The 13th Symposium on Polar Science

15 – 18 November 2022

National Institute of Polar Research
Research Organization of Information and Systems

Session S

Towards the next six-year Japanese Antarctic Research Project (phase X)

Program and Abstracts

Conveners
Yoshifumi Nogi, Gen Hashida, Akira Sessai Yukimatu, Yuichi Aoyama, Akinori Takahashi, and Takeshi Tamura (NIPR)

【S】Towards the next six-year Japanese Antarctic Research Project (phase X)

Scopes

The current six-year Japanese Antarctic Prioritized Research Project (phase IX), focusing on the "Investigation of changes in the Earth system from Antarctica," will be terminated this year (the fiscal year 2022) by the end of the wintering-over of the 63rd Japanese Antarctic Research Expedition. At the same time, a new six-year Prioritized Research Project (phase X) with the interdisciplinary scientific theme of "The future global environment system as inferred through investigating the past and present of the Antarctic" will commence. In common with phase IX, both Ordinary and Exploratory category research projects will also be conducted during phase X, along with routine and monitoring observations. The development and direction of future Antarctic research will be discussed by summarizing the results from phase IX and looking forward to new challenges and opportunities in phase X.

Conveners : **Yoshifumi Nogi, Gen Hashida, Akira Sessai Yukimatu, Yuichi Aoyama, Akinori Takahashi, and Takeshi Tamura (NIPR)**

Real-time Oral presentations (10:00 – 12:00, 13:30 – 16:30)

Date: Tue. 15 November

Note: [I] represents an invited talk.

Chair: Gen Hashida (NIPR)			
	10:00 - 10:10	Opening address by the director-general of NIPR	*Takuji Nakamura (NIPR)
	10:10 - 10:20	Towards the next six-year Japanese Antarctic Research Project (phase X)	*Yoshihumi Nogi (NIPR)
So1	**10:20 - 10:50**	Global Atmospheric System Probed by Close Observations of Antarctic Atmosphere	*Kaoru Sato (The University of Tokyo), Masaki Tsutsumi (NIPR, SOUKENDAI), Takuji Nakamura (NIPR, SOUKENDAI), Toru Sato (Kyoto University), Akinori Saito (Kyoto University), Yoshihiro Tomikawa (NIPR, SOUKENDAI), Koji Nishimura (RISH, Kyoto University), Masashi Kohma (The University of Tokyo), Taishi Hashimoto (NIPR, SOUKENDAI), Mitsumu K. Ejiri (NIPR, SOUKENDAI), Takuo T. Tsuda (The University of Electro-Communications), Takanori Nishiyama (NIPR, SOUKENDAI), Makoto Abo (Tokyo Metropolitan University), Takuya D. Kawahara (Shinshu University), Akira Mizuno (ISEE, Nagoya University), Tomoo Nagahama (ISEE, Nagoya University), Hidehiko Suzuki (Meiji University), Ryuho Kataoka (NIPR, SOUKENDAI), Yoshimasa Tanaka (NIPR, SOUKENDAI)
So2	**10:50 - 11:20**	Achievements of Research of Ocean-ice BOundary InTeraction and Change around Antarctica (ROBOTICA)	*Shigeru Aoki (Hokkaido University), Takeshi Tamura (National Institute of Polar Research), Team ROBOTICA
So3	**11:20 - 12:00**	Third Dome Fuji Deep Coring: an Oldest Ice Core	*Kenji Kawamura (NIPR), Third Dome Fuji Project Members

Lunch			
Chair: Akinori Takahashi (NIPR)			
So4	**13:30 - 14:00**	The Heart of the East AnTarctic Cryosphere-Ocean Synergy System (HEAT-CROSS)	*Kohei Mizobata (Tokyo University of Marine Science and Technology), Daisuke Hirano (National Institute of Polar Research), Ryosuke Makabe (National Institute of Polar Research), Takeshi Tamura (National Institute of Polar Research)
So5	**14:00 - 14:30**	A study of global atmospheric circulation variability explored through comprehensive observations with the large atmospheric radar and complementary techniques	*Masaki Tsutsumi (NIPR & SOKENDAI), Kaoru Sato (University of Tokyo), Toru Sato (Kyoto University), Takuji Nakamura (NIPR & SOKENDAI), Akinori Saito (Kyoto University), Yoshihiro Tomikawa (NIPR & SOKENDAI), Koji Nishimura (Kyoto University), Masashi Kohma (University of Tokyo), Taishi Hashimoto (NIPR & SOKENDAI), Mitsumu K. Ejiri (NIPR & SOKENDAI), Hidehiko Suzuki (Meiji University)
So6	**14:30 - 14:50**	Glacier, grounding line and ice shelf dynamics — the driver of the rapid mass loss of the Antarctic ice sheet —	*Shin Sugiyama (Hokkaido University), Chiyuki Narama (Niigata University), Masahiro Minowa (Hokkaido University), Takanobu Sawagaki (Hosei University), Masashi Niwano (Meteorological Research Institute), Tsutomu Yamanokuchi (RESTEC), Kazuki Nakamura (Nihon University), Yuichi Aoyama (NIPR)
	14:50 - 15:10	Break	
Chair: Akira Sessai Yukimatu (NIPR)			
So7	**15:10 - 15:30**	Reconstruction of the East Antarctic Ice Sheet variability and understanding of the abrupt ice mass loss	Yusuke Suganuma (NIPR & SOKENDAI), Takeshige Ishiwa (NIPR & SOKENDAI), *Jun'ichi Okuno (ROIS, NIPR & SOKENDAI), JARE Prioritized Research Sub-Theme 1-2 Project members
So8	**15:30 - 15:50**	Clouds, aerosols, and atmospheric circulations over the Southern Ocean	Jun Inoue (NIPR & SOKENDAI), Kazutoshi Sato (Kitami Institute of Technology), Atsushi Yoshida (NIPR), *Yutaka Tobo (NIPR & SOKENDAI), Yoshihiro Tomikawa (NIPR & SOKENDAI), Yuji Yoshida (Kitami Institute of Technology), Fumiyoshi Kondo (Japan Coast Guard Academy), Yasushi Uji (NIED), Shingo Shimizu (NIED), Kosuke Noborio (Meiji University), Takuji Waseda (The University of Tokyo)
So9	**15:50 - 16:10**	Space environmental changes and their effects on the Earth's atmosphere explored from the polar cap region	*Ryuho Kataoka (NIPR)
So10	**16:10 - 16:30**	Crustal architecture of the Indian Ocean Sector of the Antarctic continent: summary of the current phase IX and towards the next phase X (JARE 65-)	*Tomokazu Hokada (NIPR & SOKENDAI), JARE geology group

Global Atmospheric System Probed by Close Observations of Antarctic Atmosphere

Kaoru Sato[1], Masaki Tsutsumi[2,3], Takuji Nakamura[2,3], Toru Sato[4], Akinori Saito[4], Yoshihiro Tomikawa[2,3], Koji Nishimura[4], Masashi Kohma[1], Taishi Hashimoto[2,3], Mitsumu K. Ejiri[2,3], Takuo T. Tsuda[5], Takanori Nishiyama[2,3], Makoto Abo[6], Takuya D. Kawahara[7], Akira Mizuno[8], Tomoo Nagahama[8], Hidehiko Suzuki[9], Ryuho Kataoka[2,3], and Yoshimasa Tanaka[2,3]

[1]*The University of Tokyo*, [2]*National Institute of Polar Research*, [3]*The Graduate University for Advanced Studies, SOKENDAI*, [4]*Kyoto University*, [5]*The University of Electro-Communications*, [6]*Tokyo Metropolitan University*, [7]*Shinshu University*, [8]*Nagoya University*, [9]*Meiji University*

A major issue in climate models used to predict future climate including global warming is how to incorporate the effects of relatively small-scale atmospheric waves called atmospheric gravity waves (GWs) having horizontal wavelengths from 10 to 1000 km. In this project, the PANSY radar, a large atmospheric radar capable of observing wind velocity fluctuations associated with atmospheric gravity waves over Syowa Station in unprecedented detail, will be combined with various observation instruments that use radio waves and light to measure temperature and material distribution. The goal is to clarify the role of atmospheric gravity waves in the large-scale dynamical variablity in the atmospheric system including general circulation and interhemispheric coupling.

We are leading an international joint research project, Interhemispheric Coupling Study by Observations and Modelling (ICSOM), which targets an interesting interhemispheric coupling (IHC) discovered in the late 2020: when warming occurs in the winter polar stratosphere, the upper mesosphere in the summer hemisphere also becomes warmer with a time lag of days. This IHC phenomenon is considered to be a coupling through the processes in the middle atmosphere, i.e., the stratosphere, mesosphere, and lower thermosphere. Several plausible mechanisms have been proposed so far, but still controversial. This is mainly because of the difficulty in studying GWs having small scales which are hard to be observed and simulated, regardless of their important role in the middle atmosphere dynamics. In this project, by networking sparsely but globally distributed radars including the PANSY radar and MF radar at Syowa Station, mesospheric GWs have been simultaneously observed in seven boreal winters since 2015/16. We have succeeded in capturing five stratospheric sudden warming events and two polar vortex intensification events. This project also includes the development of a new data assimilation system to generate long-term reanalysis data for the whole middle atmosphere, and the simulations by a state-of-art GW-permitting general circulation model using the reanalysis data as initial values. By analyzing data from these observations, data assimilation, and model simulation, comprehensive studies are ongoing to elucidate the mechanism of IHC. In this talk, we will show the overview and progress of ICSOM.

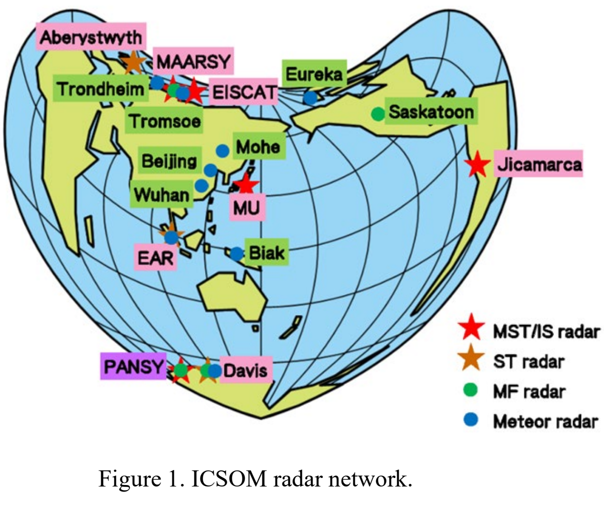

Figure 1. ICSOM radar network.

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Achievements of Research of Ocean-ice BOundary InTeraction and Change around Antarctica (ROBOTICA)

Shigeru Aoki[1], Takeshi Tamura[2] and Team ROBOTICA
[1] *Institute of Low Temperature Science, Hokkaido University*
[2] *National Institute of Polar Research and Team ROBOTICA*

The Antarctic and surrounding Southern Ocean are changing. Acceleration of ice mass loss and warming of the coastal ocean in West Antarctica are the problems of substantial impacts on the global climate system. In East Antarctica, which has been considered to be stable and attracted relatively less attention, regional characteristics of interactions among climate subsystems have been recently revealed and potential evidences of variations on various time scales from decades to millennium have been accumulating. Off Sabrina Coast, Wilks Land, underneath the Totten Glacier Ice Shelf, whose drainage system as a whole has a potential of 3.5m rise of global sea level and ice discharge is accelerating, a potential pathway of warm water access has been discovered (Greenbaum et al., 2015). Along the East Antarctic coast, sea ice formation and subsequent brine rejection in polynyas, including Cape Darnley Polynya as the head of the list, result in production of Dense Shelf Water and lead to the export of bottom water (Ohshima et al., 2013; Kitade et al., 2014). In the Lützow-holm Bay off Enderby Land, decadal or longer-term variabilities of sea ice condition have been observed (Ushio, 2006). Despite the global impact of these coastal variabilities, investigations of the mechanisms and variabilities in East Antarctica are insufficient.

Under the project called ROBOTICA for the 9th six-year plan (2016-2023), we planned to utilize state-of-the-art unmanned observations such as under-ice oceanographic, seafloor and cryospheric observations using ROV/AUVs, geodetic network observations of ice/ocean motion and deformation using GPS/ GNSS, and oceanographic observations using tethered and moored profiling observation systems to acquire the detailed environmental information both in time and space. With these implementations, we made intensive, interdisciplinary observations for the three typical regions of importance (Fig. 1).

In Lützow-holm Bay the warm water heat supply and ice-ocean interaction has been clarified. In front of Shirase Glacier, our shipboard hydrography has detected the warm water inflow through the deep glacial canyon and subsequent meltwater outflow in the upper layer (Hirano et al., 2020). Direct measurements through the ice shelf of the Langhovde Glacier provided the evidence of the under-ice ocean circulation melting the ice from the below (Minowa et al., 2021). Weddell seals captured the access of deep near-surface warm water even in autumn (Kokubun et al., 2021). For the ice system, satellite measurements clarified the interannual changes in motion of landfast sea ice and Shirase Glacier Tongue, indicating the mutual interactions (Nakamura et al., 2022) and in-situ measurements revealed the interannual variability in sea ice properties (Sahashi et al., 2022).

For the region off Cape Darnley Polynya significant progress have been made for the understanding in the sea ice and dense water formation processes. The minimum of sea ice cover in 2017 has provided the excessive heat in melting the Amery Ice Shelf to anomalously freshen the Cape Darnley Polynya (Aoki et al., 2022). These changes in summer environment can change the relatively stable sea ice production in winter so far (Tamura et al., 2016) for the coming decades. The findings are possible with the technical deployment of a state-of-the-art tethered profilers (Aoki et al., 2020).

Off Sabrina Coast, we conducted intensive oceanographic and geophysical observations during Dec. 2019 and Feb.-Mar. 2020 as a program of 61st Japanese Antarctic Research Expedition (JARE61) for the first time. Bathymetric survey with multi-narrow beam were effective and describes new and detailed topographic features. Hydrographic measurements, including

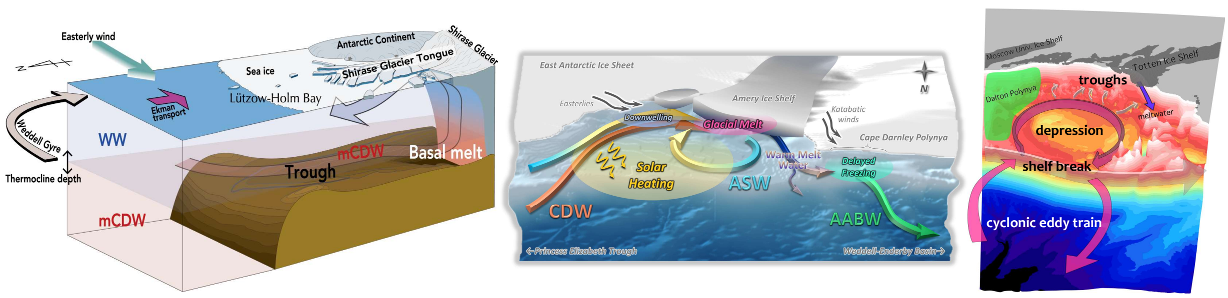

Fig. 1 Schematic diagrams for the ice-ocean environment and interactions. (left) Lützow-holm Bay, (middle) Prydz Bay/off Cape Darnley, and (right) off Sabrina Coast.

CTD/MS and XCTD, revealed the ubiquitous presence of deep warm water in this region. Air-borne XCTD and XBT helped enhance the spatial sampling in difficult access area, and largely expand the distribution of water mass property (Nakayama et al., in press). Warm water was found near the bottom throughout the study area, with its temporal change from days to years scales (Hirano et al., in revision) and shapes the nutrient and other chemical water compositions (Tamura et al., in press).

Analysis of samples obtained by ROBOTICA is on-going for the chemical, biological, and ecological studies. A new species of "mud dragon" was identified from the sediments (Yamasaki et al., 2022). Sediments and their cores were taken for the first time in this region were conducted at the marginal ice zone off Dolton Polynya, which will shed new light on the quaternary environmental change. Chemical composition of sea water will provide insight on the carbon cycle in the Southern Ocean. Our interdisciplinary achievements have promoted an acceleration in understanding of the sector and provided a big step forward for realization of sustained observation system around Antarctica.

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Third Dome Fuji Deep Coring: an Oldest Ice Core

Kenji Kawamura[1,2,3], on behalf of the Third Dome Fuji Project
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[3]*Japan Agency for Marine Science and Technology (JAMSTEC)*

Ice cores collected from the Antarctic ice sheet are time capsules that enable us to reconstruct the past environmental changes such as temperature, atmospheric composition, dust and aerosols, from local to global scales. Two deep ice cores haven been drilled at Dome Fuji, East Antarctica, which contain continuous environmental signals over the past 720,000 years. The Dome Fuji core is the second oldest deep ice core next to the EPICA Dome C core that is 800,000-years old (the third oldest core is the Vostok core with 420,000 years). These coring sites have basal melting; thus, the older ice does not exist beneath these sites.

The International Partnership in Ice Core Sciences (IPICS) has proposed "Oldest Ice Core" project since the early 2000s, which aims to collect ice cores dating back to 1.5 million years ago, covering the climatic transitional period (Mid-Pleistocene Transition) when the periodicity of glacial-interglacial cycles changed from ~40,000 to ~100,000 years. Such old ice cores may be collected around the inland domes and ridges of East Antarctica, given that the ice sheet is frozen to bedrock (thinner ice and/or smaller geothermal heat flux) and horizontal flow is slow. As emphasized by IPICS, to ensure the reliability of data from the oldest ice cores, it will not be enough to drill only one ice core at one site in Antarctica, because the old ice layers are expected to only exist in the layers within 100 – 200 m from the bedrock where the ice is warm and the thinning is extreme. This, it is highly important to collect multiple ice cores from different regions and compare the results, which can only be done with the international efforts. The European and the Australian projects have determined the drilling sites near Dome C, and other countries aim to drill ice cores at different sites. The drillings in the different regions are complementary towards the ultimate goal of obtaining the reliable climatic records.

With these backgrounds, the Japanese Antarctic Research Expedition (JARE) has conducted its inland activities to locate potential sites for collecting an Oldest Ice Core in the Dome Fuji region. During its Phase IX 6-year program, JARE carried out ground-based glaciological surveys to select deep drilling points near Dome Fuji where old ice may exist. In JARE 59, 60, and 63, extensive field activities including radar surveys were conducted, mainly in the southern area of the Dome Fuji region. Currently, the optimal drilling site is being investigated through the analyses of the data obtained from these activities combined with numerical modeling of the ice sheet.

In the JARE Phase X, the main construction of the drill site will take place in JARE 64 and 65, and the deep drilling (from on-site preparation to reaching the bedrock) is expected to progress from JARE 65 to 68, in parallel to the further developments (in Japan) and deployment of deep drill and logging device, as well as new technologies such as deviation drilling and rock coring towards the last part of the Phase X. The main outcome of our Phase X project will be the acquisition of the ice core dating back more than one million years (the analyses and research will require budgets outside JARE). The analyses of the old ice cores for various species such as water isotopes, impurities and gaseous components that record regional- to global-scale climate changes may shed light on the unresolved climatological questions such as the causes and processes of the Mid-Pleistocene Transition. The scientific activities other than deep ice coring include glaciological observations from the coastal to inland regions for better understanding of the recording processes of environmental parameters on the ice sheet, near-surface snow and firn properties (such as critical factors for surface albedo), as well as surface mass balance and precipitation.

The Heart of the East AnTarctic Cryosphere-Ocean Synergy System (HEAT-CROSS)

Kohei Mizobata[1], Daisuke Hirano[2], Ryosuke Makabe[2] and Takeshi Tamura[2]
[1]*Department of Ocean Sciences, Tokyo University of Marine Science and Technology*
[2]*National Institute of Polar Research*

The future response of Antarctic ice sheet melting is a major uncertainty in future projections of global sea level rise. The melting of the Antarctic ice sheet has been observed not only in West Antarctica, but also in East Antarctica, which has a huge ice volume in recent years. Warm water inflow and associated melting has already been observed at Shirase Glacier, Amery Ice Shelf and Totten Ice Shelf. For the Totten shelf, efficient poleward transport processes of warm Circumpolar Deep Water by the standing cyclonic eddies in the Australian-Antarctic Basin have been revealed (Mizobata et al., 2020; Hirano et al., 2021). Current climate models do not incorporate this process at least in East Antarctica. Spatiotemporal variability of the warm water inflow and its dominant factors need to be clarified in order to predict the future response of ice sheets. In addition, freshwater discharge due to the enormous ice sheet melt will not only raise sea level but also cause changes in the quality of sea ice produced, lower density of Antarctic Bottom Water (Shimada et al., 2022), and changes in marine ecosystems and carbon cycles (Takahashi et al., 2022). We will focus on the cryosphere-ocean synergy system and coastal-open ocean interaction, and conduct in-situ observations by research vessels such as SHIRASE in coastal and open ocean regions for the next six years. For the field observations, we plan to install mooring systems to enable year-round observations, in addition to the usual hydrographic observations. Satellite observations and numerical modeling will also be incorporated to optimize the design of field observations and the integration of findings. Through these efforts, the causes and effects of the melting process of the East Antarctic ice shelves, especially the Totten Ice Shelf, will be clarified.

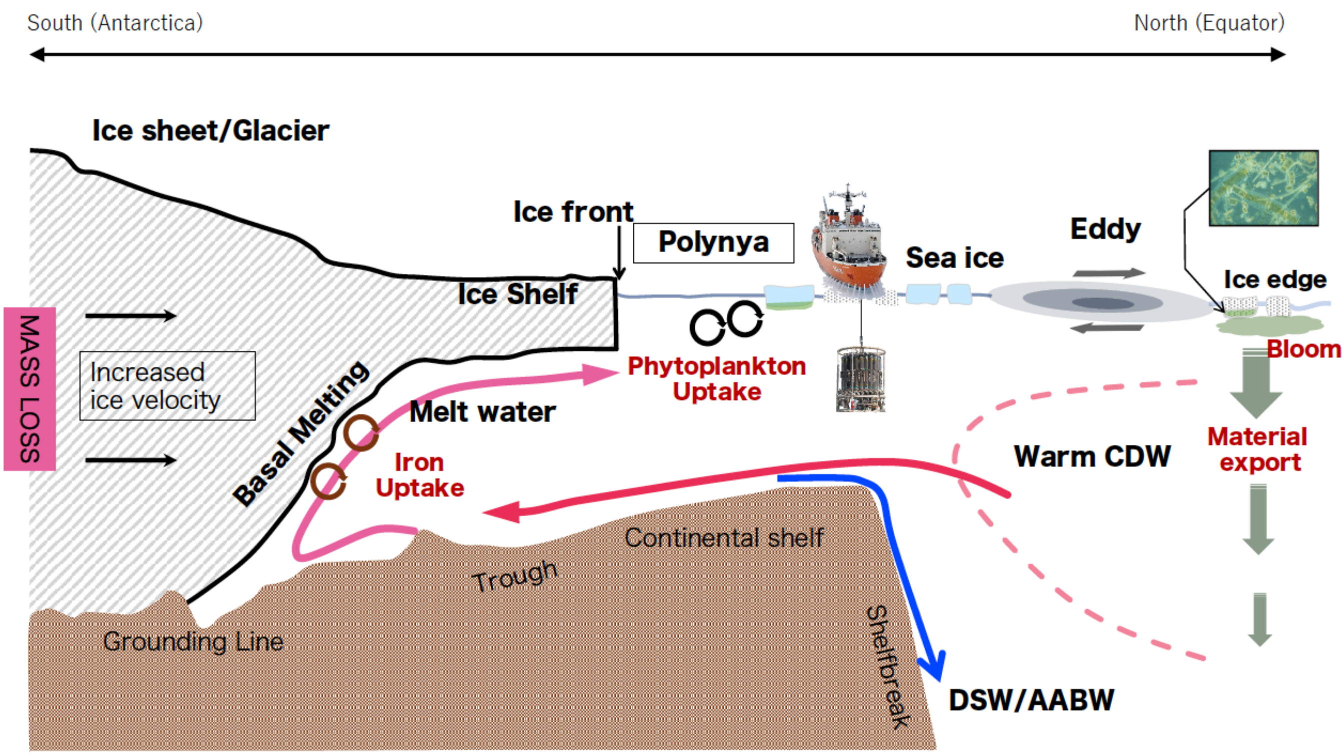

Figure 1.　Various processes to be focused on in this project.

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A study of global atmospheric circulation variability explored through comprehensive observations with the large atmospheric radar and complementary techniques

Masaki Tsutsumi[1,2], Kaoru Sato[3], Toru Sato[4], Takuji Nakamura[1,2], Akinori Saito[4], Yoshihiro Tomikawa[1,2], Koji Nishimura[4], Masashi Kohma[3], Taishi Hashimoto[1,2], Mitsumu K. Ejiri[1,2], Hidehiko Suzuki[5]

[1]*National Institute of Polar Research,* [2]*The Graduate University for Advanced Studies, SOKENDAI,*
[3]*The University of Tokyo,* [4]*Kyoto University,* [5]*Meiji University*

For the comprehensive understanding of the behavior of Antarctic atmosphere and also the global atmosphere we have been conducting integrated atmosphere observations at the Syowa station (69S, 39E) since the phase VIII of Japanese Antarctic Research Expedition (JARE) (JARE 52 to 57: 2011-2016) as one of the prioritized JARE projects, using a large aperture atmospheric radar (the PANSY radar) as the core facility together with various radio and optical instruments. The PANSY radar started continuous observations of mesosphere, stratosphere and troposphere (MST) using its quarter system in 2012, and after a few years of system adjustment the whole radar system consisting of over 1000 Yagi antennas has been fully operational since October 2015 through the whole phase IX.

In the phase X (JARE 64 to 69: 2023-2028) we will continue the comprehensive atmosphere observations in the Antarctic in a wide height range with complementary observation facilities such as the MF radar for mesosphere and lower thermosphere winds and the airglow radiometer for OH rotational temperature at the mesopause region. We will be able to successfully create a long time data base exceeding one solar cycle by the end of the JARE X, which is useful for the study of various atmospheric phenomena with a wide range of periodicities from several minutes to a solar cycle. In addition, advanced observation techniques are to be more often conducted during the phase X such as various spatial and range imaging measurements and ionosphere measurements by fully utilizing the high versatility of the PANSY system.

We are also planning to conduct super pressure balloon (SPB) observations of atmospheric gravity waves over the Antarctic continent in order to directly study the horizontal structure of Antarctic atmosphere. Its first test experiment was successfully conducted in the summer season of January –February 2022 prior to the phase X, and more intense operations throughout a year are scheduled during the phase X.

Interdisciplinary collaborations are also planned with other prioritized JARE projects. The importance of high quality Antarctic atmosphere data for weather forecasting is to be tested by incorporating PANSY data in a weather forecasting system. The influence of energetic particles precipitating from the ionosphere and magnetosphere on the polar atmosphere is studied, and the effects on the ionosphere by the atmospheric waves propagating from below are also studied.

Glacier, grounding line and ice shelf dynamics
— the driver of the rapid mass loss of the Antarctic ice sheet —

Shin Sugiyama[1], Chiyuki Narama[2], Masahiro Minowa[1], Takanobu Sawagaki[3], Masashi Niwano[4], Tsutomu Yamanokuchi[5], Kazuki Nakamura[6] and Yuichi Aoyama[7]

[1]*Hokkaido University,* [2]*Niigata University,* [3]*Hosei University,* [4]*Meteorological Research Institute,* [5]*Remote Sensing Technology Center of Japan,* [6]*Nihon University,* [7]*National Institute of Polar Research*

Recent observations show mass loss of the Antarctic ice sheet along the coast. The loss of ice is attributed to increasing amount of ice shelf basal melting and subsequent retreat of grounding line, which leads to acceleration of outlet glaciers. Overview of the changes are reported by satellite remote sensing, but in-situ measurements are necessary to understand the mechanisms driving the changes occuring at glaciers and ice shelves. To improve our understanding of dynamic changes observed at Antarctic outlet glaciers, grounding line and ice shelf, we perform field observations on outlet glaciers teminating in Lützow-Holm Bay, East Antarctica (Figure 1 left).

We plan field campains under the framework of Japanese Antarctic Research Expedition in the austal summers in 2023/24 and 2026/27. The activity in 2023/24 is focused on ground-based and airborne measurements of glacier and ice sheet surfaces (Figure 1 middle). We utilize geophysical instruments (e.g. GNSS, seismic sensor, ice radar) to investigate the mechanisms of ice flow, calving, subshelf melting and grounding line migration. Measurements are also performed by devices mounted on an aircraft, helicopter and unmanned aerial vehicle. Using the two different approaches, we acquire data in high temporal and spatial resolutions, as well as those covering a broad area and glaciers inaccessble on foot. During the second field campaing in 2026/27, a hot-water drilling system is used to drill boreholes for subglacial and englacial measurements (Figure 1 right). Based on our experience of previous borehole studies in the region (Sugiyama et al., 2014; Minowa et al., 2022), glacier dynamics and its interaction with the ocean are investigated by direct observations. Borehole data will be analyzed with aids of surface measurements, so that a link between subglacial processes and glacier dynamics is accurately understood.

In the presentation, we introduce recently performed hot-water drilling on Langhovde Glacier, as well as the background and overview of the research project. The goal of the presentation is to brush up and refine our research plans through discussion with the audience.

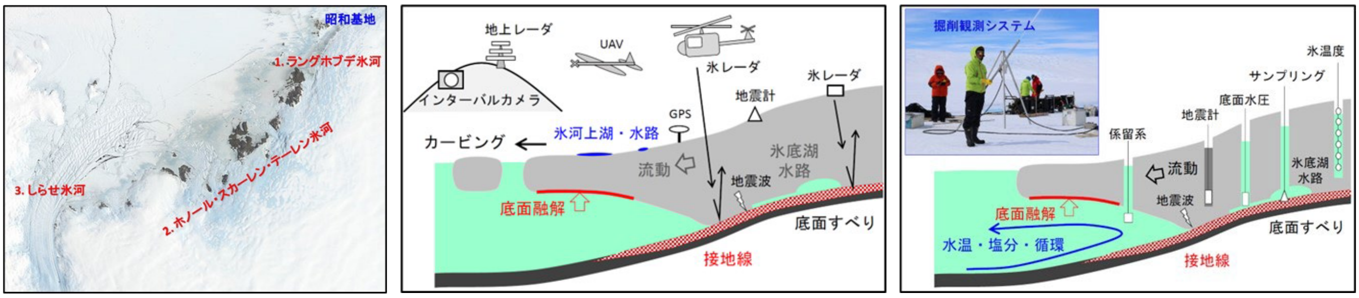

Figure 1. (Left) Study site of the project, outlet glaciers terminating in Lützow-Holm Bay, East Antarctica. Research activities planned in the project: (middle) surface measurements on and above the glacier and (right) hot-water drilling and borehole measurements.

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Reconstruction of the East Antarctic Ice Sheet variability and understanding of the abrupt ice mass loss

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Recent advances in satellite gravimetry and ice-sheet modelling have yielded refined estimates of East Antarctic Ice Sheet (EAIS) mass balance and allowed for a reexamination of its response to global climatic changes. However, because space-geodetic observations of ice-sheet change only exist for a few decades, EAIS behavior before the 1970s remains largely unknown. Modelling studies of ice-sheet sensitivity to climate change and sea-level rise also require well-constrained records of past ice-sheet changes for model validation and refinement. Together, these factors highlight the need for long-term glacio-geological records of EAIS changes. Therefore, we proposed a new project, Sub-Theme 1-2 "Reconstruction of the East Antarctic Ice Sheet Variability and Understanding of the Abrupt Ice Mass Loss", in the Phase X Priority Research Program of the Japanese Antarctic Research Program (2022-2026). In this project, we will conduct a seamless sediment coring project, which includes deep-sea sediment coring by using the icebreaker "SHIRASE", lake and shallow marine sediment coring from frozen lake/sea surface, and sediment drilling of the ice-free area along the Antarctic coast using a newly developed sediment coring and drilling system. Furthermore, we aim to reconstruct the EAIS change over the past several hundred thousand years and to elucidate the actual conditions and mechanisms of the rapid and large-scale melting of the ice sheet during the transition during the terminations from glacial periods to interglacial periods. In addition, this project will contribute to international drilling projects, such as the SWAIS-2C project, which will carry out the first sediment coring under the Ross Ice Shelf in West Antarctica. This presentation will outline the research plans and the schedule of the research activities in this project for the next 6 years.

Clouds, aerosols, and atmospheric circulations over the Southern Ocean

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Recent rapid changes in sea-ice decline and loss of ice sheets in polar regions are considered to influence the people living in the mid-latitudes through sea-level rise and extreme weather. However, the climate model used to understand the polar regions' past, present, and future has significant challenges in reproducing sea surface temperature, ocean circulation, and atmospheric circulation, particularly in the Southern Ocean. One of the critical factors is the inability to adequately represent the phase of clouds (liquid water cloud or ice cloud) responsible for the climate system's energy budget. Therefore, it is essential to understand the unique cloud formation process over the Southern Ocean. On the other hand, in the real world, extreme weather phenomena frequently occur in the wake of ocean heat waves, and it is necessary to make precise predictions. Especially in the Southern Hemisphere, there is little observation data for numerical forecasting, so it is desirable to provide high-quality observation data. To this end, it is necessary to consider a sustainable observation system that contributes to forecasting. This project will conduct observational research to elucidate the state of cloud formation processes over the Southern Ocean by the Research Vessel Shirase and a predictability study applying the data from the atmospheric radar system "PANSY" at Syowa Station. This presentation will introduce the shipboard meteorological observation system for the Japanese Antarctic Research Expedition (JARE) in the austral summer of 2022/2023 and the preliminary results of the predictability study using PANSY data.

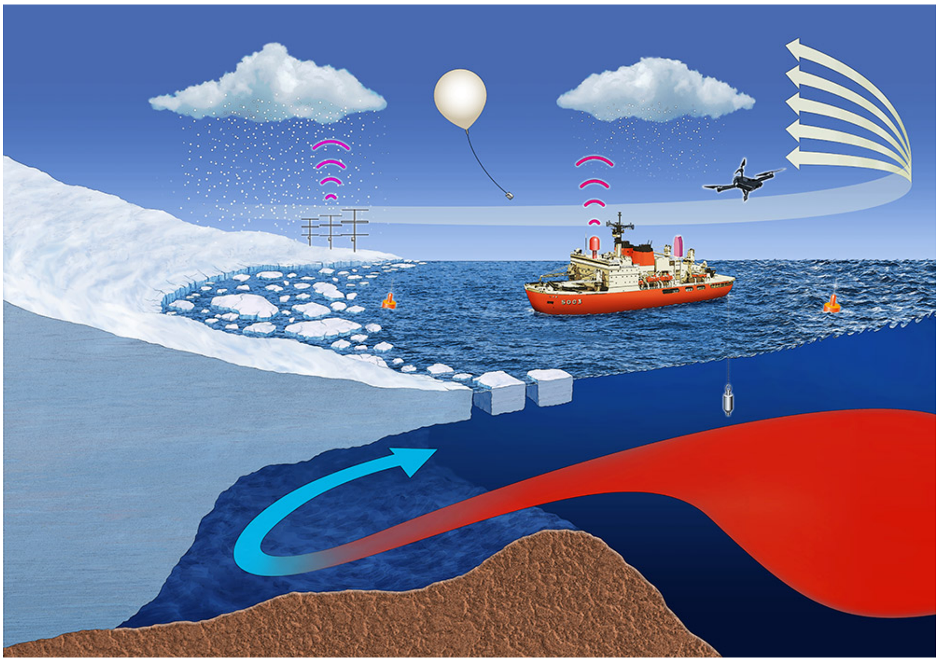

Figure 1. A schematic figure of this research project.

Space environmental changes and their effects on the Earth's atmosphere explored from the polar cap region

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New JARE Prioritized Research Project AJ1007 (Space environmental changes and their effects on the Earth's atmosphere explored from the polar cap region, 2022-2027), “auroraXcosmic project” in short, is supported by NIPR. We are studying space weather and space climate from Antarctica to understand how the Earth system is open to space. Auroras can visualize the atmospheric impact from auroral electrons and solar protons. However, the auroras in the polar cap are less understood because of relatively poor coverage of imaging observations. We will be able to solve the technical problem by developing and distributing new imagers by international collaborations. We will also contribute to real-time cosmic-ray observation network. We will then contribute better understanding of the outer boundary of Earth system, via close collaborations with simulations and data science (data will be open to public).

We are developing a new auroral imager system, including a tough housing bearable for Antarctica. The system will be low-cost, low-power, portable, and the data will be obtained real-time. The first model will be tested in new Dome-Fuji station in 2023, and then be provided or distributed for future international collaboration in Antarctica. High-energy solar protons will also be observed by neutron monitor and muon detector at Syowa Station. During the auroraXcosmic, the cosmic ray observation at Syowa will be full-system in 2024 and real-time data will be obtained every 10 min. Further, we will fully use our heritages: A suit of comprehensive geophysical observations is ongoing at Syowa Station, including SuperDARN, PANSY radar, radio, riometers, high-speed auroral imagers, and magnetometers. Unmanned network observations are also ongoing along the auroral oval via international collaborations.

Crustal architecture of the Indian Ocean Sector of the Antarctic continent: summary of the current phase IX and towards the next phase X (JARE 65-)

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Three projects (AP0915, AP0916, AP0936) of the Japanese Antarctic Research Expedition (JARE) have investigated the basement geology from 10°E to 55°E (the Indian Ocean Sector) of the Antarctic continent during the current phase IX; three seasons (JARE 58, 60, 63) in the Lützow-Holm, the Western Rayner, the Rayner and the Napier Complexes, and one season (JARE 61) in the Sør Rondane Mountains. The projects members are now working on the rock specimen collected during the field work, and several papers have already been published (Dunkley et al., 2020; Baba et al., 2021a, 2021b; Higashino and Kawakami, 2022). This part of the Antarctic continent comprises of deep crustal high-grade metamorphic and plutonic rocks that recorded the geologic history from early Archaean through Proterozoic to earliest Paleozoic over 3 billion years. For these perspecties, the area is considered by many geologiststs as an ideal field for investigating long Earth history and deep crustal processes. Following the temporal geologic summary by Shiraishi et al. (2008), significant scientific advance has been made by the JARE's geology teams (eg., Baba et al., 2019, 2021a, 2021b; Dunkley et al., 2020; Higashino et al., 2019a, 2019b; Higashino and Kawakami, 2022; Hiroi et al., 2019, Hokada et al., 2022; Horie et al., 2016; Kawakami et al., 2016, 2017; Mori and Ikeda, 2018; Satish-Kumar et al., 2021; Suzuki and Kawakami, 2019; Takahashi et al., 2018; Takamura et al., 2018, 2020; Takehara et al., 2020; Tsunogae et al., 2016; Tsubokawa et al., 2017; and referenecs therein). This presentation summarizes the current understanding of the crustal architecture of this part of Antarctica and the plan for the next phase of geology programs (phase-X; JARE 65-).

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