**Supplemental material**

Underestimation of surface *p*CO2 and air-sea CO2 fluxes due to freshwater stratification in an Arctic shelf sea, Hudson Bay

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**Figure S1. Water mass characteristics at each station based on our bottle samples.** (a) Surface-water potential temperature versus salinity, color-shaded with *p*CO2 values, with isopycnals of density anomaly (σθ) displayed in dashed lines (blue rectangle indicates samples mainly from Hudson Strait), and (b) oxygen water isotope (δ18O) versus salinity, shaded with *p*CO2 values (the dashed lines represent the mixing lines between the endmembers). SIM, SW, and MW refer to sea-ice melt, seawater, and meteoric water endmembers, respectively.

**Figure S2. Vertical gradients of DIC and TA in Hudson Bay.** Distributions of DIC (a) and TA (b) as a function of salinity at the surface (red) and at 7-m depth (blue), with the distributions of vertical gradients of DIC (c) and TA (d) versus the vertical gradients of salinity during the study time. The solid black lines in (a,b) show linear regression relationships.

**Table S1**: **Sampling stations with surface and 7-m water samples collected across the study area.**



**Figure S1. Water mass characteristics at each station based on our bottle samples.** (a) Surface water potential temperature versus salinity, color-shaded with *p*CO2 values, with isopycnals of density anomaly (σθ) displayed in dashed lines (blue rectangle indicates samples mainly from Hudson Strait), and (b) oxygen water isotope (δ18O) versus salinity, shaded with *p*CO2 values (the dashed lines represent the mixing lines between the end-members, in red squares). SIM, SW, and MW refer to sea-ice melt, seawater, and meteoric water endmembers, respectively.

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**Figure S2. Vertical gradients of DIC and TA in Hudson Bay.** Distributions of DIC (a) and TA (b) as a function of salinity at the surface (red) and at 7-m depth (blue), with the distributions of vertical gradients of DIC (c) and TA (d) versus the vertical gradients of salinity during the study time. The solid black lines (a,b) show linear regression relationships.

**Table S1**. **Sampling stations with surface and 7-m water samples collected across the study area.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Date (year-month-day) and time (UTC) | Station | Sampling meansa | Latitude | Longitude | Distanceb (km) |  FD/SB | UWc |
| Surface–0.5 m | 7 m | 7 m |
| 2018-05-31 18:57:11 | 1 | FD | 60.83 | –64.68 | 1.90 |  xd | x | x |
| 2018-06-01 00:35:21 | 3 | FD | 61.15 | –64.82 | ―e | x | x | ― |
| 2018-06-01 14:00:28 | 4 | FD | 62.04 | –69.61 | 1.78 | ○f | x | ○ |
| 2018-06-02 21:46:50 | 5 | FD | 64.29 | –78.23 | 1.98 |  ○ | x | ○ |
| 2018-06-03 04:05:55 | 7 | FD | 64.07 | –79.06 | ― | x | x | ― |
| 2018-06-03 20:32:42 | 9 | FD | 63.72 | –79.92 | 0.10 | ○ | x | ○ |
| 2018-06-04 02:31:43 | 10 | FD | 63.45 | –79.44 | 0.03 | ○ | x | ○ |
| 2018-06-04 19:28:00 | 11 | FD | 62.88 | –78.86 | ― | x | x | ― |
| 2018-06-05 18:01:10 | 15 | SB | 63.18 | –81.86 | 0.02 | ○ | x | ○ |
| 2018-06-06 18:53:10 | 16 | SB | 63.00 | –85.88 | 1.50 | ○ | x | ○ |
| 2018-06-07 21:44:28 | 17 C | SB | 63.49 | –90.64 | ― | x | ― | ― |
| 2018-06-07 23:06:04 | 17 B | SB | 63.28 | –90.35 | 0.75 | ○ | ― | ○ |
| 2018-06-08 00:00:45 | 17 A | SB | 61.18 | –90.06 | ― | x | x |  |
| 2018-06-08 19:29:59 | 18 | SB | 63.73 | –88.32 | 0.02 | ○ | x | ○ |
| 2018-06-09 17:39:35 | 19 C | SB | 62.06 | –92.47 | ― | x | ― | ― |
| 2018-06-09 18:39:35 | 19 B | SB | 61.96 | –92.27 | ― | x | ― | ― |
| 2018-06-09 19:39:35 | 19 A | SB | 61.84 | –92.17 | 0.06 | ○ | x | ○ |
| 2018-06-10 13:47:00 | 21 B | SB | 61.05 | –89.37 | ― | x | ― | ― |
| 2018-06-10 14:26:18 | 21 A | SB | 61.14 | –89.37 | ― | x | x | ― |
| 2018-06-11 17:04:32 | 22 C | SB | 60.48 | –94.57 | ― | x | ― | ― |
| 2018-06-11 17:52:39 | 22 B | SB | 60.48 | –94.57 | ― | x | x | ― |
| 2018-06-11 18:52:28 | 22 M | SB | 60.45 | –94.30 | ― | x | ― | ― |
| 2018-06-11 20:12:13 | 22 A | SB | 60.42 | –94.01 | 0.07 | ○ | x | ○ |
| 2018-06-12 17:17:49 | 24 | SB | 61.69 | –87.75 | 0.05 | ― | ― | x |
| 2018-06-14 12:13:15 | 26 | FD | 62.20 | –88.38 | 0.03 | ○ | ― | ○ |
| 2018-06-15 01:18:38 | 28 | FD | 62.41 | –89.83 | 0.06 | ○ | x | ○ |
| 2018-06-18 15:07:38 | 31 | FD | 57.50 | –91.81 | 0.04 | x | x | x |
| 2018-06-19 16:40:22 | 32 B | SB | 56.99 | –88.12 | 0.68 | ― | ― | x |
| 2018-06-19 17:10:00 | 32 A | SB | 56.99 | –88.14 | 0.50 | x | x | x |
| 2018-06-20 23:12:28 | 34 | SB | 56.51 | –86.88 | 0.78 | x | x | x |
| 2018-06-21 13:47:50 | 34B A | SB | 56.50 | –86.86 | 0.80 | x | x | x |
| 2018-06-21 14:11:37 | 34B B | SB | 56.50 | –86.88 | 0.80 | ○ | ― | ○ |
| 2018-06-22 03:04:37 | 35 | FD | 57.18 | –86.50 | 0.11 | ― | x | x |
| 2018-06-22 14:46:59 | 36B | SB | 57.77 | –86.03 | 1.24 | ― | ― | x |
| 2018-06-22 14:57:47 | 36A | SB | 57.77 | –86.03 | 1.13 | ― | x | x |
| 2018-06-23 02:54:52 | 37 | FD | 58.47 | –86.23 | ― | x | x | ― |
| 2018-06-23 15:39:00 | 38 B | SB | 58.72 | –86.31 | 0.73 | ― | ― | x |
| 2018-06-23 18:10:49 | 38 A | SB | 58.72 | –86.31 | 0.59 | x | x | x |
| 2018-06-24 06:48:54 | 39 | FD | 58.48 | –87.44 | 0.53 | ― | x | x |
| 2018-06-24 13:49:17 | 40 | SB | 58.24 | –88.58 | 0.08 | ― | x | x |
| 2018-07-04 14:35:57 | Churchill A | SB | 58.76 | –94.20 | ― | ― | x | ― |
| 2018-07-04 15:53:09 | Churchill B | SB | 58.80 | –94.19 | ― | x | ― | ― |
| 2018-07-04 17:40:42 | Churchill C | SB | 58.93 | –93.80 | ― | x | ― | ― |
| 2018-07-08 19:06:04 | 730 | FD | 56.18 | –76.70 | 0.05 | ― | x | x |
| 2018-07-09 10:45:15 | 736 | FD | 58.42 | –78.31 | 0.02 | ― | x | x |
| 2018-07-11 22:26:55 | 689 | FD | 62.34 | –75.53 | 0.04 | ― | x | x |
| 2018-07-12 17:51:04 | 341 | FD | 61.95 | –70.75 | 0.06 | ― | x | x |

aFD indicates sampling from the foredeck; SB, from a small boat.

bDistance refers to the horizontal distance between sampling via Niskin bottle and the closest measurement recorded by the underway *p*CO2 system located on the ship (underway observations were recorded only when the distance is < 2 km).

cUW indicates underway *p*CO2 measurements.

dSample was collected.

eNo sample was collected.

fSample was collected and data appear in Figure 10.