Variations of condensation nuclei at Syowa Station, Antarctica

K. Hara[1], N. Mikami[1], K. Osada[2], M. Hayashi[1], M. Shiobara[3], and T. Yamanouchi[3]
[1]*Fukuoka Univ.,* [2]*Nagoya Univ., and* [3] *NIPR*

Aerosols are present even in the Antarctic troposphere in spite of isolation from human activity. We have monitored condensation nuclei (CN) to understand global background level and its trend. The following processes have been pointed out to maintain atmospheric aerosol system in the Antarctica; (1) primary emission of sea-salt particles from the ocean in the southern Ocean, (2) primary emission of sea-salt particles from sea-ice surface, (3) release of aerosol precursors from the oceanic bioactivity, (4) new particle formation and particle growth, (5) long-range transport from the mid-latitudes, and (6) local human activity (each Antarctic station and tourism). However, each process and its contribution are still unknown. Here, we aim to elucidate processes to maintain aerosol system in the Antarctic troposphere.

CN measurement has been performed as a part of JARE monitoring measurements since April 1997 at Syowa Station, Antarctica. For CN measurements, condensation particle counter (CPC, 3010) was used from 1997 till December 2016. CPC 3783 has been used since February 2014. Minimum measurable size is 10 nm in 3010 and 7 nm in 3783. CN concentrations recorded every 1 minutes. In this study, we analyzed CPC-3010 data. Because aerosol data can be contaminated in the cases of wind dircetion from main area of Syowa Station, locally cotaminated data were screened using wind data and relative standard deviation of 10-min CN average data. Five-day backward trajectory was computed to understand air-mass history using NOAA-HYSPLIT model with vertical motion mode and NCEP-Reanaysis dataset.

Interanual trend of CN concentrations were not clear approximately for 20 year records at Syowa Station, although seasonal features of CN concentration showed year-to-year difference. Similar tendency of CN trends was observed at Neumayer Station (Weller et al., 2011; Asmi et al., 2013). Seasonal features of CN concentrations showed minimum in winter (mid-May – end-August) and maximum in summer at Syowa Station. In sipite of lower CN cocnentrations in winter, CN concentrations increased occasionally to the concentrations similar to those in spring-summer-autumn. High CN concentrations in winter were observed ofthen under the strong winds and storm conditions. Comparison between air mass history and low CN cocnentrations in winter shows air mass having low CN concentrations originated from free troposphere over the Antarctic continent. On the other hand, high CN concentrations in winter were observed in the air masses transported via boundary layer over sea-ice area. Therefore, This implies that primary emission of sea-salt particles from sea-ice surface act as major aerosol sources in the winter in the Antarctic coasts, as suggested by Hara et al. (2011a). Additionally, CN concentrations have three maximum in end-September – early-October, December, and end-February – early-March at Syowa Station. The seasonal features were also observed at other coastal stations (Neumayer, Mawson, and Troll) (Weller et al., 2011; Gras et al, 1985; Fiebig et al., 2014). However, variation of CN concentrations did not have spring maximum (September - October) but show maximum in November at Amundsen-Scott (South pole) station (Fiebig et al., 2014). The common fatures at coastal stations strongly suggests that aerosols are supplied to the Antarctic troposphere in the scale of all Antarctic coasts. High CN cocnentrations in autumn (April) and spring (October) were found in the air masses from free troposphere over Antarctic coasts and continent. This implies that new particle formation and growth processes proceeded preferentially in the Antarctic troposphere, as suggested by Hara et al. (2011b). From comparison among CN cocnentrations, sea-ice extent, solar radiation, and aerosol constitents such as $CH_3SO_3^-$, three maximum might be associated with photochemical oxidation of aerosol precursors, precursor emission from ocean surface, and new particle formation in lower free troposphere.

Acknowledgement: CN data used in this study was JARE monitoring data. The long-term CN measurements have been carried out by the wintering JARE members since JARE38.

References

Asmi, A., Aerosol decadal trends – Part 2: In-situ aerosol particle number concentrations at GAW and ACTRIS stations, ***Atmospheric Chemistry and Physics***, 13, 895-916, doi:10.5194/acp-13-895-2013, 2013.

Fiebig, M. et al., Annual cycle of Antarctic baseline aerosol: controlled by photooxidation-limited aerosol formation, ***Atmospheric Chemistry and Physics***, 14(6), 3083–3093, doi:10.5194/acp-14-3083-2014, 2014.

Gras, J. et al., Concentration and size variation of condensation nuclei at Mawson, Antarctica, ***Journal of Atmospheric Chemistry***, 3(1), 93–106, doi:10.1007/BF00049370, 1985.

Hara, K., et al., Seasonal features of ultrafine particle volatility in the coastal Antarctic troposphere, ***Atmospheric Chemistry and Physics***, 11, 9803-9812, https://doi.org/10.5194/acp-11-9803-2011, 2011a.

Hara, K. et al., Seasonal variations and vertical features of aerosol particles in the Antarctic troposphere, ***Atmospheric Chemistry and Physics***, 11(11), 5471-5484, doi:10.5194/acp-11-5471-2011, 2011b.

Weller, R et al., Characterization of the inter-annual, seasonal, and diurnal variations of condensation particle concentrations at Neumayer, Antarctica, ***Atmospheric Chemistry and Physics***, 11(24), 13243-13257, doi:10.5194//acp-11-13243-2011, 2011.

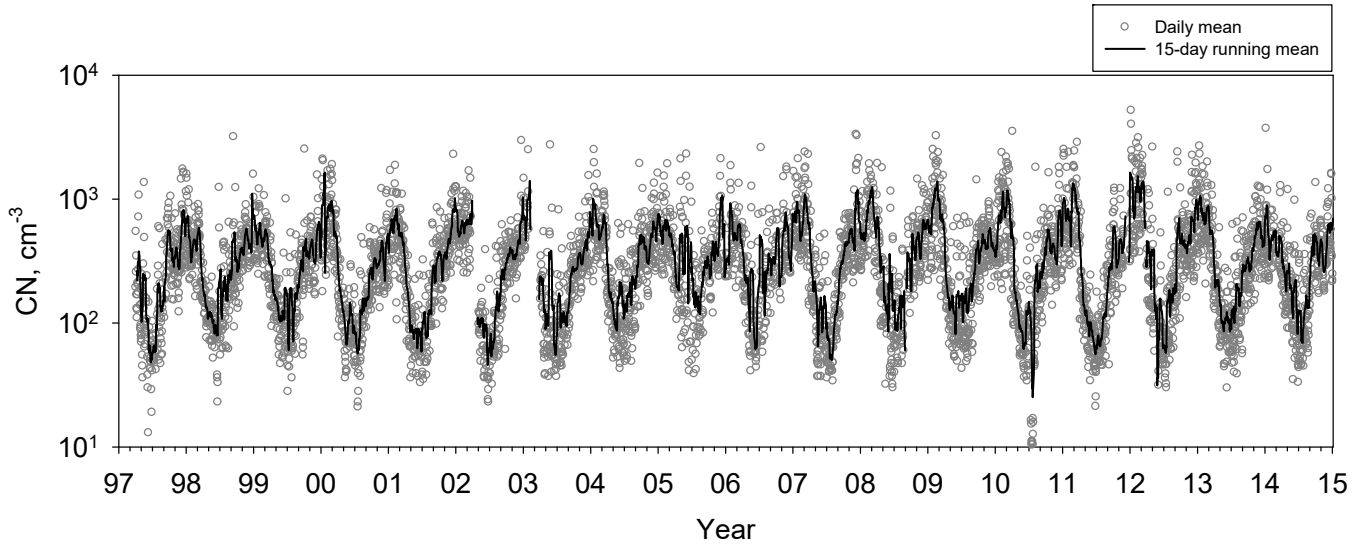

Figure 1 Variation of CN concentrations (D_p>10nm) at Syowa Station, Antarctica during March 1997-December 2014. Open circles and thick line indicate daily mean and 15-day running mean CN concentrations, respectively.