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Supplementary information for

Integrated analysis of carbon dioxide and oxygen concentrations as a quality control of ocean float data

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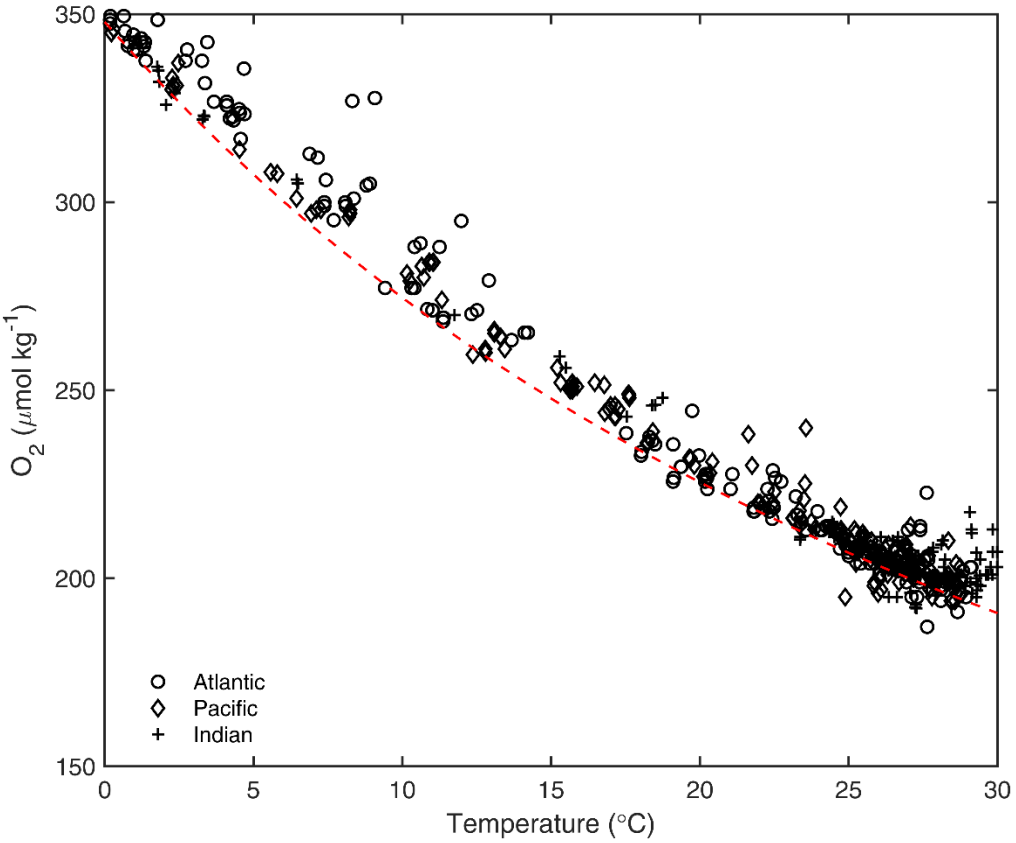
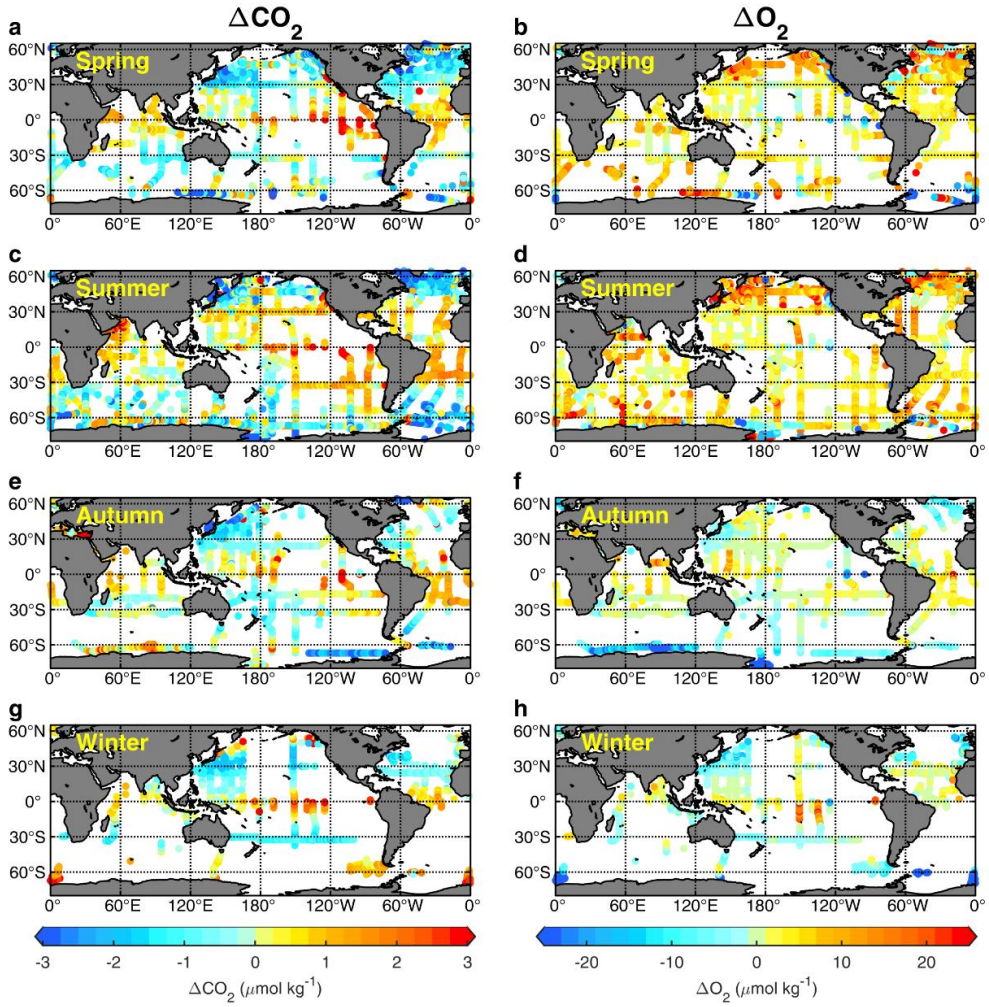
Introduction

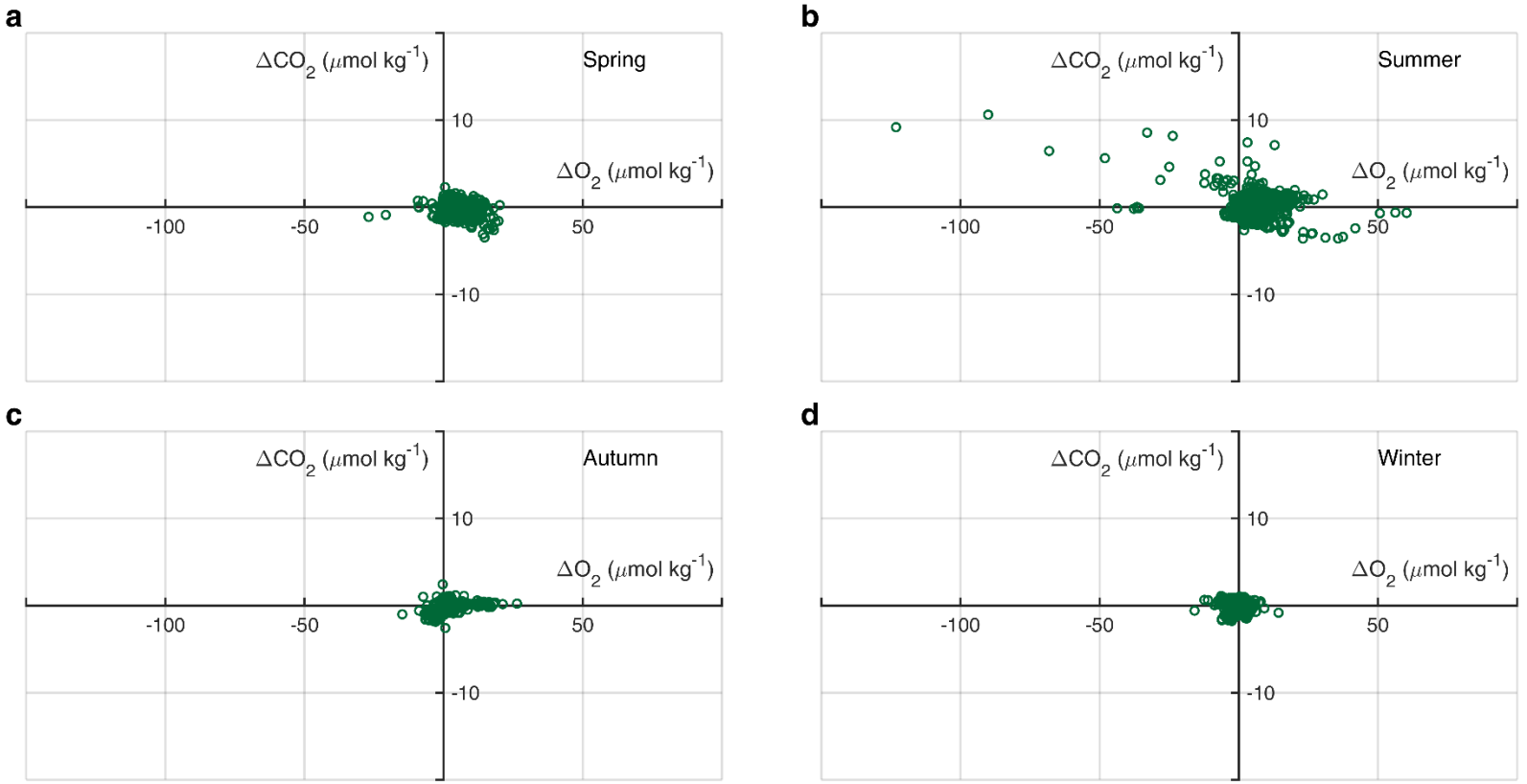
The supplementary information includes 9 figures, and 2 tables presenting supporting analyses of data from the relevant datasets.



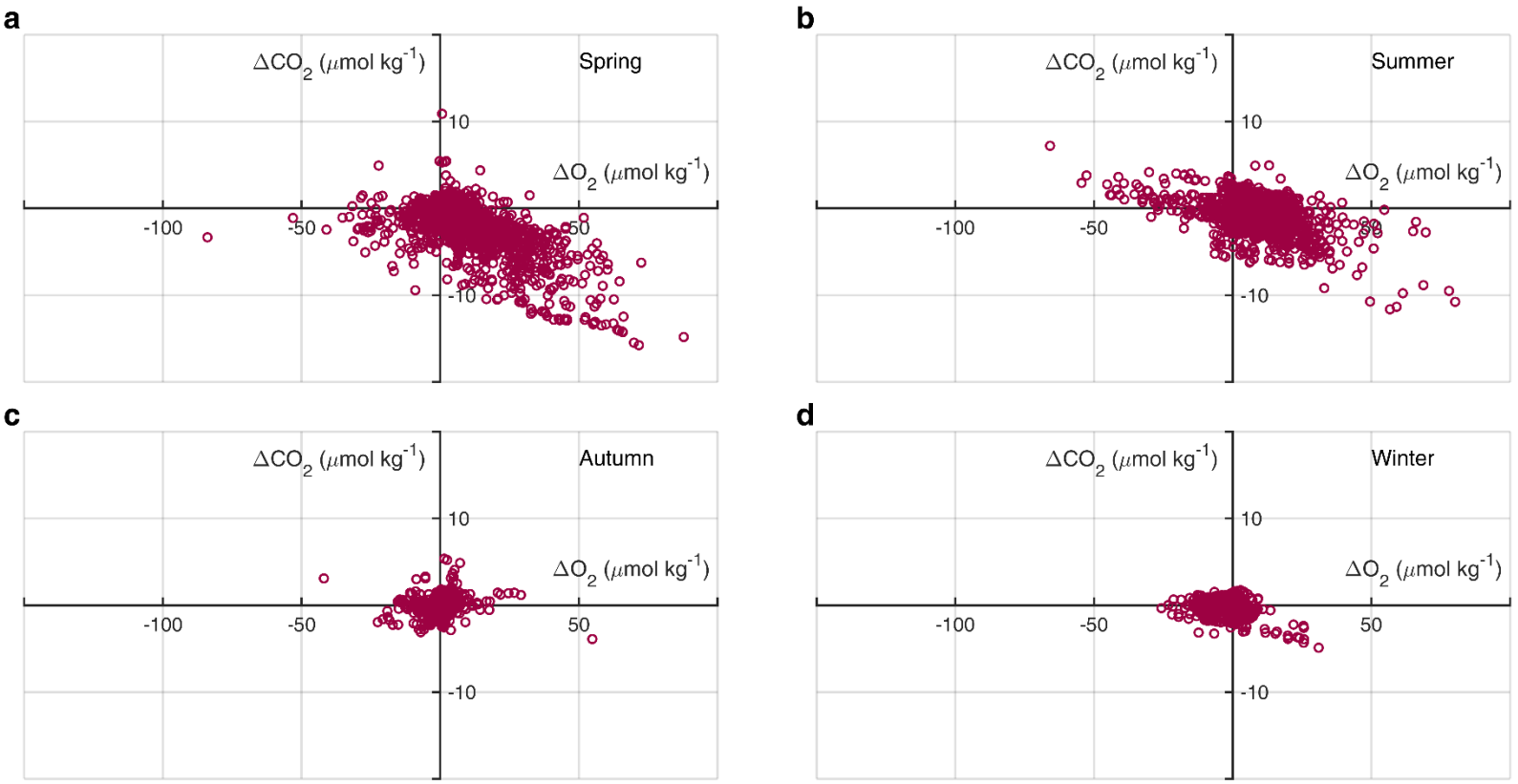
Supplementary Figure 1. The concentration of dissolved oxygen with respect to temperature in the surface ocean (<20 m depth) collected by GEOSECS program. This figure was redrawn following Broecker and Peng[1] using quality-controlled GEOSECS data as contained in the GLODAPv2020 dataset. The red dashed curve indicates the saturation values of O_2 as a function of temperature and salinity of 35. This figure suggests, for temperatures above 0°C, a close correspondence between the observed oxygen and its saturation concentration.



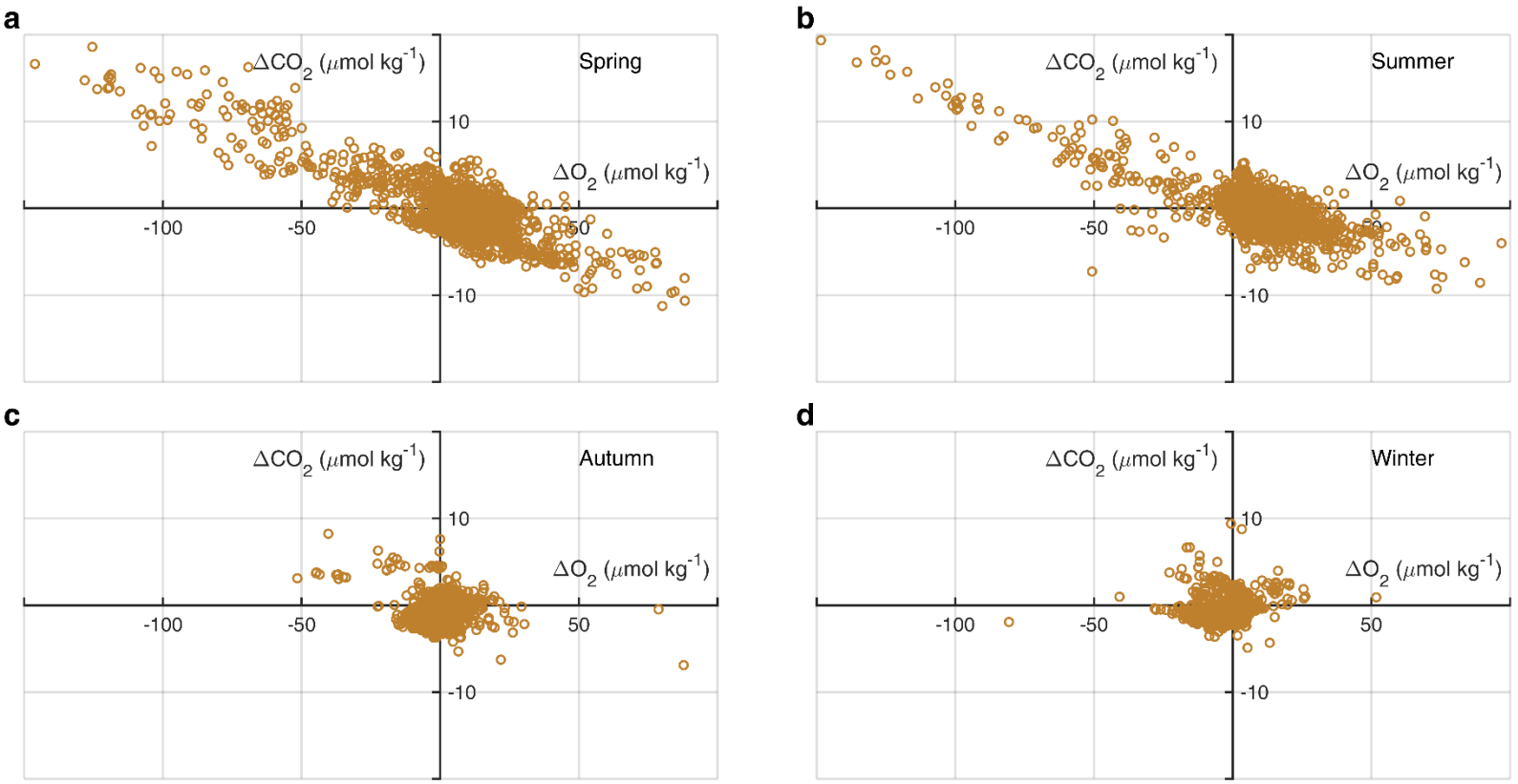
Supplementary Figure 2. Spatial distribution of sea surface ΔCO_2 and ΔO_2 concentrations relative to saturation in the global dataset GLODAPv2. Each row is a different season, for instance, panels a and b are for spring which includes both the boreal (April to June) and austral spring (October to December); $[CO_2]$ data are shown on the left and $[O_2]$ data on the right. $\Delta CO_2 = [CO_{2,obs}] - [CO_{2,sat}]$ and $\Delta O_2 = [O_{2,obs}] - [O_{2,sat}]$ as in Equations 1 and 2. The color scale is narrowed to visually emphasize the positive and negative directions in ΔCO_2 and ΔO_2.



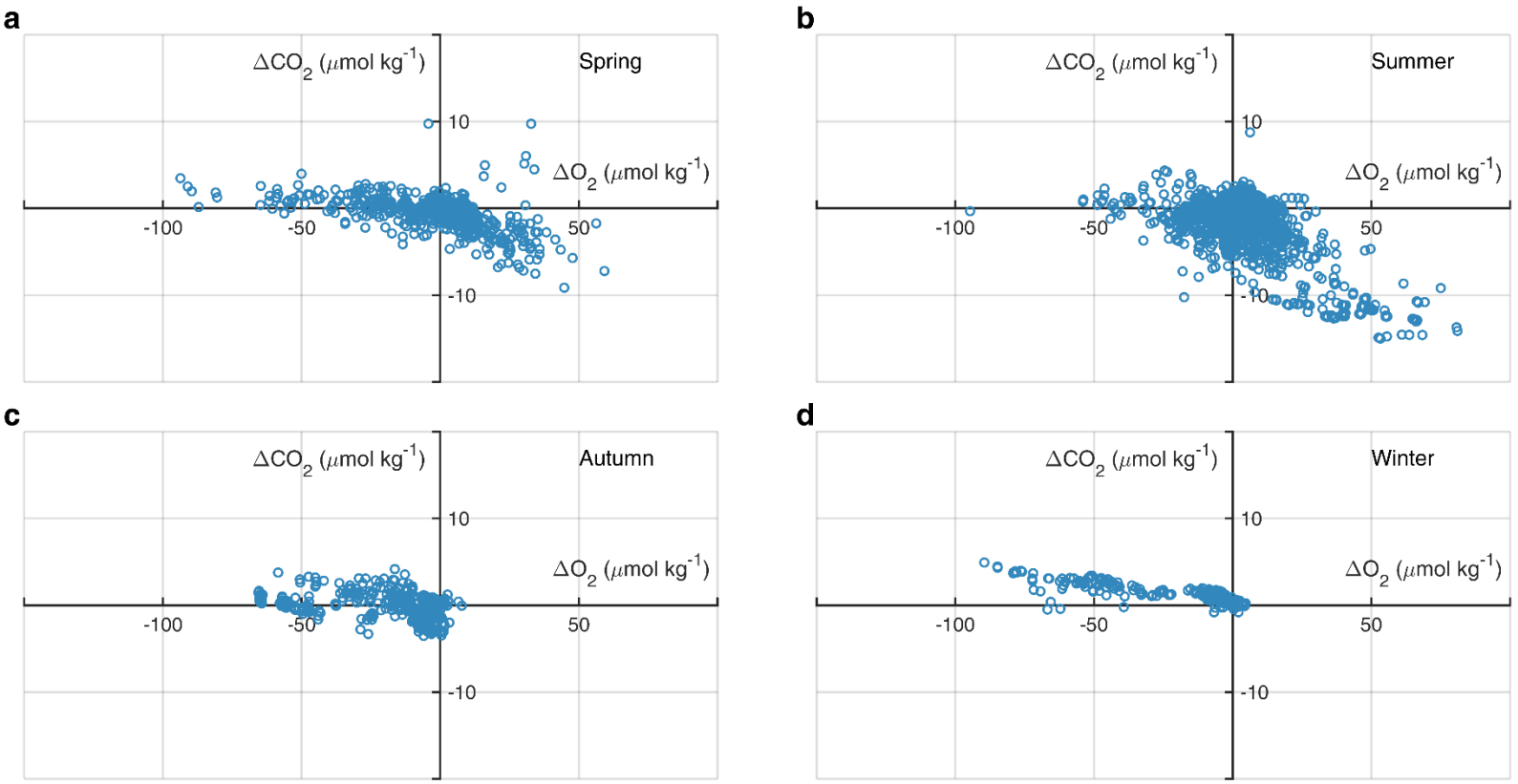
Supplementary Figure 3. CORS plots: concentrations of carbon and oxygen relative to their saturation in the surface Indian Ocean in four seasons.



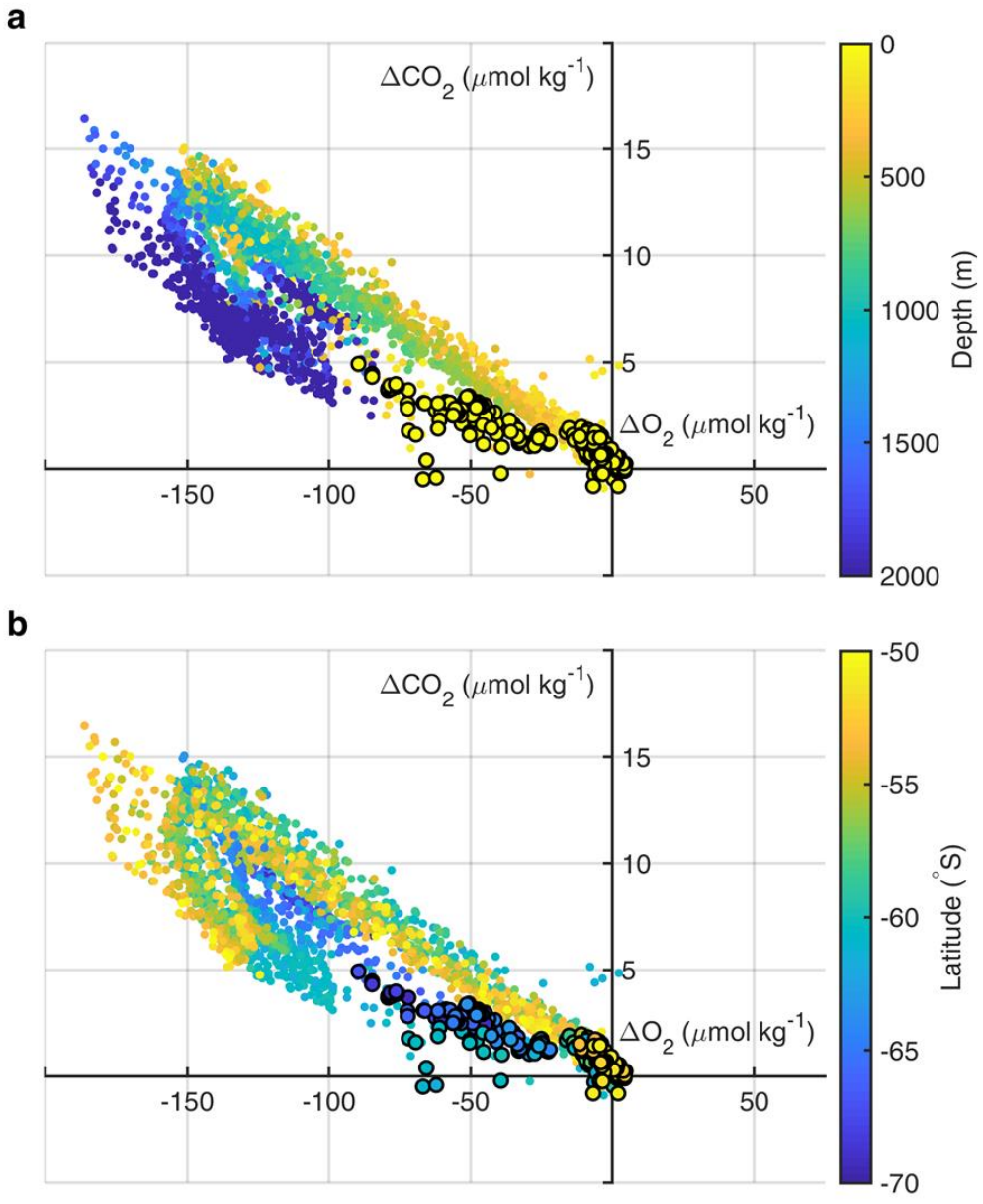
Supplementary Figure 4. CORS plots: concentrations of carbon and oxygen relative to their saturation in the surface Atlantic Ocean in four seasons.



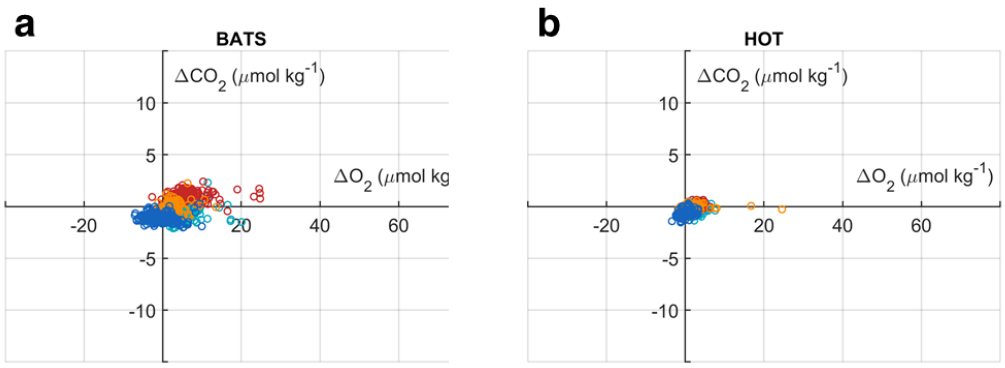
Supplementary Figure 5. CORS plots: concentrations of carbon and oxygen relative to their saturation in the surface Pacific Ocean in four seasons.



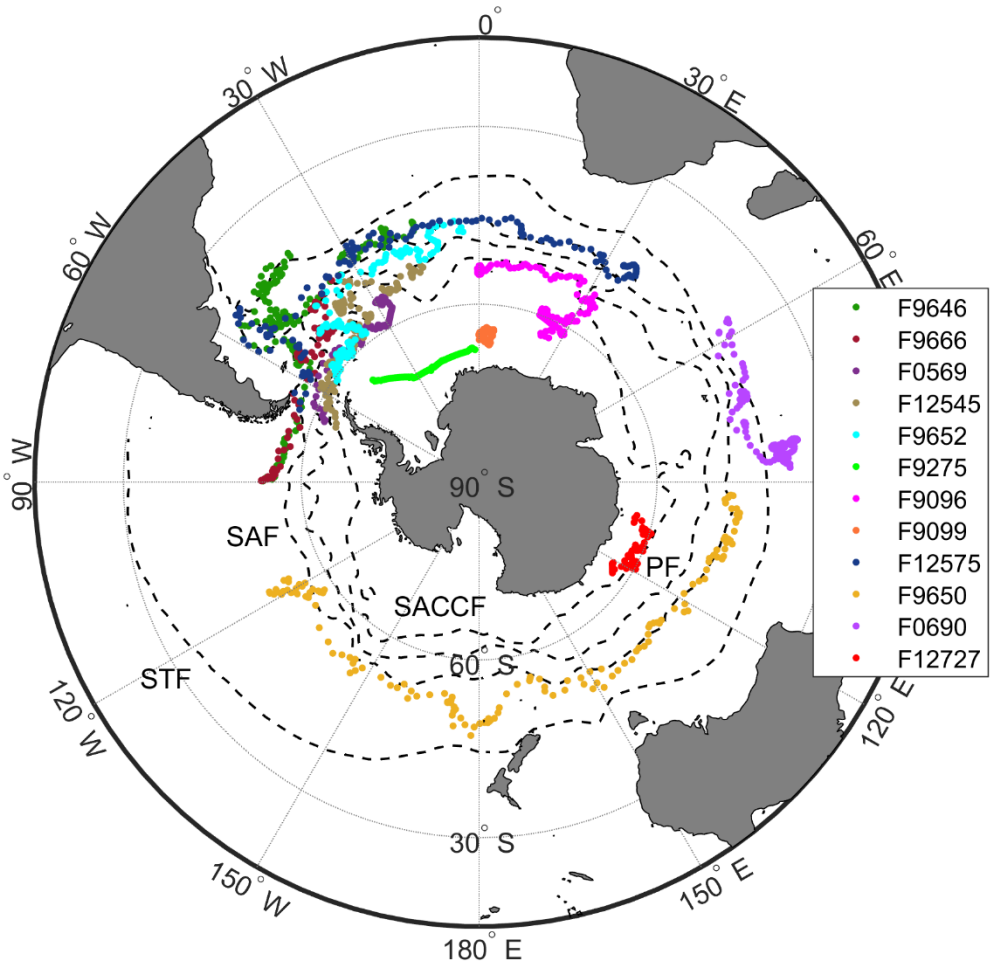
Supplementary Figure 6. CORS plots: concentrations of carbon and oxygen relative to their saturation in the surface Southern Ocean in four seasons. The Southern Ocean is defined as regions south of 50°S.



Supplementary Figure 7. CORS plots for water from all depths in the Southern Ocean in winter. (a) and (b) both show the same data but colored by different variables in each panel: (a) by depth, and (b) by latitude. Circles with solid black edges denote surface waters (shallower than 30 m), whereas circles without edges denote subsurface water (deeper than 30 m).



Supplementary Figure 8. CORS plot from time-series stations. (a) Bermuda Atlantic Time-series Study (BATS): 32.17°N 64.5°W; and (b) Hawaii Ocean Time-series (HOT): 22.75°N 158°W. Colors represent different seasons (light blue – spring, red – summer, orange – autumn, blue - winter). The time-series datasets were downloaded from https://www.ncei.noaa.gov/access/ocean-carbon-data-system/oceans/time_series_moorings.html. The concentration of CO_2 was calculated from discreate DIC and TA as described in Methods.



Supplementary Figure 9. Trajectories of 12 autonomous biogeochemical floats deployed in the Southern Ocean. Colored dots show the paths of travel of each of the floats. Dashed contours show the boundaries of the Southern Ocean fronts[2,3]. STF = Subtropical Front; SAF = Subantarctic Front; PF = Polar Front; SACCF = Southern Antarctic Circumpolar Current Front.

Supplementary Table 1. Regional correlations between NO_3^-, NO_3^- Anomaly and CORS (ΔO_2 and ΔCO_2). Correlation coefficients are shown in bold where they point to a strong or very strong correlation ($r > 0.5$). Numbers of paired values used in the correlation calculation are shown in brackets after the coefficient values.

		r*	
Corresponding figure	Region and Season	**ΔO_2**	**ΔCO_2**
		vs. NO_3^-	vs. NO_3^-
Second quadrant of Fig. 3a	The Pacific Ocean, Spring	**-0.68** (n=313, p<0.0001)	**0.80** (n=313, p<0.0001)
Fourth quadrant of Fig. 3a	The Atlantic Ocean, Spring	-0.05 (n=1341, p=0.08)	0.02 (n=1341, p=0.47)
		vs. NO_3^- $_{Anom}$	vs. NO_3^- $_{Anom}$
Second quadrant of Fig. 3d	The Southern Ocean, Winter	**-0.79** (n=225, p<0.0001)	**0.72** (n=225, p<0.0001)

* the Pearson correlation coefficient (linear correlation) between the two variables.

Supplementary Table 2. The difference of y-intercept between GLODPv2 reference and the 48 QCed floats in the high-latitude Southern Ocean.

Float ID number	y_diff*	Float ID number	y_diff*
F0507	-3.74	F12749	0.18
F0511	2.97	F12752	0.47
F0564	-1.06	F12755	-0.27
F0567	-1.12	F12758	0.19
F0569	-0.33	F12768	1.93
F0570	-4.07	F12769	-2.50
F0571	-0.88	F12781	-6.97
F11090	2.76	F12782	-1.15
F12371	-0.67	F12784	-2.65
F12378	-3.56	F12787	1.10
F12379	-4.53	F12878	5.00
F12381	-0.55	F12879	-0.09
F12390	0.50	F12886	2.40
F12398	-1.13	F12892	-0.24
F12541	1.76	F18097	2.20
F12549	-0.75	F18169	1.05
F12702	0.10	F18643	-2.10
F12708	-0.71	F8501	0.49
F12711	0.44	F9091	-2.00
F12714	1.01	F9092	-2.64
F12727	-0.37	F9094	2.79
F12730	-1.25	F9099	0.26
F12739	-1.14	F9125	-0.59
F12741	-0.88	F9275	2.70

*GLODAP-derived y-intercepts minus float-derived y-intercepts; negative (positive) values mean that float y-intercept is greater (lower) than GLODAP y-intercept.

Supplementary References

1. Broecker, W. S. & Peng, T.-H. *Tracers in the Sea*. (Lamont-Doherty Geological Observatory, Columbia University, 1982).
2. Orsi, A. H., Whitworth, T. & Nowlin, W. D. On the meridional extent and fronts of the Antarctic Circumpolar Current. *Deep Sea Research Part I: Oceanographic Research Papers* **42**, 641-673, doi:10.1016/0967-0637(95)00021-W (1995).
3. Thorpe, S. E., Heywood, K. J., Brandon, M. A. & Stevens, D. P. Variability of the southern Antarctic Circumpolar Current front north of South Georgia. *Journal of Marine Systems* **37**, 87-105, doi:10.1016/S0924-7963(02)00197-5 (2002).