Supporting Information

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The supporting information file includes 12 pages, 5 tables, and 4 figures.

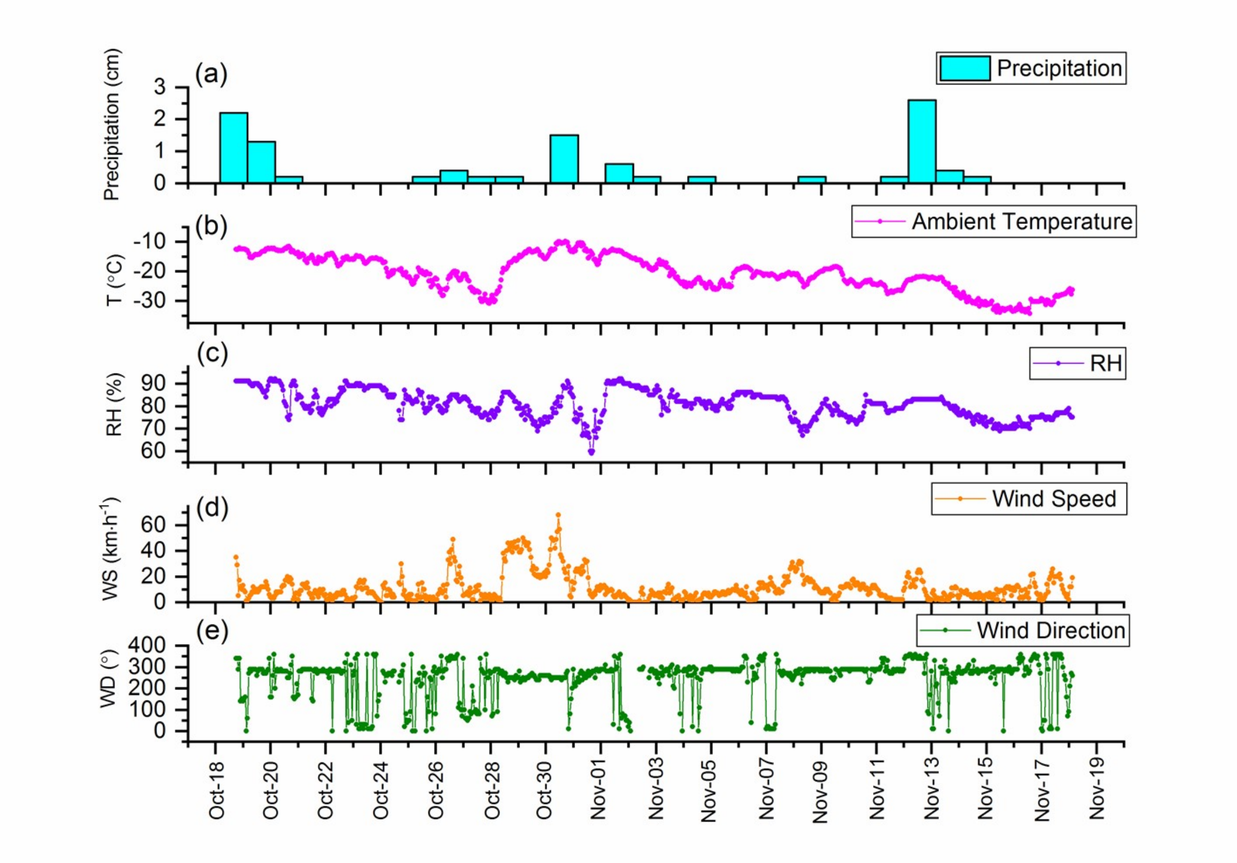

Figure S1. The time series of meteorology data at Alert during the campaign. Panel (a): Precipitation. Panel (b): Ambient temperature. Panel (c): Relative humidity. Panel (d): wind speed. Panel (e): wind direction. The meteorology data were retrieved from the Environment Canada website, http://climate.weather.gc.ca/.

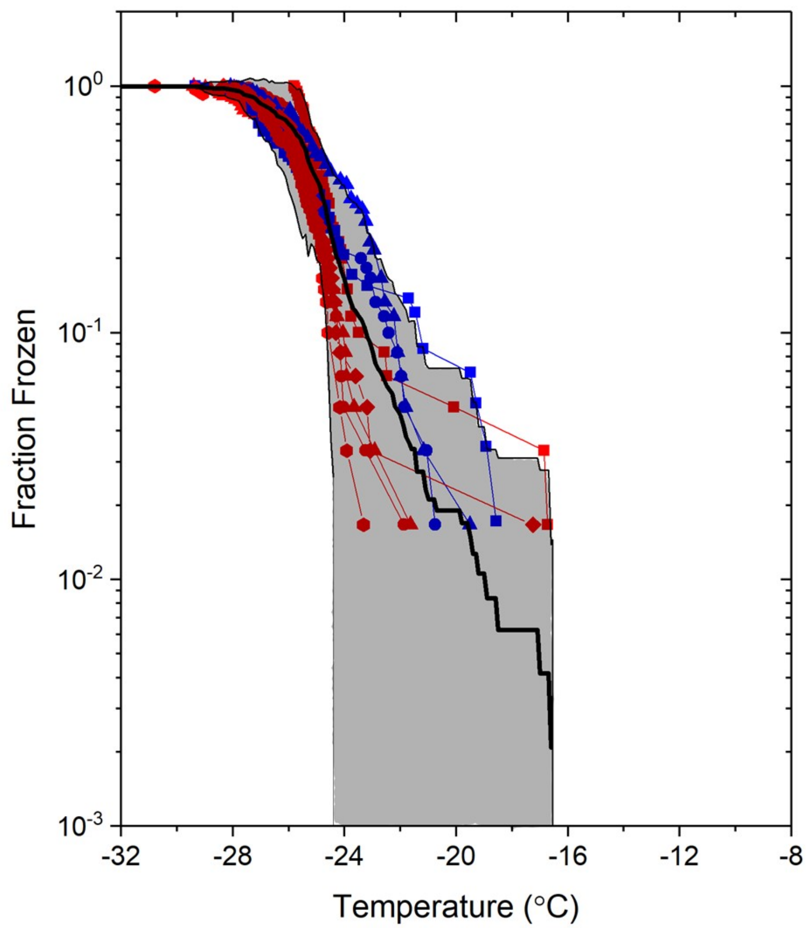

Figure S2. The fraction of frozen droplets as a function of temperature for the blanks (8 trials). Red symbols (5 trials) correspond to extracted solutions from the clean filters using Milli-Q water and blue symbols (3 trials) correspond to 0.05 M $(NH_4)_2SO_4$ solutions prepared with Milli-Q water. The freezing data for the 0.05 M $(NH_4)_2SO_4$ trials was corrected for freezing point depression caused by the salt using the method described in Section 2.3 of the main text. The black solid line is the average of the 8 trials and the shaded region corresponds to two times the standard deviations of the blanks from the 8 trials.

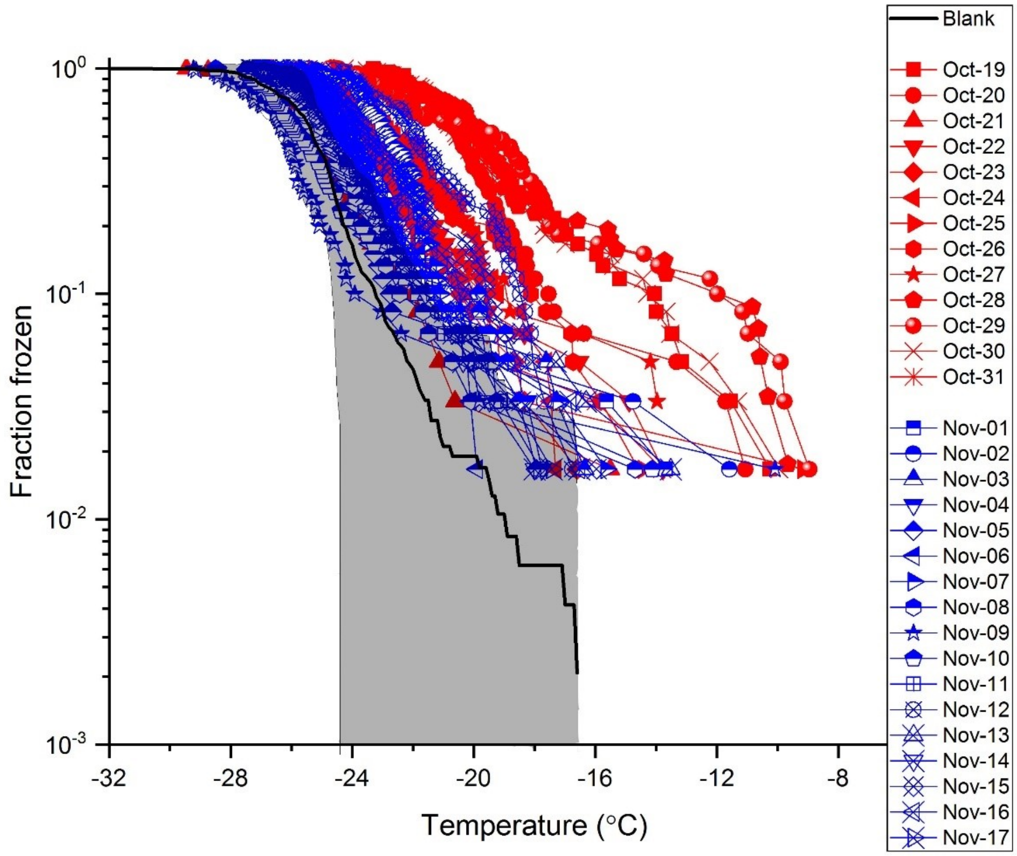

Figure S3. The fraction of frozen droplets for the 30 samples collected in the Arctic during October and November. Also included is the average of the blanks and two times the standard deviations of the blanks from the 8 trials. The black solid line is the average of the 8 trials and the shaded region corresponds to two times the standard deviations of the blanks from the 8 trials.

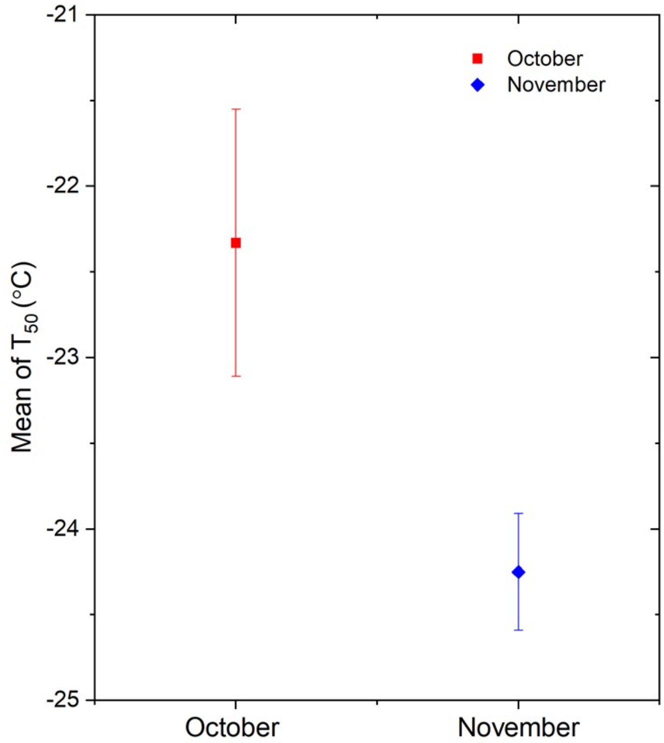

Figure S4. The mean of T_{50}, the freezing temperature at which 50% of droplets froze, for October samples and November samples. The error bars are the 83% confidence intervals. Two datasets are statistically different the 95% confidence level if their 83% confidence intervals do not overlap (Goldstein and Healy, 2009).

Table S1. Compilation of previous studies of the effect of NH_4^+ at dilute concentrations (≤ 0.1 M) on the freezing properties of different types of mineral dust INPs. In this table, ΔT_{50} is the median freezing temperature, ΔT_{onset} is the onset freezing temperature, n_m is the number of ice nucleating active sites per gram of materials, and n_s is the number of ice nucleating active sites per surface area of materials.

INP type	Freezing temperature range	Ammonium salt concentrations	Observations	References
Amorphous silica	~ -35 °C	0.004 M and 0.075 M	No significant change	Kumar et al. (2019a)
Arizona Test Dust	-20 °C to -10 °C	0.05 M	$\Delta T_{50} \cong +6$ °C n_m increased by a factor of ~ 20	Worthy et al. (2021)
Kaolinite	-25 °C to -10 °C	0.05 M	$\Delta T_{50} \cong +8$ °C n_m increased by a factor of ~ 30	Worthy et al. (2021)
K-rich feldspar	-15 °C to -5 °C	0.05 M	$\Delta T_{50} \cong +3$ °C n_m increased by a factor of ~ 10	Worthy et al. (2021)
Montmorillonite	-15 °C to -5 °C	0.05 M	$\Delta T_{50} \cong +6$ °C n_m increased by a factor of ~ 10	Worthy et al. (2021)
Feldspars	-35 °C to -20 °C	7.6 ×10^{-6} M to 0.1 M	$\Delta T_{onset} = +1$ °C to +6 °C	Kumar et al. (2018, 2019b)
Gibbsite	[a]N/A	0.004 M and 0.04 M	No significant change	Kumar et al., (2019b)
Kaolinite	-35 °C to -25 °C	0.00076 M to 0.1 M	$\Delta T_{onset} = +1$ °C to +3 °C	Kumar et al. (2019b)
Micas	~ -32 °C	0.004 M to 0.1 M	Ratio of heterogeneous freezing signal to homogeneous freezing signal increased;	Kumar et al. (2019b)
Quartz	~ -25 °C	0.004 M to 0.1 M	Ratio of heterogeneous freezing signal to homogeneous freezing signal increased; No significant change in ΔT_{onset}	Kumar et al. (2019a)
Amorphous silica	-20 °C to -10 °C	0.015 M	No significant change	Whale et al. (2018)
Arizona Test Dust	-20 °C to -5 °C	0.015 M	No significant change	Whale et al. (2018)
Feldspars	-20 °C to -5 °C	0.00015 M to 0.015 M	$\Delta T_{50} = +1$ °C to +4 °C; n_s increased by a factor of ~10	Whale et al. (2018)
Quartz	-20 °C to -15 °C	0.015 M	$\Delta T_{50} \cong +1.5$ °C n_s increased by a factor of ~5	Whale et al. (2018)

[a]Not Applicable

Table S2. Compilation of previous studies of the effect of NH_4^+ at dilute concentrations (< 0.1 M) on the freezing properties of different types of non-mineral dust INPs. ΔT_{50} is the median freezing temperature.

INP type	Freezing temperature range	Ammonium salt concentration	Observations	References
Fungi	-20 °C to -10 °C	0.05 M	No significant change	Worthy et al. (2021)
Humic Substances	-25 °C to -10 °C	0.015 M to 0.05 M	No significant change	Whale et al. (2018); Worthy et al., (2021)
Leaf-derived INPs	-10 °C to -5 °C	0.01 M to 0.1 M	No significant change	Reischel and Vali (1975)
P. *syringae*	-10 °C to 0 °C	0.05 M	No significant change	Worthy et al. (2021)
Sea-ice diatom exudates	-20 °C to -15 °C	0.05 M	No significant change	Worthy et al. (2021)
Sea-surface microlayer samples	-25 °C to -5 °C	0.05 M	No significant change	Worthy et al. (2021)
Snowmax	-15 °C to -5 °C	≤ 0.1 M	No significant change	Koop and Zobrist (2009); Worthy et al. (2021)
X. *campestris*	-15 °C to -5 °C	0.05 M	A small decrease in ΔT_{50} (≅ -0.43 ± 0.19 °C)	Worthy et al. (2021)

Table S3. Relevant information on the previous measurements of INP concentrations in the Arctic from ground-based or ship-based platforms shown in Fig.2.

Study	Platform	Location	Sampling time
Radke et al. (1976)	Ground	Utqiaġvik, Alaska, USA	March, 1970
Fountain and Ohtake (1985)	Ground	Utqiaġvik, Alaska, USA	August, 1978 – April, 1979
Bigg (1996)	Ship	Arctic Ocean	August – October, 1991
Bigg and Leck (2001)	Ship	Arctic Ocean	July – September, 1996
Conen et al. (2016)	Ground	Finnmark, Norway	July, 2015
Mason et al. (2016)	Ground	Alert, Nunavut, Canada	March – July, 2014
Creamean et al. (2018)	Ground	Oliktok Point, Alaska, USA	March – May, 2017
Si et al. (2019)	Ground	Alert, Nunavut, Canada	March, 2016
Irish et al. (2019)	Ship	Arctic Ocean	July – August, 2014
Šantl-Temkiv et al. (2019)	Ground	Villum, Greenland	August, 2016
Wex et al. (2019)	Ground	Alert, Nunavut, Canada	April, 2015 – April, 2016
Wex et al. (2019)	Ground	Utqiaġvik, Alaska, USA	June, 2012 – June, 2013
Wex et al. (2019)	Ground	Villum, Greenland	January, 2015 – November, 2015
Wex et al. (2019)	Ground	Ny-Ålesund, Norway	March, 2012, - September, 2012
Creamean et al. (2019)	Ship	Bering Strait, Arctic Ocean	August – September, 2017
Welti et al. (2020)	Ship	Arctic Ocean	July – August, 2001
Hartmann et al. (2020)	Ship	Arctic Ocean	May – July, 2017
Tobo et al. (2019)	Ground	Ny-Ålesund, Norway	July, 2016
Tobo et al. (2019)	Ground	Ny-Ålesund, Norway	March, 2017
Rinaldi et al. (2021)	Ground	Ny-Ålesund, Norway	April – August, 2018

Table S4. The residence time that each air mass spent in the 7 days prior to sampling in the footprint layer over a specific surface type (land, sea ice, sea, and snow) for each sample.

Collection date of the samples	Residence over land (s)	Residence over sea ice (s)	Residence over Sea (s)	Snow (s)
October 19th	513.33	15078.3	7204.04	14894.8
October 20th	1133.96	46781.1	4055.8	24232.5
October 21st	154.79	76579.4	5886.24	29009.1
October 22nd	326.99	40152.7	7783.69	16190.6
October 23rd	31.59	77622.3	4748.68	8489.87
October 24th	20.55	24062.2	2390.79	11421.8
October 25th	65.59	21270.2	3353.69	35879
October 26th	71.94	36990.9	2438.77	32094.6
October 27th	16.85	30637.1	600.07	39952.4
October 28th	3.05	15228.9	385.48	37134.8
October 29th	726.07	22659	577.20	61923.9
October 30th	1065.72	27905.5	2208.78	69060.7
October 31st	645.80	43054.8	6167.5	46937.3
November 1st	193.51	23231.4	16735.1	20140.4
November 2nd	374.33	49282.1	12775.7	13058.1
November 3rd	628.16	16966	12181.8	29180.7
November 4th	155.14	31995.4	2944.26	19794.5
November 5th	8.88	73468.8	1865.23	37721
November 6th	0.0087	120622	27.62	58710.9
November 7th	0.3243052	94172.4	107.14	28177.2
November 8th	0.005026	128938	6.39	95118.9
November 9th	0	154951	1.27	97707.6
November 10th	5.72×10^{-5}	122226	1.16	145639
November 11st	7.57×10^{-5}	60350.2	133.21	37868.3
November 12nd	0.018	75497.6	58.15	10154.7
November 13rd	8.8×10^{-5}	54308.4	1.73	31823.2
November 14th	8.7×10^{-5}	19470.1	3.41	58576.7
November 15th	0.0015	47464.7	11.77	63784.9
November 16th	0.28	71579.1	10.07	41065.1
November 17th	4.11	99929.7	247.25	21651

Table S5. Starting time and ending time of collection for each sample and total volume of air sampled for each sample.

Collection date of the samples	Starting time	Ending time	Total volume (L)
October 19th, 2018	2:18pm	2:18pm	17280
October 20th, 2018	2:26pm	2:26pm	17280
October 21st, 2018	2:56pm	2:56pm	17280
October 22nd, 2018	3:00pm	3:00pm	17280
October 23rd, 2018	3:10pm	3:10pm	17280
October 24th, 2018	3:20pm	3:20pm	17280
October 25th, 2018	3:27pm	3:27pm	17280
October 26th, 2018	3:38pm	3:38pm	17280
October 27th, 2018	3:44pm	3:44pm	17280
October 28th, 2018	3:51pm	3:51pm	17280
October 29th, 2018	3:57pm	3:57pm	17280
October 30th, 2018	4:03pm	4:03pm	17280
October 31st, 2018	4:09pm	4:09pm	17280
November 1st, 2018	4:16pm	4:16pm	17280
November 2nd, 2018	4:22pm	4:03pm	17052
November 3rd, 2018	4:16pm	3:16pm	16560
November 4th, 2018	3:27pm	3:27pm	17280
November 5th, 2018	3:34pm	3:34pm	17280
November 6th, 2018	3:42pm	3:42pm	17280
November 7th, 2018	3:48pm	3:48pm	17280
November 8th, 2018	3:54pm	2:54pm	16560
November 9th, 2018	3:05pm	3:05pm	17280
November 10th, 2018	3:14pm	3:14pm	17280
November 11st, 2018	3:20pm	3:20pm	17280
November 12nd, 2018	3:25pm	3:25pm	17280
November 13rd, 2018	3:37pm	3:37pm	17280
November 14th, 2018	3:42pm	3:42pm	17280
November 15th, 2018	3:49pm	3:49pm	17280
November 16th, 2018	3:58pm	3:58pm	17280
November 17th, 2018	4:03pm	9:41am	12696

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