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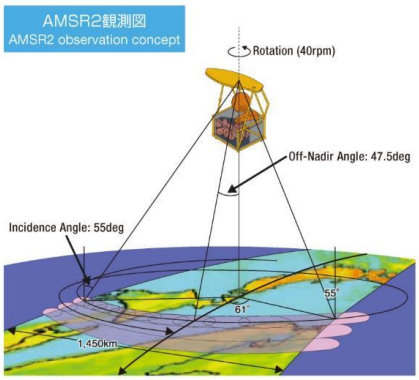
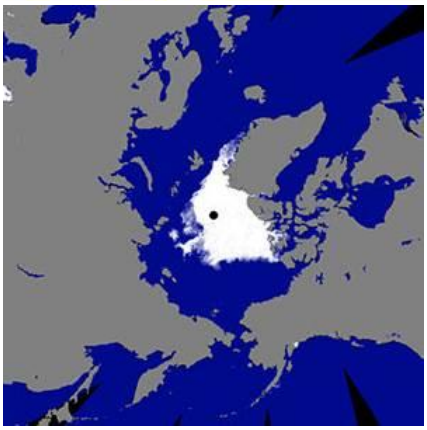




Achieving Innovative Solutions for Arctic Challenges

Science and technology for the Arctic

Japan's role through five "i"s

March 7, 2018

Advisory Board for the Promotion of

Science and Technology Diplomacy

1 Introduction – Science and Technology for the Arctic

The Arctic Ocean has been an unknown frontier to us since the beginning of recorded history. At present, the Arctic is witnessing a decrease of ice sheets, glaciers, and sea ice, which is having an impact on ecosystems and fishing. On the other hand, potentials for the development of petroleum, natural gas, and mineral resources, as well as the utilization of the Arctic Sea Route, are attracting public attention. Such trends raise new challenges for the international community, requiring Japan to formulate speedy diplomatic actions as well. Based on Japan's past efforts with oceans, Antarctica, and outer space, this recommendation, in line with "Japan's Arctic Policy" (2015), offers direction towards achieving solutions to the Arctic challenges making full use of Japan's strength in the area of science and technology. More specifically, it clarifies the roles that Japan should undertake through five "i"s: international; interdisciplinary; inclusive; ingenuity; and, innovation, associated with the perceptions of the current Arctic, thereby passing an open and sustainable Arctic down to future generations.

2 Perceptions of the current Arctic
– Knowing, preserving, and utilizing the Arctic through four "i"s

(1) The Arctic environment is experiencing rapid and drastic changes. With growing expansion of the navigable area due to the decreasing amount of sea ice, the international community's interest is soaring in business opportunities, such as the development of mineral resources, utilization of the Arctic Sea Route, and fishing. It has led to the discussions underway at the Arctic Council (AC) and other fora with regard to the appropriate economic activities and international rule-makings that simultaneously enable the conservation and sustainable development of the natural environment of the vulnerable Arctic.

(2) In the aim of understanding the Arctic and subsequently addressing the challenges it faces, it is necessary to gain insights on various factors including environment/ecosystem ranging from the land and sea to the atmosphere, and indigenous wisdom/life (industrial/resource development, disaster risk reduction, healthcare/medicine, and social/cultural development). Furthermore, insight beyond generations is also necessary. A comprehensive input of knowledge involving different states (international), covering diverse academic disciplines (interdisciplinary) and various actors such as the indigenous people and corporate enterprises (inclusive) are required. At present, however, there is insufficient observation data to implement effective measures. To understand the Arctic, preserve its ecosystems, and utilize it for new socioeconomic activities, it is necessary to collect, share, and analyze more observation data that is precise and highly-qualified on a continuous basis. To accomplish this more effectively, all the

relevant nations are required to sustainably collaborate under common standards.

(3) In that respect, in Japan, abundant valuable data collected through diverse observation technologies and unique observation capabilities have been accumulated. Japan's researchers have contributed to the concentration measurement of black carbon, the assumed environmental factor, to the analysis of the progress of ocean acidification by research vessel observation, and to the assessment of oceanic ecosystems in the Arctic. Furthermore, utilizing international collaborative research stations, Japan is undertaking the dissemination of knowledge, identification of talented researchers, and early discovery of new challenges on Arctic research. Such continuous activities as a source of ingenuity are indispensable to determine changes in the region.

3 Japan's strengths in Science and Technology
– Promoting international cooperation and creating innovation through industry-government-academia collaboration

(1) Japan's science and technology can be a driving force for structuring a cooperative relationship that will promote the creation of the 5th "i," innovation. Japan has been engaging in observations of and research on the polar regions since the 1950s, and has recently been releasing high-quality data accumulated through the data infrastructure. The integration of observation data collected from satellites, research vessels, and other means of monitoring the environment is currently progressing. Utilizing Japan's cutting-edge sensor technology and data, qualified as the basis of the earth observation activities, is effective in promoting joint research undertakings consistently extending from the exclusive economic zone of coastal states of the Arctic Ocean to the high seas (both shallow and deep seas). Earth observation via satellites is particularly indispensable to gain a perspective which grasps the earth as one planet. Sharing of sensor and observation data would foster common understanding among scientists from various nations, as a prelude to establishing grounds for creating innovation and promoting international cooperation.

(2) To create innovation with maximized use of Japan's strengths, industrial communities' ingenuity and close collaboration between the science and business sectors are indispensable. In May 2017, the Advisory Board for the Promotion of Science and Technology Diplomacy issued a "Recommendation for the Future" toward the achievement of the UN Sustainable Development Goals (SDGs). Of the four actions therein presented bearing in mind the basic concept of the 5th Science and Technology Basic Plan (Society 5.0), the two actions, namely, "Grasp and Solve: Solution Enabled by Global Data" and "Link across Sectors, Unite across the Globe" should prove critical to the achievement of the SDGs through innovation.

4 Future Direction – Encourage ingenuity through enhancement of data-based diplomatic activities and establishment of research infrastructure

(1) As a core player, Japan should continue activities in establishing the foundation of Arctic research through the accumulation and integration of data via an international network that is collected with high-precision observation technologies using satellites, by research vessels, or at ground observation stations. Utilizing its advantage of a politically neutral position as a non-Arctic state, Japan is expected to continue to provide reliable objective data to other nations.

(2) Japan should utilize the most advanced scientific findings and technologies for the fields such as the environmentally conscious (curbing marine pollution) sustainable development of mineral resources, and the use of the Arctic Sea Route while taking into account the policies of the Arctic states regarding the continental shelf. At the same time, Japan expects to engage in major fora discussions, such as the Arctic Science Ministerial or the Arctic Council (AC), and to promote data-based constructive cooperation.

(3) International cooperation of Arctic science would significantly contribute to the achievement of SDGs through the creation of innovation incorporating the vital energy of industrial sectors. To promote cooperation for ascertaining and solving current challenges by utilizing global data, Japan should strengthen bilateral and multilateral collaborations and proactively promote international joint research. In addition, Japan would be expected to further advance its own capacity of science and technology, medicine, and education, as well as develop human resources, while recognizing the international public value of the Arctic research.

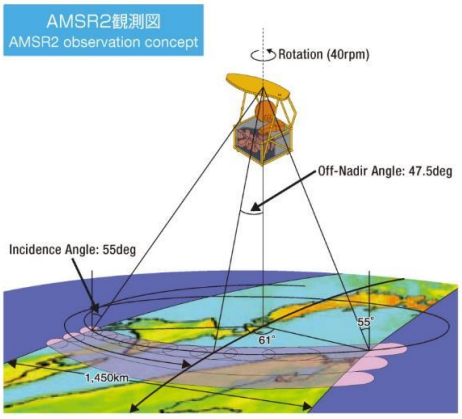
5 Conclusion – Connecting various actors and disciplines through the ice-drifting Arctic to explore the future

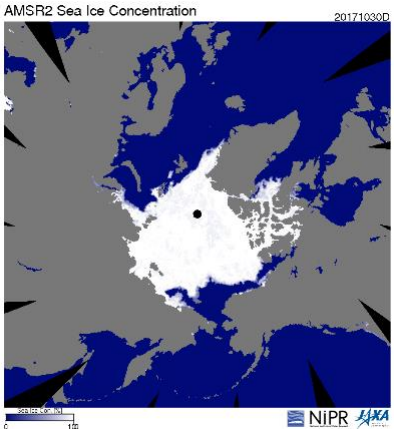
It is essential to make full use of science and technology to address challenges in the Arctic amidst recent environmental changes in the region. Under the rubric of “Japan’s Arctic Policy,” Japan should assume an active role in the international community while cooperating with other nations, aiming at connecting various actors and disciplines in the ice-drifting Arctic for exploring the future, with an emphasis on five “i”s: international; interdisciplinary; inclusive; ingenuity; and innovation.

Annex: Japan's major contribution to the Arctic research

Advanced Microwave Scanning Radiometer-2 (AMSR2)

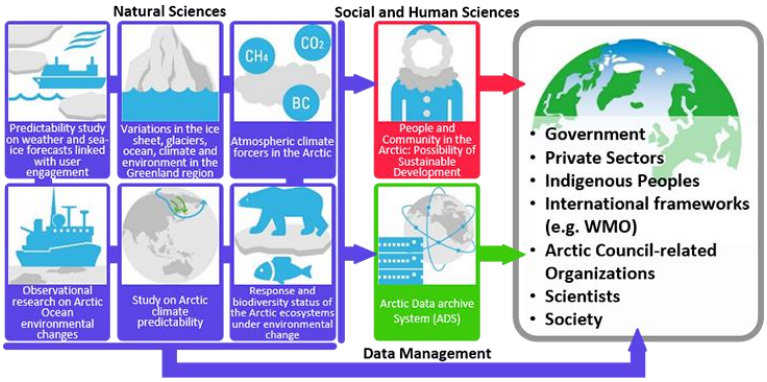
A multi-frequency passive-type microwave radiometer developed by Japan Aerospace Exploration Agency (JAXA). AMSR2's resolution is at the highest level in the world among microwave radiometers. Its observation data, including sea ice monitoring data in the Arctic sea, is globally utilized. JAXA's Global Change Observation Mission – Water (GCOM-W) satellite "Shizuku," with AMSR2 onboard, was launched in May 2012.





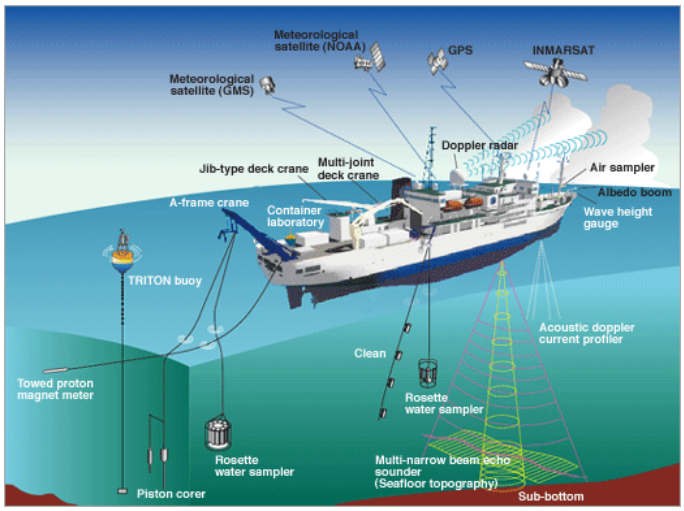
Arctic Challenge for Sustainability (ArCS)

A national science project. ArCS aims to elucidate changes in the climate and environment, clarify their effects on human society, and provide projections with the least ambiguity as possible and environmental assessments for internal and external stakeholders so that they can make appropriate decisions on the sustainable development of the region. ArCS was launched in September 2015 as a four-and-a-half year project.



Oceanographic Research Vessel "MIRAI"

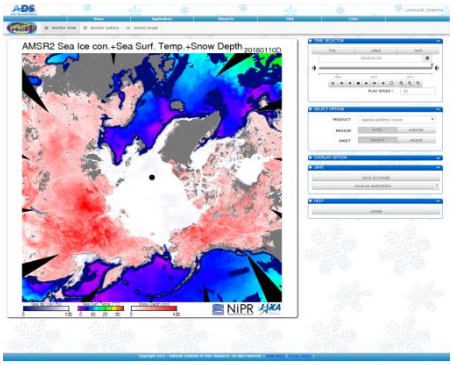
An ice-resistant research vessel developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The vessel, equipped with large observation instruments (Doppler radar), has made observational studies mainly in the Arctic Ocean on the Pacific side 15 times since 1996.



As a result of MIRAI's observations, environmental changes in the Arctic were found to have an impact on the weather in Japan and the Arctic Ocean proved to be increasingly acidified (*). In fiscal year 2016, during MIRAI's observational voyage in the Arctic Ocean, a small prototype of the Autonomous Underwater Vehicle (AUV) (see the photos) conducted an underwater (under sea ice) observational test. JAMSTEC and JAXA are engaging in the integration of observation satellite data in the field of earth's environment and *in situ* data collected through ocean observation systems such as MIRAI.

*Ocean acidification is a phenomenon making the chemical property of the seawater, which is originally mildly alkaline, more acidic as a result of CO_2 in the atmosphere being dissolved into the seawater. Increased ocean acidification is assumed to make an impact on the entire marine ecosystem. For example, skeletons of marine creatures with calcium carbonate shells, like shellfish or coral, are thereby prevented from properly forming.

Arctic Data archive System (ADS)

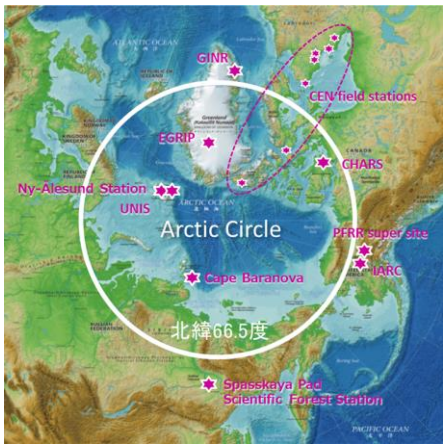


As a central repository of archived data and important infrastructure on the Japan's Arctic research, ADS aims to archive and distribute multiple observational (atmospheric, oceanic, snow ice, terrestrial, and ecological) and model simulation datasets, and promote utilization of these datasets. ADS was supported by the GRENE Arctic Climate Change Research Project (2011-2015). Since September 2015, it has been developed as part of the Arctic Challenge for Sustainability (ArCS). ADS has released various data collected by JAXA's Global Change Observation Mission – Water (GCOM-W) satellite "Shizuku." In addition, it promotes metadata collaboration with the big data system Data Integration and Analysis System (DIAS). ADS's overseas partners and international projects: World Meteorological Organization (WMO); Group on Earth Observation (GEO); Sustainable Arctic Observing Network (SAON); and International Arctic Science Committee (IASC).

Ny-Ålesund Research Station

Established by National Institute of Polar Research (NiPR) in 1991, the Institute has engaged in the atmosphere monitoring observation, greenhouse effect gas observation, changing terrestrial ecosystem observation, and other observations to investigate the Arctic's environmental change mechanism and its impact.

Other overseas research stations



■International Arctic Research Center (IARC)
■Poker Flat Research Range (PFRR) Flux Observation Super Site, JAMSTEC
■Canadian High Arctic Research Station (CHARS)
■The Centre d'etudes Nordiques (CEN)
■Spasskaya Pad Science Forest Station
■Ice Base Cape Baranov Station
■The University Centre in Svalbard (UNIS)
■The East Greenland Ice-core Project (EGRIP) Station
■Greenland Institute of Natural Resources (GINR)

Major research institutes in Japan

■Hokkaido University Arctic Research Center (ARC-HU)
■Arctic Environment Research Center (AERC), Inter-University Research Institute Corporation Research Organization of Information and Systems, National Institute of Polar Research
■Institute of Arctic Climate and Environment Research (IACE), JAMSTEC
■Japan Arctic Research Network Center (J-ARC Net)
■Japan Consortium for Arctic Environmental Research (JCAR)

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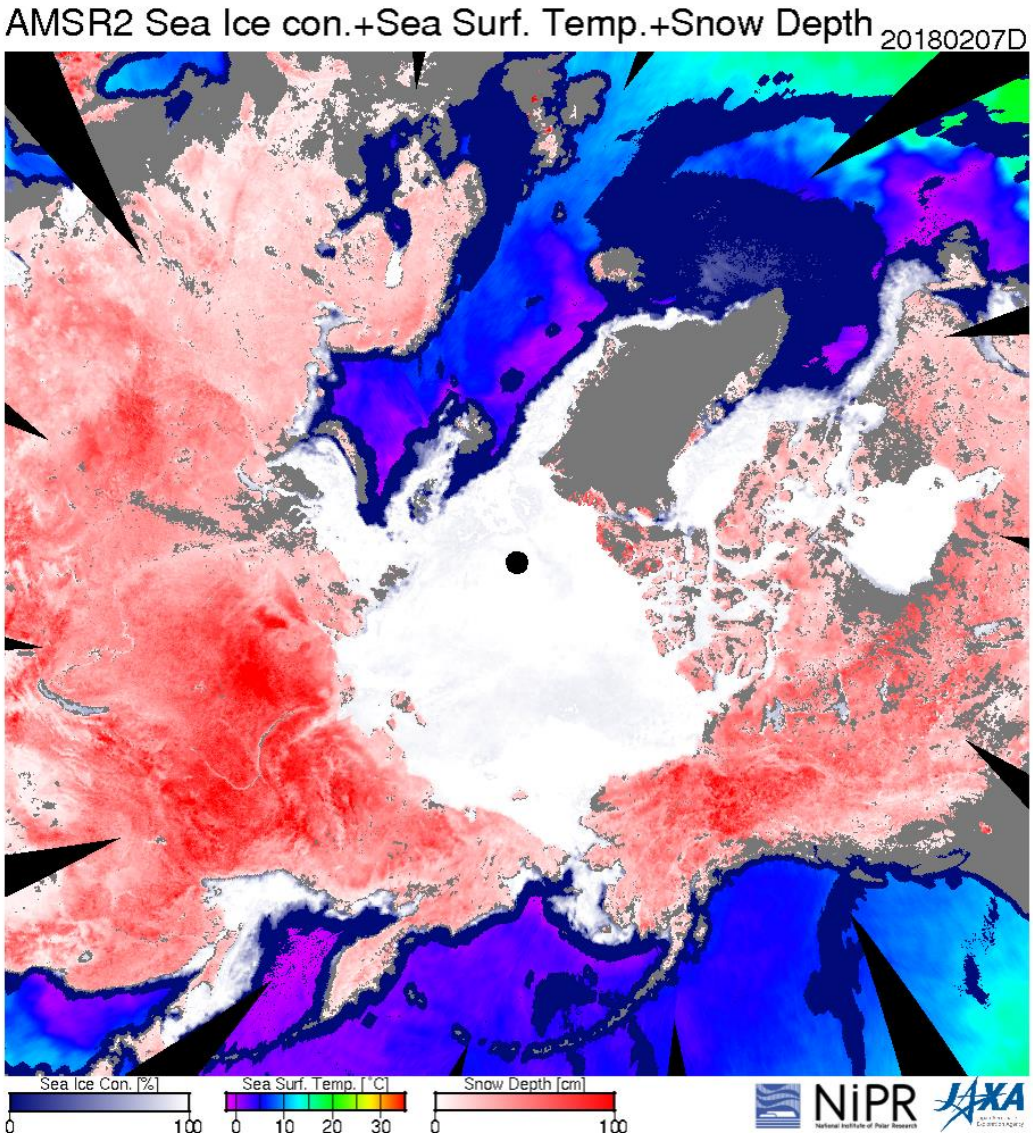
The 6th meeting of the Advisory Board for the Promotion of Science and Technology Diplomacy was held to review the draft recommendation, with the attendance of Mr. Mitsunari Okamoto, Parliamentary Vice-Minister for Foreign Affairs and Ambassador Tomoyuki Yoshida, Director-General, Disarmament, Non-Proliferation and Science Department from Ministry of Foreign Affairs of Japan. The participating government ministries and other relevant organizations are listed below.

Cabinet Office
Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Ministry of Economy, Trade and Industry (METI)
Japan Agency for Medical Research and Development (AMED)
Japan International Cooperation Agency (JICA)
Japan Science and Technology Agency (JST)
Japan Society for the Promotion of Science (JSPS)
National Institute of Advanced Industrial Science and Technology (AIST)
New Energy and Industrial Technology Development Organization (NEDO)

The Arctic study group meeting chaired by Professor Yoshifumi Yasuoka (group leader) was held under the Advisory Board for the Promotion of Science and Technology Diplomacy. Attendances include the members of the Advisory Board for the Promotion of Science and Technology Diplomacy, officials from relevant government ministries and organizations, and the following experts and organizations.

Tetsuro Urabe	Professor Emeritus, The University of Tokyo
Sei-Ichi Saitoh	Director & S.A.Professor, Arctic Research Center, Hokkaido University

National Institute of Polar Research (NiPR)
Japan Aerospace Exploration Agency (JAXA)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
The Ocean Policy Research Institute, The Sasakawa Peace Foundation



The above image shows the observation data of sea ice concentration, sea surface temperature, and snow depth in the Arctic Ocean uploaded to the Arctic Data archive System (ADS). The data was acquired with the Advanced Microwave Scanning Radiometer 2 (AMSR2) on JAXA's satellite "Shizuku" for Global Change Observation Mission – Water (GCOM-W).