Measurements of ice-nucleating particles in marine air during the Mirai Arctic cruise in 2016

Kotaro Murata[1], Yutaka Tobo[1], Fumikazu Taketani[2], Takuma Miyakawa[2], and Yugo Kanaya[2]
[1]*National Institute of Polar Research, Tokyo, Japan*
[2]*Japan Agency for Marine-Earth Science and Technology, Kanagawa, Japan*

Ice-nucleating particles (INPs) are crucial for ice particle formation in tropospheric clouds at temperatures higher than -38°C and hence play an important role in determining the radiative and microphysical properties of the clouds. However, quantification of INPs in remote areas, such as ocean and polar regions, is still challenging due to low concentrations in the marine atmosphere. In this study, measurement of INPs was performed using aerosol samples collected during a cruise of R/V Mirai across the Arctic Ocean, Bering Sea, and western North Pacific from August to October 2016. We used the National Institute of Polar Research Cryogenic Refrigerator Applied to Freezing Test (NIPR-CRAFT) device to examine the immersion freezing efficiency of the collected aerosols in the temperature range of -25°C to 0°C and measured the number concentration of atmospheric INPs as a function of temperature. The INP concentrations varied over about three orders of magnitude during the cruise. Over the Arctic Ocean (i.e., >70°N), the INPs active at -25°C were <0.08 L^{-1}. In comparison with the Arctic Ocean, INPs active at -25°C were abundant over the Bering Sea and western North Pacific; 0.03-5.5 L^{-1} during the first half leg and 0.3-41 L^{-1} during the returning leg. According to on-board measurement of black carbon concentrations and model simulations, extremely high concentrations of INPs during the returning leg would be attributed to transport of smoke from fires in Siberia. The difference in INP concentrations during the cruise indicates that INPs in marine air can vary dramatically in response to long-range transport of continental aerosols, such as smoke, in addition to local emissions from the sea surface. The observed concentrations of INPs were reasonably expressed by power law fits with the number concentrations of fluorescent biological aerosol particles measured using a Waveband Integrated Bioaerosol Sensor (WIBS-4) during the cruise. In addition, the observed concentrations of INPs seemed to be correlated with chrolophyll concentrations in sea water (i.e., an index of biological productivities in sea water). The results suggest that biological aerosol particles may play a role in determining INP populations in the marine air of this case.