A report from JCAR to inform the ICARP IV Process

Topic Area 7: Technology, Infrastructure, Logistics, and Services

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Japan Consortium for Arctic Environmental Research (JCAR) published "Long-term Plan for Arctic Environmental Research (JCAR, 2024b)" with its Executive Summary (JCAR, 2024a) that includes research priorities from viewpoints of Japanese Arctic research communities. Here, from the Executive Summary, we have extracted, edited, and added elements that the Japanese research community could contribute significantly to the implementation of priority studies for the next decade related to "Topic Area 7: Technology, Infrastructure, Logistics, and Services" of ICARP IV.

- Icebreaker observations

To advance Arctic research aimed at understanding the roles of the Arctic in the global climate system and improving the accuracy of future projections, it is essential to carry out the observational research by making maximum use of Arctic research vessels with icebreaking capabilities that can respond flexibly to the rapidly changing Arctic Ocean atmosphere-sea ice-ocean system and acquire in situ data and samples that capture ongoing changes. Japan is now building a new icebreaker that can be used for research purposes and can transect the central Arctic Ocean. In order to develop Arctic research using the new icebreaker as platforms, it will be necessary to establish a system that can deploy in-situ observations (including on ice), manned observation stations, and unmanned observations (AUVs, drones, etc.) and to expand observation research and research communities throughout the Arctic Ocean including organic collaboration with other countries.

- Satellite observations

In only half a century of satellite-based earth observation, it has played an important role in making humans aware of the fragility of the global environment, for example, by detecting the shrinkage of the Arctic sea ice extent and snow cover in the Arctic region. Satellite observation data have already been used for a wide range of research on the Arctic environment, but further improvements in sensor performance, such as higher sensitivity, higher resolution, and more wavelengths, are desired in collaboration with the development plans of space agencies around the world. To extract long-term variation trends from satellite observation data and to be able to discuss the existence of climate and environmental changes with statistical significance, it is very important to continue to develop satellite sensors with the same design concept, such as maintaining the same observation wavelength and frequency band of the sensor and adopting the same satellite orbit (observation altitude and time). In addition, it is very important to conduct long-term satellite observations of changing snow, ice and vegetation using microwave radiometers (e.g., AMSR, PALSAR) and aerosols and clouds using cloud radars, lidars, and optical radiometers (e.g., EarthCARE).

- Aircraft observations

Aircraft observation is an effective means of Arctic research in a wide range of fields of earth science. As for atmospheric sciences, it is the only means that enables direct three-dimensional observations (internal diagnostics) of atmospheric elements. In research fields of snow and ice, oceans, land, and vegetation, remote sensing from aircraft is also effective means of observation. To conduct future Arctic research, it is highly desirable to introduce an aircraft dedicated to earth observation that can conduct Arctic observation projects, and to establish a system to operate the aircraft for joint use. The establishment of an observation system is necessary as soon as possible because of the rapid Arctic warming and the accompanying major environmental changes in many areas. On the other hand, it is expected that unmanned aircraft, including drones, will be used more frequently in future observations of the Arctic region due to their high mobility, economic efficiency, and safety. Currently, the weight of onboard equipment and the observation area are limited. However, it is necessary to push forward the advancement of unmanned aircraft themselves and the development of measuring instruments to realize various earth observations.

- Observations at research stations

It is important to develop and maintain instruments and technologies for observing important parameters regarding atmosphere, cryosphere, and terrestrial ecosystems, and to concentrate them at research stations in the Arctic region. It is essential for researchers who do not have a territory in the Arctic to have a relationship with local researchers and institutions so that they can cooperate with each other for local observations and observation bases. For the sake of research efficiency and user

convenience, it is desirable that major Arctic research institutions in non-Arctic countries that host joint research activities and projects in the Arctic conclude agreements with local researchers and institutions on research cooperation and bases in advance. Also, due to the nature of the agreement, it is desirable that mutual access with researchers from the partner country or institution is possible. In addition, it is necessary to collaborate with the local community from the research planning stage, while taking into consideration the local community. In the Arctic region where people live, there is a need for researchers to deepen their expertise based on their academic interests, as well as to accumulate diverse expertise on social issues and conduct observations and surveys with consideration for the local community. The formation of overseas observation centers in the future will require collaboration not only among researchers and research institutions, but also in consideration of the local communities.

- Submarine fiber optic cables and ocean observation

Oceans are predominantly monitored by surface in-situ and remote sensing techniques. The deep ocean and the important processes occurring there often remain unobserved. Submarine fiber-optic cables can provide new ways to improve subsurface monitoring capabilities. Both the SMART (Sensor Monitoring and Reliable Telecommunications) cable and the fiber-optic Distributed Acoustic Sensing (DAS) initiatives demand collaboration between the Arctic research community and telecommunications industry. In the case of SMART cables, various types of sensors are incorporated into the part of the cable called repeater to collect extensive, longitudinal, real-time data. These cables can support ocean observation, sea level monitoring, tsunami and earthquake early warning and disaster risk reduction, including hazard quantification.

- Numerical modeling

The research infrastructure for numerical modeling first includes hardware aspects such as computers, storage, and networks. In addition to securing sufficient computing resources on state-of-the-art large computers, preparing a set of practical servers, large-capacity storage, and high-speed networks that can hold and publish data and contribute to the analysis of experimental results and model development is necessary. On the other hand, on the software side, in addition to numerical models, it is essential to maintain and grow a community of researchers who develop and use them. Depending on the scale of the model and the community, it is necessary to set up an appropriate organization, such as a model center, and to pursue methods of releasing models, such as open source, in a manner that upholds modeling diversity. In addition, the Arctic community is encouraged to stably employ human resources who are well-versed in the latest computer science and computer management techniques.

- Human resource development

Medium- to long-term activities are needed to foster young researchers who will be responsible for Arctic research and have an international perspective. To this end, outreach to high school and undergraduate students who have not decided the future research field, and the development and clarification of career paths after obtaining degrees are required, while keeping in mind the need to resolve the current serious gender imbalance. In addition, the program is expected to contribute to the development of young indigenous researchers internationally.

- Research promotion system

Arctic research requires the sharpening of specialized fields and interdisciplinary collaboration. In addition, there is a need not only to explore scientific truths but also to connect with society, such as industry and resource development, and government agencies and local governments that carry out policy activities. International movements in Arctic research are diverse and change rapidly, and international cooperation is frequently called for. To respond quickly and appropriately to these global trends, researchers should strengthen their activities, build cooperative systems, obtain information on international trends, and participate in domestic and international decision-making.

Submitted together with:
JCAR (2023): Executive Summary of Long-term Plan for Arctic Environmental Research.

References:

Japan Consortium for Arctic Environmental Research (2024a). Executive Summary of Long-term Plan for Arctic Environmental Research. https://www.jcar.org/e/longterm/

Japan Consortium for Arctic Environmental Research (2024b). Long-term Plan for Arctic Environmental Research. In press. [in Japanese]