Table S1. BC concentration (unit: ng g^{-1}) observed in the ice layer and its overlying snow and in the surface melting snow. Snow sampling were carried out over the Elson Lagoon, Chukchi Sea and Canada Basin. The sampling locations and dates are also shown.

Sampling area	Lat (°N)	Lon (°W)	BC (Ice layer)	BC (The overlying snow)	Sampling date	BC (Surface melting snow)	Sampling date	Expedition
Canada Basin	75.03	159.48	0.39	2.93	July 22st, 2010	--	--	1st South Korean Arctic Expedition
Canada Basin	77.98	159.64	0.54	3.81	July 26st, 2010	--	--	1st South Korean Arctic Expedition
Canada Basin	79.51	160.02	0.45	3.32	August 1st, 2010	--	--	1st South Korean Arctic Expedition
Elson Lagoon	71.32	156.37	0.36	1.72	May 18th, 2015	14.9	May 31th, 2015	Barrow Expedition
Elson Lagoon	71.32	156.37	0.31	1.70	May 22th, 2015	15.3	May 31th, 2015	Barrow Expedition
Elson Lagoon	71.32	156.38	0.41	1.98	May 22th, 2015	17.9	May 31th, 2015	Barrow Expedition
Chukchi Sea	71.37	156.54	0.48	2.11	May 25th, 2017	16.1	June 5th, 2017	Barrow Expedition
Chukchi Sea	71.37	156.54	0.34	1.82	May 27th, 2017	16.1	June 5th, 2017	Barrow Expedition
Chukchi Sea	71.37	156.54	0.55	2.91	May 28th, 2017	17	June 5th, 2017	Barrow Expedition
Chukchi Sea	71.37	156.55	0.50	2.43	May 30th, 2018	14.2	June 10th, 2018	Barrow Expedition
Chukchi Sea	71.37	156.55	0.36	2.11	May 30th, 2018	15.9	June 10th, 2018	Barrow Expedition
Chukchi	71.37	156.55	0.41	2.33	May 30th,	14.8	June 10th,	Barrow

Chukchi Sea	71.37	156.55			May 31th, 2018		June 10th, 2018	Barrow Expedition
Chukchi Sea	71.37	156.55	0.43	2.52	May 31th, 2018	17.3	June 10th, 2018	Barrow Expedition
Chukchi Sea	71.37	156.55	0.31	2.14	May 31th, 2018	17.5	June 10th, 2018	Barrow Expedition

Table S2. Snow thickness, snow density and BC concentrations before and after the ablation event, and the thickness of ice layer is also shown. BC values of ice layers have been presented in Table 1.

Area	Site	lat (°N)	lon (°W)	h_1 (cm)	ρ_1 (g cm^{-3})	C_{b1} (ng g^{-1})	h_2 (cm)	ρ_2 (g cm^{-3})	h_i (cm)
Elson Lagoon	1	71.32	156.37	5.5	0.32	1.22	3.0	0.36	0.7
Elson Lagoon	2	71.32	156.37	5.4	0.30	1.07	2.5	0.35	0.8
Elson Lagoon	3	71.32	156.38	10.9	0.32	1.11	5.0	0.35	1.7
Chukchi Sea	4	71.38	156.55	11.3	0.31	1.34	5.0	0.36	1.8
Chukchi Sea	5	71.38	156.55	13.2	0.29	0.91	4.0	0.35	2.5
Chukchi Sea	6	71.38	156.55	8.5	0.25	1.84	3.0	0.36	1.0
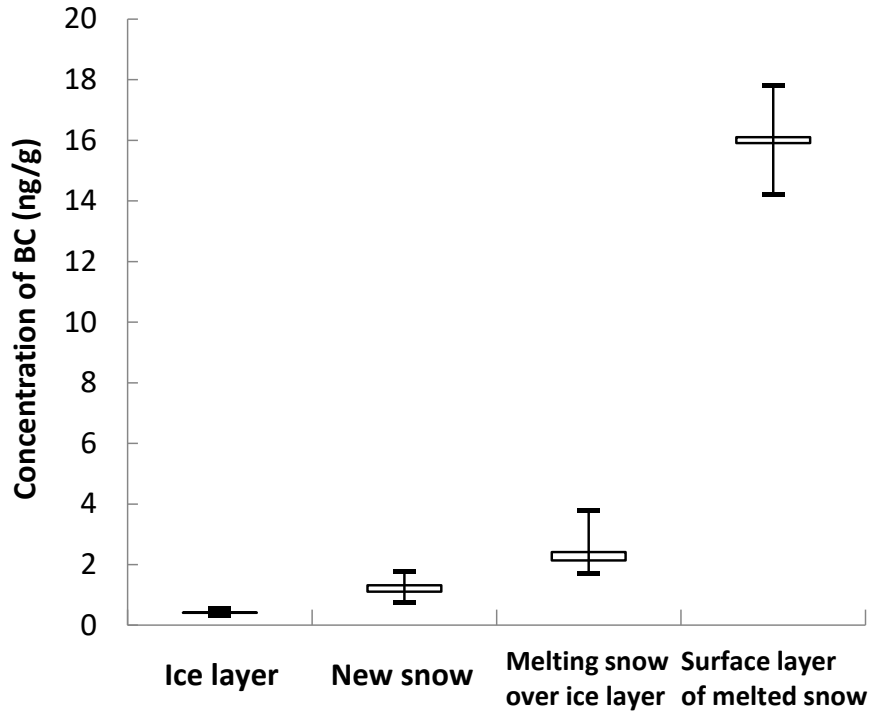
Figure S1. The BC concentrations in the ice layer and melting snow, and its concentrations in the new snow and in the surface layer of melting snow are also shown as a comparison. New-snow samples were only collected in Elson Lagoon and Chukchi Sea during the measurement period. The box indicates the mean (upper) and median (bottom) values of the observations, and the whiskers constrain the full extent of the observations.
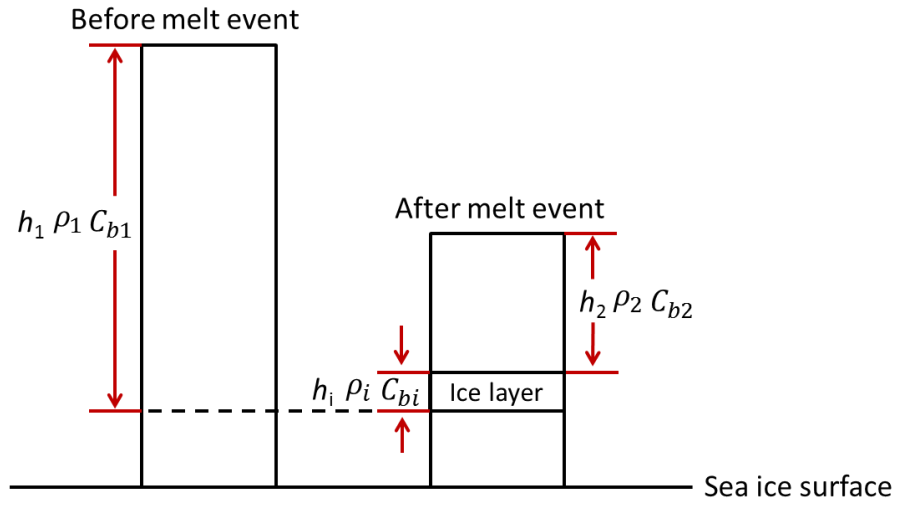
Figure S2. Conceptual sketch of snow overlying sea ice before and after the melt event. Variables relating to the snow and ice layer mentioned in Eq. (1) and Eq. (2) are shown.