

Interactive comment on “Features in air ions measured by an Air Ion Spectrometer (AIS) at Dome C” by Xuemeng Chen et al.

Anonymous Referee #3

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The article presents an analysis of data of air ions (size range 0.9 to 42 nm) taken between the 22nd of December 2010 and 16 November 2011 at the Dome C station in Antarctica. The article focuses on the first steps of new particle formation providing formation rates and growth rates. The Authors give an overview of the main features of the size distribution of the ions relating them with measured meteorological parameters, such as ion formation/loss induced by wind and by the interaction with cloud/fog droplets.

In my opinion, the manuscript is well written in most of its parts and presents data that are very interesting for the atmospheric aerosol community. However, the Referee thinks that the manuscript is punctuated with generic statements and lack of specific numbers/information. The clarity and the relevance of the paper would be increased

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by fixing those issues. Furthermore, the Referee feels that some statements in paragraph 3.1 and 3.3.2 are highly speculative and need a more thorough explanation and references to substantiate the statements. For these reason the Referee recommends publication after a revision that involves the rewriting of these parts.

Specific comments:

Major comments:

I) Page 9 line 16 to 21: The Referee is familiar with both methods to calculate the growth rates (mode fitting and appearance time) and still had hard time to follow the Authors' explanation. Please rephrase in a way that can be obvious also to the non-experts. Consider to add a figure in the supplementary material if the wording doesn't get any easier.

II) Page 12 line 8 to 10: "Owing ... the ionisation of air molecules can be neglected". The Referee thinks that this statement is highly speculative and needs to be modified. Are there measurements in the literature that support this claim? If so, please cite them. Furthermore, even if there is a snow pack, radon could make its way through the snow crystals and gamma radiation would need at least several tens of centimeter of solid ice to be shielded effectively. In addition, there can be areas, such as vertical walls that can be snow free and made of rock that is rich in uranium. If this is not the case, please state it in the paragraph with, if possible some references. Otherwise, rephrase the statement signaling its speculative nature.

III) Page 13 line 1 to 6: As CS tended to be higher during NPF can author exclude that NPF was generated by condensable vapors from "polluted" air masses from the continent? The Referee thinks that a look at back trajectories is needed in order to understand weather the source of vapors is local or from long range transport. This information would be very valuable and increase the relevance of the paper.

IV) Page 13 line 24 and 25: The Referee thinks that a look at back trajectories might

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help the Authors to be less speculative about the origin of the air mass. Therefore, the Referee feels strongly that a back trajectory analysis should be added and discussed.

V) Chapter 3.2.2: A discussion on the uncertainties of the GR is completely lacking. The Referee thinks that must be added and discussed in relation to the variability of the GRs calculated with the 2 different methods.

VI) Page 16 line 23 to 26: The Referee thinks that an estimate of the uncertainty of J2+ is necessary in order to better assess the significance of the statistical parameters included in the text. In other words, is the standard deviation of the J2+ comparable, larger or smaller with respect to the uncertainties? Please add the missing information and discuss.

Minor comments:

Abstract

1) Page1, line 24: "One ... days." Rephrase. It is unclear if the Authors want to refer to event days or event free days.

2) Page 2 Line 4 and 5: The Authors use 2 time the expression "work better" which is very vague. Please rephrase using a more precise terminology.

3) Page 2 Line 7 and 8: "The ion production ... seemed a unique feature at Dome C ..." Please be more specific. A unique feature in Dome C relative to the whole world? Relative to the other data collected in Antarctica?

4) Page 2 Line 10: "cleavage" replace with a word/rephrase using wording that is understandable to a wide audience.

3) Page 2 Line 11 and 12 "our observation ... ice crystals." This is a very interesting result! The Referee thinks that it should be explained more thoroughly in the appropriate paragraph (see comment XX)

Introduction 4) Page 2 line 17: Please add the size/mobility ranges next to "primary

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ions" and "aerosol particles" for a more complete information for the reader that might be new to atmospheric ions.

5) Page 3 line 2: "Such charged nanoparticles ... are typically observed during new particle formation (NPF) events." Confusing. Stable air ions are observed also without NPF. Please rephrase.

6) Page 3 line 9 to 20: "Carslaw et al. (2013) ... years (Fiebig et al., 2014)." Confusing paragraph. Please add a closing sentence that explains why this work is important and how it is different from the cited previous work in this way the list of previous papers on the topic will make more sense to the reader.

Methods 7) Page 5 line 4 and 5. Please add the flow rate after "high sample flow rate", which is too vague to be useful. The Referee is aware that there is a flow rate some 20 lines below, but the use of "High" is not helpful and repetita iuvant.

8) Page 7 line 21 to 23: The Referee thinks that a plot of the shifted spectrum added to the supplementary material could be very useful to the readers and AIS/NAIS users. I recommend adding it.

9) Page 9 line 4: "growth and coagulation". Remove coagulation.

10) Page 9 line 10: "Air ion and total aerosol particle data are three dimensional: " Remove. It is confusing and unnecessary.

11) Page 9 line 12 and 13: the Authors refer to " mode fitting method" and "appearance time method" throughout as "former" and "latter". Please spell them out each time. Readers will have easier times at understanding to which method the Authors are referring to.

12) Page 9 line 26: "assist". Confusing term. Please rephrase.

13) Page 3 line 3: "Sulphuric acid is considered as a key chemical species". remove "as".

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14) Page 11 line 14: "During the campaign period, there were nearly 300 days with valid air ion measurements". Please add what is the corresponding percentage of valid days as well. The Referee is aware that the Authors refer to Table 1 where this information can be retrieve, but thinks that would be of help to the reader to make it explicit in the text.

15) Page 11 line 18: "definite". Confusing adjective. Please rephrase.

16) Page 12 Line 2: "high" please add a value e.g., median or a range of warm months to help the reader.

17) Page 12 line 4: "natural ionising radiation" is a confusing term as cosmic rays are also natural and ionizing. Please change wording.

18) Page 12 line 24: remove "Markedly" it is unnecessary. Please reword the sentence to make it more understandable/intuitive. In addition, do the Authors have information about the boundary layer (BL) in February, March, October and November? Can the Authors exclude that some of those high cluster ion concentration are due to limited mixing due to shallow BL? Please elaborate and include in the text.

19) Page 13 Line 20: "Bumps ... NPF events (Fig. 3c)". Please rephrase being clearer. Consider replacing the word "bumps" with e.g., "sudden increase".

20) Page 13 line 24 and 25: "Such differences result ... different origins". Replace "differences" with "different".

21) Page 13 line 26: replace "perceptible" with "measurable"

22) Page 14 line 11: "Short after". Please be less vague, remove "short" and add temporal information in the text.

23) Page 14 line 18 to 21: "slowly growing" ... "slight growth". Please add next to this general expression the value of the GR. It will make the text more useful to the reader.

24) Page 14 line 24: Replace "owing to" with "because of"

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25) Page 16 line 19: "... and yields more representative instantaneous GRs". The word "representative" should be reserved to statistical analysis. If such analysis was done to assess whether the calculated GRs were statistically representative please add a sentence about the method used, otherwise rephrase.

26) Page 16 line 20: The Referee thinks that a comparison between the GR for ions with $D_p > 10$ nm and particles in the same size range should be discussed in this paragraph.

27) Page 17 line 17: "... 110 nm". Based on the data analyzed in this work and on literature is the activation in this size range typical? The Referee recommends, if possible, adding some discussion about this in this paragraph.

28) Page 18 line 11: "we observed wind-induced ion formation especially during the winter months". Please add some numbers to make this statement less vague. How many times in winter with respect to other months?

29) Page 18 line 24: " Ionising radiation produces primary ions via ionisation". Please either remove "via ionization" or add what is ionized e.g., "via ionization of vapor molecules"

30) Page 19 line 8: "However ... contribute to the ion burst captured by the AIS". The Referee thinks that this statement is highly speculative and unsubstantiated. The Authors should discuss more in length adding references.

31) Page 19 line 22: "similar" the wording makes the sentence too generic and vague, please discuss further, how those feature are similar.

32) Page 20 line 3: "unexpectedly" unnecessary adjective, please remove.

33) All figures of DMPS and AIS size distributions: add units to $dN/d\log D_p$ make the units of D_p consistent (all nm or all m) add thick labels so that are consistent and at least 2 in number e.g., 10 and 100 nm

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34) Page 31 caption of figure 1: specify the polarity of the ions, add units to the y-axis, uniform the units of D_p (all nm or all m) and add a tick label near the cluster band.

35) Page 32 figure 2: the x-axis is and its label are confusing. Please make the x-axis so that have the same label and take the same space in this way the reader will be able to easily compare CS and cluster ions during the same month.

36) Figure 3, all panels: adding a visual indicator for the fog would help the reader to identify the fog period. Please consider adding it.

37) Figure 3, panel c): The secondary axis have a weird grey halo, please consider fixing it.

38) Figure 5, caption: "envolvment" pleases reword, this might not be English. Maybe "evolution"?

39) Figure 7, panel f): The Referee thinks that adding a label " $D_{50} = 1.1e-7$ m", or even better " $D_{50} = 110$ nm" instead of the number alone would make the figure easier to read.

40) Figure 9 and S3, all panels: please give only the significant digits for the fit.

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