Research Organization of Information and Systems
National Institute of Polar Research (NIPR)

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GRENE Arctic Climate Change Research Project
www.nipr.ac.jp/grene/e/

Arctic

News Letter No.2

Two GRENE-Arctic research projects are using aircraft to investigate important atmospheric components. One project is measuring black carbon aerosols, which are deposited on the snow and ice and accelerate their melting by absorbing solar radiation, and the other project is observing temporal and spatial variations in greenhouse gases.

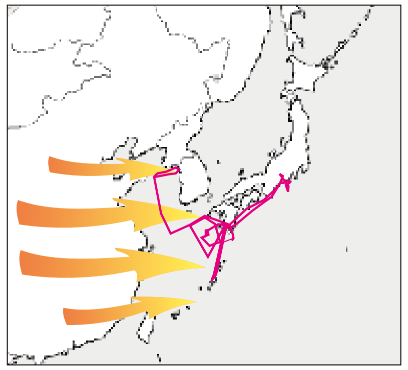
Human activities are thought to have a significant impact on both of these phenomena, and since research on the upper levels of the atmosphere (i.e., the upper boundary layer and the free troposphere) is limited, there are many unknowns in this field.

The following is an overview of the research behind these atmospheric observations which in already underway ahead of the main observation season in the summer.

In Pursuit of Aerosols Transported from Asia to the Arctic

Makoto Koike (The University of Tokyo)
Yutaka Kondo (The University of Tokyo)

Black carbon aerosols (BC) absorb significant amounts of solar radiation, and once they are deposited on the surface of snow and ice, they work to promote ice-albedo feedback. For this reason, they may be one of the factors accelerating warming in the Arctic. Under the research topic of 'Atmospheric studies on Arctic change and its global impacts' (Principal Investigator: Prof. Jinro Ukita / Niigata University), researchers are working with the other research projects to conduct precise measurements of BC concentrations in the air near the surface of the land as well as in falling snow and in snow and ice, in an effort to accurately assess the behavior of BC. The problem is that no one really knows where the Arctic's BC comes from. BC concentrations near the surface of the ground are not enough to determine the amount of BC deposited on the ground. Some BC falls from the sky when it rains or snows, so examining BC in the air at higher levels of the atmosphere is the key to discovering its origins.



Trajectory of flights conducted in February and March 2013 (pink line).
Flights were conducted from Kagoshima over the East China Sea and Yellow Sea to ascertain the transport of aerosols from the Asian continent (arrow).

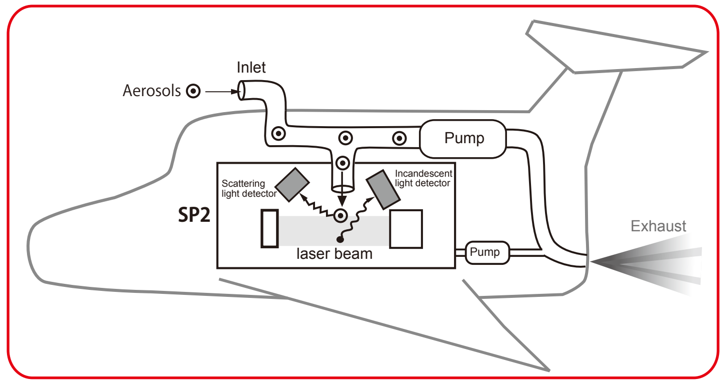
There are only a few special aircraft in Japan that can conduct atmospheric observations. The seats have been removed from the cabin to make room for equipment. There is an inlet on the top of the aircraft to collect aerosols and gases, and there are devices equipped under both wings to measure aerosols, clouds and wind speed. (Photo credit:Koike)

Research Aims

We are starting to understand how BC behaves in the air above the Arctic as a result of observation flights conducted for NASA's ARCTAS project. By analyzing increase events of BC concentrations, we have found that Russian forest fires contribute considerably to the concentration of BC in the Arctic. Meanwhile, research conducted by a separate group using the same data and global numerical models has found that contributions of anthropogenic BC transported from Asia to the Arctic likely to be greater than those from Russian forest fires. In recent years, the significance of the transport of BC from Asia has been pointed out in several studies, but a consensus has yet to be reached.

In order to quantify the amount of BC transported from Asia to the Arctic under GRENE-Arctic, we are measuring BC from research aircraft. Asia is the biggest source of BC. This means the transport of even a portion of that BC to the Arctic could have a profound impact. BC is carried up into free troposphere when warm air from Asia is transported to the cold Arctic region, and this process often coincides with precipitation. Gaining an accurate understanding of this upward transport process and the process by which BC is removed from the air by rainfall (wet deposition) is the key to quantifying the effects of Asian BC on the Arctic.

BC is generated during the combustion process and is emitted together with carbon monoxide (CO). Although a part of BC can be removed by precipitation through the upward transport, CO is not removed. Therefore, measuring the BC-CO ratio allows us to estimate the BC removal rate. By using a model that can express the detailed BC removal process, we aim to quantify the BC transported from Asia to the Arctic.



SP2 instrument: A special combination of inlet and pumps is used to bring aerosols from outside into the cabin without any loss. Scattering and incandescent light are measured to determine the size of individual aerosols and the amounts BC they contain, respectively. A device on the outside of the aircraft is used to measure cloud microphysics in order to examine the effect of aerosols on clouds.

Overview of Atmospheric Observations

In February and March 2013, we conducted research flights over the East China Sea and Yellow Sea from Kagoshima (See map on left). Korea cooperated with the Yellow Sea observations. We have had carefully examined the flight plans in advance, but we held daily meetings to determine where and how high we should fly on each flight day by examining the predicted aerosol distribution calculated with meteorological field predictions. We conducted observations from 150m to 7km above the sea, and descended in a spiral in order to obtain the vertical distribution of a fixed point. Two researchers rode on the aircraft to view data obtained in real time and make minor adjustments on the flight profile. We were able to successfully obtain high precision data on all of our flights, and we are currently in the midst of analyzing this. We plan to conduct our next round of observations during the rainy season in June and July, so that we can compare that data with the data obtained during the dry winter months.

Understanding Cycles of Greenhouse Gases

Toshinobu MACHIDA
(National Institute for Environmental Studies)
Motoki SASAKAWA
(National Institute for Environmental Studies)
Yousuke SAWA (Meteorological Research Institute)

A greenhouse gas observation over Siberia.
○-○: Atmospheric sampling on a regular JAL flight. Observations were conducted from April 2012 to January 2013 on the Paris-Haneda route and later on the Moscow-Narita route.
▲: Ground-based tower observation
□: Charter plane observation

In a research project entitled 'Studies on greenhouse gas cycles in the Arctic and their responses to climate change' (Principal Investigator:Prof. Shuji Aoki / Tohoku University), we are conducting observations from land, sea and air to shed light on the distributions and fluctuations of greenhouse gas sources and sinks.

The aerial observations are being conducted by team members from the National Institute for Environmental Studies and the Meteorological Research Institute. One set of observations was conducted by flying a charter plane over Siberia, while the other, which we discuss here, used regular commercial flights between Japan and Europe to measure the mixng ratios of carbon dioxide (CO_2) and methane (CH_4) in the atmosphere. While charter plane conducted air sampling from surface to up to 7 km altitude, the commercial flights allowed us to collect data from higher altitudes in the atmosphere, around 10 km above ground.

Onset of the European Observational Flights

Since April 2012, we have been conducting monthly observations by using commercial flight between Europe and Japan operated by Japan Airlines (JAL). We have been observing the north-south distribution of greenhouse gases since 1993 using flights between Japan and Australia. In addition to these observations, GRENE-Arctic gave us the opportunity to conduct a regular flask sampling flight over Siberia. Since there are only two aircraft that can be equipped with automatic air sampling equipment and only three equipment available, we struggled to arrange the flight schedule and management of the equipment, so partway through the year, we switched our flights from Paris-Haneda to Moscow-Narita. But thanks to cooperation from some key collaborators, we ended up conducting 12 observation flights over Siberia and will continue these observations this year as well.

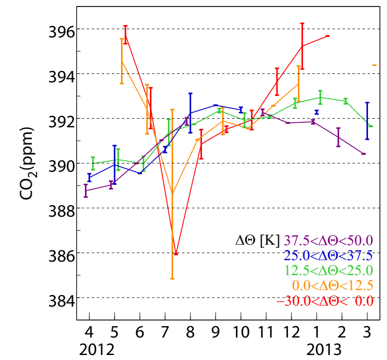
First Year's Results

In these observations, we collected air samples in the upper troposphere and the lower stratosphere. We were able to analyze the CO_2, CH_4, nitrous oxide (N_2O) and sulfur hexafluoride (SF_6) in the air, and this gave us a glimpse into some interesting air transport patterns. We noticed large seasonal changes in CO_2 in the troposphere due to the photosynthesis and respiration of terrestrial plants, although those seasonal amplitudes at 10 km were about half compared to the ground level. On the other hand, while changes in concentrations in the stratosphere were small, they increased in the summer, suggesting a totally different kind of seasonal change (top of figure on right). We also observed larger seasonal changes in CH_4 concentrations in the stratosphere than in the troposphere (bottom of figure on right). Since air descends to the lower altitudes from higher altitudes in the stratosphere in spring, CH_4 concentrations decreased. On the other hand, higher CH_4 are observed in summer, suggesting fast meridional transport of tropospheric air in low-latitude to the lower stratosphere across the tropopause. We also found that CO_2 and SF_6 above Siberia are increasing at similar growth rate as on the ground level.

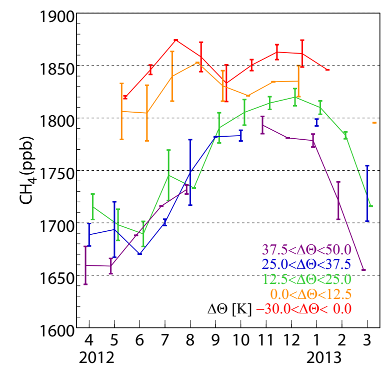
In addition to past data, we have now collected data covering latitudes from 25°N to 60°N, which has helped us to understand the seasonal changes in greenhouse gases in the northern hemisphere.

Since the air in upper atmosphere mixes well, it reflects the wide ranging impacts of human and natural activities. We will collect more data this year and further pursue our research with the aim of developing a more accurate picture of seasonal changes and annual increase.

Two types of equipment mounted on a JAL 777-200. They collect samples of air before it is drawn into the jet engine and mixed with air inside the cabin. The day after a flight arrives in Japan, the ASE equipments are sent to NIES for analysis.
(Photo credit: Japan Airlines)



Seasonal changes in CO_2 mixing ratios in the stratosphere (purple) and the troposphere (red). Different colors represent different potential temperatures zones from the tropopause. Mixing ratios in the troposphere are the lowest in summer, and seasonal fluctuations are large. While variations are smaller in the stratosphere, mixing ratios are high in the summer, suggesting a completely different pattern.



Seasonal variations of CH_4 mixing ratios in the stratosphere and the troposphere. Mixing ratios in the stratosphere are lowest in early spring and increase in the summer. Meanwhile, seasonal fluctuations in the upper troposphere are relatively smaller. This is the first time that researchers have collected high-frequency data on greenhouse gases other than CO_2 in the stratosphere.

Topics Research Project 7

2013 SUMMER ARCTIC SEA ICE FORECAST

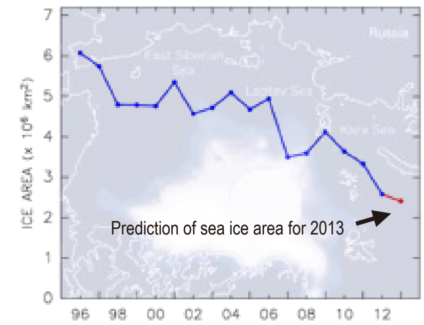
The group of the sub-research project 'Sea ice prediction and construction of an ice navigation support system for the Arctic sea routes' (Principal Investigator: Prof. Hajime Yamaguchi / The University of Tokyo) opened their 2013 SUMMER ARCTIC SEA ICE FORECAST to the public on their web page on May 31, 2013.

<Distribution of sea ice in this summer>

① Arctic sea ice area will mark a new minimum record.

② The sea routes of Russian side and Canadian side will both open.

*The Russian side will open around 21st of July and the Canadian side will open around 6th of August.



Prediction of marking a new minimum record of sea ice area (drawn in red) and the predicted sea ice distribution (background).

They will present an animation showing the predicted sea ice distribution from July 1st to November 1st with a five day interval.

http://www.1.k.u-tokyo.ac.jp/YKWP/2013arctic_e.html

Arctic Data archive System (ADS)

Hironori YABUKI
NIPR（Project Associate Prof.) / JAMSTEC

What is ADS?

In Japan, data systems in the field of Earth environmental science are administered by individual institutions and are not widely shared. The fact is that only the people involved with a certain data set are the ones using it. There are also no permanent data servers to store and manage data. The ADS breaks down these barriers: it is a data system that anyone can use. It is a tool for connecting Japanese researchers' models, observations and research on the Arctic, and our aim is for it to become a permanent platform for data storage.

Data Publish as an Evaluation Standard

In Japan, there are no evaluation standards for creating and publishing data sets. Gathering data and submitting data sets is not recognized as research output. This is because awareness of data archives has not been very high; however, in recent years, as more researchers conduct research in a globalizing world, they have started to recognize the importance of archiving data so that they can use each other's data. That being said, creating and publishing data sets is still not a recognized evaluation standard, so we must elevate the act of creating and publishing data sets until it is considered as such. This cannot be achieved by the National Institute of Polar Research (NIPR) alone; it will likely require awareness-raising throughout the research community as well as new laws for funding organizations.

Amid this backdrop, ADS was born. At present, we are managing data primarily from within GRENE-Arctic. We use ADS as a tool to treat data sets as evaluation standards as soon as they are published. In the future, we will expand ADS to serve as a place for publishing data on the Arctic from outside of GRENE-Arctic, and we would like to build it into a worldwide center for data on cryosphere regions.

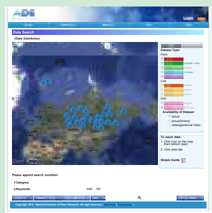
Data: A Shared Asset

As global warming progresses, there is an urgent need to collect and archive observation data. Looking back at the 1930s and 1940s, warming was advancing in the Arctic just as it is today. Back then, I don't know if researchers were conscious of warming, but they probably had insufficient data to discover the warming process, given that there were fewer observation stations than today. If such data were systematically stored and digitized, we might be able to use them to help us unlock the mechanisms underlying the warming process in the Arctic today. Ideally, there should be data on hand when you want to use it. Data should not only be available to the person who collected them; they also need to be accessible to anyone, and that, in turn, enhances their value.

On several occasions throughout history, polar expeditions have served to generate new ideas about data. For example, Japan was motivated to begin Antarctic expeditions by the International Geophysical Year (IGY) of 1957-1958. Afterwards, the World Data Center was established to save the the data collected during IGY for future generations. Fifty years later, the two-year period from March 2007 to March 2009 was designated as International Polar Year (IPY), and this led to the establishment of the World Data System (WDS). In this way, polar observations have led to new developments on the front of data disclosure. Using the GRENE-Arctic as a springboard, we intend to further expand the disclosure of Japan's data.

From Information to Intelligence

We are working to make the ADS a globally accessible system that makes finding data easy. The ADS relies on researchers to collect data, and we believe it can help accelerate our own research in the process. We plan to improve the ADS so that it goes beyond a simple information tool to become a tool for generating intelligence.



https://ads.nipr.ac.jp/

Principle Investigator's Perspective

Jinro Ukita
(Niigata University)

Atmospheric Studies on Arctic Change and its Global Impacts

The goal of the Atmospheric Studies Group is to develop a comprehensive understanding of atmospheric processes in the Arctic. Our group is composed of four teams and 55 researchers with 17 co-PIs and 5 PDs. The Black Carbon Aerosol Team aims to unlock the big picture of black carbon aerosols in the Arctic, including their emission, transport, deposition and effects on radiation. The Clouds and Radiation Team focusses on cloud behavior in the Arctic and attempts to link it with the Arctic heat budget.

Jointly, these two teams comprise the Aerosol, Clouds and Radiation Subgroup. The other Atmospheric Circulation Subgroup studies why global warming is progressing more rapidly in the Arctic and how the changes in the Arctic influence weather and climate in lower latitudes including Japan, based on data analysis and numerical simulation.

What is unique about our research project is its broad perspective in terms of spatial extension. The atmosphere transports advects substances and also, via circulation, spreads climatic signals from one region to an other via the mechanism called teleconnection. Our study area is not limited to the high Arctic, but also includes tropical and middle latitudes. Vertically we cover from the upper ocean to the middle atmosphere in a seamless manner, a significantly more comprehensive view than Arctic studies in the past. In terms of social contribution, our research aims at better understanding how changes in the Arctic affect Japan's climate, and we feel this is very important.

In FY2013, we target the following three tasks: ⅰ) surface and aircraft observations of the black carbon; ⅱ) numerical simulation looking into the details of Arctic teleconnection; and ⅲ) operating newly constructed cloud radar. We collect black carbon data year-round both from the Atlantic side (Ny-Ålesund) and from the Pacific side (Point Barrow). We also conduct aircraft observations to develop a clearer picture of how aerosols are transported and deposited. The second task is to simulate Arctic teleconnection under various forcing conditions, including those from anomalous sea ice cover, sea surface temperature, ozone, and CO_2. Regarding cloud radar observations, we have had some setbacks but are ready to begin.

Being a PI of such a large research group, my philosophy is to take a balanced view on individual and group research needs. This is extremely important as we scientists often focus on and study rather limited issues rather than addressing larger and overarching research questions directly. The most important aspect is to aim for a high scientific standard. Saying this is easy but, in reality, every day is a struggle. Eighteen months have passed since the project began, and I am now starting to gain a fully-developed picture of our work. Last, I would like to take this opportunity to express my appreciation, once again, to the many individuals and organizations who have provided us with moral and financial support for this highly needed area of research.

Profile: Sports or Study ?

Nowadays I do not have much free time, but when I do, I try to go swimming and skiing. I have enjoyed sports ever since I was a kid, let's say, too much so that I did not develop a keen interest in science until I became an adult. That being said, one of my friend's father was a university professor, and I remember thinking how it seemed like a good job to have. But now that I think of it, he was an economics professor from Oxford, so the work he did bears no resemblance to what I do in now.

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National Institute of Polar Research 10-3, Midoricho, Tachikawa, Tokyo 190-8518, Japan

Photo supplied by ：top-Makoto KOIKE（The University of Tokyo）
bottom-Masami DITO (National Institute for Environmental Studies)