Responses to reviewer 2

The changes in the manuscript are shown in italics here in the responses and they are marked in red in the revised manuscript.

1. **Page 3., line 27: remove "totally"**

The word 'totally' is removed as suggested by the reviewer.

2. **Section Introduction: MS deals with polar region, however a brief summary or overview on similarities/differencies with Arctic region would be advantegous.**

In this manuscript, Antarctica is studied because of its remoteness from anthropogenic sources, not because of its polar character. In this respect, Antarctic differs substantially from Arctic areas, the latter of which are exposed strongly to anthropogenic sources outside much of the summer season. We feel that discussing the similarities/differences between Antarctica and Arctic might confuse the readers, rather than be helpful in putting the results of this paper into a larger context.

3. **Section Introduction: more specific information on cosmic radiation needed**

A short statement is added in the introduction on page 4 lines 3-4 as suggested by reviewer 1 regarding the ionisation by cosmic radiation as follows:

Also stronger cosmic ray ionisation can be expected at polar regions than mid-latitudes (Kazil et al., 2006; Bazilevskaya et al., 2008).

4. Section 2.1: the description of AIS speaks for itself, but there is no information about diffusion losses what is a relevant question for nanoparticles. How were the sampling lines set up? How long were they? How were the diffusional losses taken into account?

The AIS had a separate copper inlet tube through the wall of the measurement container, similar to the one used by Virkkula et al. (2007) at Aboa. It was 30 cm long and its inner diameter was 16 mm. The volume of the inlet was thus ~0.06 L and with the inlet flow of 60 LPM the residence time within the inlet tube was 60 ms. The diffusional losses of ions inside the AIS was taken into account in the data inversion software designed for the AIS (Mirme et al., 2007). However, we did not take into account the possible diffusional loss of the inlet, because a reliable diffusional loss correction requires the knowledge of the temperature profile at the inlet. The AIS sat in a cabin of room temperature, but the inlet was extended outside of the cabin. We had no temperature measurement at the sampling inlet. Including a diffusional loss correction based on assumptions for inlet temperatures would actually introduce uncertainties to the measured number size distributions of air ions. Therefore, we decided to report the data without inlet diffusional loss correction. This issue is explained in the revised manuscript in the second last paragraph of section 2.1.1. as

The deployed AIS had a separate 30 cm long inlet that extended outside the measurement cabin. The inlet tube had an inner diameter of 16 mm. However, since we had no measurement of the temperature profile of the inlet, a correction for the inlet diffusional loss is not feasible. Therefore, we report the number size distribution data of air ions without the inlet diffusional loss correction.

5. Page 9., line 5: The units have to standardized in the paper, and the form of "nm h-1" should be preferred instead of "nm/h".

'nm h-1' is now used in the manuscript as the reviewer suggested.

6. Page 10., equation 7: remove the integration limits 0 and infinite (see Dal Maso et al., 2005)

Limits are removed as the reviewer suggested.

7. Page 10., line 22: Was the dry condensation sink calculation used? What about RH dependency?

Yes, we used the dry condensation sink. Under moisture conditions, the application of the hygroscopy correction can increase the condensation sink, which is important to be taken into account for the determination of the amount of condensable vapour source. However in this study, the condensation sink was used as a proxy for aerosol loadings in the atmosphere, where the RH effect is not crucial. Also dome C is rather cold, which makes it a relatively dry place.

8. Page 11., line 15: Summary on classification of the measurement days would help to better understand the distinction of the days, and thus the description of Table 1. has to be shortened

We decided to remove Table 1 from the manuscript completely according to the comment of reviewer 1. The information contained in Table 1 is given in the text.

9. Page 15., 1. paragraph: Repetition from earlier.

The methods for the growth rate determination are briefly repeated in this paragraph to help the readers to recall the difference between them. We decided to leave this paragraph as it is, because we think that this paragraph can assist readers in understanding the features in GRs presented in the following text in section 3.2.2.

10. Page 16. line 4: The interpretation of intervals has to standardized in the paper, e.g. instead of "0.5 – 25", "0.5–25" should be used everywhere.

The interval expression is fixed in the manuscript as suggested by the reviewer.

11. Page 11., line 3: Is there any possible reason why the ion formation rates are comparable to those environments? Any comments regarding to altitudes?

Dome C typically has much smaller condensation sinks (CS) than the sites reported by Manninen et al. (2010) and Nieminen et al. (2011). CS at Dome was in the order of

10^{-4} $cm^{-3}s^{-1}$ (Järvinen et al., 2013), whereas CS reported for the other site were in the order of 10^{-3} $cm^{-3}s^{-1}$(Manninen et al., 2010; Nieminen et al., 2011). A low CS means a low uptake of vapour and electric charges on the aerosol particles. Although vapour sources are limited at Dome C, the availability of vapours in the air for nucleation and growth may be comparable to that at the other sites due to the low CS. The availability of vapours is the most essential factor regarding ion formation in the size range of 2-3 nm.

The high altitude of Dome C would mean a higher exposure to cosmic radiation and therefore a high contribution to ionisation in the atmosphere by comic radiation. However, since there was no ionising radiation measurement, it is not possible to tell how comparable the overall ionising radiation level at Dome C is to that at other sites, which makes it impossible to deduce the role of enhanced cosmic ray ionisation at the high altitude in relation to ion formation rates.

12. Page 39, Fig. 9: Ionising radiation as third variable (colored circles) could be added to the plot. Also, the non-linear relation is evident at least in case of Fig. 9b.

We appreciate that reviewer's suggestion. However, we had no ionising radiation measurement during the 2010-2011 campaign. Therefore, it is not possible to have ionising radiation plotted as a third variable in Fig. 9.

The reviewer could be right that there is a two-step linear relationship between the logarithm of the 1.9-10 nm ion concentration and wind speed, which seems to also exist between the cluster ion concentration and wind speed. The description in the manuscript regarding this feature is revised and also the fittings in Figs. 9 and S4 are updated accordingly. In the revised manuscript, all fitting parameters are presented in Table S1.

By putting together all the 36 wind-induced ion formation events, the logarithm of the ion concentration exhibited linear relations to the wind speed (Fig. 9), like also observed at Aboa (Virkkula et al., 2007). For both cluster ions and ions in the size range of 1.9-10 nm, there seemed to be a two-step linear relation with a breakpoint at around 7 m s^{-1} (Fig. 9). Winds below this threshold value were less efficient in producing ions than winds with speeds > 7 m s^{-1}. This feature could be also recognised in the Aboa data, but with the threshold in wind speeds lying at around 17 m s^{-1} (Fig. S4). The effect of wind on ions seemed to be stronger at Dome C than at Aboa (Table S1 and Fig. S4).

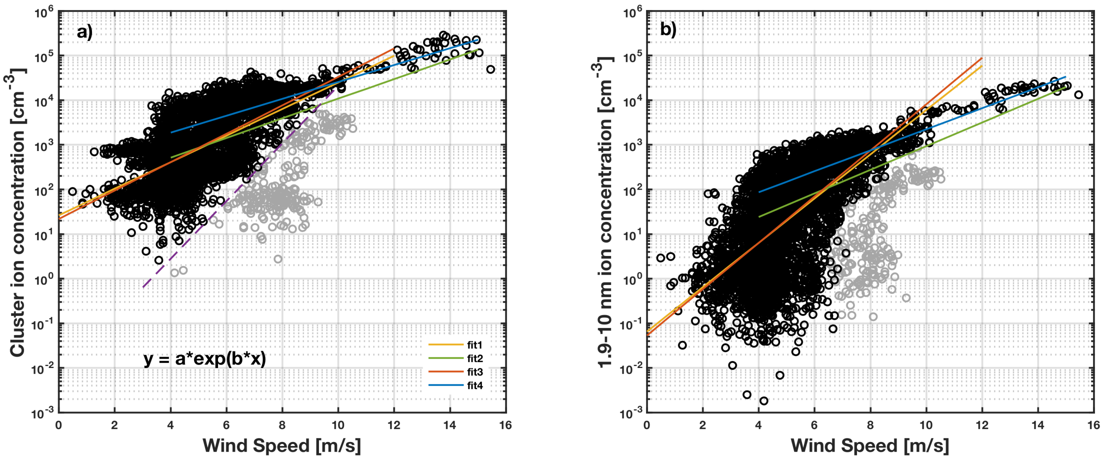

Figure 9. Ion concentrations as a function of wind speeds. a) ion concentration in the cluster size range (0.9-1.9 nm) and b) ion concentration in the size range of 1.9 and 10 nm. The solid lines are linear fits to the data. Fits 1 and 3 are to data with a wind speed below the threshold wind speed (7 m/s) and Fits 2 and 4 are to data above the threshold wind speed. Fits 1 and 2 are obtained based on all data below or above the wind speed threshold, respectively. The data points in grey colour, however, are not taken into account in determining the fitting coefficients for fits 3 and 4. These grey data points correspond to cluster ion concentration values below the purple dashed line ($y = 0.0074 \cdot e^{1.4855x}$). The coefficients of these fits as well as the 95% confidence bounds of the coefficients and coefficient of determination measuring the goodness of fit are shown in Table S1.

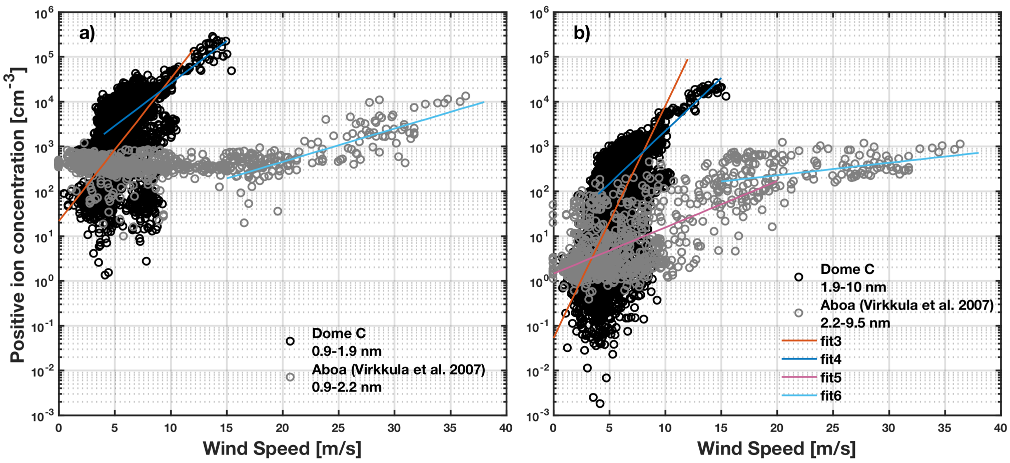

Figure S4. Ion concentrations as a function of wind speeds. a) Ion concentration in the cluster size range: 0.9-1.9 nm for Dome C (black circles) and 0.9-2.2 nm for Aboa (grey circles, from Virkkula et al. (2007)). b) Ion concentration in the size range of 1.9-10 nm for Dome C (black circles) and in the intermediate size range of 2.2-9.5 nm for Aboa (grey circles, from Virkkula et al. (2007)). The Aboa ion data were reported in mass diameters. The size ranges referred here are reconverted from the measured electrical mobility channels in mobility diameters. The solid lines are linear fits to the logarithm of the ion concentration data. The fitting parameters are given in Table S1. A wind speed threshold of 17 m/s is used for characterising the 2-step linear feature.

Table S1. Coefficients for the fittings shown in Figs. 9 and S4. R^2 is the coefficient of determination measuring the goodness of fit, which denotes the fraction of the total variation in the data can be explained by the fit. For Dome C data shown in Fig. 9, fits 1 and 2 are obtained based on all data below or above the wind speed threshold (7 m/s), respectively. The grey data points in Fig. 9 are used in determining the fitting coefficients for fits 3 and 4. For Aboa data shown in Fig. S4, a wind speed threshold of 17 m/s is used.

DOME C (Fig. 9)	Cluster (0.9-1.9 nm) ion concentrations vs. wind speeds					
	Fits	*a*	*b*	95% conference interval for *a*	95% conference interval for *b*	R^2
	1	0.69	26.34	[0.65 0.73]	[21.62 32.10]	0.24
	2	0.51	68.64	[0.41 0.60]	[29.88 157.67]	0.12
	3	0.73	21.83	[0.69 0.77]	[18.02 26.44]	0.28
	4	0.44	327	[0.40 0.47]	[244.95 436.53]	0.52
	1.9-10 nm ion concentrations vs. wind speeds					
	Fits	*a*	*b*	95% conference interval for *a*	95% conference interval for *b*	R^2
	1	1.14	0.07	[1.08 1.2]	[0.05 0.09]	0.29
	2	0.61	2.1	[0.71 0.88]	[0.88 5.01]	0.15
	3	1.19	0.05	[1.25 0.04]	[0.04 0.07]	0.31
	4	0.54	9.87	[0.58 7.18]	[7.18 13.58]	0.58
ABOA (Fig. S4)	0.9-2.2 nm ion concentrations vs. wind speeds					
	Fits	*a*	*b*	95% conference interval for *a*	95% conference interval for *b*	R^2
	6	0.17	14.98	[0.15 0.19]	[9.02 24 88]	0.66
	2.2-9.5 nm ion concentrations vs. wind speeds					
	Fits	*a*	*b*	95% conference interval for *a*	95% conference interval for *b*	R^2
	5	0.24	1.45	[0.22 0.26]	[1.26 1.68]	0.35
	6	0.06	63.24	[0.04 0.09]	[34.72 115.18]	0.17

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