Paper: acp- 2016-795

Interactive comment on " Seasonal variations in physical characteristics of aerosol particles at the King Sejong Station, Antarctic Peninsula", Kim et al.

General remarks

The authors report the measurements of aerosol number concentrations, cloud condensation nuclei (CCN), black carbon, and meteorological conditions over a six-year period.

The authors claim in the *Introduction* that "it is necessary to have long-term observations at different regions because aerosol particles vary temporally and spatially." It seems to me that the authors do not make full use of the data measured for a relatively long time (March 2009 to February 2015).

Given extensive data available, interest in the paper would be enhanced if the authors had obtained more significant results. For instance, in addition to a seasonal trend, the authors should check if an annual trend exists for aerosol number concentrations, CCN, and air temperature.

I will discuss in detail several points which need to be broadened, analysed and corrected.

Specific coments

A) Page 5

Line 12 and following:

The experimental part should be broadened highlighting the important points. The authors should clarify:

a) If the relative humidity (RH) of the sampled air was adjusted (e.g. at 40%) or not at the inlet of the SMPS.

b) The length and diameter of the main tube and the tubes connecting the stack with the sampling devices, showing if the flow is laminar or turbulent.

c) If the total counting efficiency of the system (main line and sampling lines) was computed.

d) If CPC and DMA were calibrated before and during the campaigns, which lasted about six years.

e) If particle, CN and CCN concentrations are shown in standard conditions.

Line 18 and following:

"The aethalometer was used to measure the concentration of light absorption particles at two wavelengths (370 and 880 nm). In this study, we used the results obtained by measuring light absorption at 880 nm to determine the BC concentrations."

Please insert the manufacturer of the aethalometer. The authors should clarify why they take into account aerosol absorption at 880 nm.

B) Page 7

Line 3 and following:

" Fig.3 depicts monthly variations of the meteorological parameters measured from…

The authors should discuss possible correlations between the considered parameters, and possible variations in these parameters (e.g. temperature trend) during the period considered (2009 – 2015).

Line 6 and following

"…the observation site was relatively humid and warm condition compared to other Antarctic stations…"

The statement should be changed to:

"..the observation site was relatively humid and warm compared to inland Antarctic stations..".

Line 16:
"(DJF).....(JJA)"
Should be changed to: …"maximum in the summer (from December to February, DJF) and minimum in the winter (from June to August, JJA)".

Line 20:
"*There are no significant anthropogenic sources of aerosol particles in Antarctica, therefore, our results were in good agreement… "*
The statement should be changed to: "Our results were in good agreement with the results…".

C) Page 8
Line 2 and following:
" The major compounds of aerosol particles found at a coastal Antarctic regions were non-sea salt sulphate and methane sulphonate (MSA) derived from oxidation of DMS produced by phytoplankton (Weller et al., 2011).
Weller et al.'s conclusion (2011) is different. They write referring to Neumayer station*: "From thermodenuder experiments we deduced that the portion of volatile (at 125°C) and semi-volatile (at 250°C) particles which could be both associated with biogenic sulphur aerosol, was maximum during austral summer, while during winter non-volatile sea salt particles dominated."*.

Atmospheric marine aerosol consists prevalently of primary aerosol (organic material, sea-salt) produced on the ocean surface by bubble bursting and wave crest disruption, and biogenic secondary aerosol (non-sea-salt sulphate and methanesulphonic acid from oxidation of DMS emitted by phytoplankton, and ammonium from biological reduction processes of N-cycle compounds).
During the 2002-2003 summer season, Fattori et al. (2005) reported that the coastal site ("Mario Zucchelli Station" in Terra Nova Bay) was affected by primary and secondary marine input: the sea spray contribution was dominant in the coarse fraction whereas the biogenic source prevailed in the fine fraction.

Line 8 and following
"The CN concentrations typically increase in the summer due to high biological activity, while they decrease in the winter when biological activity is low.…"

The CN concentration is related not only to biological activity, but also to primary aerosol. Primary aerosol includes inorganic salts, inorganic and organic mixture, and biological particles.
The contribution of primary aerosol to the total aerosol concentration depends mainly on wind speed and the season, and it is higher in winter and lower in summer. In general, factors affecting total particle number concentrations are the air mass type, meteorological conditions, and whether or not nucleation-mode particles are present.

Line 14 and following
"O*ur results suggest that $CN_{2.5}$ concentrations may be more closely coupled with solar radiation intensity than with temperature"*.

The problem is more complex. An important parameter could interfere, i.e. the ocean temperature, which is different from air temperature. For instance, at the Antarctica research station Aboa Virkkula et al. (2009) observed that the annual maximum daily-averaged particle concentration was later, in February, than the maximum in solar radiation intensity. They concluded that the particle concentrations are more closely linked with the ocean temperature than with solar radiation. Peak sea temperature in polar regions is reached in late summer.
As the authors measured both solar radiation and CN concentration, it could be important to point out if there is a delay between the maximum CN and the maximum solar radiation.

In the summer 2014 the $CN_{2.5}$ and CN_{10} concentrations are much lower compared to remaining considered years (Fig.4), but the solar radiation (Fig. 3) remains roughly stable during the summer in the years 2010-2015. These data should be explained.

Line 17 and following
" *The monthly mean CN concentrations increased from September to February…"*
Several papers report the annual variation of CN with the maximum in summer and the minimum in winter in coastal areas (Bigg et al., 1984; Gras and Adriaansen, 1985; Gras, 1993; Jaenicke et al, 1992) and in inland stations (Bigg et al., 1984; Samson et al., 1990). A few references should be cited.

D) Page 9
Line 10 and following:
"The clear seasonality of CCN concentrations is probably caused by the seasonal trend of CN concentrations…"
The statement should be changed to: The clear seasonality of CCN concentrations follows the trend of CN.

E) Page 10
Line 3 and following
"The fraction at the SS value of 0.2% during the winter(JJA) was similar to those measured in Mace Head and Finokalia, which are regions representative of marine environment."
"Our observations suggests that the major components in the aerosol particles that are activated to CCN at an SS of 0.2% should be hygroscopic sea salts during winter, while compounds less hygroscopic than sea salt would be dominant during the summer.".

Comparison with the Finokalia site appears inappropriate, as Bougiatioti et al. (2009) performed measurements at Finokalia from mid-June to mid-October (i.e. summer and autumn), not in winter. In addition, Bugiatioti et al. state that "Finokadia is located at a unique "crossroad" of aged aerosol types (marine boundary layer, Saharan desert, European sub-continent, biomass burning events) during the summer period." In the case of King Sejong Station, only a few cases of air masses originated from the continent of South America were shown. The authors' conclusion appears to be oversimplified and should be better explained. In addition to sea-salts, sea-spray aerosol includes organic material (prevalently water insoluble) which possesses a low hygroscopic growth factor, while simultaneously having a CCN activation efficiency higher than soluble non-sea-salt sulphate (Ovadnevaite et al., 2011).

Line 8 and following
"Fig. 10 illustrates the seasonal variations in the mean activation ratio of CCN concentrations at an SS of 0.4%..."
As in the previous paragraph, the authors discuss the trend of CCN concentration at SS= 0.2 %, I expect the authors considered the seasonal variations of the ratio between CCN and CN concentrations at supersaturation 0.2%, instead of 0.4%.

F) Page 11
Line 16 and following
"The BC concentrations observed at our station were slightly higher than those at other stations in Antarctica…." "Additionally, no clear seasonal patterns were observed in our study throughout the entire observation period.".
The BC concentrations measured by the authors are much higher than those at other Antarctic stations. Please compare the concentrations shown in the paper concerning South Pole, Halley,

Neumayer, and Ferraz station (0.65 ng m^{-3}, 1.0 ng m^{-3}, 2.6 ng m^{-3} and 8.3 ng m^{-3}. respectively), with those measured at King Sejong Station. The very high concentration measured needs to be explained. In addition, it appears to me that a seasonal trend can be noted from Fig.12, i.e. prevalently lower values during winter.

G) Page 12

Line 6

As mentioned earlier in Sec. 2.3

Please change to: As mentioned earlier in Sec. 2.2

Line 8

"Although they are unreliable due to the low observation frequency…."

I suggest changing this statement to: " The very few cases of air masses originated from the continent of South America show the highest BC and CCN concentrations (Table 1).

H) Page 14

Line 3 and following

"The activation fraction of aerosol particles at the King Sejong Station….was lower than at the Arctic sites indicating that less hygroscopic compounds in aerosol particles should be dominant".

No reference is shown for Arctic sites.

The conclusion appears superficial. I recall Ovadnevaite et al.'s paper (2011) which shows that sea-spray aerosol enriched in primary organic matter (prevalently hydrophobic) possesses more CCN activation efficiency than more soluble particles dominated by nss-sulphate.

Line 13

"Although the BC and CCN concentrations were the highest when the air mass originated from the South American continent, the results are not significant because only a small amount of data was analyzed.".

I suggest changing this to: " The very few cases of air masses originated from the continent of South America showed the highest BC and CCN concentrations."

I) Page 21

Figure 1 shows devices like OPC and Nephelometer, not used in the measurements.

References

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