

Characterization of aerosol particles at Cape Verde close to sea and cloud level heights - Part 2: ice nucleating particles in air, cloud and seawater

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S1 Seawater samples

Table S1. The information of seawater samples at OS, including sample number, start time, end time, location, salinity, sodium chloride (NaCl) mass concentration, PH value and water temperature.

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Location	Salinity [g L ⁻¹]	NaCl [g L ⁻¹]	PH value	Temperature [°C]
SML01	2017/09/18 12:35:00	2017/09/18 13:00:00	-	-	-	-	-
ULW01	2017/09/18 12:35:00	2017/09/18 13:00:00	-	34.1	29.23	8.14	25.0
SML02	2017/09/20 09:32:00	2017/09/20 10:54:00	16°53'20 N, 24°54'22 W	36.2	31.03	8.11	26.7
ULW02	2017/09/20 09:32:00	2017/09/20 10:54:00	16°53'20 N, 24°54'22 W	36.3	31.11	8.12	26.7
SML03	2017/09/25 10:45:00	2017/09/25 11:48:00	16°53'46 N, 24°54'19 W	36.4	31.20	8.14	25.5
ULW03	2017/09/25 10:45:00	2017/09/25 11:48:00	16°53'46 N, 24°54'19 W	36.4	31.20	8.15	26.0
SML04	2017/09/26 11:05:00	2017/09/26 11:51:00	16°53'50 N, 24°54'27 W	36.1	30.94	8.12	26.4
ULW04	2017/09/26 11:05:00	2017/09/26 11:51:00	16°53'50 N, 24°54'27 W	36.3	31.11	8.15	25.1
SML05	2017/09/27 09:50:00	2017/09/27 11:00:00	16°53'38 N, 24°54'16 W	36.3	31.11	8.15	23.7
ULW05	2017/09/27 09:50:00	2017/09/27 11:00:00	16°53'38 N, 24°54'16 W	36.4	31.20	8.14	24.0
SML09	2017/10/04 09:15:00	2017/10/04 10:00:00	-	-	-	-	-
ULW09	2017/10/04 09:15:00	2017/10/04 10:00:00	-	36.2	31.03	8.23	23.7
SML12	2017/10/07 10:22:00	2017/10/07 11:35:00	16°53'25 N, 24°54'18 W	36.7	31.46	8.22	21.2
ULW12	2017/10/07 10:22:00	2017/10/07 11:35:00	16°53'25 N, 24°54'18 W	36.4	31.20	8.22	21.8
SML13	2017/10/09 09:30:00	2017/10/09 10:17:00	16°53'42 N, 24°54'08 W	36.6	31.37	8.19	21.5
ULW13	2017/10/09 09:30:00	2017/10/09 10:17:00	16°53'42 N, 24°54'08 W	36.4	31.20	8.13	23.6
SML14	2017/10/10 09:30:00	2017/10/10 10:30:00	16°53'43 N, 24°54'13 W	36.4	31.20	8.19	21.7
ULW14	2017/10/10 09:30:00	2017/10/10 10:30:00	16°53'43 N, 24°54'13 W	36.3	31.11	8.18	22.4

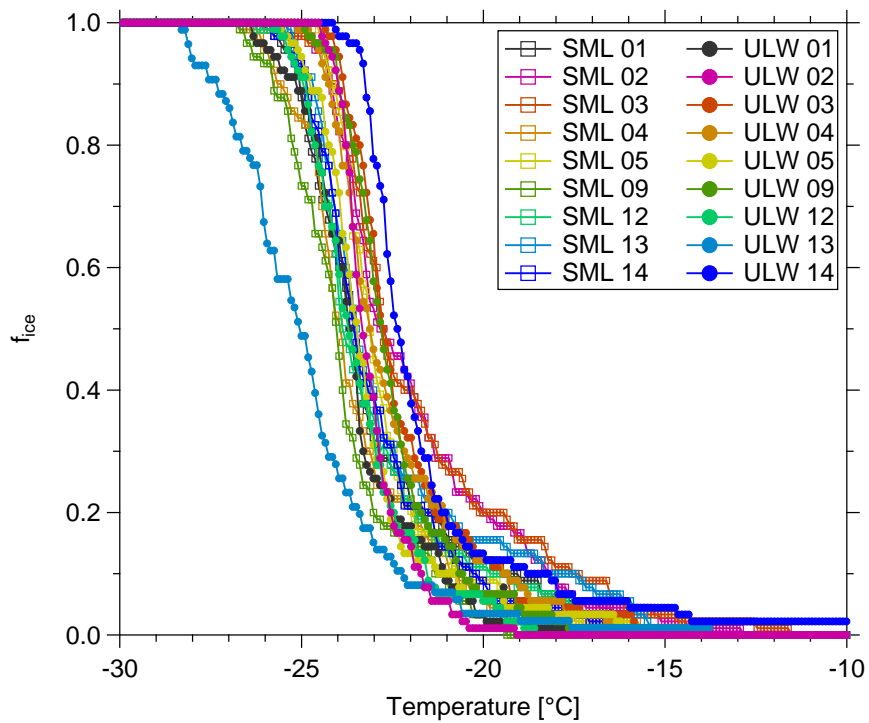


Figure S1. Frozen fraction (f_{ice}) measured by LINA as a function of temperature in SML and ULW. All temperatures have been corrected for freezing point depression.

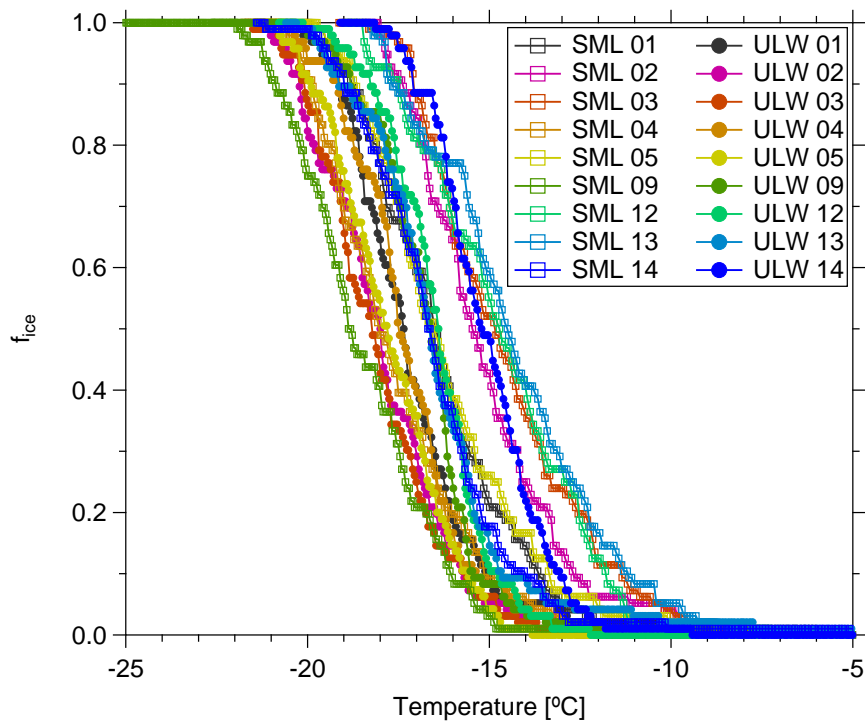


Figure S2. f_{ice} measured by INDA as a function of temperature in SML and ULW. All temperatures have been corrected for freezing point depression.

S2 Filter samples

S2.1 CVAO PM₁₀

Table S2. The information of PM₁₀ filter samples at CVAO, including sample number, start time, end time, duration, total sampling volume, sampling volume per well, sodium (Na⁺) and chloride (Cl⁻) mass concentration, total particle surface area concentration (A_{total}) and sample type.

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration [h]	Total Volume [std L ⁻¹]	Volume Per Well [std L ⁻¹]	Na ⁺ $\mu\text{g m}^{-3}$	Cl ⁻ $\mu\text{g m}^{-3}$	A_{total} $\mu\text{m}^2 \text{cm}^{-3}$	Type
CVAO1583	2017/09/19 21:00:00	2017/09/20 21:00:00	1439.34	660.289	33.6882	4.40	6.19	370	PM ₁₀
CVAO1585	2017/09/22 16:00:00	2017/09/23 16:00:00	1439.34	660.289	33.6882	3.09	4.97	89	PM ₁₀
CVAO1586	2017/09/23 16:00:00	2017/09/24 16:00:00	1439.34	660.289	33.6882	2.36	3.36	78	PM ₁₀
CVAO1587	2017/09/24 16:00:00	2017/09/25 16:00:00	1439.34	660.289	33.6882	2.83	3.54	158	PM ₁₀
CVAO1588	2017/09/25 16:00:00	2017/09/26 16:00:00	1438.90	660.792	33.7139	3.32	4.98	277	PM ₁₀
CVAO1589	2017/09/26 16:00:00	2017/09/27 16:00:00	1439.61	661.462	33.7481	1.41	1.99	159	PM ₁₀
CVAO1590	2017/09/27 16:00:00	2017/09/28 16:00:00	1439.71	661.644	33.7573	1.77	2.70	198	PM ₁₀
CVAO1591	2017/09/28 16:00:00	2017/09/29 16:00:00	1439.73	661.420	33.7459	5.04	8.41	325	PM ₁₀
CVAO1592	2017/09/29 16:00:00	2017/09/30 16:00:00	1439.73	660.289	33.6882	6.49	11.26	297	PM ₁₀
CVAO1593	2017/09/30 16:00:00	2017/10/01 16:00:00	1439.73	660.821	33.7153	5.32	8.99	238	PM ₁₀
CVAO1594	2017/09/29 16:00:00	2017/09/30 16:00:00							Blind filter
CVAO1595	2017/10/01 16:00:00	2017/10/02 16:00:00	1439.36	659.330	33.6393	4.52	6.67	172	PM ₁₀
CVAO1596	2017/10/02 16:00:00	2017/10/03 16:00:00	1439.71	660.629	33.7056	3.71	6.49	171	PM ₁₀
CVAO1597	2017/10/03 16:00:00	2017/10/04 16:00:00	1439.71	660.629	33.7056	-	-	169	PM ₁₀
CVAO1598	2017/10/05 16:00:00	2017/10/06 16:00:00	1439.55	659.264	33.6359	2.58	3.33	162	PM ₁₀
CVAO1641	2017/10/06 16:00:00	2017/10/07 16:00:00	1439.73	658.670	33.6056	4.67	6.91	244	PM ₁₀
CVAO1642	2017/10/07 16:00:00	2017/10/08 16:00:00	1439.71	661.187	33.7341	5.46	8.54	271	PM ₁₀
CVAO1643	2017/10/08 16:00:00	2017/10/09 16:00:00	1439.71	659.785	33.6625	5.22	7.98	230	PM ₁₀
CVAO1644	2017/10/07 17:00:00	2017/10/08 17:00:00							Blind filter

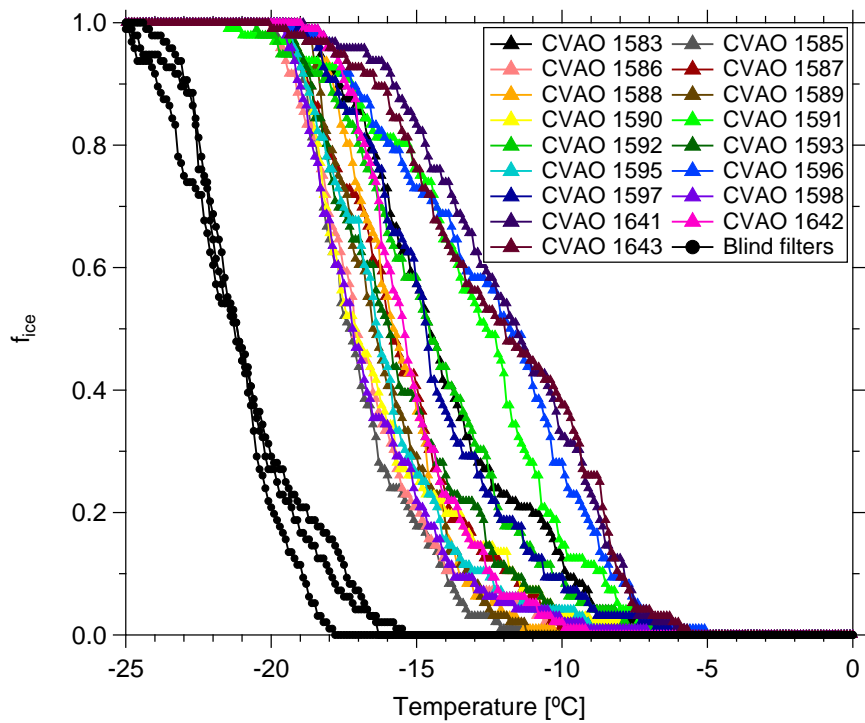


Figure S3. f_{ice} measured by INDA (without background subtraction) as a function of temperature in CVAO PM₁₀ filters. f_{ice} of blind filters are shown by black dots.

S2.2 CVAO PM₁

Table S3. The information of PM₁ filter samples at CVAO, including sample number, start time, end time, duration, total sampling volume, sampling volume per well and sample type.

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration [h]	Total Volume [std L ⁻¹]	Volume Per Well [std L ⁻¹]	Type
CVAO924	2017/09/19 21:00:00	2017/09/20 21:00:00	1439.36	661.200	33.7347	PM ₁
CVAO925	2017/09/21 21:00:00	2017/09/22 21:00:00	1439.36	661.200	33.7347	PM ₁
CVAO926	2017/09/22 16:00:00	2017/09/23 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO927	2017/09/23 16:00:00	2017/09/24 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO928	2017/09/24 16:00:00	2017/09/25 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO929	2017/09/25 16:00:00	2017/09/26 16:00:00	1439.21	664.115	33.8834	PM ₁
CVAO930	2017/09/26 16:00:00	2017/09/27 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO931	2017/09/27 16:00:00	2017/09/28 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO932	2017/09/28 16:00:00	2017/09/29 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO933	2017/09/29 16:00:00	2017/09/30 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO934	2017/09/30 16:00:00	2017/10/01 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO935	2017/09/29 16:00:00	2017/09/30 16:00:00				Blind filter
CVAO936	2017/10/01 16:00:00	2017/10/02 16:00:00	1438.53	659.798	33.6632	PM ₁
CVAO937	2017/10/02 16:00:00	2017/10/03 16:00:00	1439.55	660.255	33.6865	PM ₁
CVAO938	2017/10/03 16:00:00	2017/10/04 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO939	2017/10/04 16:00:00	2017/10/05 16:00:00	1439.36	661.200	33.7347	PM ₁
CVAO940	2017/10/05 16:00:00	2017/10/06 16:00:00	1439.18	661.071	33.7281	PM ₁
CVAO941	2017/10/06 16:00:00	2017/10/07 16:00:00	1439.58	662.336	33.7927	PM ₁
CVAO942	2017/10/07 16:00:00	2017/10/08 16:00:00	1439.58	662.122	33.7817	PM ₁
CVAO944	2017/10/08 16:00:00	2017/10/09 16:00:00	1439.55	660.377	33.6927	PM ₁

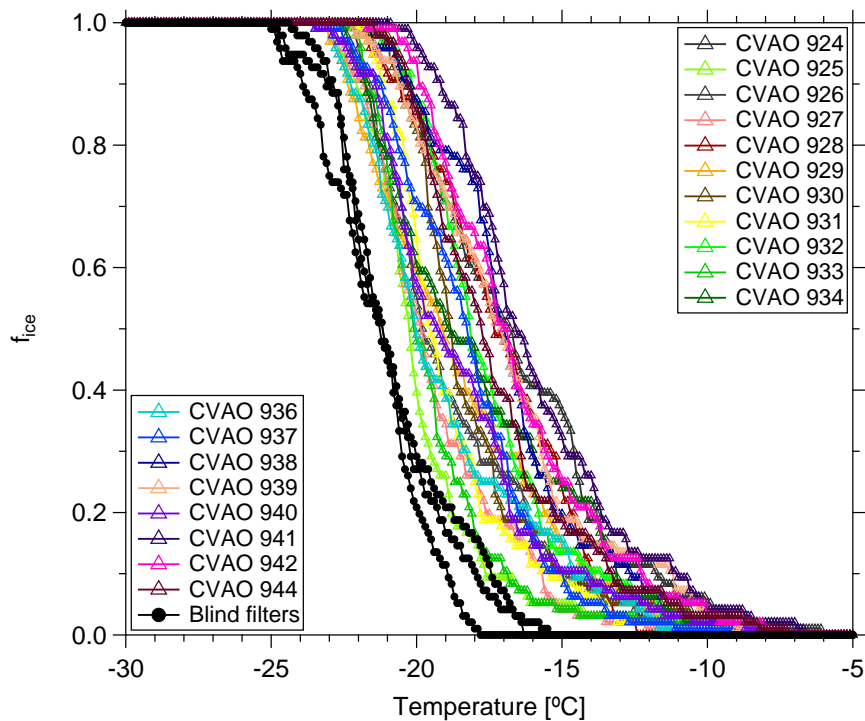


Figure S4. f_{ice} measured by INDA (without background subtraction) as a function of temperature in CVAO PM₁ filters. f_{ice} of blind filters are shown by black dots.

S2.3 MV PM₁₀

Table S4. The information of PM₁₀ filter samples at MV, including sample number, start time, end time, duration, total sampling volume, sampling volume per well, cloud time (percent of the time MV was in cloud during the filter was sampled) and sample type.

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration [h]	Total Volume [std L ⁻¹]	Volume Per Well [std L ⁻¹]	Cloud time [%]	Type
MV1600	2017/09/21 16:39:00	2017/09/22 16:23:00	1382.86	601.870	30.7077	67.44%	PM ₁₀
MV1601	2017/09/22 16:23:00	2017/09/23 15:59:00	1418.31	615.998	31.4285	17.39%	PM ₁₀
MV1602	2017/09/23 15:59:00	2017/09/24 16:01:00	1440.60	625.035	31.8896	6.12%	PM ₁₀
MV1603	2017/09/24 16:01:00	2017/09/25 16:11:00	1449.61	629.660	32.1255	4.17%	PM ₁₀
MV1604	2017/09/25 16:13:00	2017/09/26 16:19:00	1444.90	627.655	32.0232	61.70%	PM ₁₀
MV1605	2017/09/26 16:20:00	2017/09/27 16:23:00	1440.58	627.381	32.0092	65.96%	PM ₁₀
MV1606	2017/09/27 16:23:00	2017/09/28 16:59:00	1464.99	637.541	32.5276	79.59%	PM ₁₀
MV1607	2017/09/28 17:01:00	2017/09/29 16:28:00	1406.21	611.922	31.2205	97.83%	PM ₁₀
MV1608	2017/09/29 16:30:00	2017/09/30 16:28:00	1676.36	760.265	38.7890	93.75%	PM ₁₀
MV1609	2017/10/01 19:02:00	2017/10/02 17:09:00	1326.63	576.405	29.4084	47.73%	PM ₁₀
MV1610	2017/10/02 17:09:00	2017/10/03 17:09:00	1439.36	624.715	31.8732	52.08%	PM ₁₀
MV1611	2017/10/03 17:10:00	2017/10/04 16:27:00	1396.11	606.390	30.9383	50.00%	PM ₁₀
MV1612	2017/10/04 16:27:00	2017/10/05 16:00:00	1408.61	613.421	31.2970	69.05%	PM ₁₀
MV1613	2017/10/05 16:00:00	2017/10/06 16:01:00	1441.46	627.486	32.0146	79.59%	PM ₁₀
MV1614	2017/10/06 16:03:00	2017/10/07 16:02:00	1439.46	625.832	31.9302	87.23%	PM ₁₀
MV1615	2017/10/07 16:02:00	2017/10/08 18:12:00	1439.36	627.485	32.0145	100.00%	PM ₁₀
MV1616	2017/10/08 18:13:00	2017/10/09 12:04:00	1071.60	467.526	23.8534	100.00%	PM ₁₀

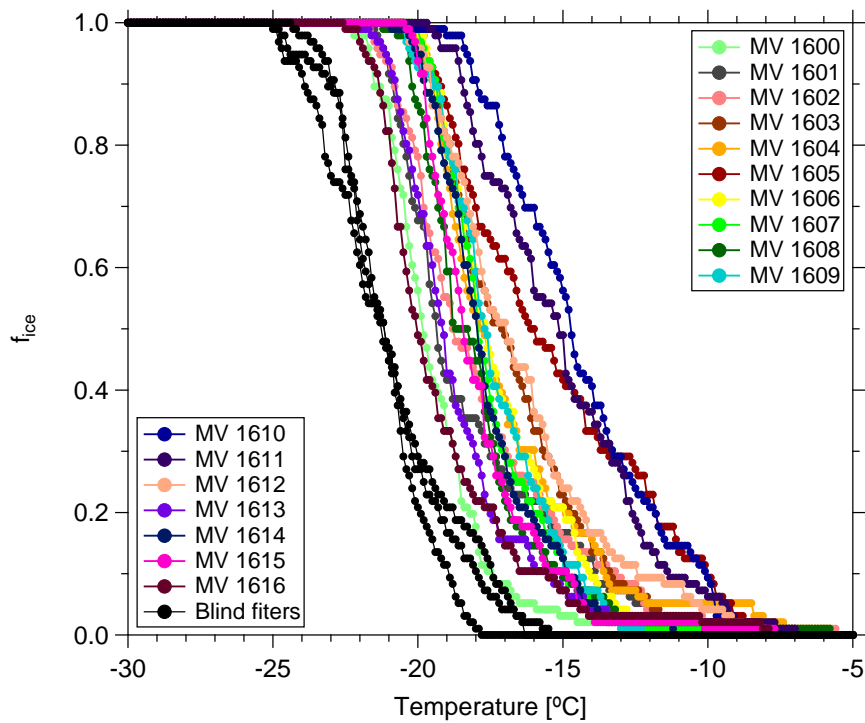


Figure S5. f_{ice} measured by INDA (without background subtraction) as a function of temperature in MV PM₁₀ filters. f_{ice} of blind filters are shown by black dots.

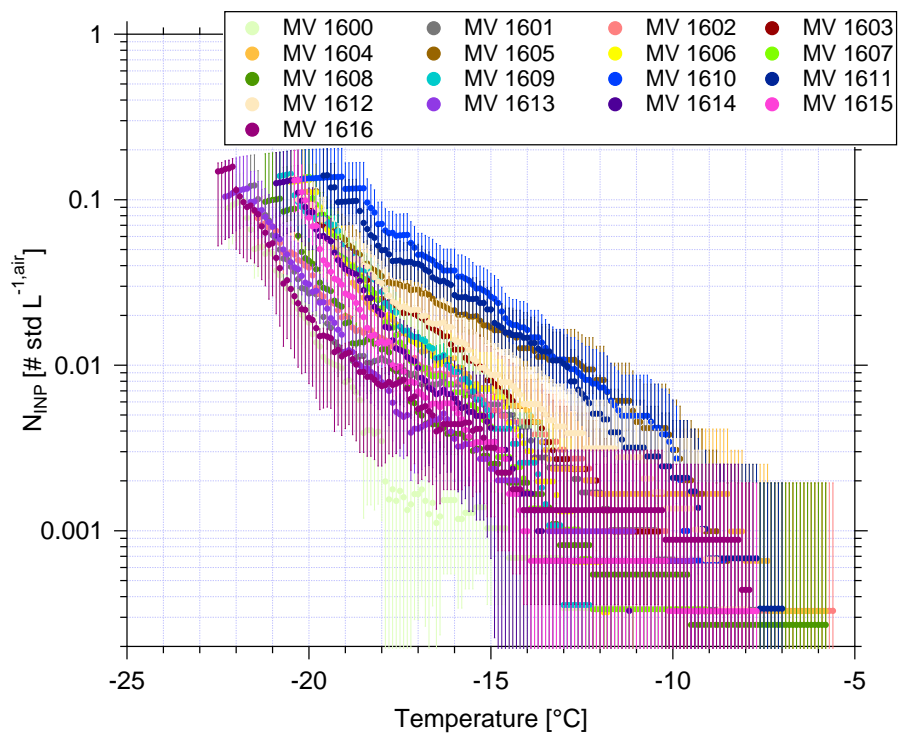


Figure S6. N_{INP} as function of temperature in MV PM₁₀ filters. N_{INP} are background-corrected. Error bars show the 95% confidence interval.

S3 Cloud samples

Table S5. The information of cloud water samples, including sample number, start time, end time, duration, volume, sodium (Na^+) and chloride (Cl^-) mass concentration and $N_{\text{CCN},0.30\%}$.

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration (h) [h]	Volume [mL]	Na^+ mg L^{-1}	Cl^- mg L^{-1}	$N_{\text{CCN},0.30\%}$ cm^{-3}
Cloud01	2017/09/20 13:25:00	2017/09/20 18:20:00	4.92	185	8.44	15.51	551
Cloud03	2017/09/26 19:00:00	2017/09/27 08:00:00	13.00	435	8.32	14.15	387
Cloud04	2017/09/27 19:00:00	2017/09/28 07:30:00	12.50	544	5.00	9.27	239
Cloud05	2017/09/28 19:00:00	2017/09/29 07:30:00	12.50	537	14.18	24.57	560
Cloud11	2017/10/04 19:00:00	2017/10/05 07:30:00	12.50	150	46.11	70.30	481
Cloud12	2017/10/05 07:45:00	2017/10/05 17:38:00	9.88	78	22.75	36.99	494
Cloud13	2017/10/05 17:40:00	2017/10/05 20:10:00	2.50	133	16.97	25.23	442
Cloud14	2017/10/05 20:10:00	2017/10/05 23:30:00	3.33	131	17.31	24.36	473
Cloud15	2017/10/05 23:30:00	2017/10/06 04:00:00	4.50	120	21.85	31.95	491
Cloud16	2017/10/06 04:05:00	2017/10/06 08:00:00	3.92	120	16.87	19.77	445
Cloud19	2017/10/06 18:00:00	2017/10/07 06:30:00	12.50	537	18.34	29.10	482
Cloud20	2017/10/07 06:48:00	2017/10/07 10:48:00	4.00	88	28.19	41.54	510
Cloud24	2017/10/08 19:00:00	2017/10/09 07:00:00	12.00	537	24.54	32.46	625

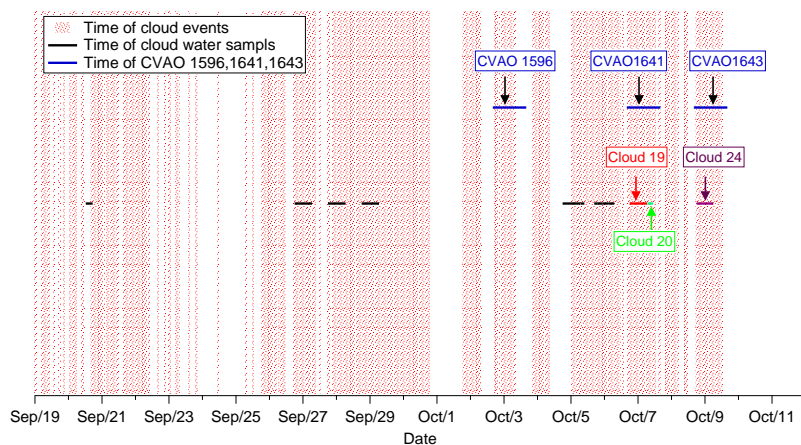


Figure S7. Times during which MV was in clouds (in red shadows) and the sampling time of all cloud water and that of some selected CVAO PM_{10} filters.

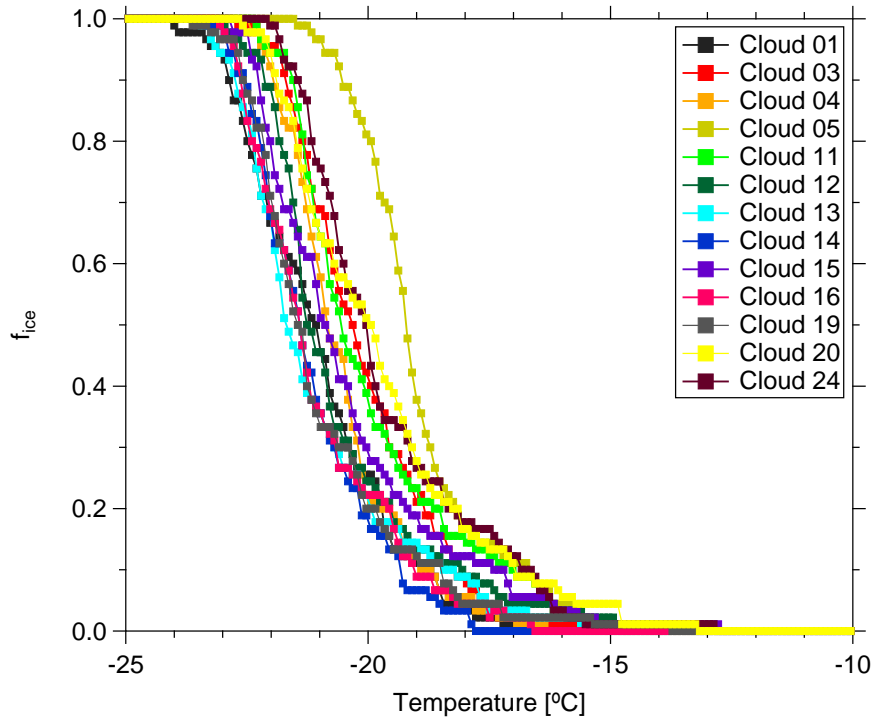


Figure S8. f_{ice} measured by LINA as a function of temperature in cloud water.

S4 Particle surface area size distribution

A thorough aerosol characterization has been done during the measurement campaign, and is described in detail in Gong et al. (2019). Fig. S10 shows the median particle surface area size distribution (PASD) for the whole campaign. Error bars show the 75th and 25th percentiles. Two different modes were observed, i.e., a small mode (30-500 nm) and a larger mode (500 nm-10 μm). The larger mode particle surface area is about 3 times higher than the small mode. Based on the PASD, the concentrations for the total surface area of the particles were calculated. The total particle surface area concentration (A_{total}) varied from 35 to 824 $\mu\text{m}^2 \text{cm}^{-3}$, with a median of 116 $\mu\text{m}^2 \text{cm}^{-3}$. The averaged A_{total} during each CVAO PM_{10} sampling period varied from 78 to 370 $\mu\text{m}^2 \text{cm}^{-3}$ (summarized in Tab. S2). Based on airborne measurements in the Saharan dust layer, Price et al. (2018) found A_{total} mainly above 100 with a maximum of 688 $\mu\text{m}^2 \text{cm}^{-3}$, which is higher than values found for this study, likely due to the fact that Cape Verde is at some distance to the Sahara and also that less strong dust events were sampled.

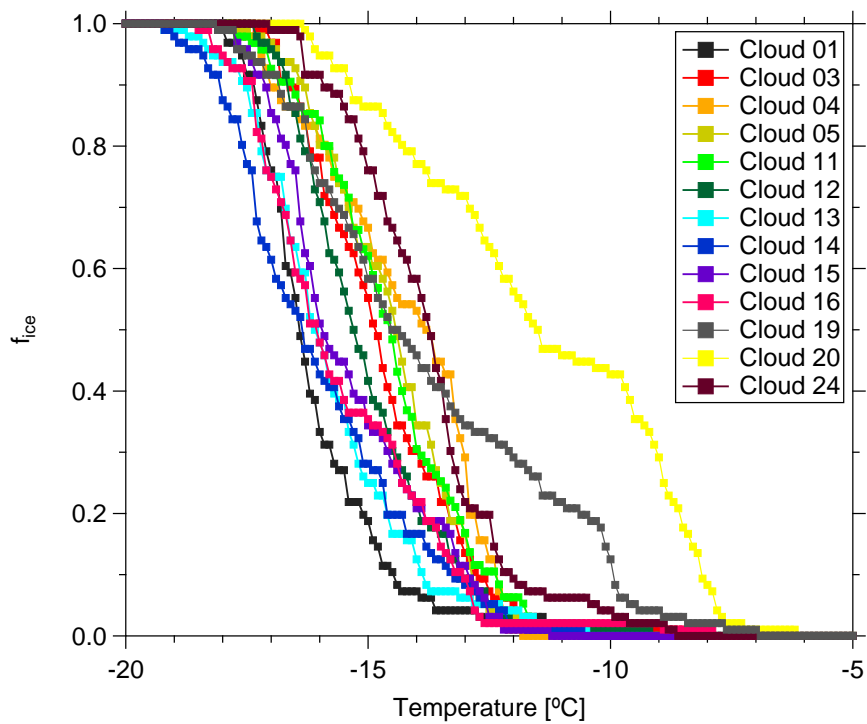


Figure S9. f_{ice} measured by INDA as a function of temperature in cloud water.

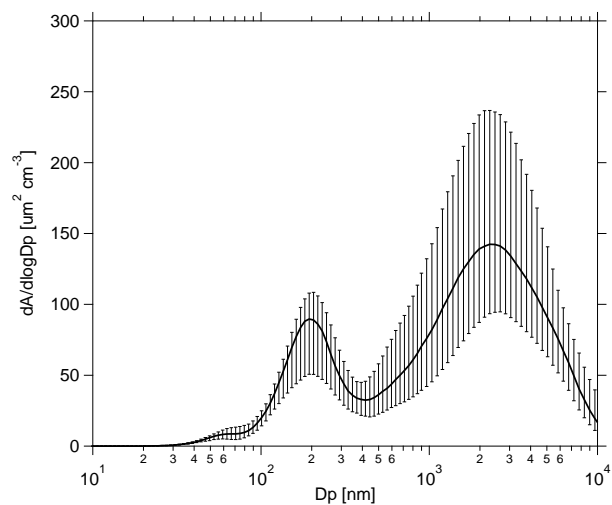


Figure S10. The median PASD during the whole campaign. The error bar indicates the range between the 75th and 25th percentiles.

References

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- Price, H. C., Baustian, K. J., McQuaid, J. B., Blyth, A., Bower, K. N., Choularton, T., Cotton, R. J., Cui, Z., Field, P. R., Gallagher, M., Hawker, R., Merrington, A., Miltenberger, A., Neely III, R. R., Parker, S. T., Rosenberg, P. D., Taylor, J. W., Trembath, J., Vergara-Temprado, J., Whale, T. F., Wilson, T. W., Young, G., and Murray, B. J.: Atmospheric Ice-Nucleating Particles in the Dusty Tropical Atlantic, *Journal of Geophysical Research: Atmospheres*, 123, 2175–2193, <https://doi.org/doi:10.1002/2017JD027560>, <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2017JD027560>, 2018.
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