Press Releases

February 20, 2016
JAMSTEC
National Institute of Polar Research

World's First Ship-based Observations of Atmospheric Black Carbon Particles over Arctic Ocean

-Towards more sophisticated prediction of climate changes around the globe-

Overview

Dr. Fumikazu Taketani at Institute of Arctic Climate and Environmental Research, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) and his research team performed measurement of black carbon (BC) aerosol particles[*1] using a highly sensitive online instrument, a single particle soot photometer (SP2[*2]) on board during a cruise by the JAMSTEC's R/V *Mirai* across the Arctic Ocean. Single-particle-based observations with the SP2 enable the measurement of even extremely low BC mass concentrations of 0.01ng/m^3. As a result, the team's ship-based observations revealed that BC concentrations over the Arctic Ocean fluctuate over a wide range between 0.01ng/m^3 and 20ng/m^3 during the period from summer to autumn. Moreover, the analysis of morphology of these particles found that several BC particles are attached to the surfaces of non-BC material at a more significant level compared to those in other regions. As such examples had not been reported so often, these findings provide important information about understanding of BC's optical properties and removal process from the atmosphere.

In the Arctic Ocean, where no sufficient platform for atmospheric observation is in place, air-craft observation has been a common method for measuring BC in the air. However, these data are not enough for verification because available data are only in a very short span of time from several seconds to minutes. This is the first ship-based measurements over the Arctic Ocean, which provided quantitative data for understanding BC concentration. Further observation data will continue to be accumulated while these data will be utilized for climate prediction with atmospheric chemical transport models. Elucidation of long-term BC dynamics in the Arctic should also help clarify the Earth's radiative budget and transport process of BC.

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The above results were posted on the *Journal of Geophysical Research Atmosphere* on February 20, 2016 (JST). In addition, they were also highlighted in the *Research Spotlight*, American Geophysical Union's *EOS*.

Title: Ship-borne observations of atmospheric black carbon aerosol particles over the Arctic Ocean, Bering Sea, and North Pacific Ocean during September 2014
Authors: Fumikazu Taketani[1], Takuma Miyakawa[1], Hisahiro Takashima[1,2], Yuichi

Komazaki[1], Xiaole Pan[3], Yugo Kanaya[1], Jun Inoue[4,1]
1. JAMSTEC 2. Fukuoka University 3. Kyushu University 4. National Institute of Polar Research

*1 An aerosol particle is a colloid of fine solid particles or liquid droplets suspended in ambient air. It significantly interacts with the solar radiation.

*2 SP2 is an instrument using laser-induced incandescence technique that measures the particles size and BC mass content of individual aerosol particles. With high power from laser in the instrument, light-absorbing particles containing black carbon are heated to the temperature to emit incandescence light. The incandescent emission is measured and correlated to the black carbon mass.

*3 Arctic Challenge for Sustainability (ArCS) Project is a national flagship project funded by the Ministry of Education, Culture, Sports, Science and Technology. Launched in September, 2015, it aims to elucidate the changes in the climate and environment, clarify their effects on human society, and provide accurate projections and environmental assessments for internal and external stakeholders so that they can make appropriate decisions on the sustainable development of the Arctic region. The National Institute of Polar Research (NIPR), the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Hokkaido University are playing key roles in driving this project.

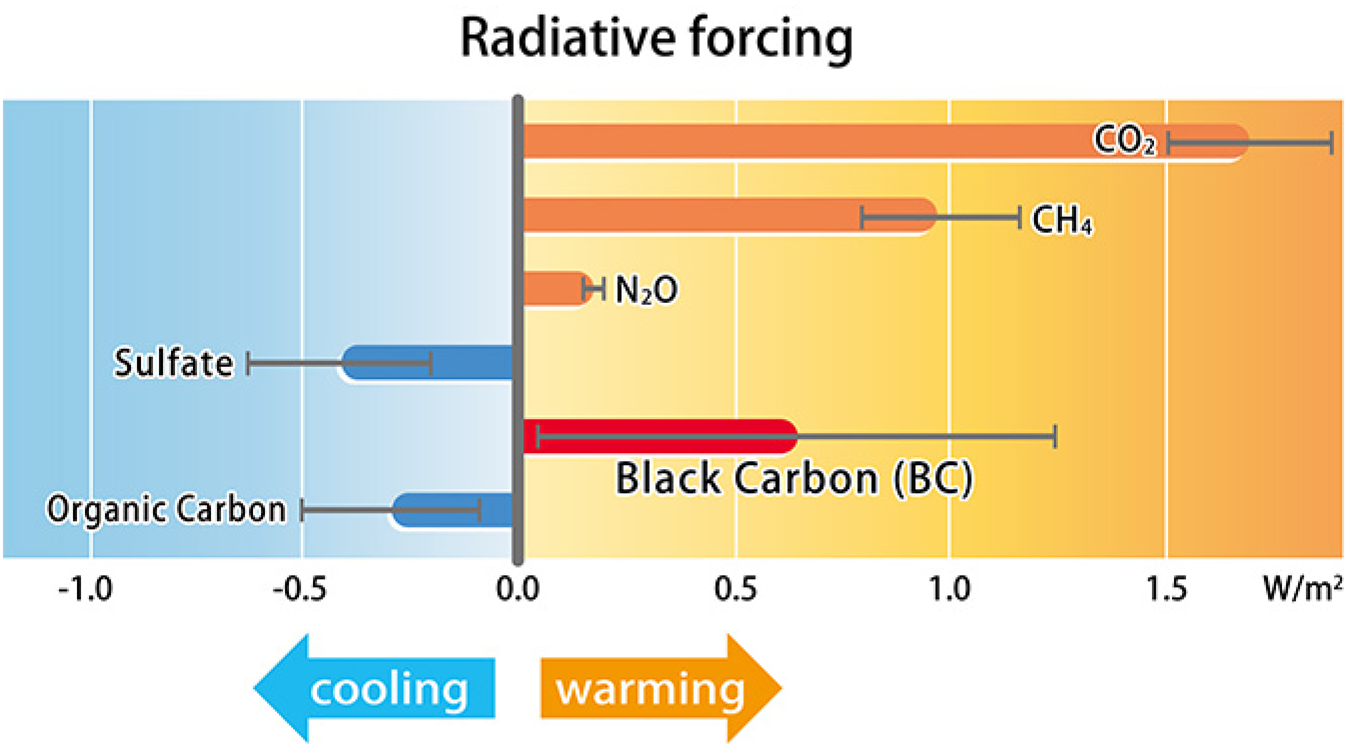

Figure 1: Radiative-forcing Components (prepared based on the IPCC Fifth Report) The right direction arrow indicates effect of warming air and the left cooling air. While sulfate and organic carbon in aerosol particles cools air by scattering sunlight, BC (shown in red here) warms air by absorbing light. Chemical elements such as BC, CO_2 and CH_4 are considered to be major contributors to global warming. However, BC has been reported with larger errors (as shown in gray bars) due to lack of sufficient data on concentration level, quantities, emission and removal process.

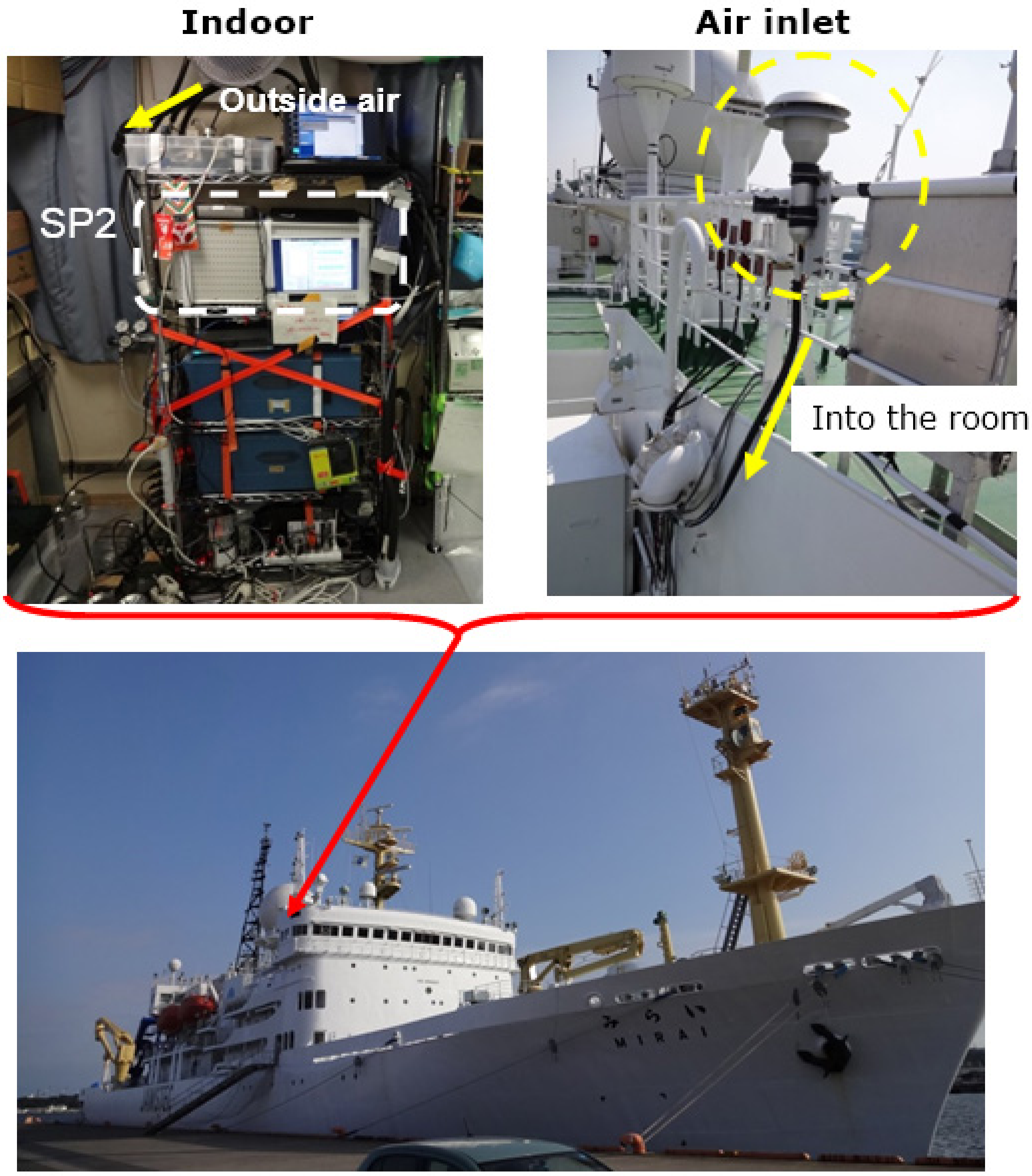

Figure 2: The upper left shows equipment installed in an observation room located on the top floor of R/V *Mirai* (photo at the bottom), while the right an outdoor-air inlet. Continuous observational data were collected by taking open air from tubes. Based on data of relative wind direction and velocity from the bow, influences of smoke emitted from a chimney at the back of the vessel were excluded from obtained data for analysis.

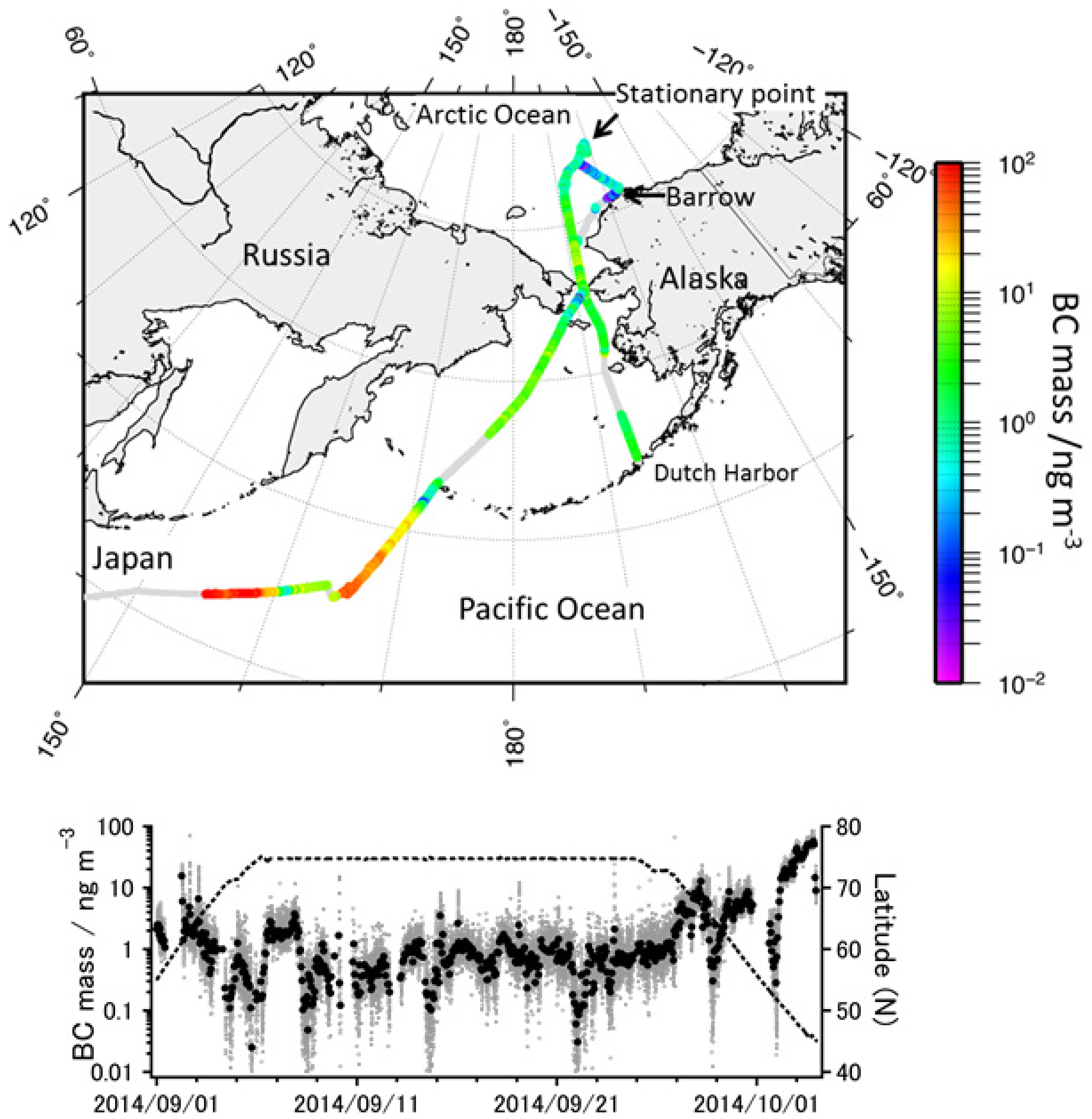

Figure 3: Observation results of BC mass concentrations over the Arctic Ocean
(Upper) Variations of BC mass concentrations along the sea track: The gray line shows the cruise track and the colored ones indicate the level of BC mass concentrations. The BC mass concentrations over the Arctic Ocean range from 0.1 (shown in blue) to 10 (shown in green) ng/m^3. On the other hand, BC concentration levels are higher between 10 (shown in yellow) and 100 (shown in red) ng/m^3 in areas at a latitude of 50 degrees north or below, which is probably due to impacts from the Eurasian continent.
(Bottom) Time-dependent variations of BC mass concentrations: The gray and black dots show the BC mass concentration averaged at 1 minute and 1 hour, respectively. The dotted line indicates latitudes at the time of observation (right axis). Even during observations at the stationary point (74.75N, 162.00W) from September 6 to September 24, 2014, BC concentration ranges 0.01 to 20ng/m^3. A little higher level of BC observed around September 7, 2014 seemed to be affected by emission from land.

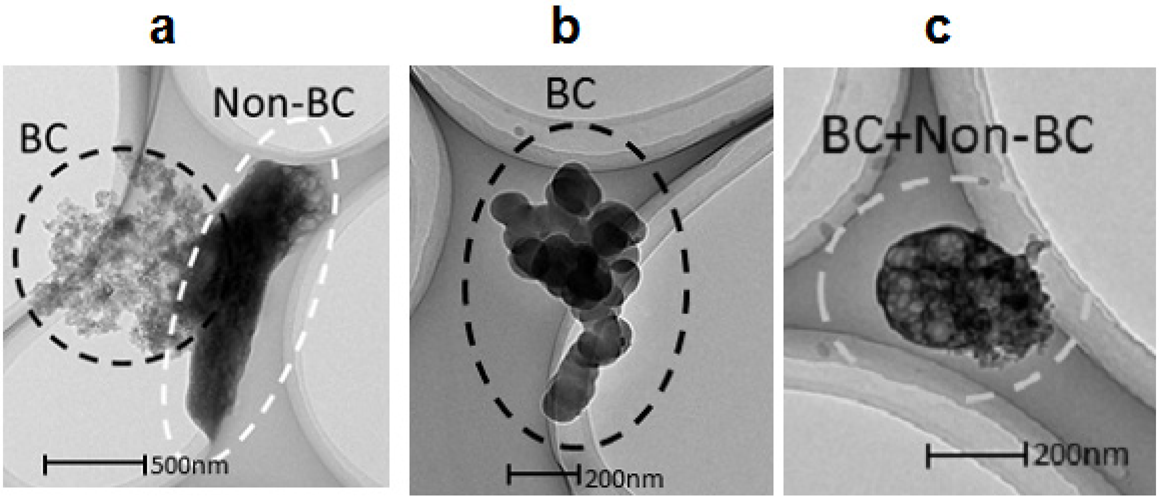

Figure 4: TEM (transmission electron microscope) images of BC (a) BC particles attached to the surface of non-BC material; (b) Bare BC particles; and (c) BC particle coated with non-BC material. Depending on BC types, BC's absorption of sunlight varies. For example, light absorption is increased by BC particles coated with non-BC material. It means understanding of BC types in the air could lead to better assessment of climate variation. These study results identified the a) type of BC at a significant level over the Arctic Ocean

Contacts:
(For this study)
Fumikazu Taketani, Senior Scientist, Institute of Arctic Climate and Environmental Research, JAMSTEC
(For press release)
Hiroyasu Matsui, Press Division, Public Relations Department, JAMSTEC
Hiromi Obama, Public Relations Section, National Institute of Polar Research