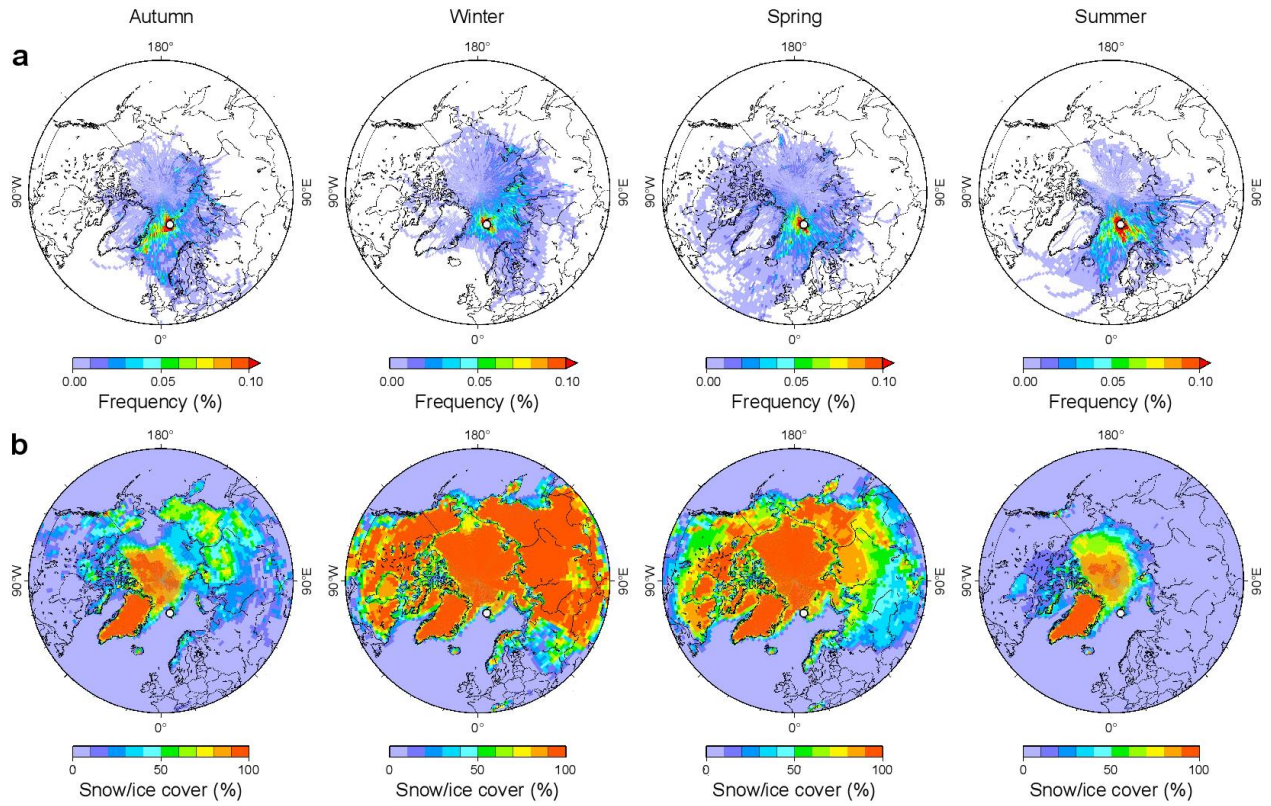
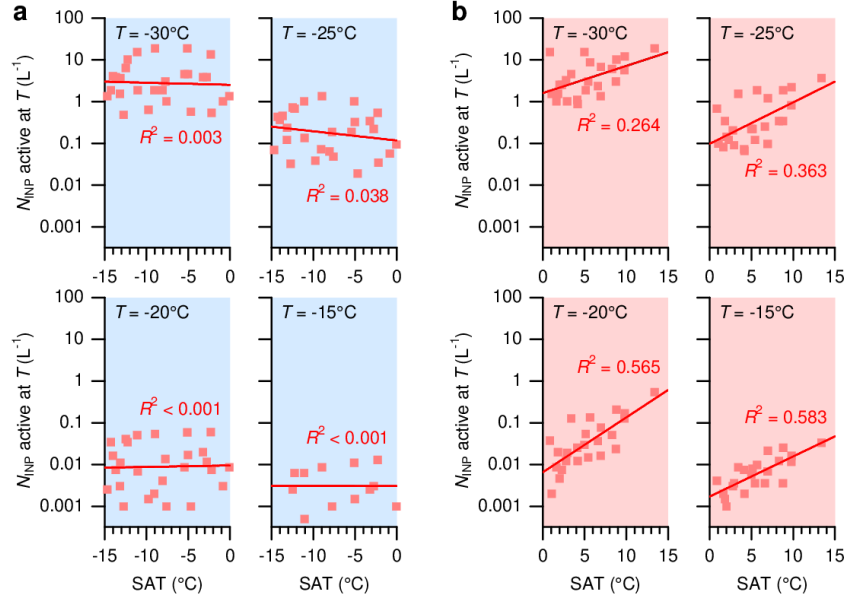
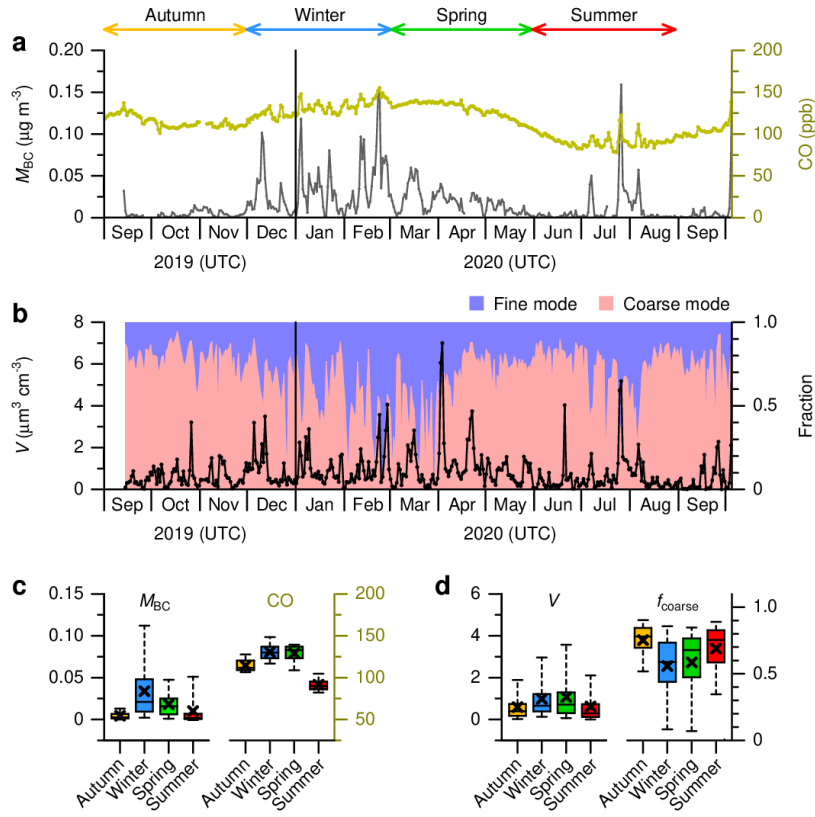




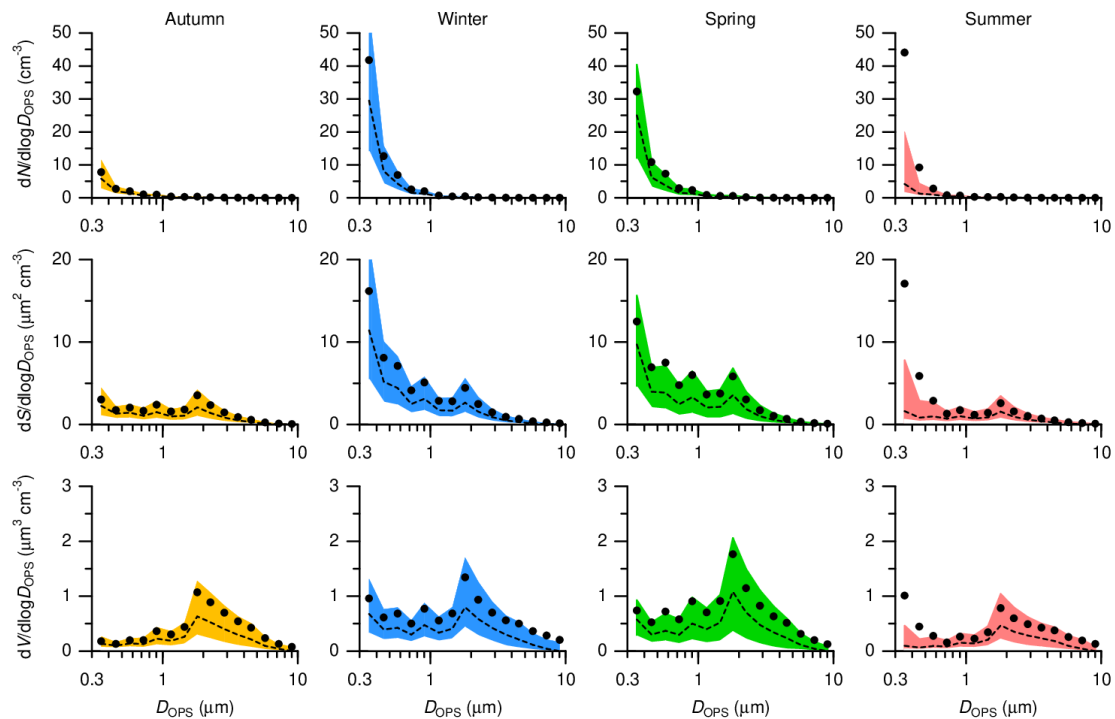
Supplementary Fig. 1 | Seasonal characteristics of air masses and snow/ice conditions in Svalbard and its surroundings during the MOSAiC project year. The distributions of (a) five-day backward trajectories that ended over the location of the Zeppelin Observatory (500 m above mean sea level) and (b) snow/ice covers in autumn (September 2019 to November 2019), winter (December 2019 to February 2020), spring (March 2020 to May 2020), and summer (June 2020 to August 2020). The frequency of the trajectories represents the percentage of the number of endpoints per grid square to the total number of endpoints.



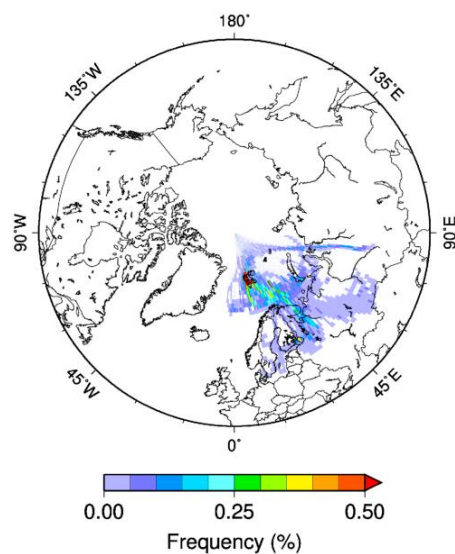
Supplementary Fig. 2 | Possible link of the near-surface conditions with the variation of ice nucleating particles (INPs) active at a given temperature (T) over Svalbard. **a Comparison of the weekly mean number concentrations of INPs (N_{INP}) at the Zeppelin Observatory with the weekly mean surface air temperature (SAT) at Longyearbyen for the period when local INP emissions from the ground surfaces were limited. **b** Same as (**a**), but for the period when local INP emissions from the ground surfaces were expected. The equations fitted to the data are summarized in Supplementary Table 2.**



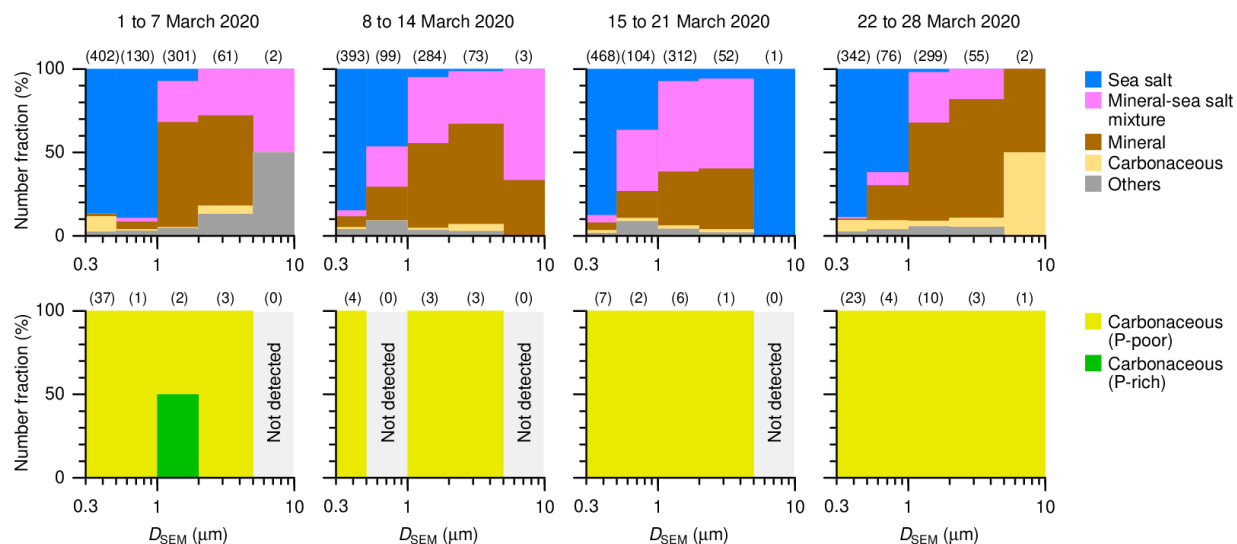
Supplementary Fig. 3 | Continuous measurements of ambient black carbon (BC), carbon monoxide (CO), and aerosols at the Zeppelin Observatory during the MOSAiC project year. a Times series of the daily mean BC mass concentrations (M_{BC}) and CO mixing ratios. **b** Times series of the daily mean aerosol volume concentrations (V) derived from the measurements of aerosol particles with optical diameters between 0.3 and 10 μm . Also shown are the fractions of fine mode (0.3 to 1 μm in diameter) and coarse mode (1 to 10 μm in diameter) particles. **c** Seasonal trends of the M_{BC} and CO values. The cross marks indicate the mean, the boxes represent the 25th, 50th (median) and 75th percentiles, and the whiskers represent the 5th and 95th percentiles. **d** Seasonal trends of the V values and the fractions of coarse mode particles (f_{coarse}).



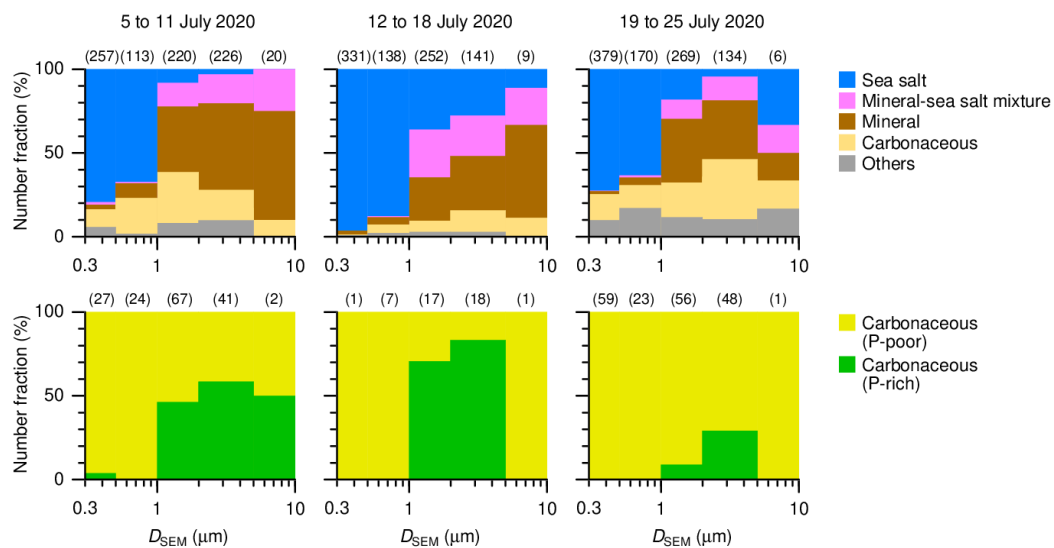
Supplementary Fig. 4 | Seasonal trends of the number ($dN/d\log D_{OPS}$), surface area ($dS/d\log D_{OPS}$), and volume ($dV/d\log D_{OPS}$) concentration distributions of ambient aerosol particles at the Zeppelin Observatory during the MOSAiC project year. The data are presented against optical diameter (D_{OPS}) measured by an optical particle sizer (OPS). The dots and dashed curves represent the mean and median values, respectively, and the shading ranges represent the 25th and 75th percentiles.



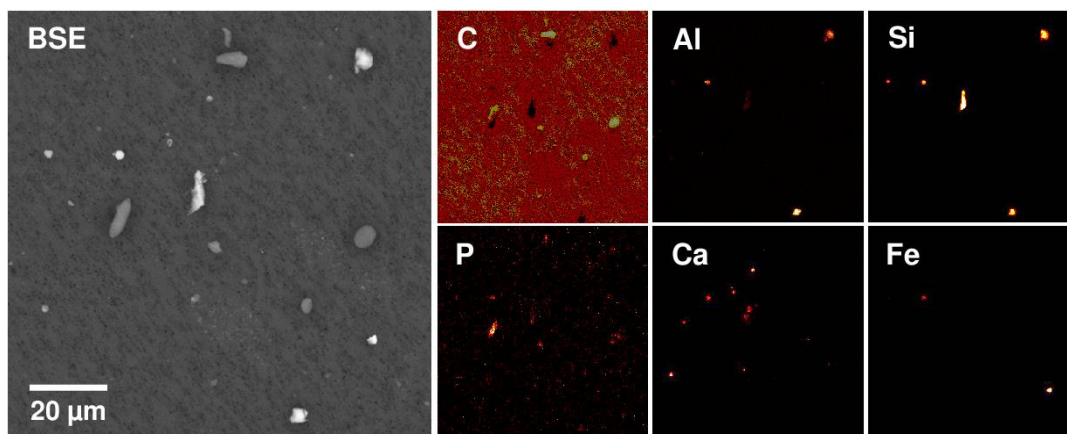
Supplementary Fig. 5 | Five-day backward trajectories that ended over the location of the Zeppelin Observatory for the high BC, CO, and aerosol period from 24 July to 7 August 2020. The BC, CO, and aerosol data during this period are presented in Supplementary Fig. 3.



Supplementary Fig. 6 | Size and compositions of ambient aerosol particles collected at the Zeppelin Observatory in March 2020. The results are based on the scanning electron microscopy (SEM) with energy-dispersive X-ray (EDX) analysis of the samples collected for the period from 1 to 28 March 2020 (4 weekly samples). Their number fractions are presented against area-equivalent diameter (D_{SEM}) obtained by means of single-particle SEM/EDX analysis. The bottom panels show the number fractions of P-poor and P-rich particles in carbonaceous particles presented in the top panels. The number in parentheses represents the number of the analyzed particles for each size bin.



Supplementary Fig. 7 | Same as Supplementary Fig. 6. but for the ambient aerosol particles collected in July 2020. The results are based on the SEM/EDX analysis of the samples collected for the period from 5 to 25 July 2020 (3 weekly samples).



Supplementary Fig. 8 | Backscattered electron (BSE) and elemental mapping (C, Al, Si, P, Ca, and Fe) images of ambient aerosol particles collected at the Zeppelin Observatory for the period from 19 to 25 July 2020. Note that relatively high background C signals (reddish in color) originate from the substrate (polycarbonate filter) used for the aerosol particle sampling.

Supplementary Table 1 | Coefficients of the equation $N_{\text{INP}} = \exp(a \cdot \text{SAT} + b)$ in Fig. 3.

N_{INP} (L^{-1})	SAT ($^{\circ}\text{C}$)	a	b	R^2	Figure
N_{INP} active at $T = -30^{\circ}\text{C}$	<0	0.0028	1.0480	<0.001	Fig. 3b
N_{INP} active at $T = -25^{\circ}\text{C}$	<0	-0.0417	-2.0492	0.024	
N_{INP} active at $T = -20^{\circ}\text{C}$	<0	0.0153	-4.5990	0.003	
N_{INP} active at $T = -15^{\circ}\text{C}$	<0	0.0021	-5.7669	<0.001	
N_{INP} active at $T = -30^{\circ}\text{C}$	>0	0.1734	0.4867	0.230	Fig. 3c
N_{INP} active at $T = -25^{\circ}\text{C}$	>0	0.2782	-2.3667	0.351	
N_{INP} active at $T = -20^{\circ}\text{C}$	>0	0.3644	-5.0673	0.534	
N_{INP} active at $T = -15^{\circ}\text{C}$	>0	0.2701	-6.4126	0.564	

Supplementary Table 2 | Coefficients of the equation $N_{\text{INP}} = \exp(a \cdot \text{SAT} + b)$ in Supplementary Fig. 2.

N_{INP} (L^{-1})	SAT ($^{\circ}\text{C}$)	a	b	R^2	Figure
N_{INP} active at $T = -30^{\circ}\text{C}$	<0	-0.0120	0.9259	0.003	Supplementary Fig. 2a
N_{INP} active at $T = -25^{\circ}\text{C}$	<0	-0.0509	-2.1425	0.038	
N_{INP} active at $T = -20^{\circ}\text{C}$	<0	0.0080	-4.6544	<0.001	
N_{INP} active at $T = -15^{\circ}\text{C}$	<0	-0.0012	-5.7884	<0.001	
N_{INP} active at $T = -30^{\circ}\text{C}$	>0	0.1500	0.4736	0.264	Supplementary Fig. 2b
N_{INP} active at $T = -25^{\circ}\text{C}$	>0	0.2286	-2.3241	0.363	
N_{INP} active at $T = -20^{\circ}\text{C}$	>0	0.3025	-5.0275	0.565	
N_{INP} active at $T = -15^{\circ}\text{C}$	>0	0.2212	-6.3661	0.583	

Supplementary Table 3 | Coefficients of the equation $\text{NDVI-positive area} = a \cdot \text{SAT} + b$ in Fig. 4c.

NDVI-positive area (%)	SAT ($^{\circ}\text{C}$)	a	b	R^2	Figure
NDVI > 0	>0	3.4500	5.2038	0.885	Fig. 4c
NDVI > 0.2	>0	1.6496	1.2550	0.820	
NDVI > 0.4	>0	0.3866	0.3672	0.712	

Supplementary Table 4 | Number of the analyzed particles for SEM/EDX analysis.

Period	Fine mode (0.3 to 1 μm)	Coarse mode (1 to 10 μm)
1 March (00:00 UTC) to 7 March (23:59 UTC), 2020	532	364
8 March (00:00 UTC) to 14 March (23:59 UTC), 2020	492	360
15 March (00:00 UTC) to 21 March (23:59 UTC), 2020	572	365
22 March (00:00 UTC) to 28 March (23:59 UTC), 2020	418	356
5 July (00:00 UTC) to 11 July (23:59 UTC), 2020	370	466
12 July (00:00 UTC) to 18 July (23:59 UTC), 2020	469	402
19 July (00:00 UTC) to 25 July (23:59 UTC), 2020	549	409