Table S1: The starting and ending date, latitude (°S), and longitude(°E) are presented for each aerosol filter deployment. The wind speed (WS; m s^{-1}), atmospheric temperature (Atm T; °C), relative humidity (RH; %), and the number of daylight hours (hrs) were calculated as an average (Avg) over the duration of each filter deployment. For WS, Atm T and RH the standard deviations (SD) are also shown. Filter deployments are separated into early Summer (ES), Weddell Sea (WS) and late Summer (LS) depending on the location and time of sampling.

Cruise	Collection Dates		Latitude (ºS)		Longitude (ºE)		WS (m s^{-1})		Atm T (ºC)		RH (%)		Daylight
Leg ID	Start Date	End Date	Start	End	Start	End	Avg	SD	Avg	SD	Avg	SD	(hrs)
ES 1	2018-12-07	2018-12-08	34.5	37.0	14.8	12.7	5.2	1.8	15.7	0.6	73.4	4.8	14.5
ES 2	2018-12-08	2018-12-09	37.1	41.8	12.6	8.8	5.0	3.3	14.7	1.1	65.9	10.9	14.9
ES 3	2018-12-09	2018-12-10	41.8	44.1	8.8	6.8	9.8	2.3	10.7	0.7	100.3	2.7	15.3
ES 4	2018-12-10	2018-12-12	45.0	50.8	6.1	0.6	13.3	3.1	3.6	1.9	76.6	9.2	16.0
ES 5	2018-12-14	2018-12-16	59.7	68.3	0.0	0.0	6.1	2.0	-2.6	0.6	76.1	8.8	21.3
ES 6	2018-12-16	2018-12-19	68.5	70.1	0.0	-2.1	8.8	4.8	-2.4	1.8	78.3	8.3	24.0
ES 7	2018-12-19	2018-12-21	70.1	70.2	-2.1	-2.1	11.7	1.8	-3.4	1.9	69.5	12.3	24.0
WS 8	2019-01-04	2019-01-06	67.4	64.0	-16.0	-37.0	8.3	4.4	-2.2	0.5	77.4	5.8	22.1
WS 9	2019-01-06	2019-01-08	63.9	62.5	-37.8	-49.2	6.4	3.2	-2.0	0.7	82.9	7.3	19.8
WS 10	2019-01-08	2019-01-10	62.5	65.7	-49.2	-60.2	6.9	3.9	-2.8	0.6	74.3	7.4	20.2
WS 11	2019-01-10	2019-01-12	65.7	66.6	-60.2	-59.6	5.3	1.4	-2.7	1.0	69.2	5.1	21.4
WS 12	2019-01-12	2019-01-14	66.6	66.1	-59.6	-60.4	4.6	1.2	-1.7	0.9	84.0	6.8	21.3
WS 13	2019-01-14	2019-01-16	66.1	65.8	-60.4	-60.5	8.4	2.4	-3.9	1.2	78.7	4.9	20.6
WS 14	2019-01-16	2019-01-18	65.8	65.8	-60.5	-60.7	4.6	0.7	-3.2	1.6	76.4	8.5	20.2
WS 15	2019-01-18	2019-01-20	65.8	66.4	-60.7	-60.3	5.4	1.1	-3.9	0.6	83.8	5.3	20.1
WS 16	2019-01-20	2019-01-22	66.4	66.4	-60.3	-59.9	3.7	1.9	-2.8	0.6	82.5	3.2	20.0
WS 17	2019-01-22	2019-01-26	66.4	64.7	-59.9	-57.2	5.1	2.6	-2.9	0.6	83.4	5.7	19.2
WS 18	2019-01-26	2019-01-28	64.7	63.9	-57.2	-52.0	8.2	1.8	-0.9	0.9	87.4	4.4	18.2
WS 19	2019-01-28	2019-01-31	63.9	62.1	-52.0	-49.9	10.5	4.8	-1.6	0.9	87.8	5.0	17.6
WS 20	2019-01-31	2019-02-01	62.1	62.2	-50.1	-58.9	7.0	3.6	-1.0	2.2	79.8	5.7	17.1
WS 21	2019-02-01	2019-02-06	62.2	61.9	-58.9	-48.7	10.4	3.1	1.5	0.9	89.4	5.0	16.8
WS 22	2019-02-06	2019-02-09	62.0	69.0	-48.2	-52.0	7.7	4.1	-3.6	3.1	87.6	4.1	17.3
WS 23	2019-02-09	2019-02-11	69.0	68.6	-52.0	-52.4	5.6	1.8	-6.2	1.8	80.7	3.3	17.9
WS 24	2019-02-11	2019-02-13	68.6	68.8	-52.4	-51.8	3.3	2.0	-7.8	1.1	82.6	3.8	17.6
WS 25	2019-02-13	2019-02-16	68.8	68.9	-51.8	-41.3	6.9	3.9	-5.2	1.5	81.7	6.5	17.2
WS 26	2019-02-16	2019-02-19	68.9	69.5	-41.3	-8.6	11.9	4.5	-0.6	0.5	90.3	5.5	16.8
WS 27	2019-02-19	2019-02-21	69.6	70.3	-8.2	-2.7	8.2	2.9	-5.3	2.3	76.1	8.1	16.6
LS 28	2019-02-27	2019-03-01	69.3	60.0	-4.0	-2.3	8.6	2.4	-0.7	1.4	74.1	6.5	14.7
LS 29	2019-03-01	2019-03-03	60.0	59.5	-2.8	-26.1	10.1	4.3	-0.2	0.6	80.8	5.3	13.9
LS 30	2019-03-03	2019-03-04	59.5	55.9	-26.1	-33.8	13.0	3.7	0.2	0.9	71.4	5.8	13.6
LS 31	2019-03-04	2019-03-10	55.8	49.5	-34.0	4.1	16.4	7.5	4.2	1.4	88.8	6.6	13.1
LS 32	2019-03-10	2019-03-12	49.5	43.1	4.1	7.8	11.9	2.4	8.6	2.5	90.0	4.7	12.7
LS 33	2019-03-12	2019-03-13	43.1	36.3	7.8	13.3	11.5	1.0	17.5	2.6	84.3	4.0	12.5
LS 34	2019-03-13	2019-03-14	36.1	34.4	13.4	17.8	10.2	2.3	20.0	0.4	82.1	5.0	12.4

Table S2: Accepted reference values for $\delta^{15}N$ vs. N_2 in air and $\delta^{18}O$ vs. VSMOW in ‰ for the calibration standards used. The pooled standard deviation in ‰ and sample size (1 SD_p, n = x) is also reported.

Standard	IAEA-N3	USGS34	USGS35	Citation
$\delta^{15}N$	4.7 (0.12, n = 61)	-1.8 (0.09, n = 61)		Böhlke et al., 2003
$\delta^{18}O$	25.6 (0.57, n = 61)	-27.9 (0.54, n = 61)	57.5 (0.44, n = 65)	Böhlke et al., 2003

Table S3: The mass weighted average N and O isotopic composition of atmospheric coarse mode NO_3^- (> 1μm) are shown ($\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$; ‰), along with total coarse-mode nitrate concentration ($[NO_3^-]$; ng m^{-3}). The average (Avg) and standard deviation (SD) for the duration of each filter deployment are shown. Filter deployments are separated into early summer (ES), Weddell Sea (WS) and late summer (LS) depending on the location and time of sampling.

Cruise	$[NO_3^-]$ (ng m^{-3})		$\delta^{15}N\text{-}NO_3^-$ (‰)		$\delta^{18}O\text{-}NO_3^-$ (‰)	
Leg ID	Avg	SD	Avg	SD	Avg	SD
ES 1	106.1	39.0	-5.0	0.9	36.7	3.7
ES 2	174.2	53.6	-5.7	0.2	40.5	1.7
ES 3	374.2	65.5	-2.7	0.3	51.7	1.8
ES 4	31.9	27.1	-14.5	1.7	16.5	3.2
ES 5	109.3	13.9	-32.2	0.2	70.0	0.5
ES 6	63.1	10.9	-43.1	0.9	62.0	1.7
ES 7	114.2	11.0	-33.5	1.4	52.3	0.6
WS 8	22.3	6.4	-30.3	1.3	50.9	4.8
WS 9	52.3	1.7	-30.1	0.2	53.1	0.4
WS 10	42.6	5.5	-21.0	1.3	48.4	0.6
WS 11	48.0	25.3	-20.1	2.2	23.7	9.5
WS 12	34.2	5.4	-38.1	0.8	60.3	1.9
WS 13	31.6	9.0	-15.9	0.9	23.4	1.4
WS 14	32.7	21.2	-17.1	0.8	20.1	0.7
WS 15	35.1	15.1	-19.6	2.2	28.7	7.2
WS 16	40.9	7.5	-23.9	0.6	30.6	1.9
WS 17	72.2	20.0	-18.2	0.7	29.2	2.7
WS 18	94.8	9.5	-11.6	0.3	42.0	1.4
WS 19	60.0	18.3	-23.5	1.2	18.8	2.0
WS 20	55.8	7.0	-25.0	0.4	51.3	2.1
WS 21	24.1	1.8	-24.2	0.2	52.3	0.6
WS 22	29.1	8.9	-15.5	1.5	45.0	0.7
WS 23	28.1	7.1	-37.8	1.4	50.5	3.8
WS 24	80.6	15.5	-18.7	0.2	28.6	2.0
WS 25	56.3	15.7	-27.7	3.0	34.8	2.0
WS 26	36.2	9.7	-18.4	0.9	43.6	5.8
WS 27	57.1	14.6	-17.0	0.3	30.3	1.8
LS 28	39.1	5.4	-25.6	0.6	50.5	2.8
LS 29	27.0	5.6	-20.8	1.2	51.2	3.7
LS 30	22.3	4.3	-23.9	1.0	48.9	3.5
LS 31	45.7	10.0	-14.0	0.2	44.9	1.6
LS 32	83.2	10.6	-11.2	0.1	45.3	1.4
LS 33	158.2	9.5	-6.6	0.1	57.9	0.8
LS 34	282.5	28.9	-4.6	0.1	58.9	0.9

Table S4: Estimated contribution of alkyl nitrates, lightning NO_x, and snow emissions to atmospheric NO_3^- formation for early summer (ES) and late summer (LS) filter deployments. The $\delta^{15}N$ signature of NO_3^- derived from oceanic alkyl nitrates is also presented ($\delta^{15}N\text{-}NO_3^-{}_{AN}$) for samples with an alkyl nitrate source > 10%.

Cruise leg ID	Alkyl nitrates (%)	Lightning (%)	Snow emissions (%)	$\delta^{15}N\text{-}NO_3^-{}_{AN}$ (‰)
ES 1	42.7	57.3	0.0	-11.7
ES 2	29.1	70.8	0.0	-19.7
ES 3	4.5	95.3	0.0	-
ES 4	97.0	3.0	0.0	-14.9
ES 5	81.3	0.0	18.7	-28.6
ES 6	35.1	0.0	64.9	-34.1
ES 7	1.9	0.0	98.1	-
LS 28	95.7	0.0	4.3	-24.6
LS 29	89.9	0.0	10.1	-17.8
LS 30	77.2	0.0	22.8	-16.8
LS 31	86.4	13.6	0.0	-16.2
LS 32	34.0	66.0	0.0	-33.0
LS 33	26.6	73.4	0.0	-24.9
LS 34	8.5	91.5	0.0	-