

**Variability of Atmospheric CO<sub>2</sub> Over the Arctic Ocean: Insights From the O-Buoy  
Chemical Observing Network**

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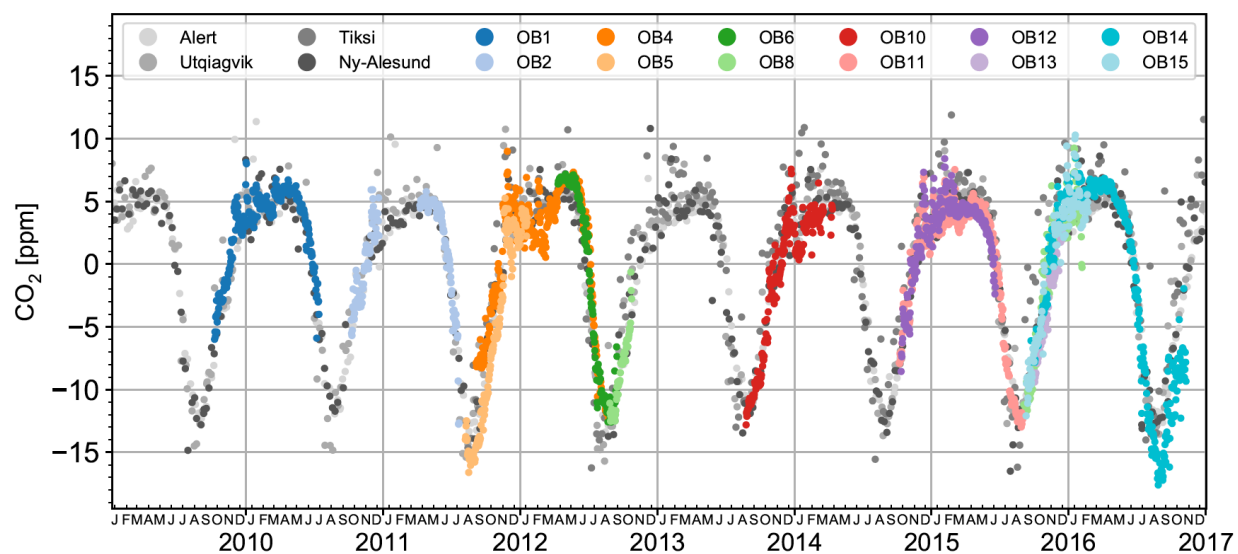
Tables S2 to S4

**Additional Supporting Information (Files uploaded separately)**

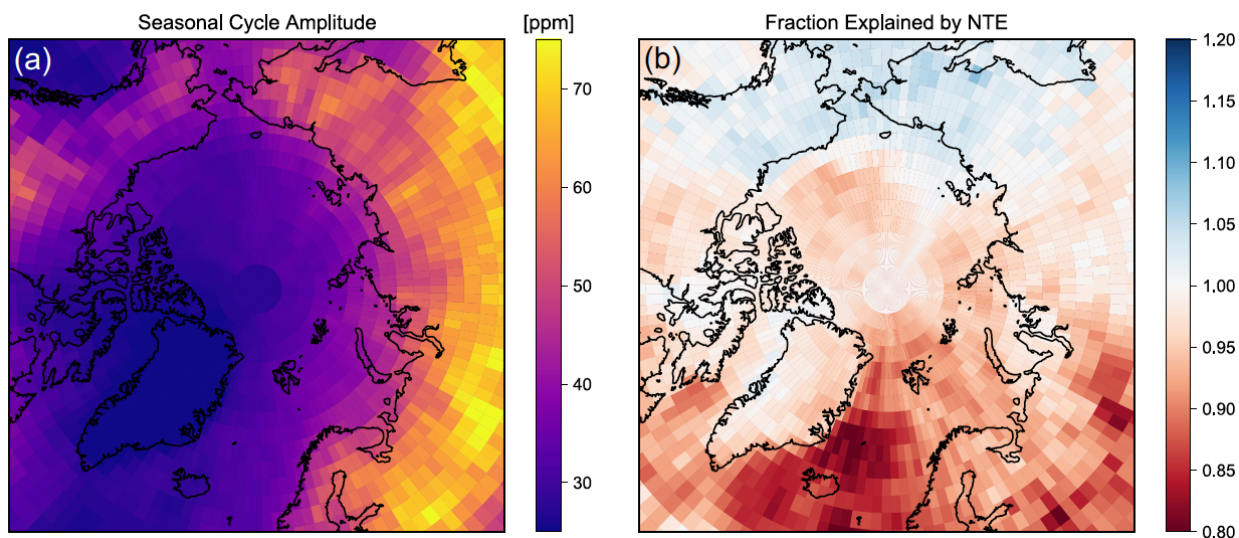
Captions for Tables S1 and S5

## Introduction

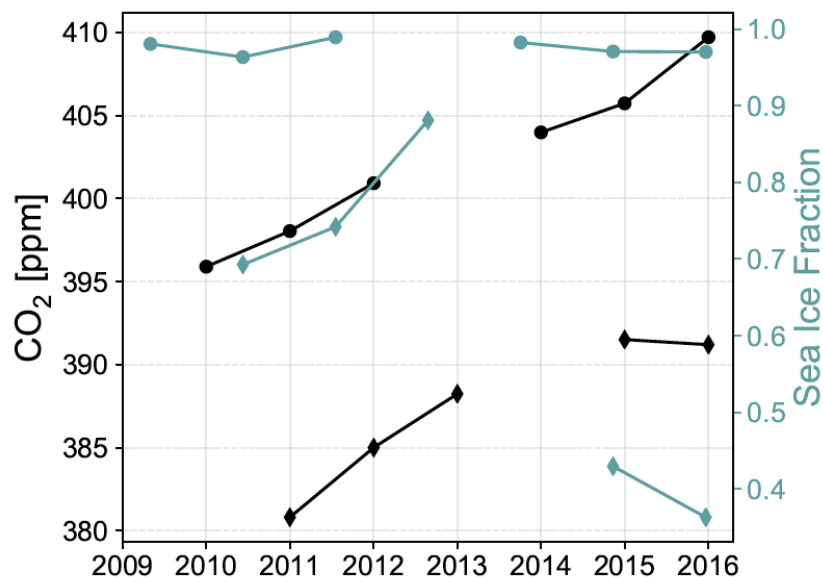
This supporting information includes figures and tables that are not included in the original manuscript. Any methods are explained in corresponding captions.



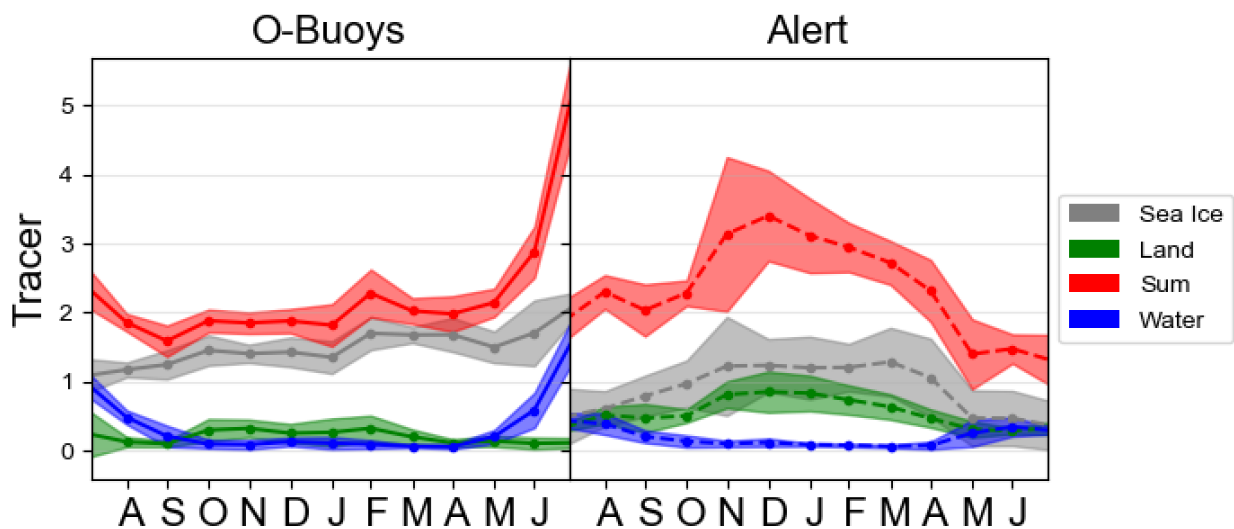
**Figure S1.** Detrended CO<sub>2</sub> mixing ratios for the O-Buoys and land stations. All data are daily averages. The trend at Utqiagvik, AK was removed from all time series.



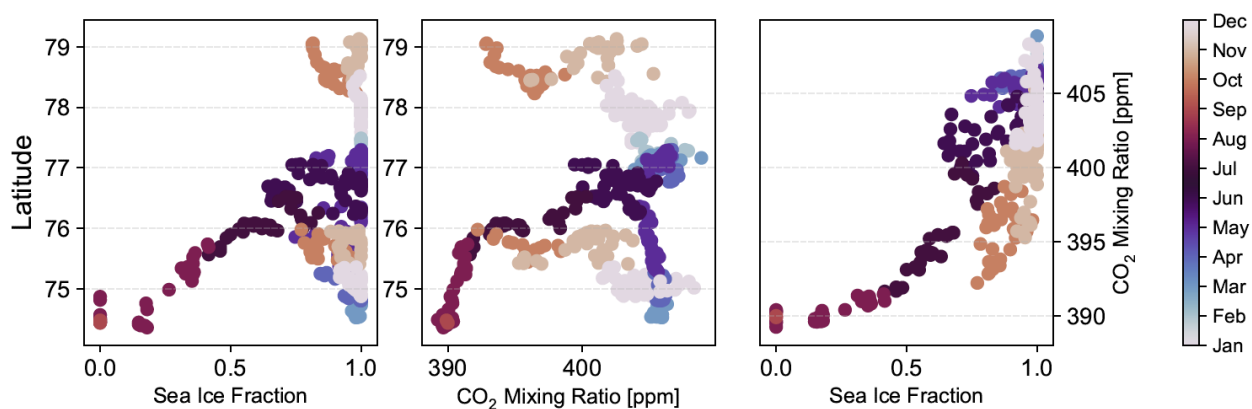
**Figure S2.** (a) Greatest seasonal cycle amplitudes calculated as the maximum and minimum daily CO<sub>2</sub> mixing ratios in the model surface layer, averaged over years 2011, 2012, 2015, and 2016. (b) The fraction of the seasonal cycle amplitude in (a) explained by the seasonal cycle amplitude of the net terrestrial biosphere flux tag, or net terrestrial exchange (NTE), calculated as  $NTE / CO_2$ . Where the fraction exceeds 1, other CO<sub>2</sub> surface fluxes partially offset the amplitude due to NTE.



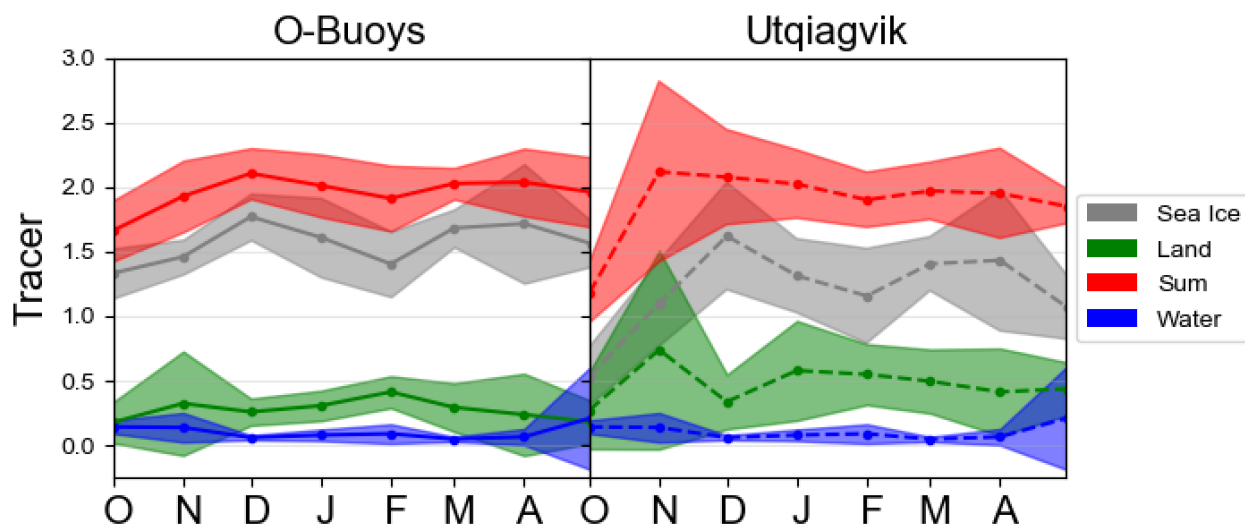
**Figure S3.** Interannual variability of CO<sub>2</sub> (black) and sea ice fraction (teal) at the O-Buoys, averaged during the CO<sub>2</sub> maxima (April–May; dots) and CO<sub>2</sub> minima (August–September; diamonds).



**Figure S4.** GEOS-Chem surface contact tracer abundance (unitless) at the locations of O-Buoys 4, 6 (Central Arctic through Fram Strait) and 5 (Beaufort Gyre) (left) and Alert, NU (right) for August 2011–July 2012. The tracers indicate integrated upwind airmass contact with respective surface (sea ice, land, open water, or sum of all surface contact) on the timescale of the 5-days tracer lifetime. Shading indicates standard error of the mean.



**Figure S5.** Relationships between CO<sub>2</sub> mixing ratio, sea ice concentration, and latitude for O-Buoys 11 and 12 in the Beaufort Gyre, which were deployed 2014–2015. Colors show the month of observation. All data are daily means.



**Figure S6.** GEOS-Chem surface contact tracer abundance (unitless) at the locations of O-Buoys 11 and 12 in the Beaufort Gyre (left) and Utqiagvik, AK (right) for April 2014–April 2015. The tracers indicate integrated upwind air mass contact with respective surface (sea ice, land, open water, or sum of all surface contact) on the timescale of the 5-days tracer lifetime. Shading indicates standard error of the mean.

**Table S1.** O-Buoy deployment locations, dates, and number of CO<sub>2</sub> measurements.

MERRA-2 Resolution	$R^2$		RMSE	
	$2^\circ \times 2.5^\circ$	$0.5^\circ \times 0.625^\circ$	$2^\circ \times 2.5^\circ$	$0.5^\circ \times 0.625^\circ$
Sea-level pressure	0.983	0.993	1.27 hPa	0.82 hPa
Air temperature	0.977	0.980	2.47 K	2.43 K
Relative humidity	0.890	0.885	3.60 %	3.77 %
Wind speed (3m)	0.558	0.591	2.12 m s <sup>-1</sup>	2.17 m s <sup>-1</sup>

**Table S2.** O-Buoy deployment locations, dates, and number of CO<sub>2</sub> measurements.

Period		April–May	August–September
Ice-covered Arctic Ocean	Observed	$2.1 \pm 0.01$	$2.1 \pm 0.02$
	Modeled	$1.9 \pm 0.01$	$2.4 \pm 0.03$
Coastal land stations	Observed	$2.3 \pm 0.03$	$2.4 \pm 0.06$
	Modeled	$2.0 \pm 0.05$	$2.0 \pm 0.07$

**Table S3.** Multi-year mean growth rate of CO<sub>2</sub> (units of ppm yr<sup>-1</sup>) of over 13 ice-tethered O-Buoys in the Arctic Ocean and around 4 land-based, marine boundary layer monitoring stations (Utqiagvik, Alert, Ny-Alesund, Tiksi). Ranges show standard error. Data cover 2009–2016, except that Tiksi, Russia began sampling CO<sub>2</sub> in 2011 and the O-Buoy August–September data cover the 2012–2016 period only, as buoys in previous years succumbed to sea ice loss.

Season/Month	Error $\pm$ SD [ppm]		Season/Month	Error $\pm$ SD [ppm]	
	O-Buoys	Coastal Stations		O-Buoys	Coastal Stations
DJF	$-1.2 \pm 2.0$	$-1.8 \pm 2.0$	JJA	$-4.4 \pm 2.8$	$-4.0 \pm 2.7$
December	$-1.0 \pm 2.2$	$-1.5 \pm 2.1$	June	$-2.8 \pm 1.8$	$-2.6 \pm 1.6$
January	$-1.3 \pm 1.9$	$-1.9 \pm 2.2$	July	$-5.5 \pm 2.9$	$-4.0 \pm 2.8$
February	$-1.5 \pm 1.7$	$-1.9 \pm 1.6$	August	$-5.4 \pm 2.7$	$-5.4 \pm 2.8$
MAM	$-1.5 \pm 1.4$	$-1.7 \pm 1.7$	SON	$-2.5 \pm 2.4$	$-3.4 \pm 2.3$
March	$-1.1 \pm 1.7$	$-1.7 \pm 1.7$	September	$-3.8 \pm 2.4$	$-4.5 \pm 2.3$
April	$-1.4 \pm 1.4$	$-1.4 \pm 1.6$	October	$-2.6 \pm 2.0$	$-3.2 \pm 2.1$
May	$-1.7 \pm 1.1$	$-2.0 \pm 1.6$	November	$-1.4 \pm 2.2$	$-2.4 \pm 2.1$

**Table S4.** Mean seasonal and monthly model error (model minus observation) and standard deviation of error (SD) at the times and locations of the O-Buoys, and averaged at the coastal stations (Alert, Utqiagvik, Ny-Alesund, and Tiksi).

**Table S5.** Correlation coefficient ( $R$ ) between daily observed CO<sub>2</sub> mixing ratios and observed sea ice concentrations with the seasonal cycle removed (i.e. following the NOAA ESRL method, we removed the smoothed curve from each series, which is the function fit plus the filtered residuals using a short term cutoff value of 80 days), averaged monthly at each O-Buoy. Marker of \*\*\* indicates  $p$ -value  $< 0.05$ , \*\* indicates  $0.05 \leq p$ -value  $< 0.25$ , \* indicates  $0.25 \leq p$ -value  $< 0.50$ , no marker indicates  $p$ -value  $\geq 0.50$ .