Supplementary Informations

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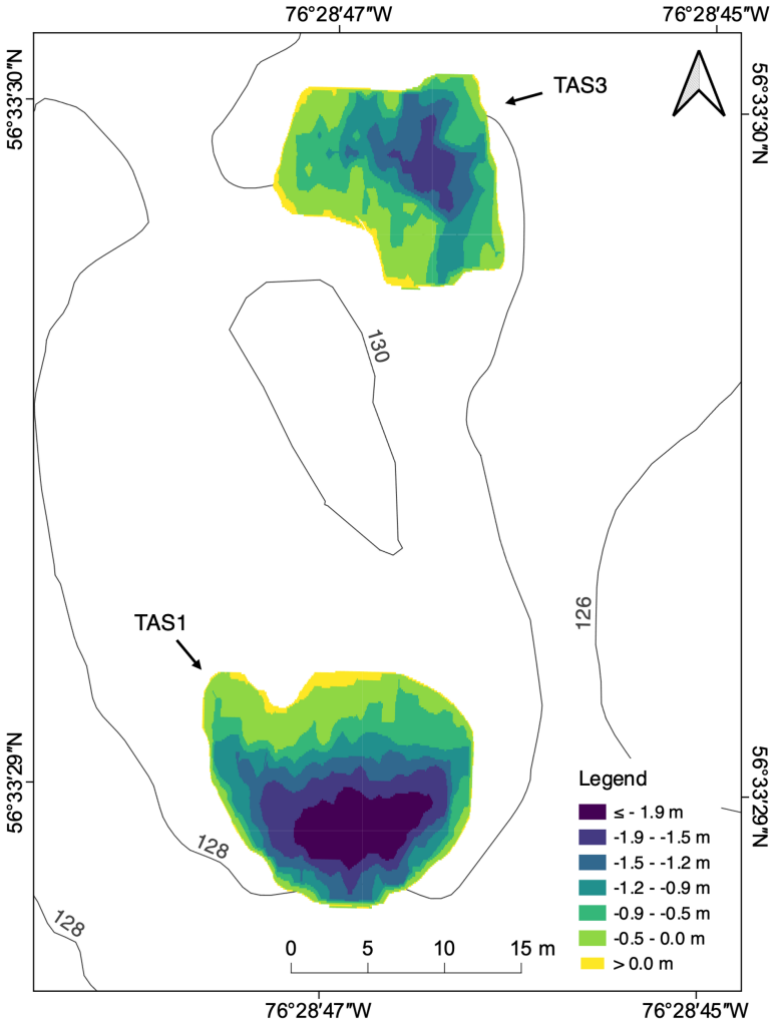

Figure S1. Bathymetric maps of lakes TAS1 and TAS3 obtained on 07 July 2022.

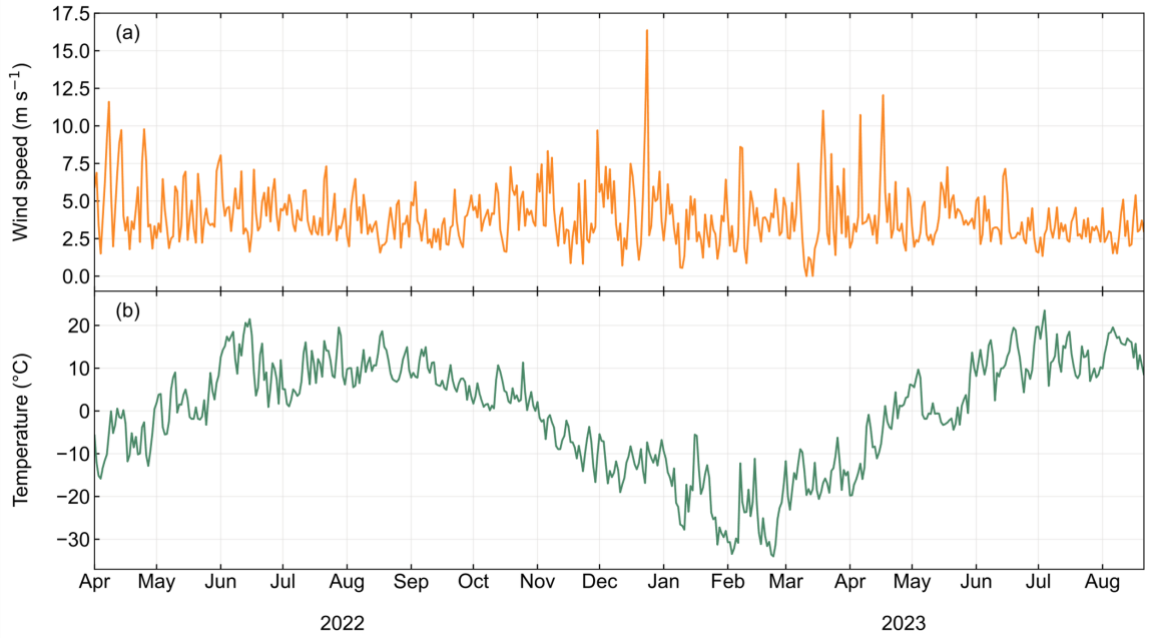

Figure S2. Weather conditions in the Tasiapik Valley from summer 2022 to summer 2023, showing (a) wind speed at 10 m and (b) air temperature. The brackets on top indicate the measurement campaign periods.

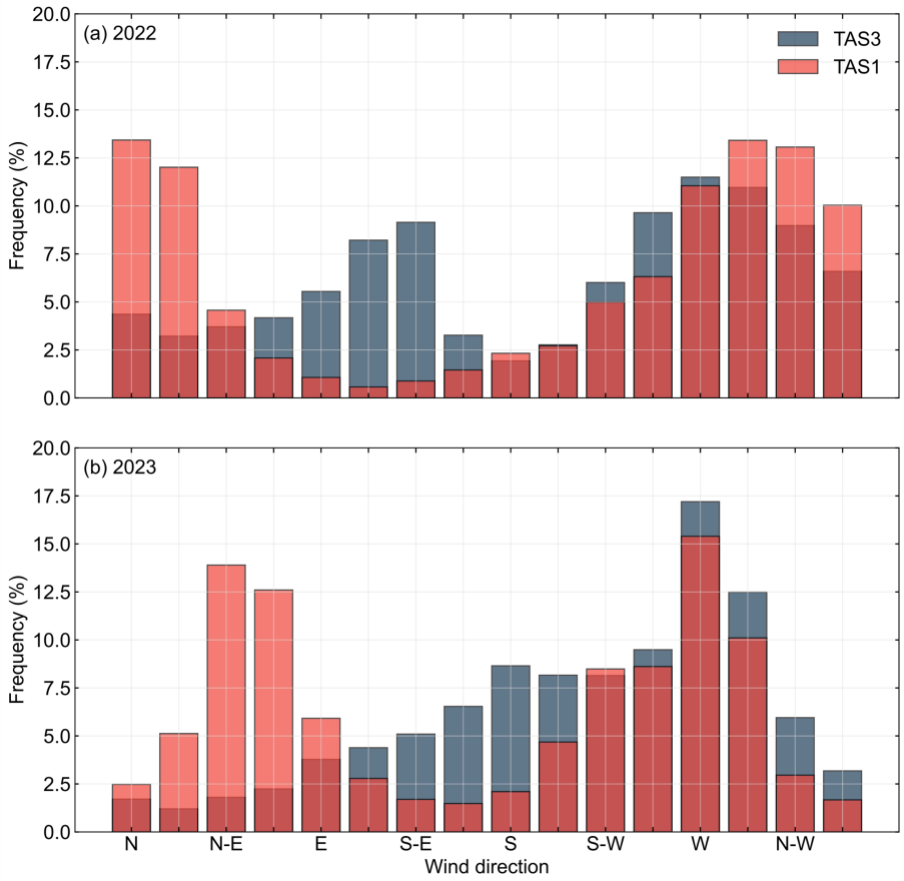

Figure S3. Wind direction frequency at lakes TAS1 and TAS3 for (a) July 2022 and (b) August 2023.

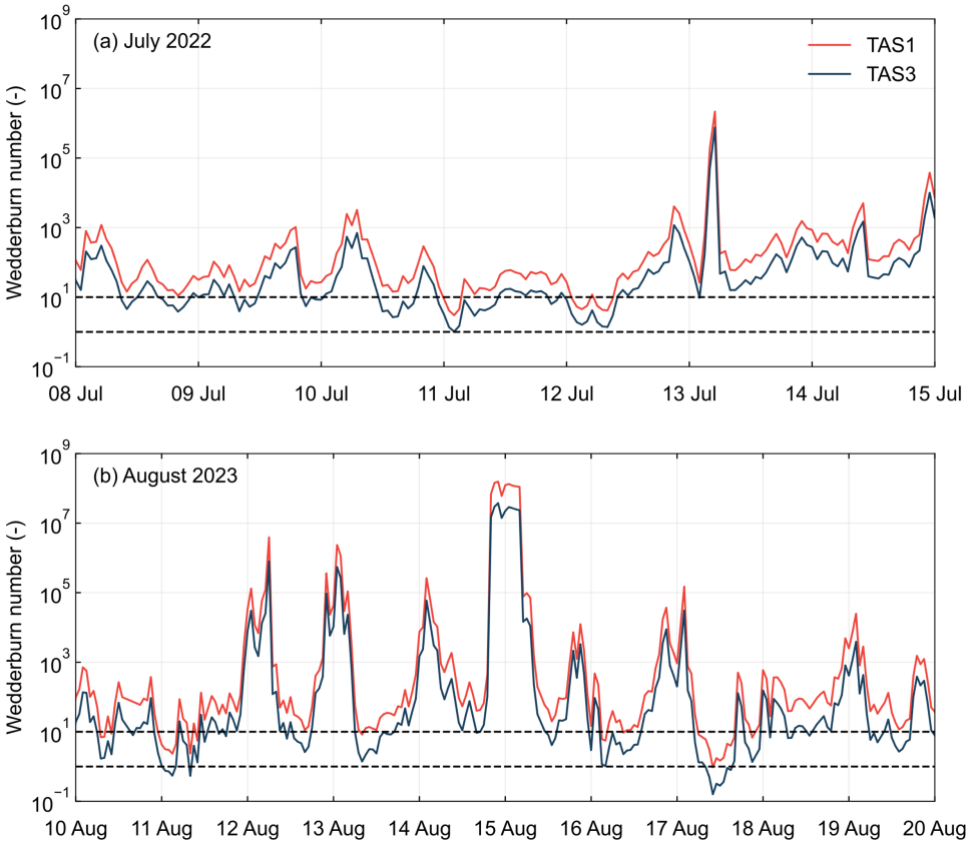

Figure S4. Wedderburn number (dimensionless) at lakes TAS1 and TAS3 during the measurement campaigns of (a) July 2022 and (b) August 2023.

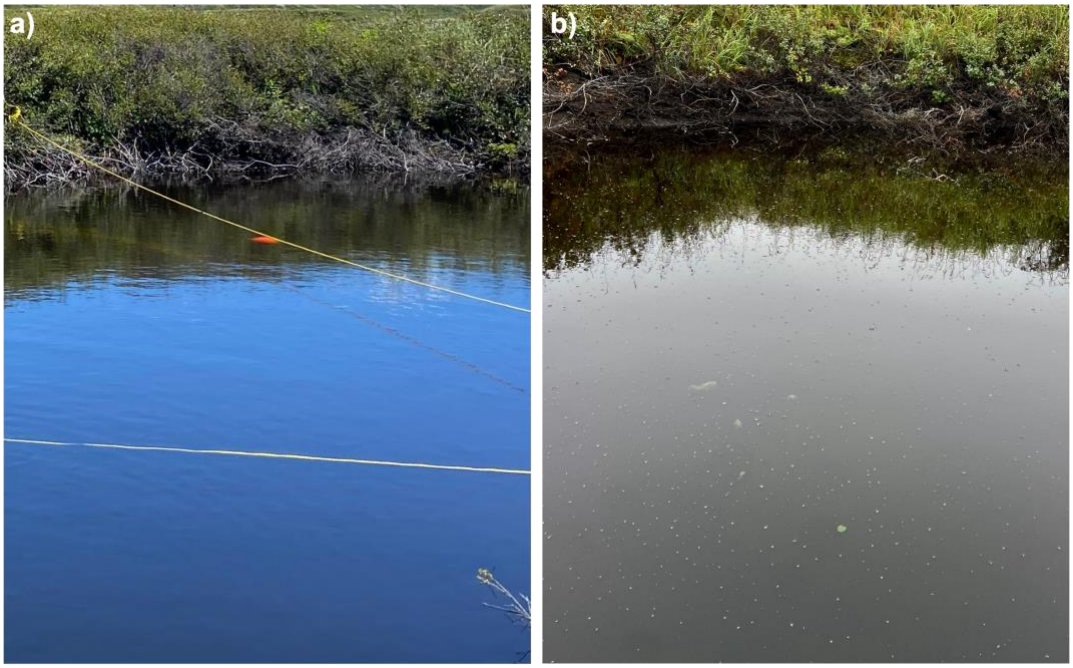

Figure S5. Photographs of the water surface of lake TAS3 taken on calm days in (a) July 2022, showing no visible bubbles, and (b) August 2023, highlighting the marked presence of escaping bubbles.

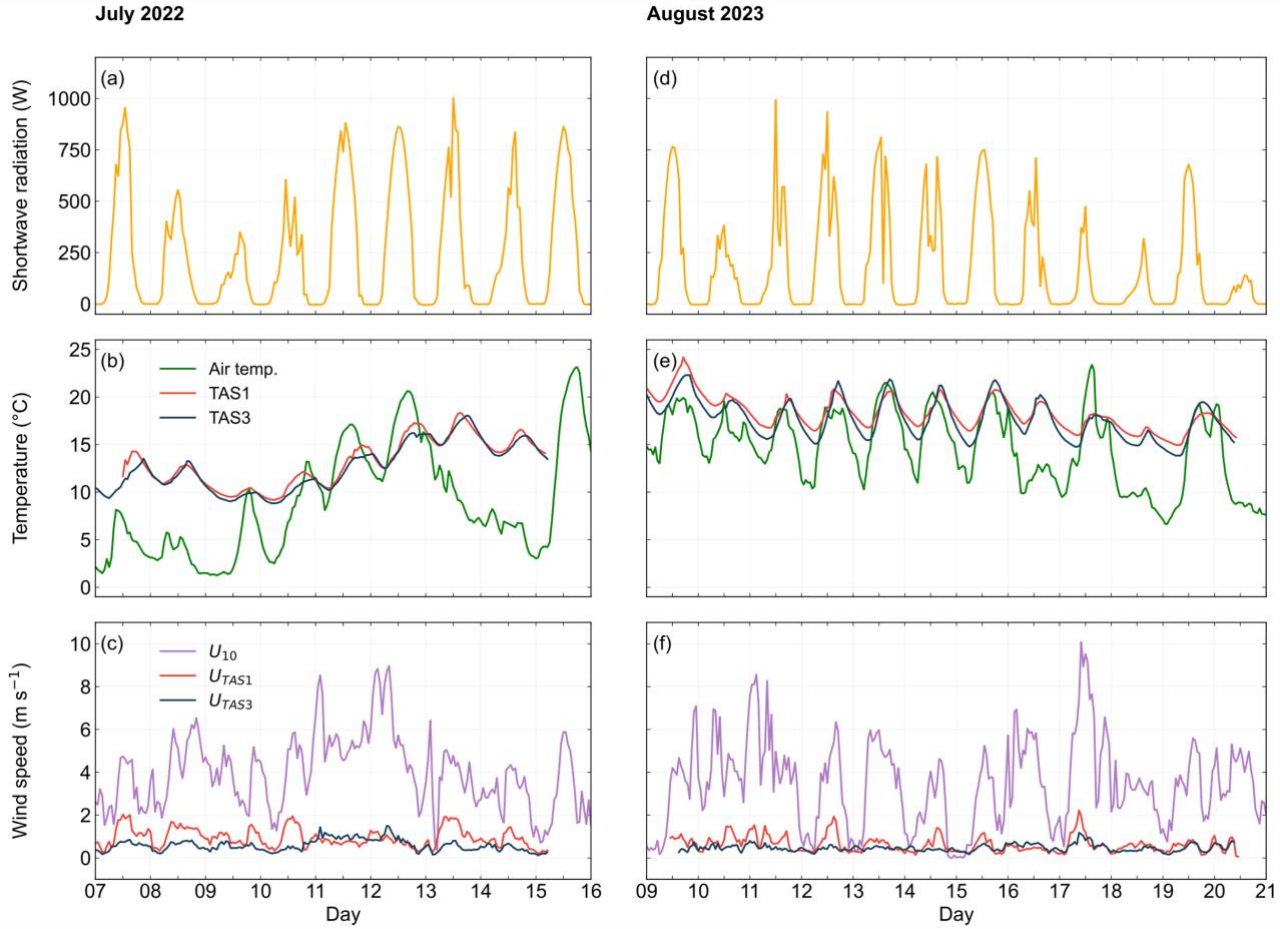

Figure S6. Shortwave radiation, air temperature, surface temperature in lakes TAS 1 and TAS3, and wind speed at 10 m in July 2022 (a, b, c) and August 2023 (d, e, f).

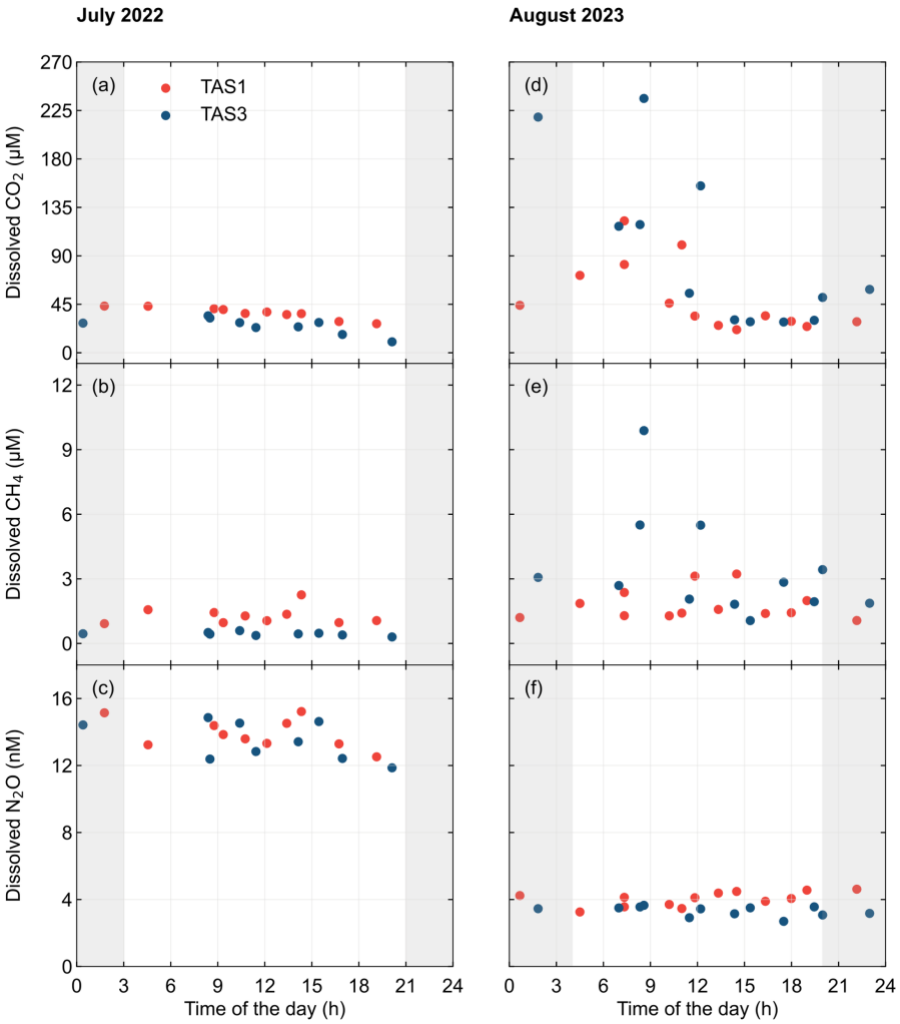

Figure S7. Near-surface concentrations of CO2, CH4 and N2O in July 2022 (a, b, c) and August 2023 (d, e, f) for TAS1 and TAS3.

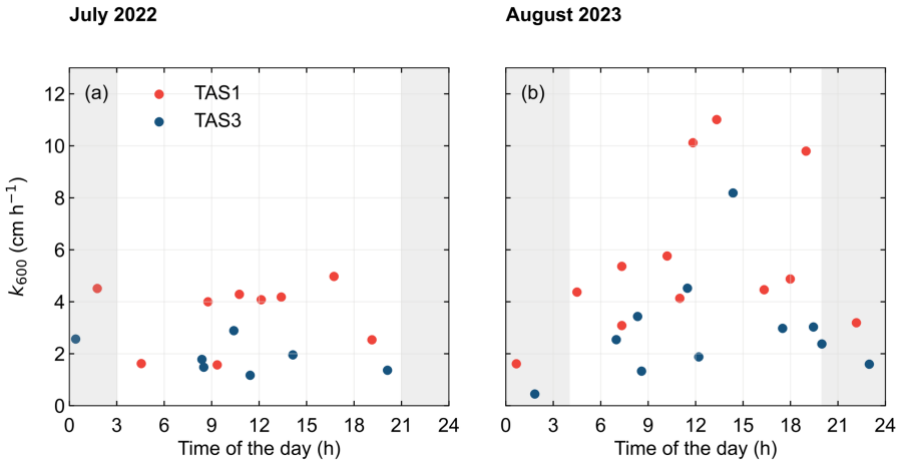

Figure S8. Gas transfer coefficient estimated from the gas chamber method in (a) July 2022 and (b) August 2023 for lakes TAS1 and TAS3.

Table S1. Depth from lake bottom of the submersible automated data loggers of Temperature (HOBO U22-001), conductivity (HOBO U24-001, also measures temperature), pressure (HOBO U20L-01, also measures temperature), and dissolved oxygen (PME miniDOT, also measures temperature). Maximum depth varied between 248 and 290 cm in TAS1, and between 149 and 232 cm in TAS3.

Automated loggers	TAS1	TAS3
	Depth from bottom (cm)	
Pressure and temperature	18	22
Conductivity, oxygen and temperature	58	44
Temperature	97	66
Temperature	136	99
Temperature	176	121
Oxygen	193	144
Conductivity and temperature	210	144

Table S2. Date and time (EST) of the chamber flux measurements at lakes TAS1 and TAS3 in July 2022 and August 2023.

Lake	July 2022	August 2023
TAS1	2022-07-07 9:14	2023-08-10 11:50
	2022-07-07 13:36	2023-08-11 19:10
	2022-07-11 1:59	2023-08-12 22:41
	2022-07-11 16:09	2023-08-13 18:18
	2022-07-12 11:53	2023-08-14 10:28
	2022-07-12 19:03	2023-08-14 13:48
	2022-07-13 8:37	2023-08-15 1:23
	2022-07-13 10:51	2023-08-15 16:55
	2022-07-15 4:19	2023-08-16 5:09
		2023-08-18 11:41
		2023-08-19 8:00
		2023-08-20 8:00
TAS3	2022-07-07 10:41	2023-08-10 13:44
	2022-07-07 14:22	2023-08-11 20:19
	2022-07-08 8:42	2023-08-12 23:36
	2022-07-11 0:59	2023-08-13 19:42
	2022-07-11 17:15	2023-08-14 11:45
	2022-07-12 11:11	2023-08-14 14:42
	2022-07-12 19:47	2023-08-15 2:15
	2022-07-13 9:50	2023-08-15 17:53
	2022-07-15 4:57	2023-08-16 7:18
		2023-08-18 12:46
		2023-08-19 8:54
		2023-08-20 9:03

Table S3. Bottom concentrations of CO2, CH4 and N2O measured in lakes TAS1 and TAS3 with the headspace method. Values are expressed as mean ± standard deviation (min - max). N = 4 in 2022 and N = 2 in 2023. Water was sampled about 15 cm above sediments.

	July 2022		August 2023	
Bottom concentration	TAS1	TAS3	TAS1	TAS3
CO_2 (µM)	315.6 ± 225.6 (89.8 - 510.5)	333.4 ± 239.0 (135.1 - 646.8)	813.5 ± 3.4 (811.1 - 815.9)	770.4 ± 63.2 (725.7 - 815.1)
CH_4 (µM)	103.1 ± 81.1 (26.2 - 174.5)	92.3 ± 98.1 (16.3 - 222.7)	591.6 ± 97.9 (522.4 - 660.9)	400.1 ± 147.0 (296.2 - 504.0)
N_2O (nM)	11.3 ± 2.9 (7.3 - 14.0)	10.7 ± 3.3 (7.6 - 14.2)	-	-

Table S4. Gas transfer velocities (k_{600}) measured with the floating chamber in lakes TAS1 and TAS3 using surface GHG concentrations obtained by the headspace method. Values are expressed as mean ± standard deviation (min-max).

	k_{600} (cm h^{-1})	
Period	TAS1	TAS3
July 2022	3.5 ± 1.4 (1.6 - 5.0)	1.9 ± 0.6 (1.2 - 2.9)
August 2023	5.7 ± 3.0 (1.6 - 11.0)	2.9 ± 2.1 (0.5 - 8.2)

Table S5. Gas transfer velocities (k_{600}) estimated with the surfacer renewal model in lakes TAS1 and TAS3. Values are expressed as mean (min-max).

Lake	k_{600} (cm h^{-1})
Summer 2022	
TAS1	3.0 (0.8 - 6.4)
TAS3	3.6 (0.9 - 7.9)
Fall 2022	
TAS1	3.0 (0.3 - 7.2)
TAS3	3.4 (0.3 - 8.1)
Spring 2023	
TAS1	3.3 (0.7 - 6.2)
TAS3	3.7 (0.8 - 6.9)
Summer 2023	
TAS1	3.0 (0.4 - 7.0)
TAS3	3.7 (0.4 - 8.8)

Table S6. Average bottom concentrations of CO2, CH4, and N2O in lakes TAS1 and TAS3 estimated across limnological seasons. These estimates were derived from summer average surface concentrations measured during the campaigns (for summer estimates), total gas concentrations in the water column during summer (for fall estimates), and the summer-to-winter gas concentration ratio reported by Matveev et al. (2019) (for spring estimates).

Lake	CO_2 (µM)	CH_4 (µM)	N_2O (nM)
Summer 2022			
TAS1	37.9	1.3	13.9
TAS3	25.0	0.4	13.5
Fall 2022			
TAS1	52.1	7.7	14.0
TAS3	70.0	13.3	13.5
Spring 2023			
TAS1	34.9	8.2	-
TAS3	46.9	14.1	-
Summer 2023			
TAS1	51.1	1.8	4.0
TAS3	94.2	3.5	3.3
Fall 2023			
TAS1	186.2	62.8	-
TAS3	275.9	99.8	-
Spring 2024			
TAS1	124.7	66.7	-
TAS3	184.8	106.0	-

References

Matveev, A., Laurion, I., & Vincent, W. F. (2019). Winter Accumulation of Methane and its Variable Timing of Release from Thermokarst Lakes in Subarctic Peatlands. *Journal of Geophysical Research: Biogeosciences*, *124*(11), 3521-3535. https://doi.org/10.1029/2019JG005078