Revision of Master Plan Proposal ‘Frontier of Polar Science’ - Study on Global Environmental Change through Development of the Antarctic and Arctic Observations -

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Our proposal for the Master Plan 2017 of large scale research projects by Science Council of Japan is to install a platform in the polar region in order to contribute to the understanding the global environmental change by providing invaluable information from the Antarctic and the Arctic region. This proposal was discussed by a joint IASC and SCAR working group in Science Council of Japan, and submitted by National Institute of Polar Research. This paper presents the background, the outline of the proposal and the revision for Master Plan 2020.

The global environmental change attains great interest by the governments and general public, as well as scientists on the earth and planets. The Arctic and the Antarctic regions significantly affect global environment and also provide invaluable information on its variation. In the Arctic region, for example, temperature increase due to the global warming is the largest on the globe. The climate change is most significantly emerging which causes change of ecology, human economic activity and life. On the other hand, very little is known on the response of the huge Antarctic ice sheet to the global warming, and hence a possible change in Antarctica on a global scale and its prediction are of greatest interest. Variations in the polar regions are not independent but teleconnected through ocean and atmospheric circulations, and therefore it is necessary to consider them to be one unified system. Moreover, the Arctic and Antarctic regions are the best observation and/or investigation field for space/planetary sciences, atmospheric/hydrospheric sciences, and solid earth sciences, indicating that the polar regions are important windows for earth and planetary sciences.

Keywords: polar science, Antarctic, Arctic

Abrupt changes and interactions of polar oceans and ice sheets as a research subject in Master Plan 2020

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Ice sheets and polar oceans are fundamental components of unique environments in the Antarctic and Arctic regions. The Antarctic ice sheet, which stores ~90% of entire ice on the globe, is interacting with the surrounding Southern Ocean characterized by Antarctic Circumpolar Current and Coastal Current. In the Arctic, the Greenland ice sheet is situated at a corner of the Arctic Ocean, discharging freshwater and sediments into the ocean from numbers of outlet glaciers. Both in the Antarctic and the Arctic, changes in the ocean are affecting mass balance of the ice sheets, and in turn physical and chemical conditions of the ocean are influenced by freshwater discharge from the ice sheets. Further, the changes in the oceans and ice sheets affect not only on polar systems, but also give imact on global environments, such as sea level rise and thermohaline circulations. Thanks to recent advance in remote sensing and numerical modelling techniques, as well as increasing amount of field data collected in the field, overview of the ocean and ice sheet systems is progressively understood. However, changes at the deeper regions in the ocean and the interior of the ice sheets are difficult to observe, and processes occurring at the ice-ocean interface are complex. Thus, further effort is needed to better understand recent changes in the polar oceans and ice sheets, mechanisms connecting the ocean to the mass change of the ice sheets, consequences of ice sheet changes to the polar oceans, and how these interactions between the ocean and the ice sheets drive global environmental changes. With this background, we present recent progress in the understanding of the polar oceans and ice sheets, and propose techniques, instruments, facilities and observational platforms, which are needed to tackle the problems for the next 5-10 years. For example, construction of a new icebreaker for operation both in the Arctic and Antarctica should help a breakthrough in the field of polar science. Development and utilization of AUV (autonomous underwater vehicle) and ROV (remotely operated vehicle) would be strong tools for understanding of the key processes of glacier-ocean interaction. The objectivce of the presentation is to stimulate discussion among the polar, ocean and ice sheet researchers to develop a research plan for Master Plan 2020 to be called by Science Council of Japan.

Keywords: Antarctica, Arctic, ice sheet, ocean

Interpretation of both-polar environmental variability through the investigation of sea ice variability

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Sea ice area has been continuously monitored by satellite observations since 1970’s. Long-term record of sea ice area to date reveals prominent difference between sea ice areas in the Arctic Ocean and the Southern Ocean. Drastic sea ice reduction has been observed, especially after 1990’s in the Arctic Ocean, while sea ice area has gradually increased in the Southern Ocean. Although sea ice variability is considered to be the response to recent climate change, no detailed mechanisms controlling these different results is explained. To understand sea ice variability, which is one of the key mechanisms for global climate variability, the integrated/multidisciplinary investigation is quite indispensable for both polar oceans, where shows different sea ice dynamics.

Sea ice variability is affected by the variability of atmosphere, ice sheet and ocean. Also sea ice variability modulates the variability of atmosphere, ice sheet, ocean and ecosystems. The atmosphere-ice-ocean system with their complicated interaction is still unclear, even the research for each process has been carried out. Resolving the mechanisms of this complicated system could contribute to forecasts of climate variability/weather/ice-navigation and conservation of ecosystem. However, few research groups cannot do this kind of effort. Hence, interdisciplinary and comprehensive research activity is needed.

Until now, the investigations in both polar oceans using available satellite observations, numerical simulation, and ice-strengthened vessel have been conducted in Japan. However, observations of the atmosphere above sea ice, the ocean underneath sea ice and ice sheet close to sea ice are big challenges for us due to the existence of sea ice. To overcome this situation, installation of Japanese own icebreaker, which can conduct direct measurements in sea ice area, is most effective solution.

Currently, Japanese research activities are usually conducted on the other country’s icebreaker because Japan does not have our own icebreaker. However, the utilization of academic icebreaker will enable us to conduct interdisciplinary observational research covering the atmospheric science, glaciology, oceanography, and submarine geology. Furthermore, interdisciplinary observational research with icebreaker in both polar oceans will contribute to the interpretation of earth environmental variability through the investigation of sea ice variability. Installation of icebreaker, which is needed for breakthrough in polar science and the study of climate change, will open the door which leads to a new stage of global climatic and environmental science.

Keywords: both polar oceans, sea ice variability, atmosphere-ice-ocean system, research icebreaker

Sea ice changes evidenced in the both polar regions

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Sea ice in the Arctic has recorded decreasing trend of area and thickness, and significant decreas was happen in 2012. Sea ice area in 2016 was 2nd lowest record. After seasonal minimun. ice recovering speed was low and lowest ice covered area has recorded until now.
On the other hand, sea ice area in the Southern Ocean recorded maximum in Autumn of 2014, however, next year, in July 2015, the ice covered area quited the expand even the middle of freezing season. namely, the sea ice area became the minimum year of the record. As the reduced areal condition has been continued since then, the total sea ice coverage, the sum of Arctic and Southern Ocean showed drastic drop in 2016.
Discussions on climate change and prediction such as IPCC, the future decline of Arctic sea ice is a well defined concern, large varaibility of sea ice around Antactica and uncertainty of future prediction are concern. This presentation introduces recent large variation of sea ice in polar regions aiming to provide available information for discussions on big project.

Keywords: Arctic, Antarctic, Sea ice, Climatic change, Polar observation

Japanese contribution to the Year of Polar Prediction (YOPP)

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To evaluate the impact of additional observation on the predictability of weather and sea-ice patterns at high latitude and beyond, Japan has contributed to establishing an experimental Arctic observing network as part of an international collaboration. It was shown that the incorporation of additional Arctic observations improves the initial analysis and enhances the skill of weather and sea-ice forecasts. Based on these achievements, Japan will extend this activity during the Year of Polar Prediction (YOPP), from mid-2017 to mid-2019, under the Japanese flagship projects, called ArCS (Arctic Challenge for Sustainability) and JARE (Japanese Antarctic Research Expedition). Using a data assimilation technique and observation data obtained from ships, land stations and drifting buoys under international collaborations, the impact of additional polar observations on predicting extreme evens in local (e.g. along Northern Sea Route) and remote regions (e.g. extreme weather events at mid-latitudes) will be assessed, contributing to optimizing a sustainable polar observing network on a cost-benefit basis.

Keywords: Arctic & Antarctic, numerical predictions for weather and sea ice, observations & modelings

Towards drilling of deep ice core exceeding 1 Ma for reconstructing past climate

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In the next phases of Antarctic glaciological research, National Institute of Polar Research together with Dome Fuji Ice Core Consortium (ICC) plans to perform various activities related to the third deep ice-core drilling in the vicinity of Dome Fuji, in order to obtain the “oldest ice” with age much older than 800 kyr. This is also a contribution to International Partnership in Ice Core Sciences (IPICS), which defines the oldest ice project as most challenging. During the next six years (JARE Phase IX), we (i) investigate glaciological conditions (ice sheet surface conditions, englacial conditions and subglacial conditions) of the candidate site area; (ii) determine the exact location of the drilling site, and (iii) start pilot hole drilling, casing and shallow/middle range deep drilling. The drilling will then continue to reach the bedrock and obtain the old ice core.

Keywords: Antarctic ice core, Climate change, Glacial-interglacial cycles

