean. (b) Analysis of the relationships between the attenuation coefficients and B_1' or $S_{275\text{-}295}$ across the Pacific and Indian Oceans. The data used in this analysis were obtained from Fig. S5a.

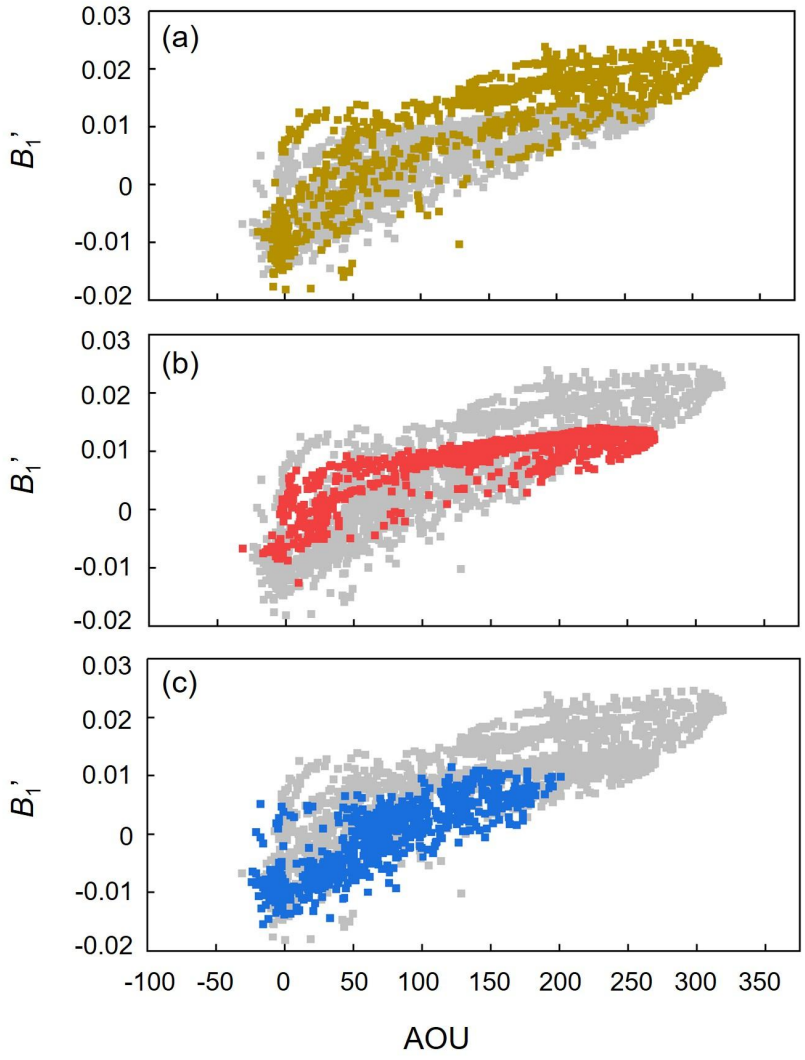


Fig. S6. A linear relationship between B_1' and apparent oxygen utilization (AOU) across the three oceans. (a) The Pacific Ocean. (b) The Indian Ocean. (c) The Atlantic Ocean. The light gray dots in the background represent the comprehensive data encompassing all three oceans.

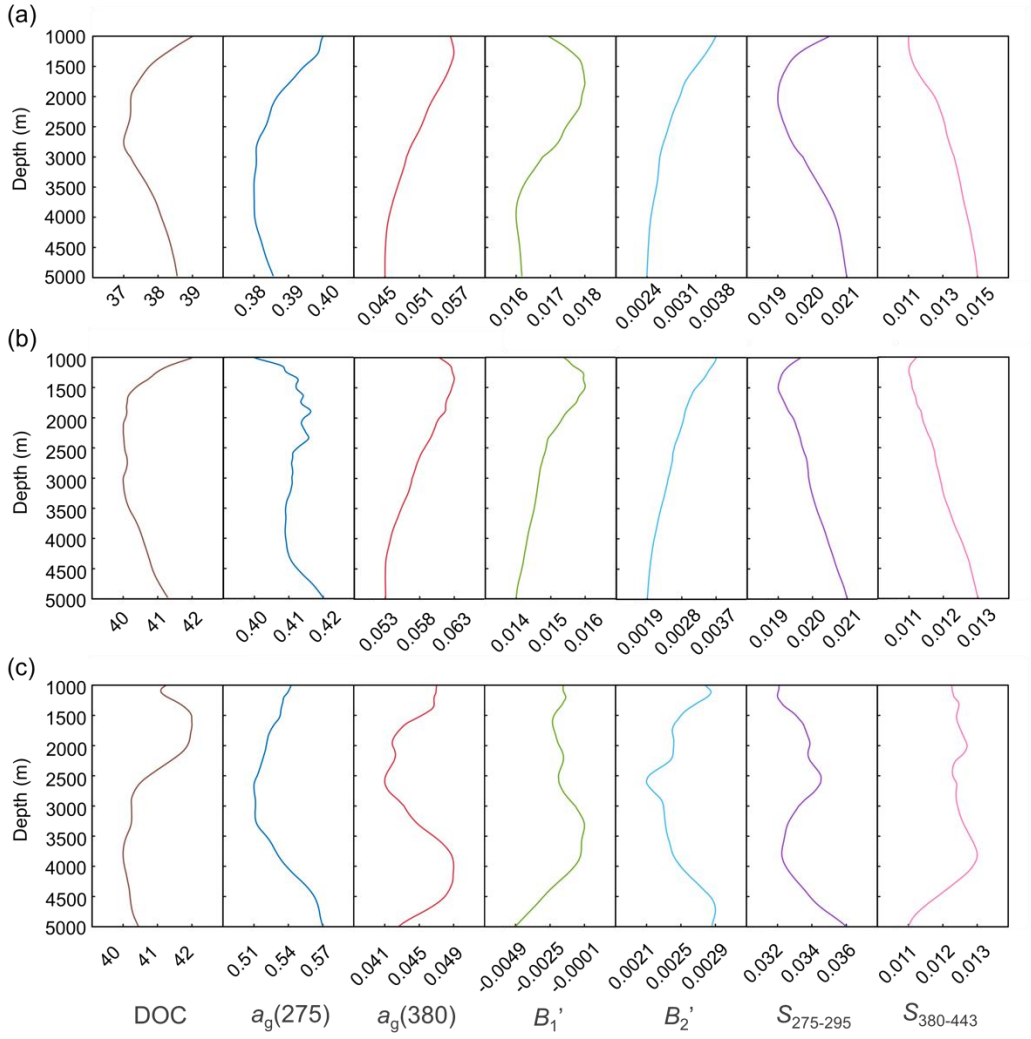


Fig. S7. The vertical distribution of average dissolved organic carbon (DOC) and spectroscopic parameters across the three oceans. (a) The central Pacific Ocean. (b) The eastern Indian Ocean. (c) The central Atlantic Ocean. For each panel, from left to right in order are: DOC (μmol L^{-1}), $a_g(275)$ (m^{-1}), $a_g(380)$ (m^{-1}), B_1' (m^{-1}), B_2' (m^{-1}), $S_{275\text{-}295}$ (nm^{-1}), and $S_{380\text{-}443}$ (nm^{-1}).

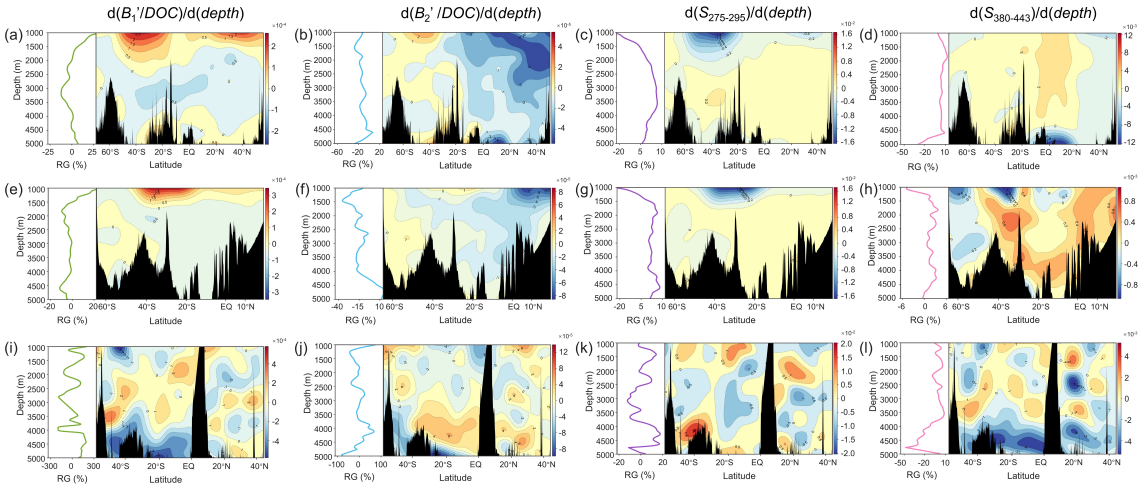
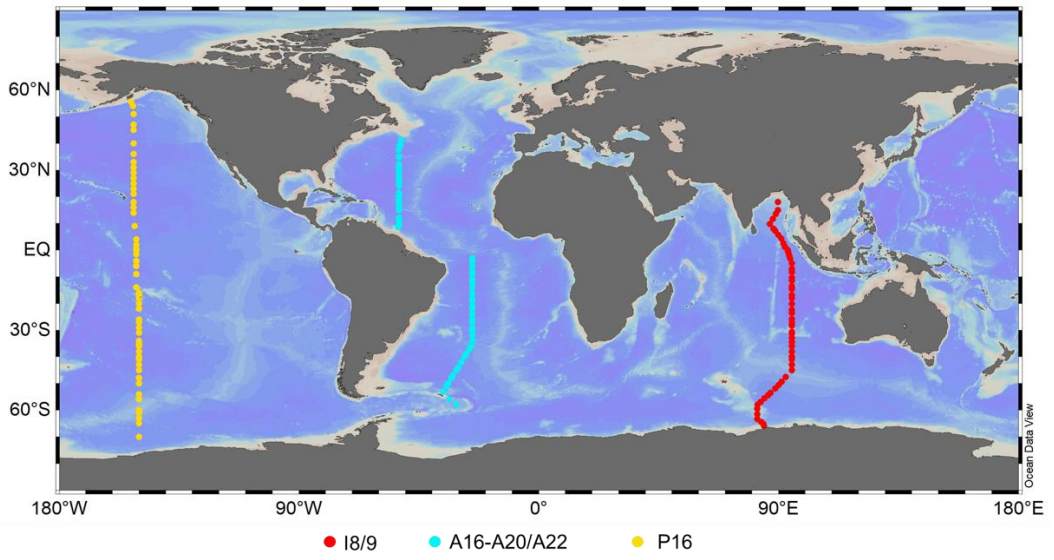


Fig. S8. The distribution of the degradation rates of spectral parameters with depth across three oceans. (a-d) The Pacific Ocean. (e-h) The Indian Ocean. (i-l) The Atlantic Ocean. (a,e,i) d(B_1'/DOC)/d(depth) (L μmol^{-1} m^{-1} km^{-1}). DOC stands for dissolved organic carbon. (b,f,j) d(B_2'/DOC)/d(depth) (L μmol^{-1} m^{-1} km^{-1}). (c,g,k) d($S_{275-295}$)/d(depth) (nm^{-1} km^{-1}). (d,h,l) d($S_{380-443}$)/d(depth) (nm^{-1} km^{-1}). The left graph in each panel depicts the average ratio of gradient (RG), which quantifies the percentage of degradation in spectral parameters that would occur with a decrease in depth with unit 1 km.



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74 **Fig. S9. Sampling points for the central Pacific, eastern Indian, and central**
75 **Atlantic oceans on climate variability and predictability (CLIVAR) lines P16,**
76 **A20/A22-A16, and I8/I9, respectively.** P16 started at 55.5°N, and ended at 70.0°S.
77 A20/A22 started at 41.3°N, and ended at 8.6°N. A16 started at 3.0°S, and ended at
78 58.0°S. I8/I9 started at 18.0°N, and ended at 65.8°S. This figure is drew using Ocean
79 Data View (Schlitzer, Reiner, Ocean Data View, odv.awi.de, 2023).

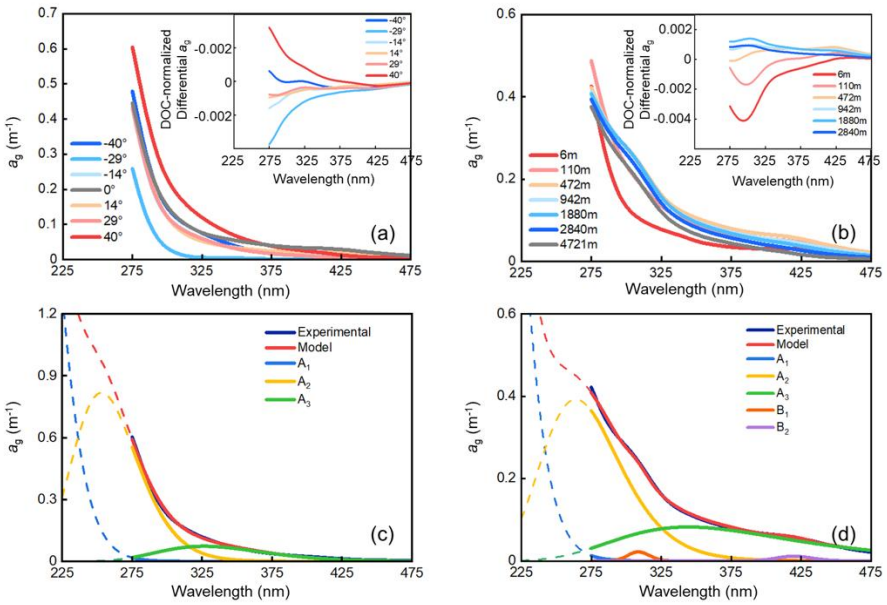

Fig. S10. Deconvolution of the chromophoric dissolved organic matter (CDOM) UV-Vis spectrum. (a) The original and dissolved organic carbon (DOC)-normalized differential spectra of CDOM in the sea surface along the meridional line at 150°W. The reference spectrum is selected as the spectra located at 0°. The sign of a latitude value determines its direction, with positive values indicating north latitude and negative values indicating south latitude. (b) The original and DOC-normalized differential spectra of CDOM in the vertical water column at 4°N, 150°W. The reference spectrum is selected as the spectrum at a depth of 4721 m. (c) Deconvolution of the original CDOM spectrum at 40°N, 150°W in the sea surface. (d) Deconvolution of the original CDOM spectrum at 4°N, 150°W at a depth of 942 m. The dotted lines in panels c and d complement the absorbance of the spectrum within the range of 225-275 nm, based on the deconvolution of original spectrum.