

Supplementary materials

Surface snow bromide and nitrate at Eureka, Canada in early spring and implications for polar boundary layer chemistry

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Table S1. Overview of relative standard deviations of duplicate analyses for 2019 samples (n=36), and average limits of detection (LOD)^a and limits of quantification (LOQ)^b. The units are parts per billion (ppb).

	MSA	Cl ⁻	Br ⁻	NO ₃ ⁻	SO ₄ ⁼	Na ⁺	K ⁺	Mg ²⁺
Relative Standard deviation	-	1.2	1.8	2.3	1.1	2.5	10.3	9.5
LOD ^a (ppb)	7	13	16 ^c	30 ^d	51	16	48	18
LOQ ^b (ppb)	25	42	19 ^c	50 ^d	171	53	160	61

^a LOD = 3x standard deviation of filter blank average peak area. ^b LOQ = 10x standard deviation of filter blank average peak area. ^c and ^d Br⁻ and NO₃⁻ did not have filter blank background and therefore LOD and LOQ were defined as 3x and 10x the minimum measurable peak area, respectively.

Table S2. Statistical results for the ionic analysis of the 2018 snow samples at the Sea ice, Onshore, PEARL and Creek sites.

25 The units are ppb.

2018											
	0-0.5cm			Column average			n	mean	std	median	
	n	mean	std	median	n	mean	std	median			
Sea ice	[Br ⁻]	36	18.2	8.3	18.9	80	858.4	680.9	609.5		
	[Cl ⁻]	30	444.8	218.0	448.9	80	206399.3	183149.0	111014.3		
	[Ca ²⁺]	33	97.0	105.0	48.2	80	2542.3	2060.1	1131.5		
	[F ⁻]	30	1.8	0.5	1.9	73	22.1	7.6	22.9		
	[K ⁺]	30	64.3	1.6	63.4	80	2163.9	1608.9	1113.1		
	[MSA]	26	6.9	4.7	5.7	2	31.0	4.0	31.0		
	[Acetate]	34	894.8	585.5	960.2	24	5401.4	575.0	5310.0		
	[Formate]	26	271.0	3.8	269.3	28	220.5	106.2	181.8		
	[NH ₄ ⁺]	34	7.8	4.3	6.9	53	92.1	70.0	71.4		
	[Oxalate]	34	325.2	223.9	387.1	41	725.5	676.9	199.6		
	[Mg ²⁺]	32	45.3	18.6	44.8	81	8228.6	6310.1	4196.2		
	[Na ⁺]	32	73.0	45.9	75.7	75	33054.2	16601.3	25753.9		
	[NO ₃ ⁻]	33	196.8	62.2	205.7	87	306.8	170.6	289.2		
	[SO ₄ ²⁻]	34	70.4	36.3	54.4	69	15718.7	9332.6	16959.7		
Onshore	nss-[Br ⁻]	36	17.3	7.7	18.5	82	463.0	538.4	302.8		
	nss-[SO ₄ ²⁻]	32	46.7	24.8	41.0	70	8365.5	11060.4	6392.8		
	[Br ⁻]	33	21.3	8.7	23.7	60	26.0	18.3	20.0		
	[Cl ⁻]	27	406.2	237.1	404.4	66	4353.8	2508.1	3788.3		
	[Ca ²⁺]	32	251.6	209.6	132.7	66	645.6	310.1	727.1		
	[F ⁻]	8	1.0	0.9	1.0	63	2.4	1.2	2.1		
	[K ⁺]	33	22.2	25.6	8.8	65	132.9	79.7	142.9		
	[MSA]	4	12.5	5.3	11.9	34	1.4	1.3	0.8		
	[Acetate]	32	428.9	44.4	429.4	56	71.7	18.2	69.9		
	[Formate]	31	62.6	12.3	62.7	58	33.9	12.0	32.0		
	[NH ₄ ⁺]	30	24.0	6.3	22.6	57	20.2	5.7	19.4		
	[Oxalate]	33	16.4	4.5	17.5	73	44.3	30.0	35.8		
	[Mg ²⁺]	26	34.0	29.0	23.4	66	467.1	299.2	456.1		
	[Na ⁺]	27	164.9	109.2	166.8	65	1832.3	1309.0	1646.5		
PEARL	[NO ₃ ⁻]	34	199.6	89.9	175.4	66	242.6	45.1	245.9		
	[SO ₄ ²⁻]	33	148.9	107.4	93.0	64	595.4	170.6	610.0		
	nss-[Br ⁻]	33	18.4	7.1	19.6	61	14.9	11.3	12.7		
	nss-[SO ₄ ²⁻]	23	48.8	34.8	32.7	65	105.8	300.6	92.7		
	[Br ⁻]	8	6.7	4.9	4.2	37	2.1	1.2	1.7		
	[Cl ⁻]	8	893.9	732.9	504.2	38	273.0	193.5	248.4		
	[Ca ²⁺]	8	56.7	59.2	43.5	42	76.5	37.9	66.3		
	[F ⁻]	6	1.2	0.5	1.1	24	0.5	0.3	0.4		
	[K ⁺]	7	14.0	11.2	9.9	37	7.3	3.3	8.0		
	[MSA]	6	0.6	0.3	0.7	37	16.9	7.0	15.4		
	[Acetate]	7	348.2	9.3	344.6	36	90.4	82.2	62.8		
	[Formate]	8	285.2	141.9	361.7	39	23.1	4.7	25.2		
	[NH ₄ ⁺]	2	27.1	9.7	27.1	43	13.0	10.9	8.5		
	[Oxalate]	8	80.5	40.4	101.7	37	6.8	2.4	8.1		
	[Mg ²⁺]	7	27.4	42.9	8.7	38	24.0	15.1	19.2		
	[Na ⁺]	7	136.1	316.9	14.9	37	153.8	113.3	130.5		
Creek	[NO ₃ ⁻]	8	128.1	41.1	115.5	37	44.1	16.4	41.0		
	[SO ₄ ²⁻]	8	90.5	38.0	83.5	41	168.6	85.5	157.4		
	nss-[Br ⁻]	8	5.1	2.1	4.1	36	0.9	1.0	0.9		
	nss-[SO ₄ ²⁻]	7	48.5	51.5	67.1	44	102.2	75.3	97.1		
	[Br ⁻]	12	4.8	0.7	4.8	27	50.7	46.1	32.9		
	[Cl ⁻]	12	266.8	114.3	241.8	27	32.9	3708.9	5759.4		
	[Ca ²⁺]	13	250.8	170.8	217.7	22	367.2	277.8	332.9		
	[F ⁻]	12	0.6	0.3	0.5	27	4.7	3.0	3.9		
	[K ⁺]	11	5.0	2.0	4.4	22	21.7	15.5	18.5		
	[MSA]	10	23.1	13.0	26.5	18	1.3	0.7	1.2		
	[Acetate]	12	389.3	41.9	380.8	23	346.6	3.1	346.2		
	[Formate]	13	60.2	24.2	54.9	27	258.7	149.1	361.6		
	[NH ₄ ⁺]	13	30.2	10.3	28.0	20	19.9	23.4	2.6		
	[Oxalate]	13	14.6	2.1	14.2	27	85.8	36.4	102.8		
	[Mg ²⁺]	13	34.9	27.2	29.9	23	125.0	123.1	96.2		
	[Na ⁺]	12	119.9	53.3	104.6	23	362.3	306.3	323.8		
	[NO ₃ ⁻]	13	89.8	32.4	90.3	25	257.5	46.8	249.6		
	[SO ₄ ²⁻]	13	123.2	26.4	131.5	26	5810.7	3498.0	5855.0		
	nss-[Br ⁻]	11	4.1	0.4	4.2	27	45.0	43.0	31.6		
	nss-[SO ₄ ²⁻]	12	93.2	18.7	92.6	26	5573.7	3418.4	5228.8		

Table S3. Statistical results for the ionic analysis of the 2019 snow samples at the Sea ice, Onshore, PEARL and 0PAL sites.

The units are ppb.

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2019												Column average								
	Airborne			0-0.2cm			0.2-0.5cm			0.5-1.5cm			n	mean	std	median	n	mean	std	median
Sea ice	[Br ⁻]			40	32.0	15.8	29.7	51	242.3	330.4	67.5	36	744.2	410.3	855.7	66	516.7	429.3	463.0	
	[Cl ⁻]			41	2171.4	2437.4	888.2	33	6406.4	8554.6	2283.8	16	102367.8	87654.3	96375.4	33	58851.3	73766.5	18989.6	
	[Mg ²⁺]			36	235.2	303.6	108.3	43	4104.6	5190.7	1391.6	17	6424.1	5374.7	9533.4	46	4923.9	4783.7	1898.9	
	[Na ⁺]			38	678.7	741.5	344.5	34	3443.8	4547.8	1011.4	12	27357.6	33809.3	7968.8	19	8974.9	7001.7	8798.8	
	[NO ₃ ⁻]			37	214.3	96.0	217.3	61	299.3	144.1	319.3	61	180.0	72.9	178.5	75	165.6	73.4	158.7	
	[SO ₄ ²⁻]			41	436.3	284.3	455.5	42	2855.4	4149.2	886.7	21	11805.9	9265.4	9545.5	40	5657.5	6006.4	2455.8	
	nss-[Br ⁻]			39	28.2	16.4	27.3	32	19.6	15.1	15.6	8	47.0	61.9	15.9	17	18.2	14.5	12.3	
	nss-[SO ₄ ²⁻]			39	241.0	146.5	277.1	28	177.2	261.9	119.5	8	298.7	288.6	231.5	19	145.8	256.5	65.9	
	[Br ⁻]			38	31.8	13.9	29.5	58	30.6	17.4	24.7	64	77.6	68.6	42.4	104	79.3	74.4	39.0	
	[Cl ⁻]			39	1013.9	883.8	525.5	46	1917.4	1767.9	1457.9	38	3067.0	3301.4	2203.3	62	3606.8	2998.6	2429.6	
Onshore	[Mg ²⁺]			31	43.6	47.3	16.9	56	766.3	1049.3	214.0	62	1257.8	1279.4	2373.3	102	1271.0	1263.6	533.2	
	[Na ⁺]			39	392.3	352.4	234.6	46	864.4	750.0	633.9	56	6409.2	7888.0	1202.8	93	6843.1	7727.8	1629.3	
	[NO ₃ ⁻]			36	233.0	123.6	221.8	61	237.8	135.0	227.4	63	211.4	94.2	257.7	101	190.0	94.6	197.6	
	[SO ₄ ²⁻]			42	394.4	231.8	420.8	51	582.6	465.8	481.3	64	1409.6	1103.4	827.6	104	1438.7	1103.0	1103.9	
	nss-[Br ⁻]			38	28.5	14.8	27.1	50	16.8	13.1	15.9	56	28.9	26.4	17.0	89	24.9	25.3	13.3	
	nss-[SO ₄ ²⁻]			42	246.1	212.0	272.6	46	230.5	182.4	181.9	50	-132.3	978.1	141.0	91	448.5	1261.8	117.0	
	[Br ⁻]			21	27.6	14.2	31.1	31	23.9	9.4	24.6	32	17.6	7.9	13.9	28	15.3	3.9	14.4	
	[Cl ⁻]			19	950.8	430.2	810.6	33	627.9	231.8	659.0	57	4285.0	4098.2	1675.6	58	4515.2	3121.5	1869.4	
	[Mg ²⁺]			19	50.2	46.8	27.0	32	25.2	16.3	20.4	56	321.6	356.0	93.4	58	325.4	273.6	130.6	
	[Na ⁺]			19	456.5	224.1	405.8	34	271.3	119.5	249.2	56	1965.3	1335.3	839.9	58	2139.4	1470.4	985.3	
PEARL	[NO ₃ ⁻]			18	138.5	85.2	141.8	23	77.1	31.3	70.0	51	79.9	38.8	62.1	58	88.1	39.1	71.0	
	[SO ₄ ²⁻]			20	529.4	341.4	568.3	35	366.8	207.1	388.6	58	743.9	425.7	735.1	57	551.6	304.2	423.4	
	nss-[Br ⁻]			21	22.7	16.0	18.5	31	22.1	9.6	23.4	33	0.4	10.0	-1.7	31	-3.8	6.4	-5.1	
	nss-[SO ₄ ²⁻]			22	445.0	407.7	437.3	36	306.7	211.2	332.3	56	222.5	215.1	195.9	56	0.5	147.4	-105.5	
	[Br ⁻]			42	30.4	18.8	26.8	5	11.6	0.8	11.6	9	23.7	12.3	22.4	5	27.8	5.3	31.2	
	[Cl ⁻]			42	2032.2	1978.8	1247.7	6	1591.7	1687.2	970.7	9	3072.0	1913.2	3855.2	5	3512.7	1752.6	2455.2	
	[Mg ²⁺]			38	148.9	157.4	97.3	3	221.4	138.2	189.6	9	237.6	183.7	319.9	5	286.9	176.5	187.3	
0PAL	[Na ⁺]			41	850.3	883.2	534.6	6	720.3	790.2	438.5	9	1432.4	904.9	1860.9	5	1623.9	802.2	1164.9	
	[NO ₃ ⁻]			40	211.4	127.2	174.3	3	59.5	12.9	56.3	8	133.7	66.3	112.6	5	125.1	14.5	128.1	
	[SO ₄ ²⁻]			45	525.9	347.1	414.5	6	235.1	187.6	192.1	9	486.1	354.7	535.6	5	590.0	50.1	574.5	
	nss-[Br ⁻]			40	19.5	15.0	14.1	6	8.1	5.4	10.9	9	14.9	8.9	9.9	5	17.8	9.5	24.5	
	nss-[SO ₄ ²⁻]			44	208.2	228.0	236.7	4	53.6	51.5	56.3	9	126.6	182.0	27.0	5	182.4	168.5	295.2	

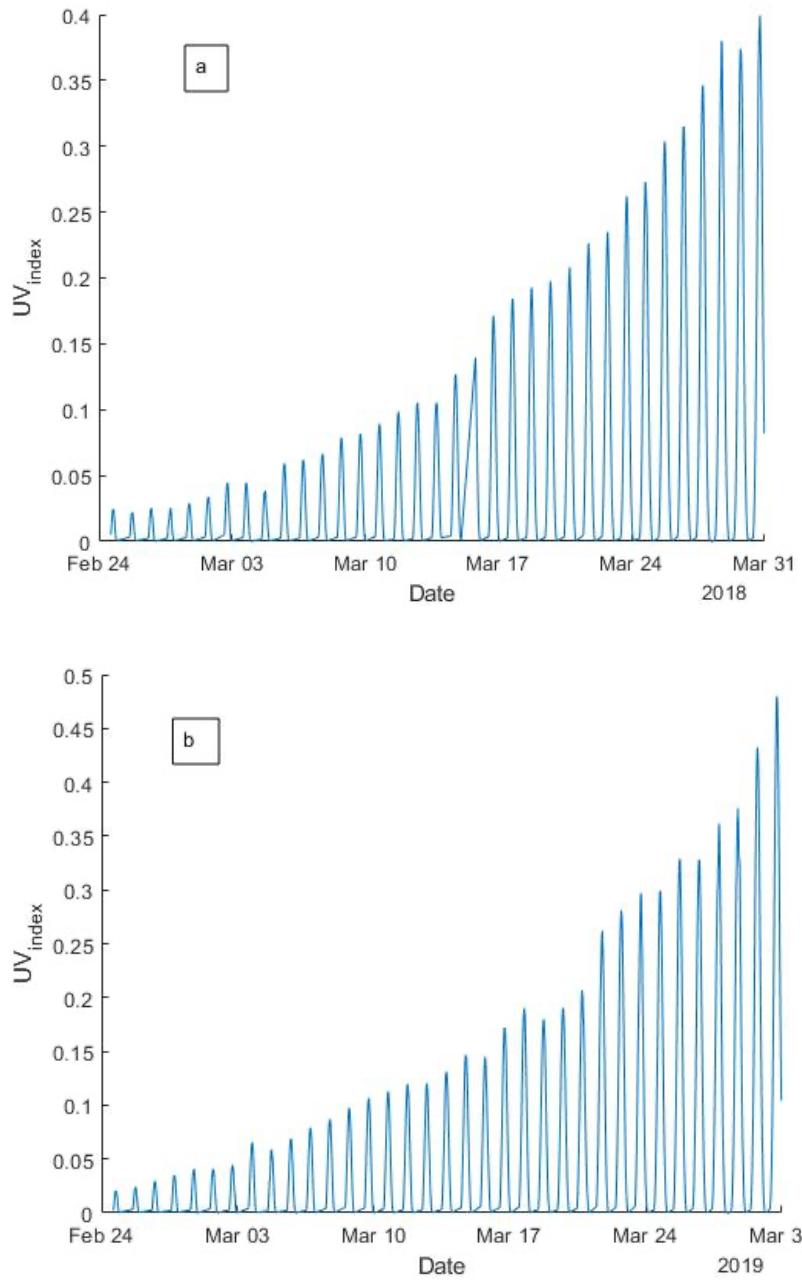
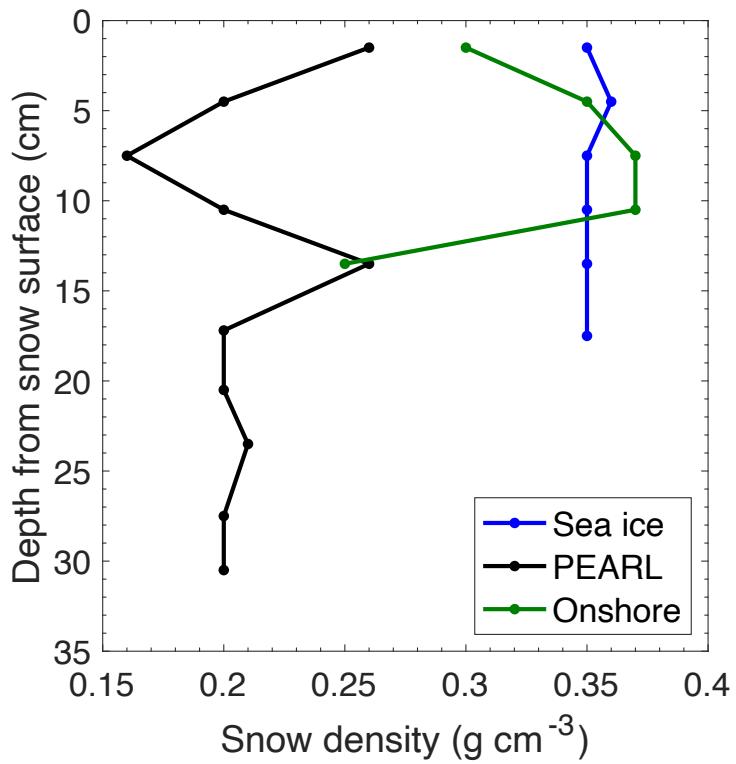
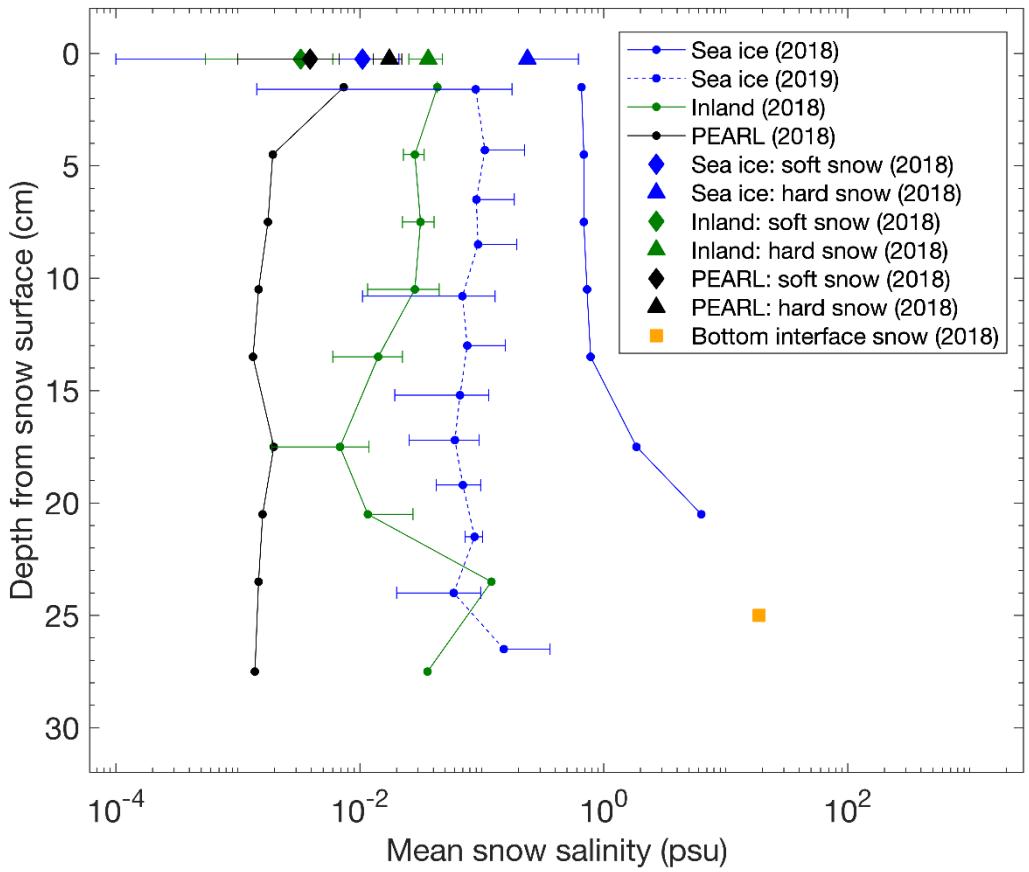


Figure S1. UV index at Eureka, Canada (79.989N, 85.934W, 8.7 m) during (a) March 24-31, 2018 and (b) March 24-31, 2019.



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Figure S2. Snow density profiles measured in 2018 at the Sea ice, Onshore, and PEARL sampling sites (see Figure 1).



70 Figure S3. Snow salinity profiles in 2018 and 2019 samples. Top 0.5 cm snow sample mean salinities (collected in 2018) are plotted at a depth of 0.25 cm. At each site, two types of surface snow are collected: one is soft fluffy white colour snow and one is hard, light brown colour snow. The horizontal error bar represents one standard deviation value. 2019 sea ice profiles include two columns. 2018 inland profile includes two columns – one from Onshore and one from Creek site.

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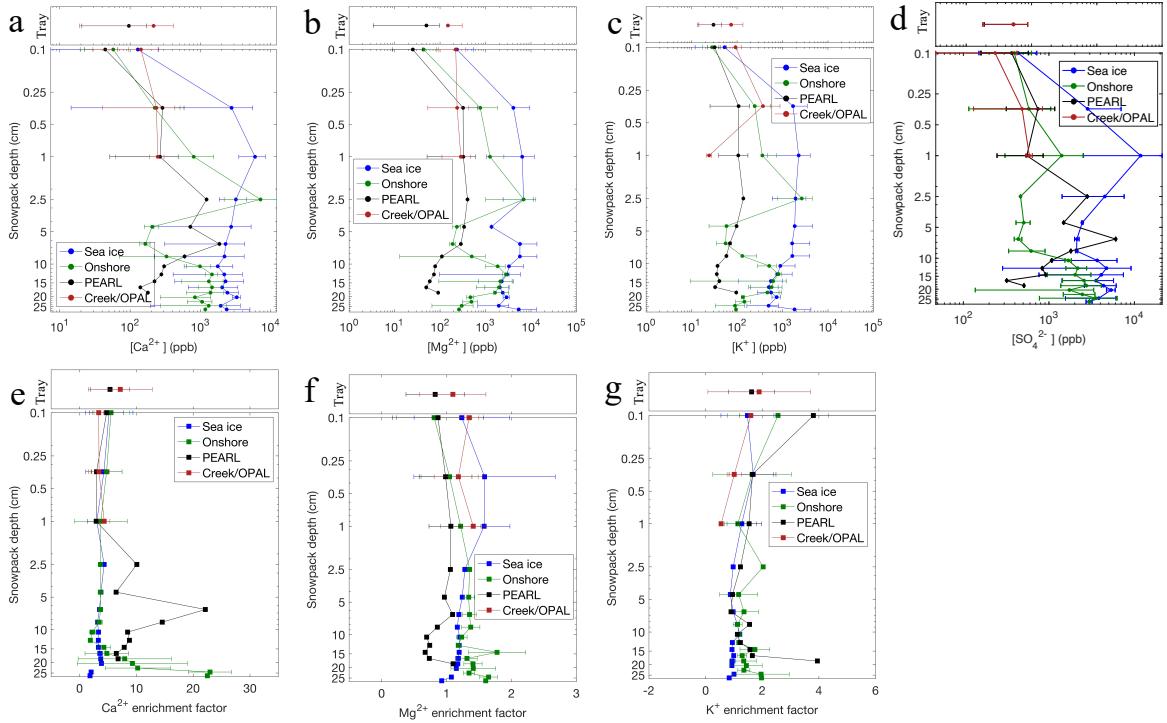


Figure S4. Vertical profiles of 2019 ions (a) $[\text{Ca}^{2+}]$, (b) $[\text{Mg}^{2+}]$, (c) $[\text{K}^+]$, (d) $[\text{SO}_4^{2-}]$, and enrichments of (e) $[\text{Ca}^{2+}]$, (f) $[\text{Mg}^+]$, and (g) $[\text{K}^+]$ (see Section 3.2 for details).

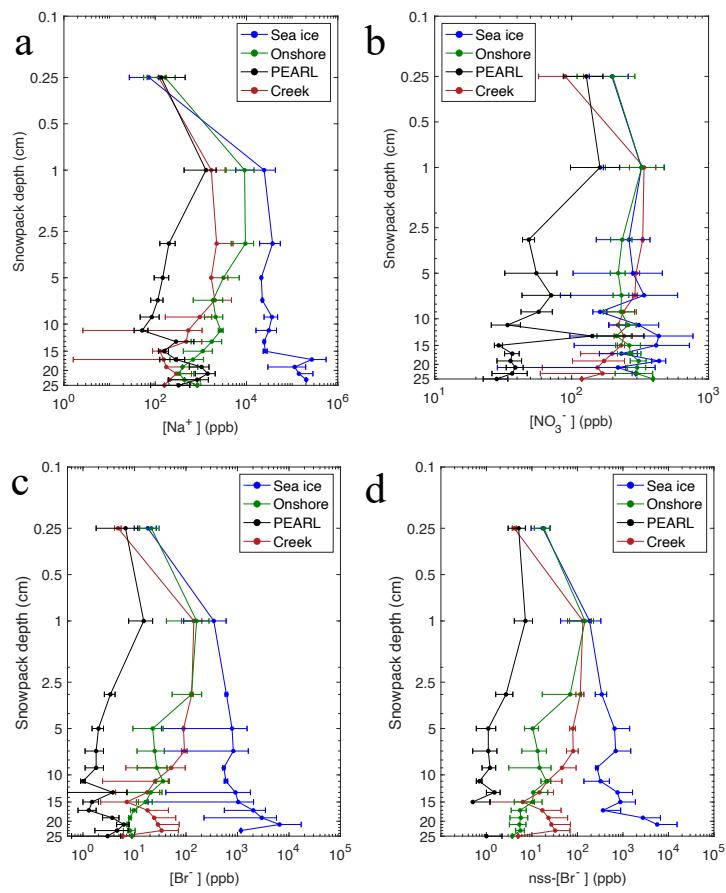
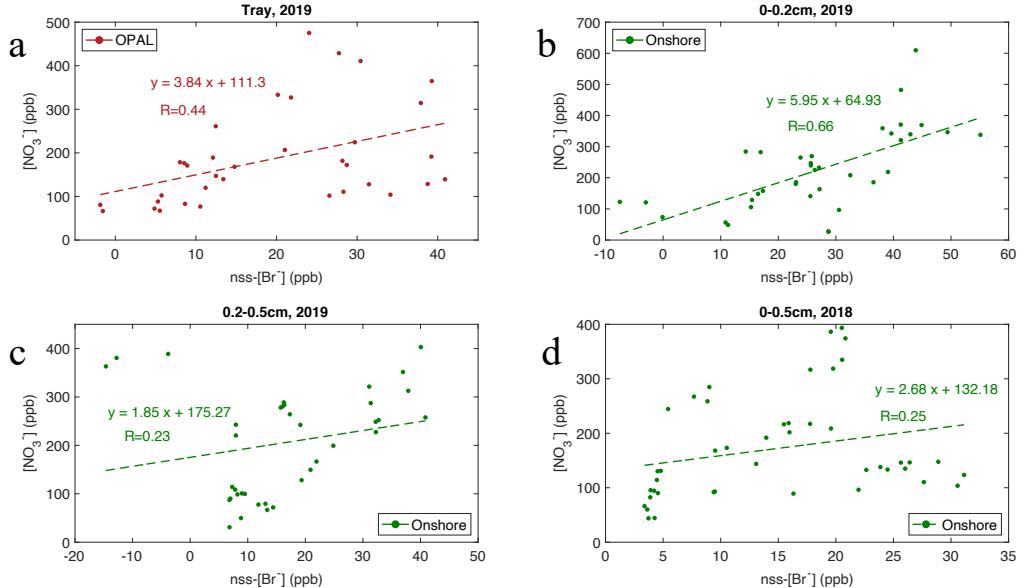


Figure S5. Vertical profiles of 2018 ions (a) $[\text{Na}^+]$, (b) $[\text{NO}_3^-]$, (c) $[\text{Br}^-]$, and (d) nss- $[\text{Br}^-]$.



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Figure S6. Same as Figure 7, except here nss[Br⁻] is used in the scatter plot and relationship analysis.