Arctic Challenge for Sustainability project

Interim activity report

In the Arctic Ocean, sea ice has been decreasing lately on an unprecedented scale. This is an area that has a marked influence on global warming, recording the lowest sea ice extent every few years. While recent studies have revealed a close link between meteorological changes in the Arctic and the climate of mid-latitude regions, including Japan, efforts have also become active for resource development and commercial utilization of Arctic sea routes as a result of environmental changes in the Arctic.

The Arctic Challenge for Sustainability (ArCS), a project for research on the Arctic region, started in September 2015 as a project subsidized by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan for the purposes of scientifically understanding the environmental changes taking place in the Arctic for precise prediction of such changes, and providing necessary and sufficient information to institutional and individual stakeholders in Japan and abroad, such as international organizations, local governments, private sector entities, indigenous communities, and NGOs.

Already halfway through, this leaflet has been prepared to introduce to readers the scientific activities carried out up till now.

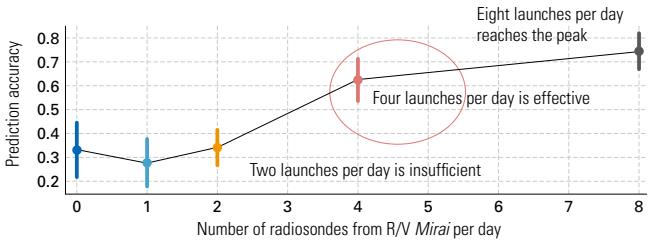
ArCS
Arctic Challenge for Sustainability

Scientific elucidation of actual environmental changes in the Arctic for accurate prediction

Prediction and navigation

Back cover: **Theme 1**

We participated in aerologic monitoring over the Arctic Ocean on board the R/V *Mirai*, and additional upper-air monitoring activities at German and Canadian observation stations in the Arctic region. As a result of these special monitoring efforts, it has been clarified that i) integrating monitored data in the numerical models will improve a skill of weather forecast; ii) it is optimal for the effective improvement of meteorological forecasting around the Arctic Ocean to conduct aerologic monitoring four times a day; and iii) greater accuracy in the ocean wind forecast will improve the prediction precision of sea ice distribution along the Northern Sea Route. We observed ocean waves in the Arctic Ocean, obtained wave height data for the first time as a Japanese organization, and clarified that the maximum wave height and wind speed that ships are likely to encounter. Wave height and wind speed have been becoming greater on a long-term basis in summer in the Arctic Ocean because the probability of strong winds blowing in open water has become greater due to the decrease of the total sea ice area. The findings of these facts will surely contribute to safer voyages of Japanese and other ships navigating the Arctic Ocean.



Influence of the daily observation times on board the RV *Mirai* on prediction accuracy.

Ice sheet/glacier and environment changes in Greenland

Back cover: **Theme 2**

In cooperation with researchers from Denmark, Switzerland, Canada, and other countries as well as local residents, We carried out on-the-spot monitoring of ice calving glaciers and fjords at Qaanaaq in the northwest of Greenland, as well as analysis of satellite data and numerical modeling. These research results have found that glaciers have rapidly been disappearing since the beginning of the 21st century due to increased air and seawater temperatures, and that suspended matter coming from glaciers is an important nutrient salt supply source for marine creatures, suggesting that increased meltwater would cause serious changes to the marine environment and ecology.

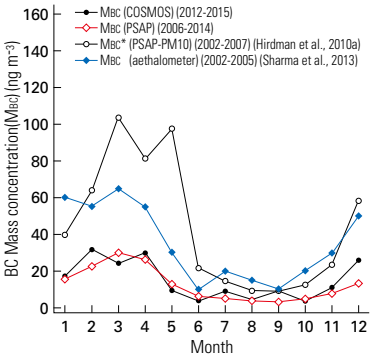
Also, we have been participating in the East Greenland Ice Core Project (EGRIP), which is carried out in Greenland by 12 countries. In 2017, the drilling reached 900m depth and the ice core was analyzed down to 350m. Analysis of the core showed characteristic crystal orientation fabric, which will provide us with valuable new information on the ice flow dynamics.

Ice core processing at EGRIP site

Atmospheric climate forcers (Black carbon measurement)

Back cover: **Theme 3**

We have established a new method of precisely measuring black carbon (BC) particles for an extended time period using COSMOS, a unique continuous BC measuring instrument, developed in-house, with greater precision. The difference between conventional continuous measurement results and COSMOS-obtained results are so important that it has been decided that each participating country will review conventional measurement results referring to the observation results of the new method.



Measurements of BC concentration in the atmosphere at Ny-Ålesund, Norway, by means of various measurement methods. For the first time, it is shown that conventional measurement results shown are much higher than COSMOS-measurement results.

Arctic Ocean observational research

Back cover: **Theme 4**

Based on observation results by R/V *Mirai*, T/S *Oshoro-Maru*, as well as year-long mooring results, We were able to clarify seasonal variations on primary production (including the first observational evidence of fall bloom) and zoo-plankton dynamics at the Hope Valley of the southern Chukchi Sea (one of the biological hot spot in the Pacific-side of the Arctic Ocean) and the progress of ocean acidification, for the first time.

We successfully made a quantification of carbon dioxide fluxes in the Arctic Ocean (at 60 degrees north latitude or higher seas) by processing observation data using new analysis technique. As a result, CO2 uptake in the Arctic Ocean is estimated to be 10% of the total in the entire ocean, while the Arctic Ocean accounts for only 3% of the world's ocean surface area.

Arctic ecosystems

Back cover: **Theme 6**

Ocean: A new method to monitor phytoplankton size distribution from satellite has been developed. It has been confirmed that latitudinal shift of the benthic organisms that are food for marine mammals, in synchronization with changes in biomass and size of phytoplankton in the Bering Strait and its adjacent waters. We have also predicted that walleye pollock, the main marine product of the Bering Sea, will move northward due to warming.

Land: We studied the behavior of seabirds on St. Lawrence Island, Alaska, and obtained the first year-round tracking records of thick-billed murres in this region. In the area of microorganism research, the discovery of two new fungi has been reported in an effort to clarify ecosystems in the Arctic land area, in which information on biodiversity and ecological function research is comparatively sparse.

International collaborative research

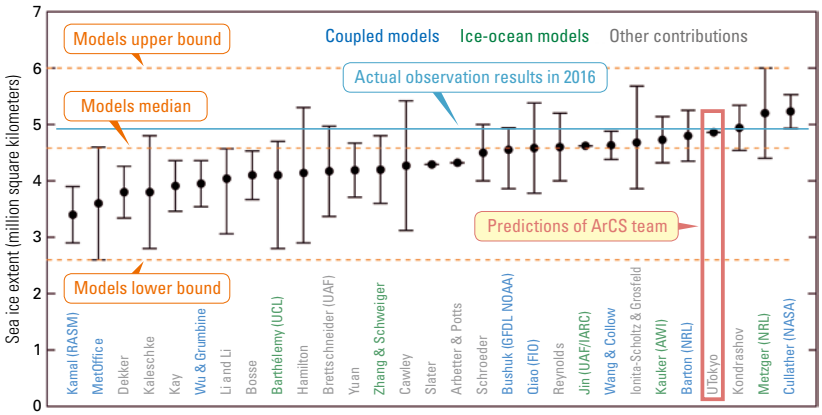
In cooperation with research institutions in the Arctic countries, ArCS research activities are being carried out by effectively utilizing the research infrastructure of Japan, such as research and observation stations (see page 4) and the oceanographic research vessel *Mirai*.

Marine observation in the Bering Strait using R/V *Mirai*

Climate predictability

Back cover: **Theme 5**

For forecasting sea ice distribution, new algorithmic programs have been developed and further improved, using measurement data obtained by the advanced microwave scanning radiometers AMSR-E and AMSR2, developed by the Japan Aerospace Exploration Agency (JAXA). Based on sea ice data from the satellite for the period from December 2015 to April 2016, the sea ice thickness at the end of April 2016 was estimated, which was then used as benchmark data to predict sea ice distribution during summer. Our predictions of sea ice decrease, minimum distribution, and total sea ice area matched with actual observation results with high precision, recording top-level marks in the Sea Ice Outlook.



The June report of the Sea Ice Outlook, an international project for the comparison of sea ice prediction results (https://www.arcus.org/sipn/sea-ice-outlook).

Prediction of the impact of environmental changes on people and economic activities in the Arctic

People and community in the Arctic

Back cover: **Theme 7**

A research team composed of Japan, Russia, the United States, and Germany conducted a field survey to explore the thermokarst transformation and the people's land use in the Sakha Republic, Russia. Interdisciplinary approaches clarified the mutual long-term interaction between natural history and local culture and estimated the impact of permafrost thaw by global warming. Analyses based on meteorology and hydrology (refer to Theme 3) clarified that temperature rise and increased wetness were apparently progressing, which increased river flow volume, sometimes likely to cause floods. Anthropological study (refer to Theme 7) has found that there is indigenous knowledge that distinguishes between the floods of three seasons (ice-out, snow-melting, and summer), of which the ice-out-based flood has given positive influence to the local society while lately increasing floods have a negative influence. The result contributes to a new perspective of Arctic human-environment history.

Water-covered houses due to a flood caused by the breaking of ice

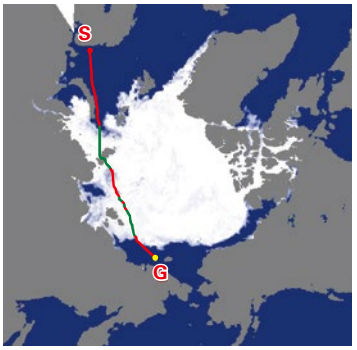
Publication of research outputs to stakeholders in Japan and overseas

Data management

Back cover: **Theme 8**

Publication, analysis, and presentation of scientific data: The obtained data by the ArCS project and other related information are published and archived in its Arctic Data archive System (ADS, https://ads.nipr.ac.jp/). In March 2016, this system was connected to the data portal of the Global Earth Observation System of Systems (GEOSS).

Vessel navigation support system: Sea surface temperatures, wind speed on the sea, sea ice concentration, and other JAXA satellite data are published after being visualized on a quasi–real time basis. The VEssel Navigator by Unitized System (VENUS), an information system for providing sea ice data to ships, has been developed, and implementation on commercial vessels has been progressing as an important information tool for deciding on sailing routes in sea-ice waters. A new online Arctic route search system has been created by combining satellite-based data and numerical models, and this system is published over the internet.



Ship route search results on the Arctic route search system. Green lines indicate the section for which escort by an ice-breaker is required.

Co-designing of Arctic research

Unprecedented efforts for cooperation with indigenous peoples of research areas in the Arctic

Sakha Republic in Russia: The interdisciplinary field worker team on the environment and development (see the lower part of page 2) is planning to evaluate the impact of the permafrost thaw in cooperation with local governments as stakeholders, and to publish environment educational materials for local residents. Research on wild reindeer clarifies the impact of climate warming on their lives. Working together with Russian scientists, research team suggests the conservation policies on wild reindeer based on our research results to the local administration.

Greenland: The research team on Qaanaaq in the northwest (see page 1), provides the results to local residents by workshops on site. It serves as an opportunity to receive information on their livelihoods affected by environmental changes, and thus active exchanges of information are made concerning the sustainable future of Greenland.

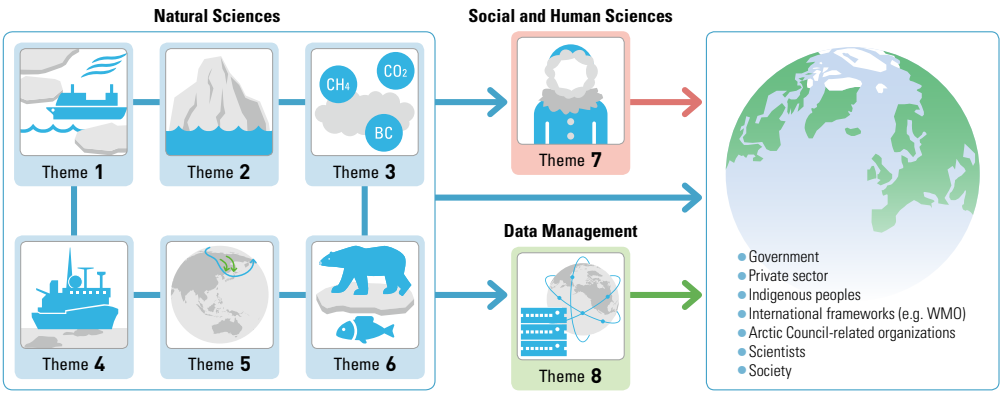
Public lecture

A yearly lecture meeting open to the general public is held to provide an opportunity to review the significance and importance of Arctic studies to be undertaken by Japan.

Contribution to the Intergovernmental Panel on Climate Change (IPCC) and other organs

We send our members to international organizations as lead author and a review editor of special IPCC reports, scientist member of the Polar Prediction Project (PPP) of the World Meteorological Organization (WMO), and joint chair of the Working Group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA). Thus, ArCS activities based on the international collaborative research menu have resulted in ArCS researchers receiving invitations to international Arctic research projects and other important activities.

International collaborated research and Information flow



The Social and Human Science theme (Theme 7) is expected to transform scientific knowledge into information that can be used by society as a whole. This theme also tackles the possible impacts of Arctic environmental changes on society and socio-economy. The Data Management theme (Theme 8) gathers and archives both observed and assimilated data, as well as results from prediction models, thus making it the ArCS data center. The data is processed into so-called "easy to understand" information for dissemination to society.

1

2

1. Seabirds living on St. Lawrence Island in Alaska
2. Measurements of atmospheric climate forcers at Ny-Ålesund, Norway.

Establishing research and observation stations

Research and observation stations have been set up in the five Arctic Ocean–rim countries (the United States, Canada, Russia, Norway, and Denmark) for the purposes of establishing a scientific cooperative relationship between these countries and Japan to facilitate research and monitoring activities on an international basis. We began to support collaborative researches at the Centre d'études nordiques (CEN) of Laval University in the Canadian Arctic, Ice Base Cape Baranova in Russia, and other research and/or observation stations in the Arctic region.

Program for overseas visits by young researchers

We support a wide range of young Japanese researchers and working staff in government offices and private corporations. ArCS provides support for their research activities, technology acquisition, and other efforts being undertaken at overseas Arctic research institutions. So far, a total of 21 specialists had been sent to universities, research institutions, and international conferences in overseas.

Dispatch of experts to the Arctic-related meetings

The Arctic Council (AC) is among ArCS's most important stakeholders. ArCS has been dispatching researchers to annual meetings of the Arctic Monitoring and Assessment Programme (AMAP) and other working groups of the AC, as well as expert group or task force conferences held under each AC working group, where dispatched researchers endeavor to contribute to the AC by introducing scientific activities undertaken in Japan as well as preparing scientific reports. For example, presentation of the knowledge that Japan has to the Expert Group on Black Carbon and Methane (EGBCM). Also, ArCS dispatched international law experts to the AC's Scientific Cooperation Task Force (SCTF), in which the experts presented and exchanged views during the final stage of the developing of the Agreement on Enhancing International Arctic Scientific Cooperation by the Arctic countries in an effort to make the agreement relevant to non-Arctic countries as well.

Furthermore, ArCS provides information concerning the current Arctic research in Japan, including that of ArCS, to the Arctic Circle and other platforms having many participants from governments and the industry sector as well as the Arctic Science Summit Week (ASSW) for Arctic researchers of all the related countries.

A meeting of the Protection of the Arctic Marine Environment (PAME) working group of the AC

Project Director
Masao Fukasawa

Achievements and challenges

ArCS activities consist of three categories: promotion of internationally collaborated research, enhancement of platforms for research in the Arctic, and dispatch of young researchers and specialists to Arctic research institutions and conferences. Here, promotion of research refers not only to natural science but also to social science to assess possible impacts of changes in the vulnerable Arctic environment on the world human activities and lives of people living there.

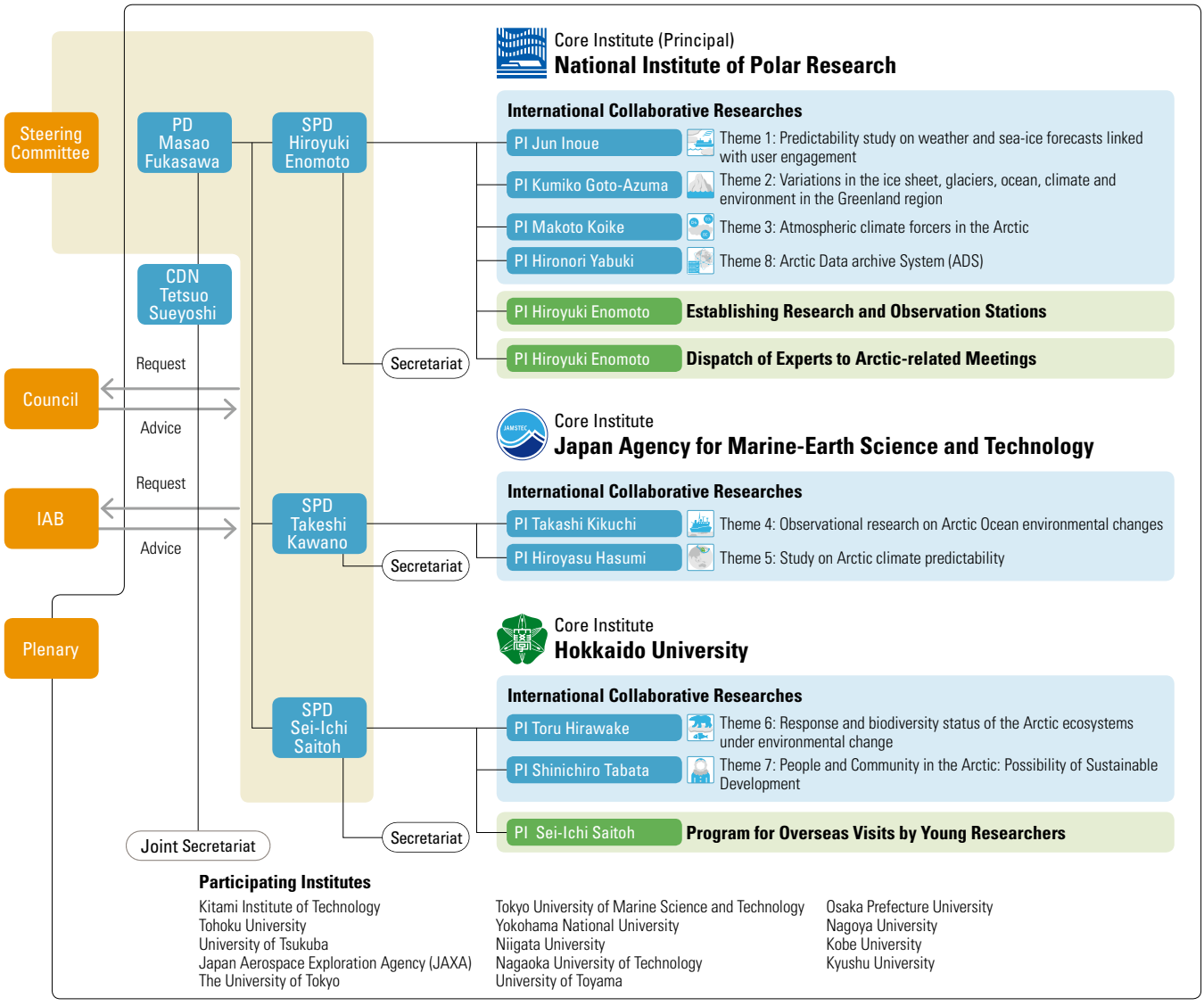
At the same time, based on research results, ArCS holds symposiums and other events comprehensively for the general public, which are also very important for ArCS to encourage understanding of the importance and significance of Arctic research with everyone even in Japan.

Three years have passed since the start of the project, ArCS's fundamental objectives are "*to understand changes in natural environment, which are taking place in the Arctic, for prediction and forecast with the least ambiguity, and to provide necessary and sufficient information to people including decision makers in Japan and abroad.*"

It is the time now when we, ArCS researchers should apply a great deal of effort to create new knowledge by integrating research results not only outlined in this booklet but also all other results obtained through ArCS.

Implementation Management System

As of December 2017



PD: Project Director SPD: Sub Project Director PI: Principal Investigator IAB: International Advisory Board CDN: Coordinator

Publication
Inter-university Research Institute Corporation
Research Organization of Information and Systems
National Institute of Polar Research
10-3, Midoricho, Tachikawa, Tokyo 190-8518, Japan

Editing
National Institute of Polar Research (NIPR)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Hokkaido University

June 13, 2018

Arctic Challenge for Sustainability

2015 – 2020
http://www.arcs-pro.jp/