



Supplement of

Characterization of aerosol particles at Cabo Verde close to sea level and at the cloud level – Part 2: Ice-nucleating particles in air, cloud and seawater

Xianda Gong et al.

Correspondence to: Xianda Gong (gong@tropos.de)

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S1 Seawater samples

chloride (NaCl) mass concentration, PH value and water temperature.										
Sample Number	Start Time	End Time	Location	Salinity	NaCl	PH value	Temperature			
	yyyy/mm/dd hh:mm:ss	yyyy/mm/dd hh:mm:ss		$[g L^{-1}]$	$[g L^{-1}]$		[°C]			

Table S1. The information of seawater samples at ocean station, including sample number, start time, end time, location, salinity, sodium

	yyyy/mm/dd hh:mm:ss	yyyy/mm/dd hh:mm:ss		$[g L^{-1}]$	$[g L^{-1}]$		$[^{\circ}C]$
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	$16^{\circ}53'20$ N, $24^{\circ}54'22$ W	36.2	31.03	8.11	26.7
ULW02	2017/09/20 09:32:00	2017/09/20 10:54:00	$16^{\circ}53'20$ N, $24^{\circ}54'22$ W	36.3	31.11	8.12	26.7
SML03	2017/09/25 10:45:00	2017/09/25 11:48:00	$16^{\circ}53'46 \text{ N}, 24^{\circ}54'19 \text{ W}$	36.4	31.20	8.14	25.5
ULW03	2017/09/25 10:45:00	2017/09/25 11:48:00	$16^{\circ}53'46$ N, $24^{\circ}54'19$ W	36.4	31.20	8.15	26.0
SML04	2017/09/26 11:05:00	2017/09/26 11:51:00	$16^{\circ}53'50 \text{ N}, 24^{\circ}54'27 \text{ W}$	36.1	30.94	8.12	26.4
ULW04	2017/09/26 11:05:00	2017/09/26 11:51:00	$16^{\circ}53'50 \text{ N}, 24^{\circ}54'27 \text{ W}$	36.3	31.11	8.15	25.1
SML05	2017/09/27 09:50:00	2017/09/27 11:00:00	$16^{\circ}53'38$ N, $24^{\circ}54'16$ W	36.3	31.11	8.15	23.7
ULW05	2017/09/27 09:50:00	2017/09/27 11:00:00	$16^{\circ}53'38$ N, $24^{\circ}54'16$ 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	$16^{\circ}53'25$ N, $24^{\circ}54'18$ W	36.7	31.46	8.22	21.2
ULW12	2017/10/07 10:22:00	2017/10/07 11:35:00	$16^{\circ}53'25 \text{ N}, 24^{\circ}54'18 \text{ W}$	36.4	31.20	8.22	21.8
SML13	2017/10/09 09:30:00	2017/10/09 10:17:00	$16^{\circ}53'42 \text{ N}, 24^{\circ}54'08 \text{ W}$	36.6	31.37	8.19	21.5
ULW13	2017/10/09 09:30:00	2017/10/09 10:17:00	$16^{\circ}53'42$ N, $24^{\circ}54'08$ W	36.4	31.20	8.13	23.6
SML14	2017/10/10 09:30:00	2017/10/10 10:30:00	$16^{\circ}53'43$ N, $24^{\circ}54'13$ W	36.4	31.20	8.19	21.7
ULW14	2017/10/10 09:30:00	2017/10/10 10:30:00	$16^{\circ}53'43 \text{ N}, 24^{\circ}54'13 \text{ W}$	36.3	31.11	8.18	22.4



Figure S1. Frozen fraction (f_{ice}) measured by LINA (Leipzig Ice Nucleation Array) as a function of temperature in sea surface microlayer (SML) and underlying water (ULW). All temperatures have been corrected for freezing point depression.



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



Figure S3. Enrichment factor (EF) as function of ice nucleation temperature. The EF=1 is shown by dashed line. Error bars show the measurement uncertainty.

S2 Filter samples

S2.1 Background subtraction

INP number concentration (N_{INP}) from the field blanks was then subtracted from that of the filter samples, and the result was converted to background corrected atmospheric INP number concentrations, as the below equation shows:

5
$$N_{\text{INP}} = (-ln(1 - f_{\text{ice},s}) + ln(1 - f_{\text{ice},b}))/V$$
 (S1)

The corrected atmospheric INP number concentration is N_{INP} , the frozen fractions measured for the filter samples and the field blanks are $f_{\text{ice,b}}$, respectively, and V is the volume of air sampled in each well.

S2.2 CVAO PM₁₀

Table S2. The information of PM_{10} filter samples at Cape Verde Atmospheric Observatory (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	End Time	Duration	Total Volume	Volume Per Well	Na^+	Cl^{-}	A_{total} $\mu \text{m}^2 \text{ cm}^{-3}$	Туре
	yyyyminiodd ini.iniii.ss	yyyymini/dd iii.iiiii.ss	[iiiiide]	[stu iii]	[300 12]	μ5 m	μg m	µm em	
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 S4. 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.



Figure S5. N_{INP} as a function of temperature from CVAO PM₁₀ filters. Background correction of N_{INP} is included for these filter samples. The field measurement of N_{INP} in PM₁₀ by Welti et al. (2018) is shown by gray shadow. Error bars show the 95% confidence interval. Black dots show the measurement background.



Figure S6. Comparison of N_{INP} as a function of temperature from CVAO 1596, CVAO 1641 and CVAO 1643 before and after heating (CVAO PM₁₀ filters). The field measurement of N_{INP} in PM₁₀ by Welti et al. (2018) is shown by gray shadow. Error bars show the 95% confidence interval. Background correction of N_{INP} is included for these filter samples.



Figure S7. Comparison of f_{ice} measured by INDA (without background subtraction) as a function of temperature from CVAO 1596, CVAO 1641 and CVAO 1643 before and after heating (CVAO PM₁₀ filters).

S2.3 CVAO PM₁

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration [minute]	Total Volume [std m ³]	Volume Per Well [std L]	Туре
CVA0924	2017/09/19 21:00:00	2017/09/20 21:00:00	1439 36	661 200	33 7347	PM1
CVA0925	2017/09/21 21:00:00	2017/09/22 21:00:00	1439.36	661.200	33.7347	PM ₁
CVA0926	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

Table S3. The information of PM_1 filter samples at CVAO, including sample number, start time, end time, duration, total sampling volume, sampling volume per well and sample type.



Figure S8. 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.

S2.4 MV PM₁₀

Sample Number	Start Time yyyy/mm/dd hh:mm:ss	End Time yyyy/mm/dd hh:mm:ss	Duration [minute]	Total Volume [std m ³]	Volume Per Well [std L]	Cloud time [%]	Туре
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}

Table S4. The information of PM_{10} 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.



Figure S9. 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 S10. 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

Sample Number	Start Time	End Time	Duration (h)	Volume [mL]	Na^+ mg L^{-1}	Cl^{-} mg L^{-1}	$N_{ m CCN, 0.30\%}$ cm $^{-3}$
	JJJJ,	JJJJ,	[]	[]	8	8	
Cloud01	2017/09/20 14:25:00	2017/09/20 19:20:00	4.92	185	8.44	15.51	551
Cloud03	2017/09/26 20:00:00	2017/09/27 09:00:00	13.00	435	8.32	14.15	387
Cloud04	2017/09/27 20:00:00	2017/09/28 08:30:00	12.50	544	5.00	9.27	239
Cloud05	2017/09/28 20:00:00	2017/09/29 08:30:00	12.50	537	14.18	24.57	560
Cloud11	2017/10/04 20:00:00	2017/10/05 08:30:00	12.50	150	46.11	70.30	481
Cloud12	2017/10/05 08:45:00	2017/10/05 18:38:00	9.88	78	22.75	36.99	494
Cloud13	2017/10/05 18:40:00	2017/10/05 21:10:00	2.50	133	16.97	25.23	442
Cloud14	2017/10/05 21:10:00	2017/10/06 00:30:00	3.33	131	17.31	24.36	473
Cloud15	2017/10/06 00:30:00	2017/10/06 05:00:00	4.50	120	21.85	31.95	491
Cloud16	2017/10/06 05:05:00	2017/10/06 09:00:00	3.92	120	16.87	19.77	445
Cloud19	2017/10/06 20:00:00	2017/10/07 08:30:00	12.50	537	18.34	29.10	482
Cloud20	2017/10/07 08:48:00	2017/10/07 12:48:00	4.00	88	28.19	41.54	510
Cloud24	2017/10/08 20:00:00	2017/10/09 08:00:00	12.00	537	24.54	32.46	625

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 $N_{\text{CCN},0.30\%}$.



Figure S11. Times during which MV was in clouds (in red shadows) and the sampling time of all cloud water and that of some selected CVAO PM₁₀ filters.



Figure S12. fice 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. S14 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 μ m). 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 μ m² cm⁻³, with a median of 116 μ m² cm⁻³. The averaged A_{total} during each CVAO PM₁₀ sampling period varied from 78 to 370 μ m² 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 μ m² cm⁻³, which is higher than values found for this study, likely due

10 to the fact that Cape Verde is at some distance to the Sahara and also that less strong dust events were sampled.



Figure S13. fice measured by INDA as a function of temperature in cloud water.



Figure S14. The median PASD during the whole campaign. The error bar indicates the range between the 75th and 25th percentiles.

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