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Atmospheric Chemistry and Physics Discussions

Interactive comment on "New particle formation events observed at the King Sejong Station, Antarctic Peninsula – Part 2: Link with the oceanic biological activities" *by* Eunho Jang et al.

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We thank Referee 3 for providing valuable comments on our manuscript. Our responses to this Referee's five scientific issues are provided below. The revised manuscript was uploaded in the form of a supplement

Scientific issues

1. Only 38% of the data are analyzed. Present a whole analysis, including air masses originating other sectors: We have a companion paper (Kim et al., New particle formation events observed at King Sejong Station, Antarctic Peninsula – Part 1: Physical

characteristics and contribution to cloud condensation nuclei) that describes the physical characteristics of the aerosol particles observed at the King Sejong station during the same period. The whole dataset of new particle formation events recorded for eight years was analyzed in detail in this companion paper. In short, Kim et al. (2018) evaluated the numerous physical parameters (e.g., occurrence, formation rate, growth rate, condensation sink, and source rate of condensable vapor) that originated from South America, Antarctic Peninsula, and the Bellingshausen and Weddell Seas, and determined that ∼80% of the new particle formation events were observed when the air mass originated from ocean domain (including the Bellingshausen and Weddell Seas) during the productive summer peiod. Therefore, we focused on the influence of marine biota on the formation of nanoparticles in this study. A total of 22,469 hourly mean number concentrations of nanoparticles were measured over the eight years. The linkage between new particle formation and environmental parameters is complicated, owing to the interplay among multiple sources and complicated processes. We have excluded the dataset that did not satisfy >90% retention over the two ocean domains to evaluate the relationship between new particle formation and oceanic biological characteristics. Thus, 8573 hourly mean number concentrations of nanoparticles were used for further analysis. To the best of our knowledge, it is based on the longest observation periods measured in the Antarctic site regarding this subject. We agree with this referee's comment that the previous version of this manuscript lacked explanation regarding the overall trend of nanoparticles, even though it was introduced in the companion paper. Therefore, we have added more description regarding "1) the general aspect of new particle formation events (e.g., frequency and potential origin) (P5, line 34 – P6, line 2)' 2) time-series transport history (Fig. 1c), 3) the reason why we focused on the dataset originating from two ocean domains (P1, lines 20–22; P6, lines 2–6) and 4) the limitations of the present study and the scope of future studies (P9, line 33 – P10, line 8)" in the revised manuscript.

2. As regards of the filter data, there are only few months of data presented, this should be stated in the abstract: A total of 84 MSA samples were analyzed daily during the

summer periods in 2013 and 2014. As this referee suggested, we have added this information to the Abstract (P1, line 29–30).

3. MSA concentration is too high (Issue 1) and local penguin emissions near the base should be discussed (Issue 2): (response to issue 1) We have added a new figure representing the daily MSA concentration and a brief explanation of MSA variation in the revised manuscript (Fig. 4a; P8, lines 16–27). The mean MSA concentration during the entire PM10 sampling period was 72.6 $\pm$ 99.1 ng m-3 (ranged from 4.2 to 657.0 ng m-3; 176.0 $\pm$ 186.2 (n=16), 68.1 $\pm$ 36.3 (n=25), 40.1 $\pm$ 30.9 (n=27), and 30.9 $\pm$ 26.2 (n=16) for Jan. 2013, Feb. 2013, Dec. 2013, and Jan. 2014, respectively), similar to the values observed at six Antarctic sites during the productive summer period. For example, the monthly mean MSA concentrations observed during the summer period were reported to be 59.3, 154.2, 63.0, 180, $\sim$60, and $\sim$100 ng m-3 in the Halley, Neumayer, Dumont d'Urville, Palmer, Zhongshan, and Marambio stations, respectively (e.g., Prospero et al., 1991; Minikin et al., 1998; Preunkert et al., 2007; Read et al., 2008; Zhang et al., 2015; Asmi et al., 2018). Note that most of the filter samples for MSA measurement were collected at a duration >3 days in these studies. As shown in Fig. 4a, an extremely high MSA concentration was observed between 14 Jan. 2013 and 17 Jan. 2013 (291.9, 386.6, 657.0, and 489.6 ng m-3 at a daily interval). During this period, the air masses originated from the Bellingshausen Sea (>90% air mass retention over the Bellingshausen Sea domain based on 2-, 3-, 4-, and 5-day air mass trajectories analysis). Such a high MSA concentration was also observed at the Antarctic site. For example, $\sim$300 ng m-3 of MSA was reported at the Zhongshan Station (located in eastern Antarctic site) for the aerosol particles collected for a sampling duration of 10–15 days. Therefore, the high MSA concentration observed at the King Sejong Station appears to be due to the high biological productivities surrounding the observation site and the relatively shorter sampling duration during the study period. (response to issue 2) Over the study period of eight years, 16 days of new particle formation events out of 101 events were observed when the air mass originated from the Antarctic Peninsula. Penguin colonies are dispersed throughout the Antarctic Peninsula (Croxall et al.,

2002), and the emission of ammonia from these colonies could trigger the formation of nanoparticles (Weber et al., 1998; Croft et al., 2016). However, this issue was beyond the scope of the present study. In the revised manuscript, we have added more description to clarify the scope of the present study (P1, line 16; P1, lines 20–22; P5, line 34 – P6, line 6).

4. Need to add more recent findings regarding this issue: We have added more references that report the roles of diverse environment factors affecting the formation of new particles in the revised manuscript (P2, lines 17–24).

5. Need to carry on a more in-depth analysis with the whole data-set available: As we mentioned above, we have a companion paper that describes the physical characteristics of the aerosol particles observed at the King Sejong station during the entire sampling period. The number concentration of the nanoparticle was at its maximum during the productive summer period, and the frequency of new particle formation was highest when the air mass originated from the ocean domain. Therefore, we focused on the influence of marine biota on the formation of nanoparticles in this study. In the revised manuscript, we have added more description to clarify the scope of the present study (P1, line 16; P1, lines 20–22; P5, line 34 – P6, line 6). We have added more description and figures to support our key findings in the revised manuscript. In short, the explanation regarding the biological characteristic (e.g., DMSP-relevant process, feasibility of PHYSAT method and oceanic DMS production capacity) of the surrounding ocean was thoroughly complemented in the revised manuscript (P4, line 34 – P5, line 6; P7, lines 3–11; P7, line 16 – P8, line 40). Figures for 8-year CN records (CN2.5, CN10 and CN2.5-10), 8-year transport history at an hourly interval, sea-surface DMSP concentration, and daily MSA concentration have been newly added in the revised manuscript (Fig. 1, Fig. 3b, Fig. 4 and Fig. S4a). Furthermore, the limitations of the present study and the scope of future studies have also been added (P9, line 28 –P10, line 8).

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-1181/acp-2018-1181-AC3-supplement.pdf

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