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KOREA
POLAR
RESEARCH
INSTITUTE

2018 ANNUAL REPORT OF KOPRI

KOPRI
Korea Polar Research Institute

2018 ANNUAL REPORT OF

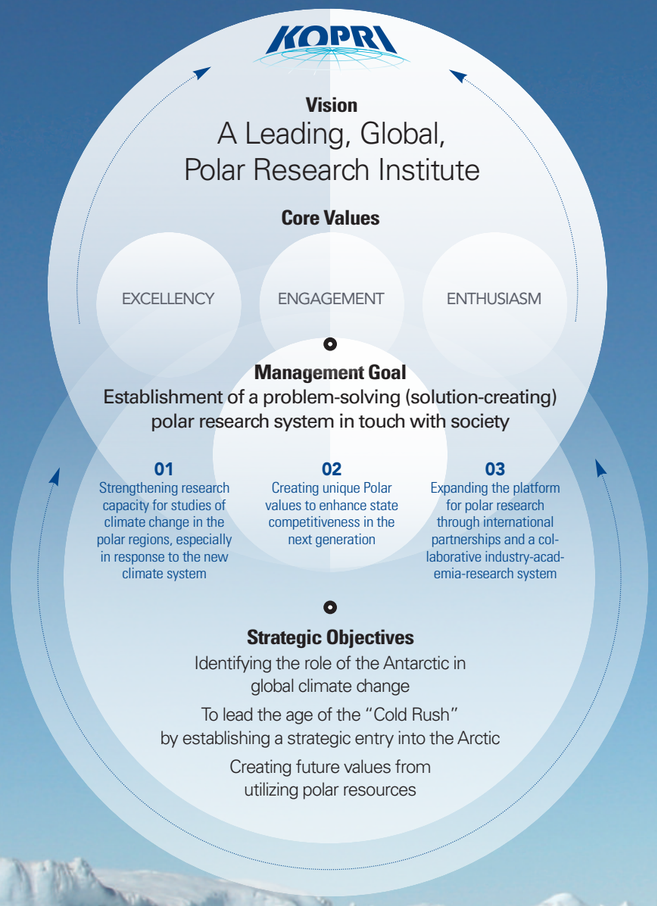
KOPRI

AT THE END OF THE EARTH, IN THE UNKNOWN LAND,

KOPRI IS OPENING A NEW WORLD

Polar regions, known as the frozen land at the end of the Earth, are essential to humanity with their role as climate controllers. Leading the world's polar science research, the Korea Polar Research Institute (KOPRI) is committed to forecasting the future environment and creating the value of polar regions, to ultimately tap into limitless opportunities and become a global top-notch polar research institute.

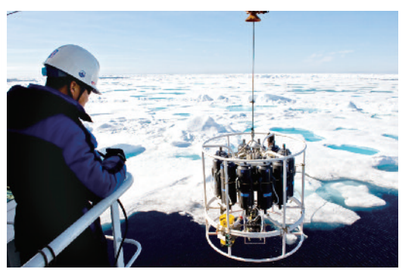
VISION & MISSION



CONTENTS

KOPRI leads the bright tomorrow with global competitiveness in polar research



BRIEF

HISTORY OF **KOPRI** 1985~2018

1980~1990

1985. 03.
Acceded to the Convention on the Conservation of Antarctic Marine Living Resources(CCAMLA)

1986. 11.
Acceded to the Antarctic Treaty as the 33rd signatory

1987. 03.
Polar Research Laboratory was established at the Korea Ocean Research and Development Institute(KORDI)

1988. 01.
The First Korea Antarctic Research Program(KARP) team conducted a survey in the vicinity of the Antarctic King Sejong Staion

1988. 02. 17.
The Antarctic King Sejong Station was inaugurated

1989.10.
Korea Joined the Antarctic Treaty as a consultative party

1990. 07.
Korea acceded to SCAR as a regular member

2000~

2002. 04.
Korea joined the International Arctic Science Committee (IASC)

2002. 04. 29.
The Arctic Dasan Station was inaugurated

2003. 12. 07.
Republic of Korea 17th Antarctic Scientific Resarch Center for wintering crew left this Jeon jaegyu

2004. 04. 16.
The Polar Sciences Laboratory was expanded to the Korea Polar Research Institute, KORDI

2009. 11.
Korean Ice-breaking Research Vessel 'ARAON' was constructed and delivered

2009. 12.
Korean Ice-breaking Research Vessel 'ARAON' departed for the Antarctic

2010~2018

2010. 07.
Korean Ice-breaking Research Vessel 'ARAON' departed for the Arctic

2011. 04.
Arctic Science Summit Week(ASSW) in Korea

2012. 07.
The Korea Maritime Institute of Science and Technology(KIOST) affiliated research institutes launched

2013. 04. 29.
The KOPRI office complex was inaugurated

2013. 05.
Korea received status as permanent observer in the Arctic Council

2014. 01.
The Antarctic Jang-Bogo Station, 1st winter research team commencement ceremony

2014. 02. 12.
The Antarctic Jang-Bogo Station completion ceremony

2014. 04. 16.
10th year foundation ceremony of the institute

2015. 09. 30.
Establishment of the Korea Arctic Research Consortium Secretariat

2016. 07. 15.
Two-step construction of the KOPRI office complex

2017. 04.
The 2nd celebration of KOPRI's night

2018. 06. 27.
Signing the P-CY01 Technology Transfer Agreement

2018. 10. 05.
Multi-purpose small vessels(Sejong1,2) launching ceremony

2018. 12
Be held the Arctic Circle Korea Forum 2018

The year 2018 marked the 30th anniversary for Korea to found a science station in the "unknown place," Antarctica.

The Antarctic research in various subjects, including climate change and marine living resources, started with the foundation of the Antarctic King Sejong Station in 2018. Following this effort, the Antarctic Jang Bogo Station and the Korea research icebreaker, Araon, were built to lead Korea to be ranked 10th in the field of polar research.

Supported by research progress, KOPRI has been committed to expanding the scope of polar research from a new perspective. Tireless exertion toward polar research for practical use provides a range of remarkable outcomes. For example, a blood-freezing technology that uses the new substance extracted from Antarctic marine microbes was developed and transferred to venture enterprises, producing a secondary profit from the license fees.

In addition, KOPRI participated in an international consortium for genome sequencing known as the Earth BioGenome Project (EBP), on behalf of Korea, tasked with the mission to lead the analysis and sequencing of the genome of polar living things for the next 10 years.

This important role of KOPRI is highlighted by the growing interest in application technologies for biological resources and required to contribute to the improvement of human well-being as well as the quality of life of organisms on Earth. In 2018, KOPRI saw a long list of research performance. To name a few, it identified the collapse process of Antarctic ice shelves for the first time in the world, which has been known as one of the causes of sea level rise; explained the self-purification of pollutants using the chemical characteristics of ice; and succeeded in securing the K-route of 720 km section.

Moreover, there was a new step taken in research support. The "Master Plan on Antarctic Research Promotion" was established as part of the five-year strategies for the Arctic, which is experiencing rapid climate change, and was opened to the rest of the world. In addition, KOPRI held the "3rd Arctic Partnership Week" to explore the sustainable Arctic future with a range of Korean and international experts participated under and to improve the country's prestige.

In particular, the third event of this year was an opportunity to announce the "2050 Polar Vision," which guides the integrated polar policy toward the next 30 years based on the past 30 years of missions and outcomes in polar regions. The Vision is considered a blueprint for Korea to leap forward to become a leading country for polar activities. In addition, a summer research building was constructed at the Antarctic King Sejong Station, and two small ships were secured for stable supplies support to create a better research environment.

KOPRI will remain committed to the steady progress of stations at polar regions and research in a multifaceted way, supported by its 30 years of knowledge on polar exploration. With an aim at responding to global environmental issues and providing new opportunities for our future generation, KOPRI makes a continuous effort in various attempts. Thank you.

Ho Il Yoon

President of the Korea Polar Research Institute

2018 RESEARCH OVERVIEW

KOPRI conducted research at a total scale amounting to KRW 58.9 billion, or KRW 600 million per researcher, throughout year 2018.

Based on the three strategic goals of "discovering the cause of climate and ecosystem change in the Polar regions in response to global environmental changes," "practicalizing polar research to create new value," and "pursuing future value through research and development in the Antarctic and Arctic regions," KOPRI conducted a total of 20 in-house projects and 11 national R&D projects.

In order to vitalize polar research and nurture polar experts, KOPRI has operated the Polar Academic Program(PAP) since 2010 to provide research funds to Korean universities that proposed creative themes for polar research. In 2018, the institute provided research funds to 16 projects from 12 universities.

Also, KOPRI launched the Polar Industrial Program(PIP) to enhance its cooperation with industries. Currently, 2 projects are being conducted under PIP.

KOPRI listed 218 research papers in major academic journals in Korea and abroad(121 in SCI-level journals; 62 in SCIE-level journals; 24 in KCI-level journals; 1 in KCI candidate journals; 1 in Korean journals; and 9 in international journals). In addition, the institute reinforced its intellectual property rights, including 21 patent applications and 18 patent registrations.

2018 Research Grant (Million won)

Total **63,587**

2018 Research Papers in Major Academic Journals in Korea and Abroad

Total **218**

Intellectual Property Rights

patent applications **21**

patent registrations **18**

2018 Research Performance (Criteria: Total Research Fund)

Division		Financial resource	Research Grant (KRW 1 million)
Main projects	In-house projects	KOPRI	43,932
	The Polar Academic Program		1,313
	The Polar Industrial Program		700
	Research&Policy Support Project		2,641
Subtotal			48,586
National R&D projects		Ministry of Oceans and Fisheries	11,001
		Ministry of Science , ICT and Future Planning	3,700
Public consignment projects		Public Organization	300
Subtotal			15,001
Total			63,587

Part. 01

RESEARCH ACTIVITIES

Investigation for the cause of different climate responses over East Antarctica and West Antarctica

Why is there rapid warming over West Antarctica while no evident warming over East Antarctica?

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In response to the marked increase in atmospheric CO_2 concentration since the industrialization, Arctic warming is very rapid everywhere, whereas in Antarctica, climate responses are different in West Antarctica from the eastern part. In West Antarctica, including the Antarctic Peninsula (AP), there is a very rapid temperature rise that results in the melting of sea and land ice. However, in East Antarctica, there is little change in temperature in the recent several decades, which leads to a slight increase in sea and land ice. Several studies have shown that the aforementioned warming over the AP and the little warming or even slight cooling in East Antarctica a are due to the increase in the Southern Annular Mode (SAM) phase. The SAM increase is associated with the strengthening of westerly winds around Antarctica, which results in a marked warming over the AP and cooling over East Antarctica. The increase in the SAM phase is reported to be due to the depletion of the stratospheric ozone in austral spring by ozone-depleting gases such as Freon. Since the early 1990s, however, ozone-depleting gases have not been used after the agreement of the Montreal Protocol, and ozone recovery has been expected. In fact, the analysis of the stratospheric ozone concentration

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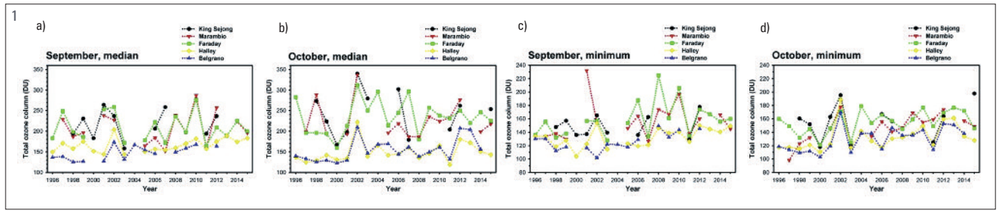

Figure 1. Year-to-year variation of September and October (the period that shows a large stratospheric ozone depletion) median (a) and (b) and minimum (c) and (d) values of total ozone concentration.

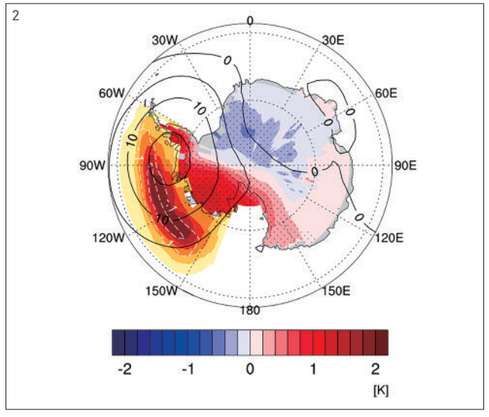

Figure 2. Surface air temperature (shading over the Antarctic continent) and 500 hPa geopotential height (black contour line) responses to the SST (shading in the ocean) and sea ice concentration (white contour line in the ocean) changes under the current Antarctic terrain.

from in-situ measurements over the AP regions, including the King Sejong Station, combined with satellite measurement data shows that there have been slight increasing trends during austral spring - the time of the most substantial ozone depletion since 1995 (Koo et al., 2018, Fig. 1). This is clear evidence that supports the recovery of the stratospheric ozone after the Montreal Protocol obtained in the King Sejong Station. As the stratospheric ozone is recovering gradually, the SAM phase may not necessarily increase and will not be able to account for the recent extension of warming toward the Amundsen Sea sector. Therefore, another set of evidence is needed. In this project, the modes of variability of surface climate using observed temperatures were deciphered, and it was found that there are two dominant modes: the first one is associated with global warming, and the second one is related to the east–west temperature contrast. As the regional climate difference in Antarctica is associated with the second mode, sensitivity experiments were performed using a global-scale numerical model to unravel the cause. It was discovered that the warm surface ocean anomaly increases the surface pressure, which means that an anticyclonic circulation anomaly developed over West Antarctica brings about warm maritime air. However, warm air is prevented from penetrating East Antarctica because of the Transantarctic Mountains. To deepen the understanding of the transport behavior, radon concentrations from the King Sejong Station and the Jang Bogo Station were measured at the same time. During austral summer, the radon concentration measured in the Jang Bogo Station is much larger than that in the King Sejong Station. The contrasting radon concentration data in both stations could be used to improve numerical model. An improved model could provide better information in understanding the mechanism for the regional climate differences in Antarctica.

Reconstruction of the Antarctic Ice Sheet and Ocean History for the Past Two Million Years

Reconstructing Paleoenvironmental Changes in Antarctica from Sediments

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As global warming continues, the frequency and intensity of natural disasters related to climate change, such as El Niño, abnormal temperature, cold surges, and tornado, are increasing, and the necessity of scientific understanding of global environmental change is demanding. By constructing paleoenvironmental changes, trends in natural global environmental changes can be identified to estimate their impacts and understand the drivers of climate change.

The polar regions represent an ideal place for detecting climate change because they are more sensitive to it compared to the mid- and low-latitude regions. In particular, Antarctica has experienced an array of global climate and environmental changes such as alterations in atmospheric carbon dioxide concentration, which affect the marine productivity of the Southern Ocean; a formation of deep water, which is the main driver of global ocean circulation; and sea level change due to an increase and decrease of the Antarctic ice sheet. In efforts to investigate these issues, Antarctic paleoenvironmental studies provide essential information to understand the trends and impacts of global climate change.

Antarctic marine sediments contain a continuous and stable change in the past environment. The goal of this project is to reconstruct the past two million years of ice sheet - ocean - climate change from sediment records, and examine the impact changes in the Antarctic cryosphere and marine environment exerted on global environmental change.

Until now, not many sediment cores longer than 10 m have been sampled in the Southern Ocean, and the longest core previously taken from the polar region by IBRV-Araon was 14.7 m long. In 2018, during the 4th leg of Araon, two sediment cores (33 m long and 29 m long, respectively) were obtained at the Perseverance Drift and the Bransfield Eastern Basin at the northern tip of the Antarctic Peninsula. The core sediments include records of climate and environmental changes since the Last Glacial Maximum. The high-resolution reconstruction of environmental changes due to changes in the ice shelf, ice sheet, and sea ice is underway using the physical, chemical, and biological climatic indicators included in these sediments. In April and July of 2018, the self-made seafloor camera housing was tested, and it was confirmed that it is possible to observe the seafloor under 2,000 m depth. The submarine camera housing is attached to a box corer or multi-corer, and is used to identify the core sediment collection process and observe the environment at the sampling site so that information on surrounding environments can be obtained.

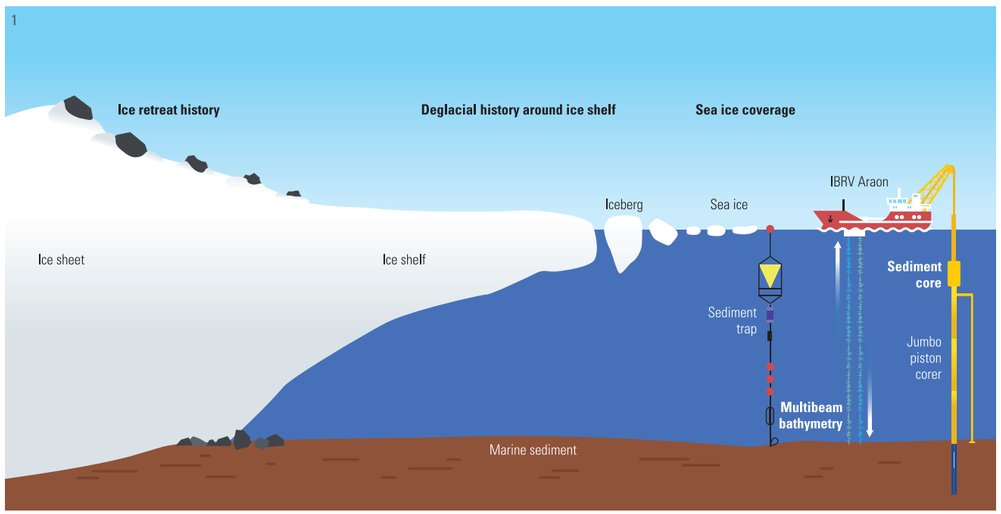

Figure 1. Strategies of "Reconstruction of the Antarctic Ice Sheet and Ocean History for the Past Two Million Years Using Sediment Records" project

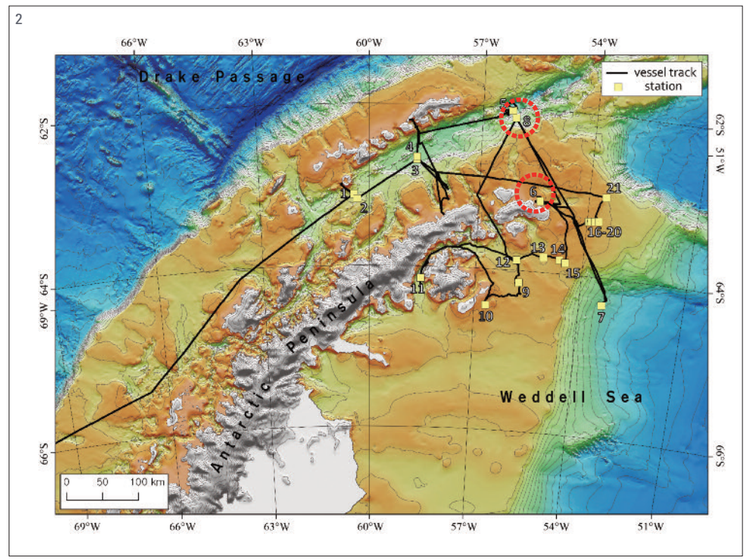

Figure 2. Study area and sediment core locations during the 2018 Antarctic Cruise on IBRV Araon

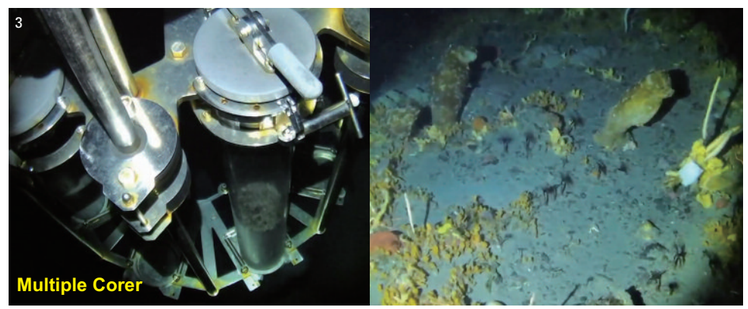

Figure 3. Multiple core sampling scenes taken by a seafloor camera and the submarine environment near the Antarctic Peninsula

Modeling responses of terrestrial organisms to environmental changes on King George Island

Observing the changes in the ecosystem of King George Island due to warming

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To understand the changes of ecosystems according to the climate change in King George Island, one of the fast-warming areas on Earth, data on the spatial and temporal changes of chemical, physical, geological, and biological processes inside the system are needed. The National Science Foundation (NSF) in the United States is running a program called the Critical Zone Observatory (CZO) to obtain comprehensive and multidisciplinary observation data. The CZO concept was also introduced to understand the small but highly complex terrestrial ecosystem of the Barton Peninsula in King George Island, Antarctica. In the first two months of 2018, multidisciplinary observational data, such as water movement, soil CO_2 emission, soil moisture, temperature, light intensity, and photosynthetic efficiency, in the KGL01 area of the Barton Peninsula could be obtained (Fig. 1). These data will be used to evaluate the correlation of environmental factors and biological responses in the region.

Maritime Antarctica, where the Barton Peninsula is located, is severely affected by climate change and the accelerating glacier retreat that forms a new ice-free area. We investigated the microtopography related to vegetational succession and its process at the newly exposed area caused by Fourcade Glacier retreat. Since the nest materials of the kelp gull (*Larus dominicus*) settled down and led the vegetational succession in this exposed area, pseudo-succession, rather than primary succession, has been progressing. As a result of comparing the coverage data of vegetation between 2014 and 2018 with a permanent quadrat, lichens extend their occupation, and the coverages of moss and freshwater algae are similar. The flowering plants that settled down in 2014 decreased around the nests; therefore, further research will be required to clarify the cause.

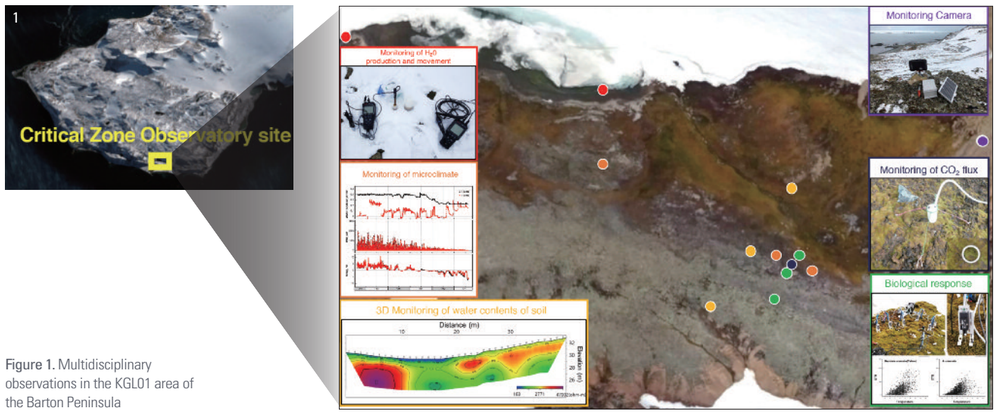

Figure 1. Multidisciplinary observations in the KGL01 area of the Barton Peninsula

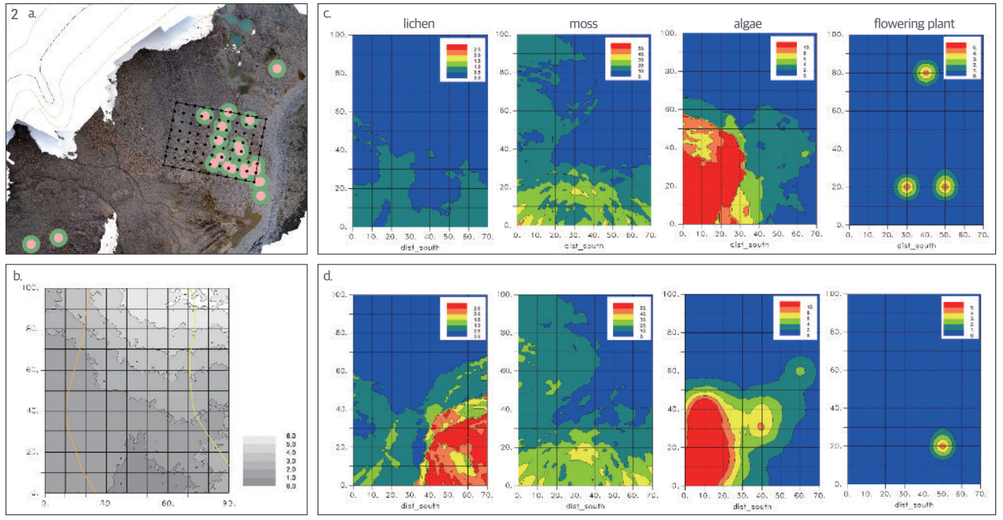

Figure 2. A result of comparing the coverage data of vegetation with a permanent quadrat at the exposed area caused by Fourcade Glacier retreat. (a) Kelp gull nests and a permanent quadrat (100 × 90 m)
(b) Microtopography of the quadrat
(c) Vegetation coverages in 2014
(d) Vegetation coverages in 2018

Understanding how life responds to environmental changes in the Barton Peninsula in Antarctica is essential in predicting the future changes of the terrestrial ecosystem. Two plant species-*Colobanthus quitensis* and *Deschampsia antarctica*-were chosen as a model system. Environmental factors (e.g., temperature, light, humidity, and so on) have been measured by sensors every hour. The electron transfer rate (ETR) that represents the amount of photosynthesis was then regressed on the measurements, producing a reliable model (Fig. 3).

The Antarctic Near-Shore and Terrestrial Observing System (ANTOS) was organized by the Scientific Committee on Antarctic Research (SCAR) to conduct a continuous observation of near-shore and terrestrial Antarctic ecosystems. Data and information on Antarctic ecosystem observations will continue to increase. The ANTOS database and webpage for the sustainable management and sharing of environmental data collected were built to enable researchers to share and utilize the accumulated data and information easily. Based on the experience, the database and webpage were made for the Linking of Antarctic Peninsula Ecosystem Sciences (LAPES) network (Fig. 4). LAPES is a network for researchers in King George Island and the Antarctic Peninsula, where the scientific bases of various countries are concentrated. Hopefully, by actively participating in it, Korea will lead the joint research in these regions.

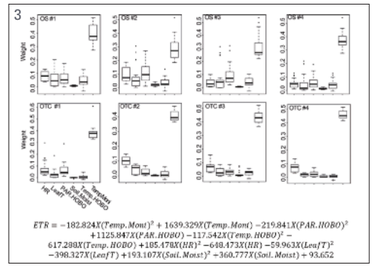

Figure 3. Electron transfer rate (ETR) of *Colobanthus quitensis* regressed on diverse environmental factors with an R square of 0.87. In the box plots, atmospheric temperature appears as the most important factor for determining the ETR.

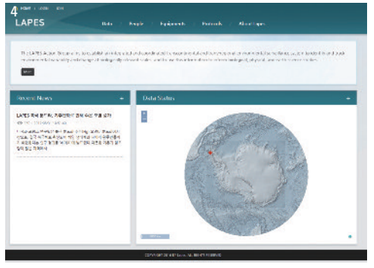

Figure 4. Webpage of LAPES (http://lapesdb.org)

Research on the Structure and Function of the Marine Ecosystems in the Antarctic Ocean

Establishing a Research Basis for the Conservation of the Marine Ecosystems in the Ross Sea Region Marine Protected Area

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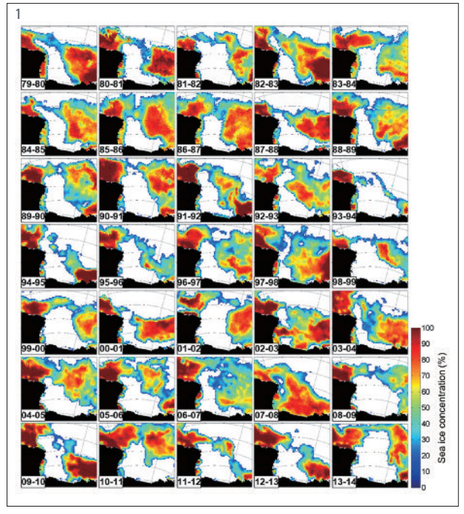
The Ross Sea region is an ecologically important area where the world's 38% of Adélie penguins, 26% of Emperor penguins, 45% of Weddell seals, 50% of Type C killer whales, and other fish- and krill-dependent marine organisms inhabit intensely. Any occurrence of a rapid environmental change or overfishing of marine resources could lead to a collapse of the food chain that links phytoplankton small predators (zooplankton, krill, small-fin fish, and so on) to large predators (penguins, cetaceans, seabirds, seals, Antarctic toothfish, and so on). In the annual meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in 2016, the designation of a Marine Protected Area in the Ross Sea was adopted to maintain the biodiversity, recover the number of species in a declining trend, and understand the impacts of climate change on the ecosystems.

Changes in the ocean environment, biodiversity, and the food chain structure are being studied to determine the structure of the ecosystems in the Ross Sea Marine Protected Area. The research on the vertical and horizontal spatial distribution of krill and other zooplankton was conducted in the coast neighboring penguin colonies using the ice-breaking research vessel, RV Araon. The bio-logging approach was used to track the foraging areas of Adélie penguins while collecting samples and analyzing the length-frequency of their main prey item, that is, krill. Changes in the area of polynya and the distribution of phytoplankton in the



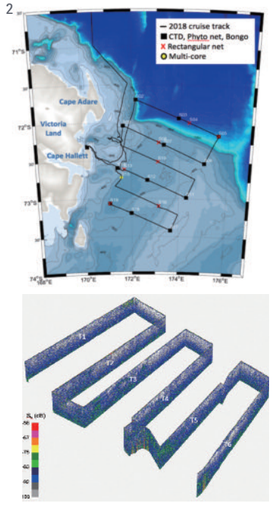
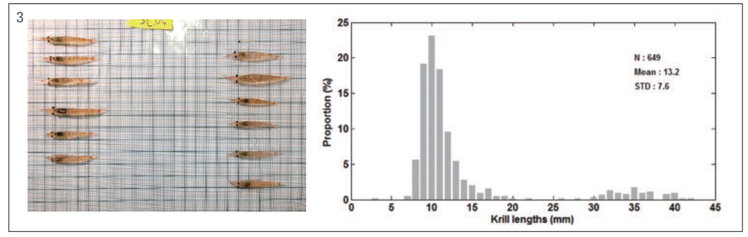


Figure 1. Sea ice concentration in percentages at the point of the maximum area of polynyas from 1979 to 2014 (Park et al., 2018)

Figure 2. Changes in the vertical-horizontal distribution of 120 kHz-volume backscattering strength (S_v dB re 1 m^{-1})



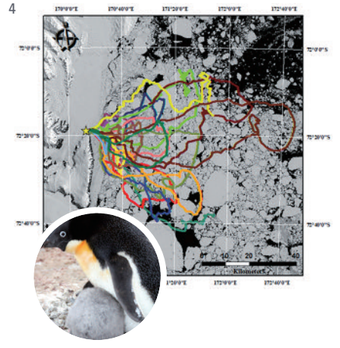


Figure 3. Length distribution of krill collected with a rectangular net

Figure 4. Investigation of the foraging areas of Adélie penguins using bio-loggers

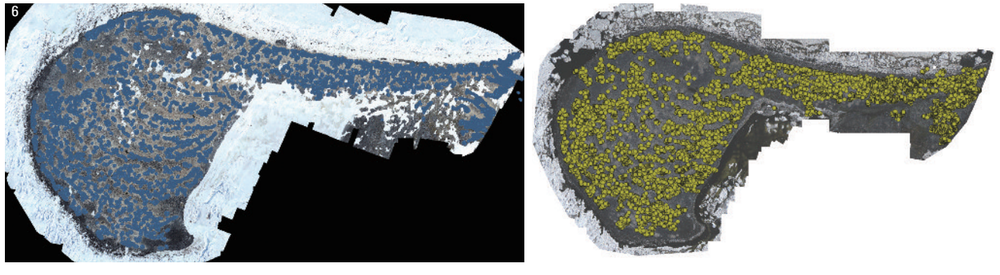
Figure 5. Research camp for the long-term monitoring established at Cape Hallett

Figure 6. Precise calculation of nest counts (Left) and chick counts (Right) based on drone images

Ross Sea, which form the foundation of marine ecosystems, were studied based on satellite images from 1987 to 2014.

CCAMLR has approved the designation of Cape Hallett-an important Adélie penguins habitat-as a CCAMLR Ecosystem Monitoring Program (CEMP) site; accordingly, a research camp and an automated monitoring system were established to implement long-term monitoring. Methods that use drones are being developed to monitor the penguin habitat environment and provide precise nest or chick counts.

This research project, which started in 2017, aims to diagnose the impact that the environmental change in the Marine Protected Area (MPA) has on the ecosystem structure and indicator taxa, to provide the scientific information required for the establishment of conservation measures and contribute to the international community's efforts to conserve the Antarctic environment.



Identifying the Role of the Antarctic in Global Climate Change

05

Ocean-to-Ice Interactions in the Amundsen Sea: Ice Shelf Melting and Its Impact on Ocean Processes

Assess marine environmental change from West Antarctica warming and ice shelf melting

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Due to the recent climate change, the thinning of ice shelves has been accelerating in the Amundsen Sea in West Antarctica. Some studies have reported that, compared to the 1990s, the ice shelve retreat rate is five times faster after 2000. This sudden mass loss of the ice shelf is related to the intrusion of warm and salty Circumpolar Deep Water onto the continental shelf of the Amundsen Sea. Moreover, the spread of meltwater from the ice shelf to the surrounding sea affects the marine ecosystem and biogeochemical cycles as well as ocean circulation.

The main goal of the KOPRI Amundsen Sea project is to assess ocean environment and process changes under the West Antarctic warming and subsequent glacial meltwater dispersion through the international collaborative Earth-observing network. Since December 2010, five surveys were conducted with KOPRI's ice-breaking research vessel, Araon. The obtained field observation data played a key role to reveal the Amundsen Sea environment change including the variation of seawater circulation, heat exchange, biogeochemical cycles, and ecosystem.

During the first phase (2010 - 2016) of the project, the investigations on ocean circulation patterns and the heat flux to the Antarctic coasts, ecosystem structures, and diversities as well as the biogeochemical cycles in the Amundsen Sea were completed. In the second phase (2017-present), focus was given on ice shelf melting and retreat, the impact of meltwater discharge to oceanic physical processes, and the following changes in biogeochemical processes and the food web structure. The project produced high-impact scientific findings from the major areas of the research, and recently, the fifth field expedition was successfully conducted from December 2017 to February 2018.

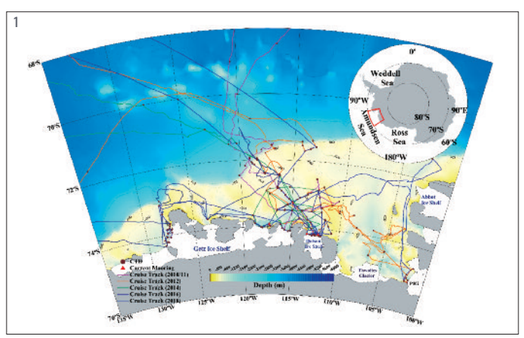

Figure 1. The field expedition using the ice-breaking research vessel, Araon, was conducted five times in the Amundsen Sea during the last eight years. The research cruise tracks the past five times (2011, 2012, 2014, 2016, and 2018) of the Amundsen Sea expeditions conducted by IBRV Araon.

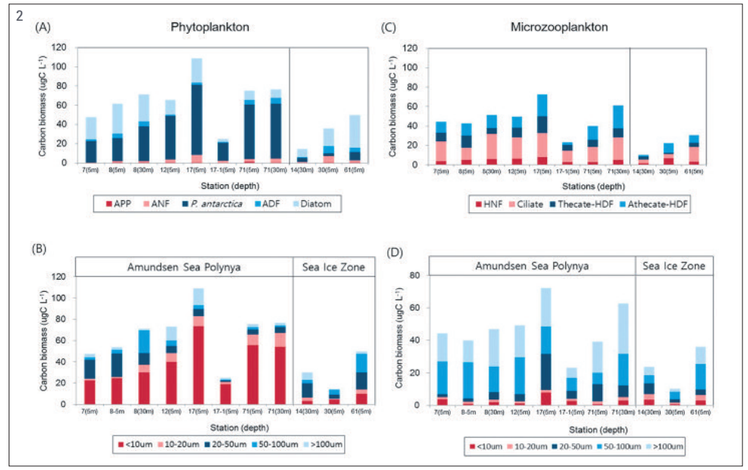

Figure 2. Trophic interactions of micro- and mesozooplankton in the Amundsen Sea polynya and adjacent-sea ice zone in austral late summer (Yang et al., Progress in Oceanography, 2019)

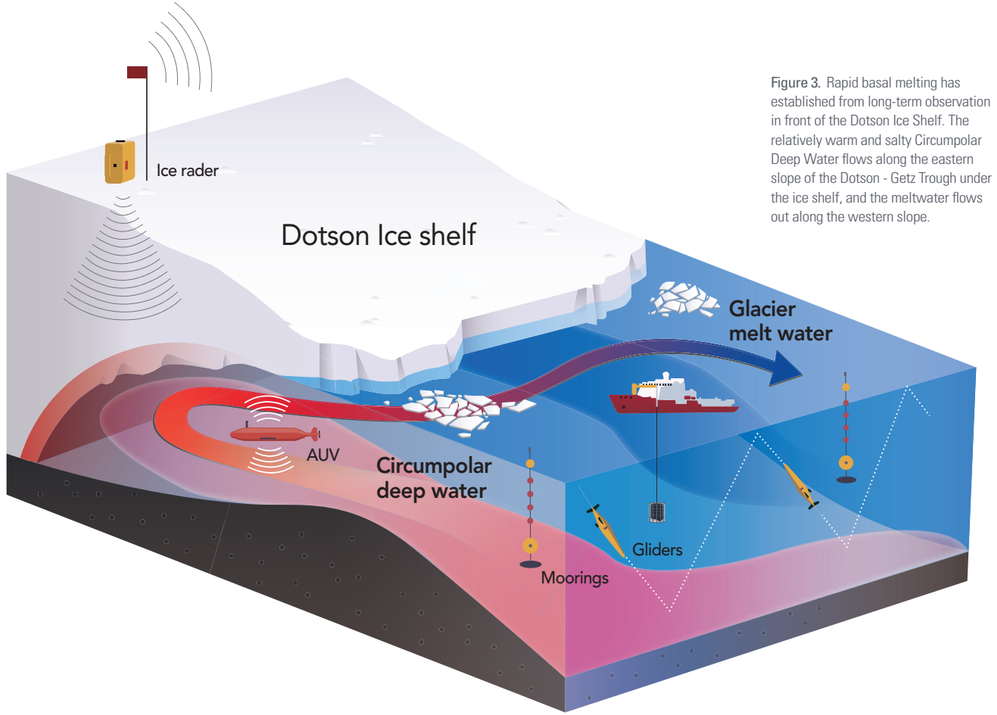

Figure 3. Rapid basal melting has established from long-term observation in front of the Dotson Ice Shelf. The relatively warm and salty Circumpolar Deep Water flows along the eastern slope of the Dotson - Getz Trough under the ice shelf, and the meltwater flows out along the western slope.

Identifying the Role of the Antarctic in Global Climate Change

06

Reconstruction of Past Climate and Environmental Changes Using High-Resolution Ice Core Records in Victoria Land, Antarctica

Recovers records of high-resolution climate and environmental changes from polar ice cores

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In the Antarctic ice sheet, where it is below –20°C in the middle of summer, snow continues to accumulate without melting, gradually increasing in density and reaching a certain depth, and turning into solid ice. The ice has captured the air of the past, and the analysis of the composition of ice reveals the atmospheric environment at the time of snow, providing relevant information on past climate and climate change. In particular, high-resolution studies can be conducted on ice cores drilled from coastal ice caps with a high snow accumulation rate.

In this study, the age of three ice cores was determined by analyzing high-resolution components in the Northern Victoria Land of Antarctica, where the Jang Bogo Station is located, and the past temperature was reconstructed with stable water isotope ratio and borehole temperature. Moreover, the ion components that indicate the sea salt components of the ice core are analyzed to reconstruct the records of past sea ice changes and correlate them with climate change, and various trace elements to restore the atmospheric environment records changed by natural/anthropogenic factors are examined. The reconstruction of records of climate and environmental changes since the last interglacial (Emian) from the ice cores of Greenland's NEEM Deep Ice Core project is also studied.

This year's representative research result was to reconstruct the temperature changes since the 17th century by directly measuring the temperature at the borehole of the ice coring hole in the Styx Glacier in Antarctica, and the first report that dust enters Greenland from the Sahara Desert in Africa besides the Gobi and the Taklamakan was introduced by analyzing lead and strontium stable isotopes in Greenland's NEEM ice cores.

1

Figure 1. Ice core drilling in the Northern Victoria Land of Antarctica

Figure 2. Climate change records since the 17th century reconstructed using borehole temperature data measured in the Styx Glacier in Antarctica (Geophysical Research Letters, 2018)

Figure 3. The origin of dust that enters Greenland was determined using lead and strontium isotope data at Greenland's NEEM ice cores (Scientific Report, 2018).

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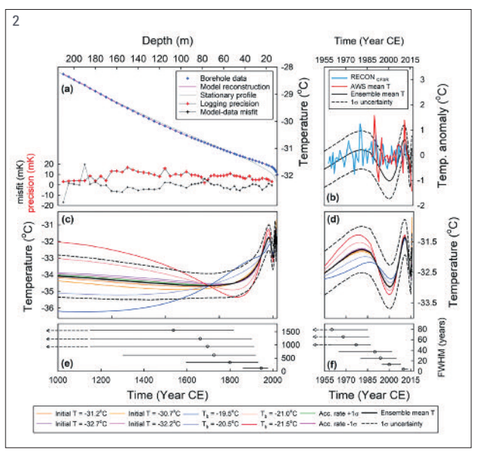

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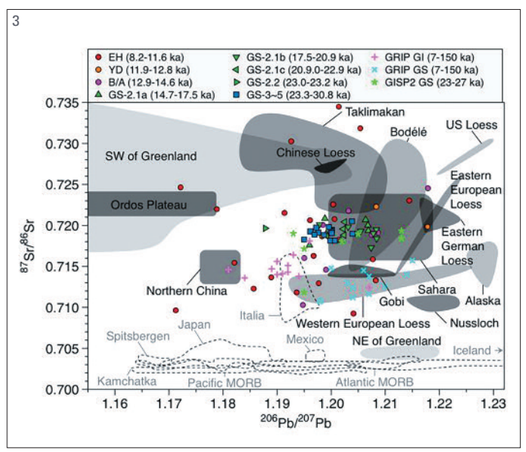

Identifying the Role of the Antarctic in Global Climate Change

07

Studies on the Changes in the Coastal Marine Systems of the Antarctic Peninsula: A 2050 Outlook

Glacier Shrinking and Impacts on the Antarctic Coastal Marine Ecosystem

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CHAMP2050 aims to assess the climate impacts on the Antarctic coastal marine environment and to elucidate driving forces and/or underlying mechanisms for ecosystem responses, particularly in the context of the ice sheet shrinking in the Antarctic Peninsula Region. In the first year (2017), a long-term data set of marine environmental monitoring was collated at the King Sejong Station, and the seasonal and decadal patterns of various oceanographic features, such as seawater properties, phytoplankton composition, and so on, were characterized. In the second year (2018), the impacts on the marine environment and major planktonic/benthic communities caused by the glacier retreat in the Marian Cove was investigated (Fig. 1). Moreover, the benthic food web structure, which turned out to be based on the benthic diatom bloom overgrowing common filter feeders in the cove, was characterized (Fig. 2). In addition, the ADCP mooring system was deployed in the Marian Cove and long-term data collection was started to study water circulation and property changes. In April of 2018, an oceanographic survey on hydrography, geochemistry, and planktonic/benthic communities was conducted in the Bransfield Strait, Maxwell Bay, and Marian Cove in collaboration with Chile, the United States, and Brazil (Fig. 3). For the first time, benthos samples (>1,000 inds) were collected from deep Antarctic waters (Fig. 4).

Figure 1. Trend of glacier retreat in the Marian Cove from 1956 to 2017

Figure 2. A wide variety of benthic animals in association with the benthic diatom bush. Ascidians, sponges, tube worms, starfish, and carnivorous worms occurred in the bush. Using isotopic tracers, it was found that the benthic food web in this rapidly deglaciated fjord is based on the benthic diatom bloom and filter feeders.

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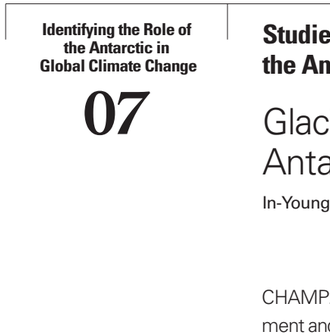

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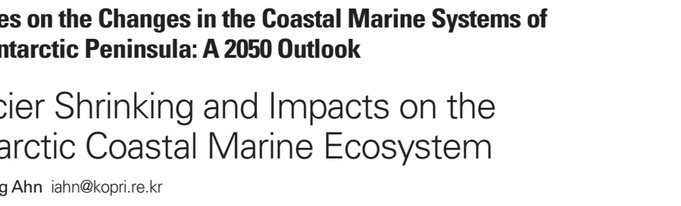

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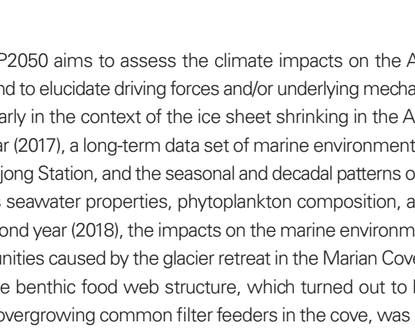

Figure 3. Oceanographic survey conducted in April 2018 in the Bransfield Strait, Maxwell Bay, and Marian Cove. Chile, the United States, and Brazil joined the cruise.

Figure 4. Benthic animal specimens (ascidians, sponges, sea spiders, sea cucumbers, and so on) collected during the Araon expedition.

Identifying the Role of the Antarctic in Global Climate Change

08

Investigating Cryospheric Evolution of the Victoria Land, Antarctica -ICE-

Conduct a multidisciplinary research on cryosphere behavior with a creative perspective

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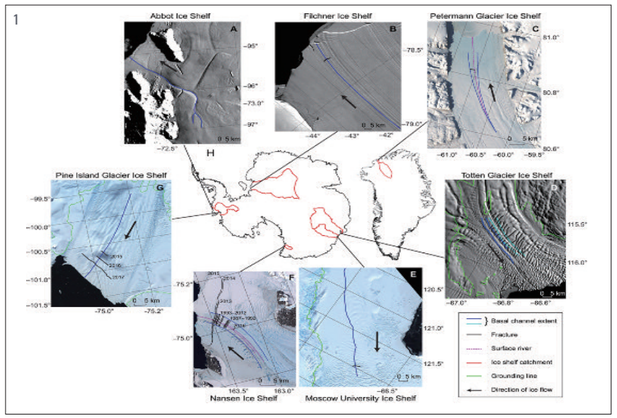
Big issues worldwide are the mass loss in the polar regions as well as the global sea-level rise caused by global warming and climate change. The multidisciplinary research that embraces cryosphere-lithosphere-hydrosphere-atmosphere is the only way to identify the role of the cryosphere in future sea-level change. The international and multidisciplinary study on the ice sheet around the Jang Bogo Antarctic station, led by KOPRI, is gathering speed toward an innovative understanding of ice sheet revolution. Seismic and geodetic observation networks are running in the long term to monitor the influence of crustal activities such as glacier isostatic adjustment and subglacial volcanism on ice sheet flow. The ice flow from grounded ice sheet forms ice shelves and ice tongues in strong interaction with the ocean. To figure out the interaction in the junction of glacier/bedrock/ocean, helicopter geophysical exploration, physical oceanography survey, basal melting monitoring, and so on are conducted. In addition to the basal melting of floating ice, the ice sheet also loses its mass through surface melting due to heat transfer from warm air and solar radiation. The Nansen Ice Shelf near the Jang Bogo Station is one of the unique ice shelves with a condition in which surface melting forms melt ponds and supraglacial rivers.

In 2018, our study on the Nansen Ice Shelf revealed that the basal channels drive active surface hydrology and transverse ice-shelf fractures. The ice flow of Campbell Glacier near the Mt. Melbourne volcano was also found to have a periodic speed-up, which indicates the role of a volcano that controls the behavior of an adjacent glacier. In the area of oceanography, high-salinity shelf water (HSSW) with an extremely high salinity was discovered in Terra Nova Bay, Antarctica, and the phenomenon might be caused by an abnormal condition of the atmosphere as well as the interaction between the atmosphere and the ocean.

Figure 1. Transverse fractures related to ice-shelf channels on Antarctic and Greenland ice shelves

Figure 2. GPS monitoring network on the Campbell Glacier in Antarctica

Figure 3. Characteristics of seawater in Terra Nova Bay, Antarctica



Identifying the Role of the Antarctic in Global Climate Change

09

Development of Analytical Methods for Climate-Regulating Components and Its Application to the Polar Environment

Provide a scientific basis for climatic feedback in polar regions

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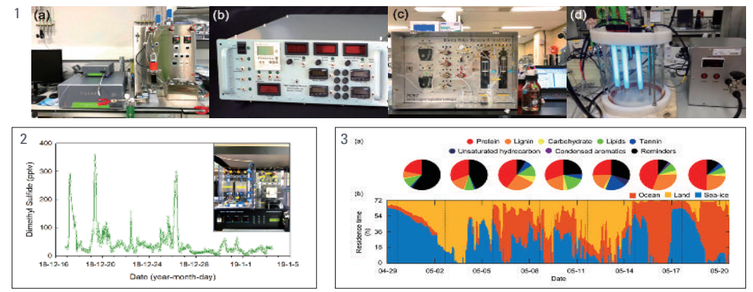
Figure 1. Newly developed analytical devices for dissolved N_2O (a), dimethyl sulfide (b), organic matter separation/extraction (c), and polar marine aerosol simulation chamber (d)

Figure 2. Continuous observation of atmospheric dimethyl sulfide at King Sejong Station using an automated analytical system developed in 2017

Figure 3. (a) Molecular characteristics of Arctic aerosols (b) Residence time of air mass passed over three major domains during the sampling period



The polar region is one of the regions that are most vulnerable to climate changes, and it undergoes rapid environmental changes (i.e., increased temperature, acidification, shallowing mixed-layer depth, sea ice decline, increased light, increased nutrient supply, reduced salinity, and glacial retreat). Such environmental changes in this region could significantly affect the marine ecosystem. For instance, the annual net primary production in the Arctic Ocean was reported to increase by 30% during the last 30 years, owing to the reduced sea ice extent and the longer growing season. Marine biota influence climate-regulating components by releasing various organic matters back into the atmosphere. Recent studies revealed that changes in the polar environment could trigger the changing emission of biologically driven climate-relevant compounds including warming gases (e.g., CO_2, CH_4, and N_2O) and cooling components (e.g., dimethyl sulfide, halogenated gases, and organic aerosol particles). However, the climate feedback roles of these climate-regulating components are not predictable, owing to the absence of continuous observation of these components at polar environments. The main goal of this research project is the development of analytical techniques for important climate–relevant compounds, and their application to the Arctic and Antarctic environments. The key achievements of this research project in 2018 are as follows: 1) development of a unique analytical system (including a nanomolar-level dissolved-N_2O analytical system that uses cavity ring-down spectroscopy, a trace-level dimethyl sulfide analytical system that uses an ozone chemiluminescence device, an automatic organic matter separation/extraction device for the analysis of the chemical properties of marine aerosol, and a polar marine aerosol simulation chamber) (Fig. 1); 2) continuous observation of atmospheric dimethyl sulfide using a newly developed analytical system at polar regions (Fig. 2); and 3) identification of the influence of biogenic organics on the chemical properties of Arctic aerosols by measuring the precise molecular composition of aerosol particles (Fig. 3). This type of analytical approach could provide broad insight into the understanding of diverse climate-relevant compounds emitted into the polar atmosphere, and is necessary for a better understanding of the magnitude and direction of ongoing climate changes in this fragile environment.

Long-Term Ecological Research (JBG-LTER) - A Joint Platform Construction of Korea, New Zealand, and Italy

Observing Offshore and Terrestrial Ecosystems around the Jang Bogo Station, Antarctica

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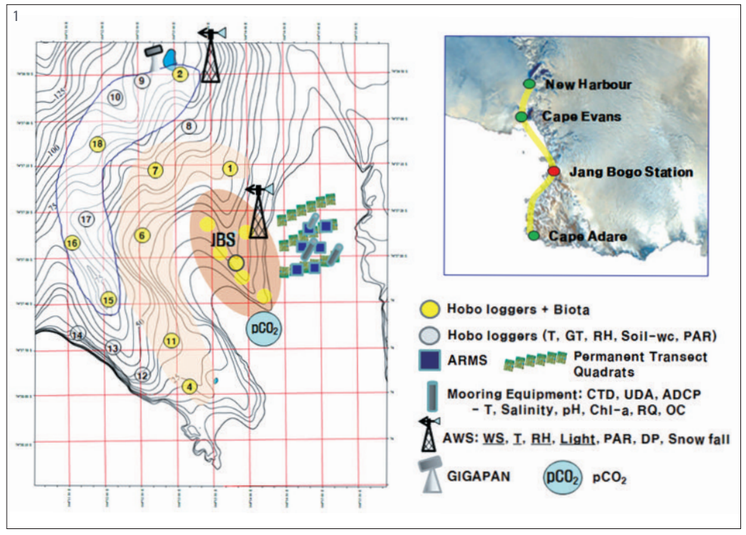


Figure 1. Continuous observation and investigation of various ecological factors, biodiversity, and species distribution in the terrestrial and offshore regions around the Jang Bogo Station in Terra Nova Bay, Antarctica

An investigation on the impact of environmental changes on Antarctic organisms and their resilience has been conducted through the construction and operation of a joint observation platform by three nations - Korea, New Zealand, and Italy - which continues its ecological monitoring around the Jang Bogo Station, Terra Nova Bay, Ross Sea, Antarctica.

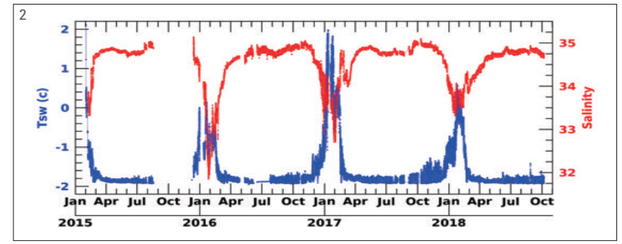
The team participated in the Antarctic Near-Shore and Terrestrial Observing System (ANTOS), which is currently registered as the Scientific Committee on Antarctic Research (SCAR) Expert Group, and carried out the joint scientific SCUBA diving exploration using the same underwater observation equipment while standardizing the data as an international collaboration with New Zealand and Italian research teams in Cape Evans - New Harbor - Terra Nova Bay (Fig. 1).

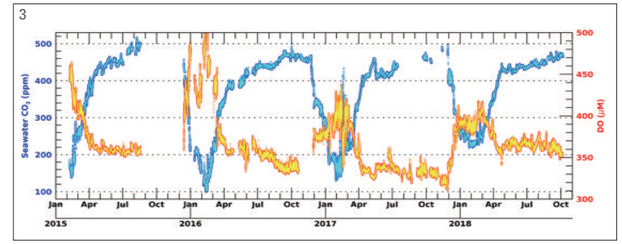
The terrestrial (atmospheric factors, such as temperature, wind speed, relative humidity, light, PAR, and snowfall, and soil factors, such as temperature, relative humidity, and PAR, by the automated weather station and Hobo logger) and coastal ecological items (seawater temperature, salinity, pH, Chl-a, RQ, OC, dissolved carbon dioxide, and dissolved oxygen by CTD, UDA, and ADCP) have been continuously observed (Figs. 1, 2, 3, and 4). Moreover, biodiversity (photosynthetic algae, mosses, protozoa, and mollusks), changes in major populations

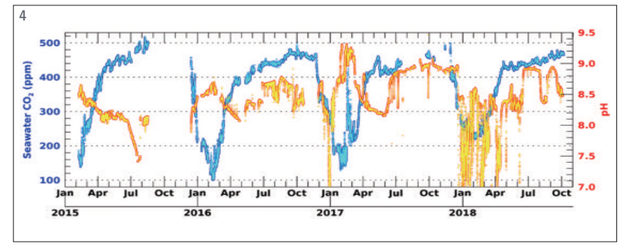
Figure 2. Time series of surface seawater temperature and salinity around the Jang Bogo Station in Terra Nova Bay, Antarctica, in 2015-2018

Figure 3. Time series of seawater carbon dioxide and dissolved oxygen around the Jang Bogo Station in Terra Nova Bay, Antarctica, in 2015-2018

Figure 4. Time series of seawater carbon dioxide and pH around the Jang Bogo Station in Terra Nova Bay, Antarctica, in 2015-2018



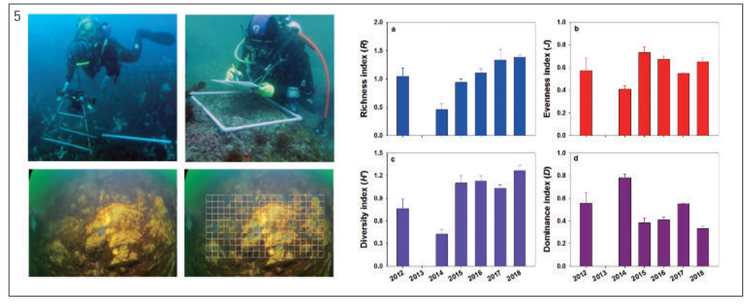




(Antarctic scallop and south polar skua), and long-term changes in the ecosystem have been investigated according to environmental changes in the terrestrial and coastal regions around the Jang Bogo Station.

Various ecological indices - richness, evenness, and diversity - and the dominance index have been inspected in a sublittoral zone near the pier of the Jang Bogo Station since 2012. After the construction of the station in 2014, the richness, evenness, and diversity indices have increased, and the dominance index has decreased. These results indicated that benthic communities had been repaired from artificial disturbance by such construction (Fig. 5).

Figure 5. Acquiring images of benthic communities through SCUBA diving, and estimating the richness, evenness, diversity, and dominance index of benthic communities from the images in 2012-2018



Investigation of Ice Chemistry to Understand Environmental Processes in Polar Regions and Its Applications

Establishing the Foundation of Ice Chemistry Research to Understand the Natural Phenomena in Polar Regions

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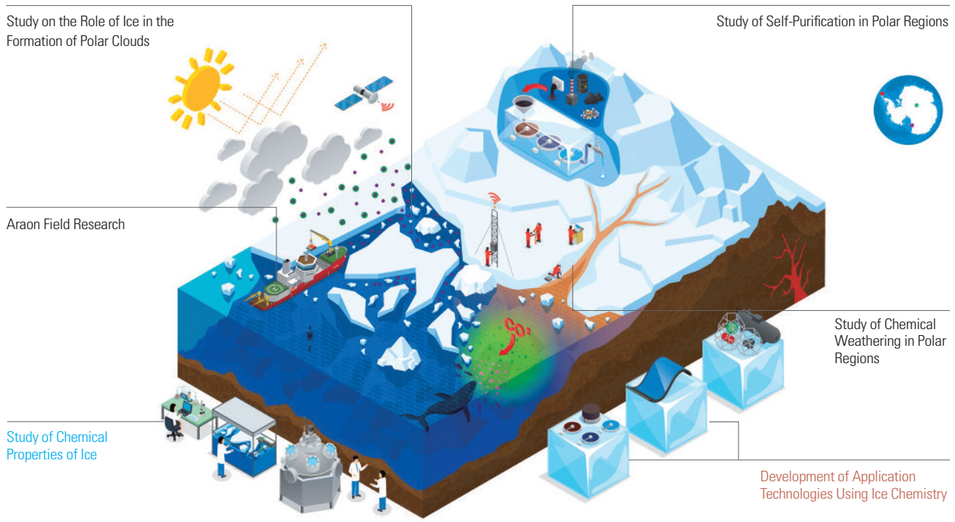
Ice is an important reservoir of water that constitutes more than 70% of freshwater on Earth and 10% – 20% of the surface of Earth, and the chemical reactions that occur in ice play important roles in the natural phenomena in polar regions. To understand the phenomena systematically and predict global effects, it is essential to understand the phenomena on and in ice at a molecular level. However, until now, ice research has focused on macroscopic fieldwork and analyses, such as glacier flow and the change of the sea ice extent, and little has been studied on the molecular properties of ice chemistry. In addition, the research on application technologies based on the unusual properties of ice chemistry is still at an elementary level.

This research project aims to investigate the unique properties of chemical reactions in ice to understand the polar and global natural phenomena as well as develop practical technology using ice chemistry. To achieve the goal, ① the construction of ice research infrastructure and fundamental studies, ② an understanding of polar natural phenomena based on ice chemistry, and ③ the development of applications for ice chemistry were conducted (Fig. 1).

Figure 1. Outline diagram of ice chemistry research project



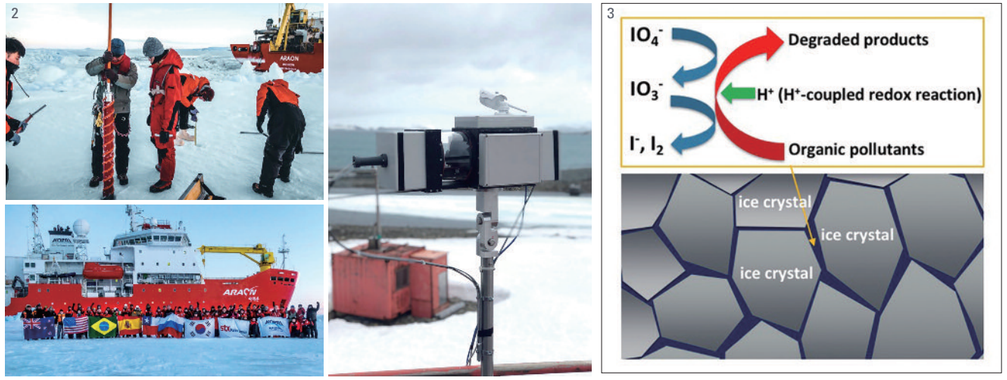


Figure 2. 2018 Araon Antarctic expedition. (Left) Snow, sea ice sampling, (Right) Halogen gas monitoring equipment(MAX-DOAS).

Figure 3. Degradation of organic pollutants by activation of periodate by freezing

In this research, which started in 2018, research infrastructure for cryogenic spectroscopy and polar environment simulation were constructed, and through joint research, an ice surface model was developed for the calculation studies of the adsorption structure of chemicals on ice surfaces.

To understand the natural phenomena of polar regions based on ice chemical reactions, fieldwork that utilized the infrastructure of the Korea Polar Research Institute and experiments that mimicked polar environments were carried out. Snow, sea ice, and seawater samples were collected in the Araon Antarctic expedition, and gas species that affect climate changes were observed. Equipment for the real-time monitoring of halogen and air pollutants in polar regions was developed in collaboration with Consejo Superior de Investigaciones Científicas (CSIC) of Spain and installed at the King Sejong Station in December 2018 (Fig. 2). In a laboratory experiment, the chemical reaction of iodine substances and nitrogen oxides in ice increased the production of active iodine, which elucidated a new nonbiological iodine formation mechanism. Furthermore, the ligand-specific dissolution of iron oxides in frozen solutions was discovered, and the acceleration of humic-/fulvic-like acid formation from organic materials and inorganic nitrogen compounds in ice as well as similarities to the organic materials in polar ice was confirmed.

Research on application technologies based on ice chemistry confirmed that large PEDOT:PSS conductive polymer sheets synthesized on an ice template had higher crystallinity and enhanced electrical conductivity than conventional methods. In addition, using the concentration property of solutes in aqueous solutions in the liquid-like layer during freezing, a new method was developed to degrade aqueous organic pollutants through the activation of periodate by freezing (Fig. 3).

This study of chemical reactions that occur in ice will lead the unexplored field of ice chemistry, play a new role of understanding polar natural phenomena, and contribute to the development of climate change models and countermeasures against climate change. Moreover, the development of application technologies using ice chemistry is expected to be utilized in various fields.

Korea - Arctic Ocean Observing System (K-AOOS) Program

Looking ahead to the future by observing rapid changes in the ice-covered Pacific Central Arctic Ocean (CAO)

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The Arctic Ocean is a region that has been most susceptible to the effects of global warming and has been exerting a significant impact on the global climate system. With the Arctic warming at a rate faster than the global average, the rapid melting of sea ice is exerting a major impact on the climate and the adjacent ecological environment, whether it be heat circulation between the ocean, sea ice, and atmosphere or changes in the oceanographic current, and so on. Research on the physical properties of sea ice motion, biogeochemical systems, and its related mechanisms needs to be undertaken to understand how climate change will affect the marine environment of the Arctic Ocean. Funded by the Korean Ministry of Oceans and Fisheries (MOF), KOPRI has been carrying out a five-year research project, the 'Korea–Arctic Ocean Observing System (K-AOOS)', from 2016 to 2020. This project assesses the most rapidly changing regions in the Pacific Central Arctic Ocean (CAO) near the Chukchi Sea and the East Siberian Sea, aiming to examine the changes in the atmospheric physical–biogeochemical marine environment that occur with changes in the sea ice and analyzing the causes of the environmental changes in the Arctic Ocean to make a prediction of future changes. In August 2018, Araon, a research on the temporal and spatial variations of sea ice distribution in the Chukchi Sea and the East Siberian Sea, unique physical changes of the ocean and sea ice, the force of ocean–atmosphere gas exchange, and the physical and biogeochemical processes of the marginal sea ice zone were carried out. Through this research, this project aims to achieve a better understanding of the phenomenon of rapid environmental change in the Pacific Central Arctic Ocean (CAO) and to construct a map of the CAO on temporal and spatial scales, to provide the scientific foundation for national strategies that address global Polar issues.

Figure 1. Korea – Arctic Ocean Observing System (K-AOOS) program using RV Araon

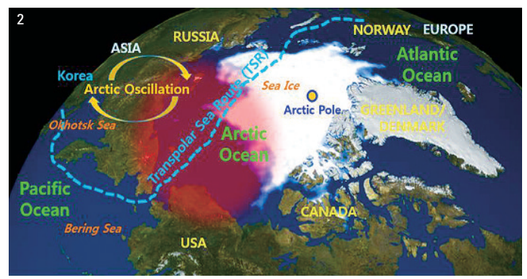

Figure 2. Pacific Central Arctic Ocean (CAO) study area in rapid sea ice decrease (red zone), affecting the climate, ecosystem, and Northern Sea Route

Figure 3. Field activity during the Arctic expedition (Top: Sea ice camp, Bottom: Araon penetrating the sea ice)

The Arctic in the Age of the Cold Rush

02

Investigation of the Seabed Resource Environment and Methane Release in the Arctic

Recovery of Gas Hydrates and Manganese Nodules Hidden in the Arctic Seabed

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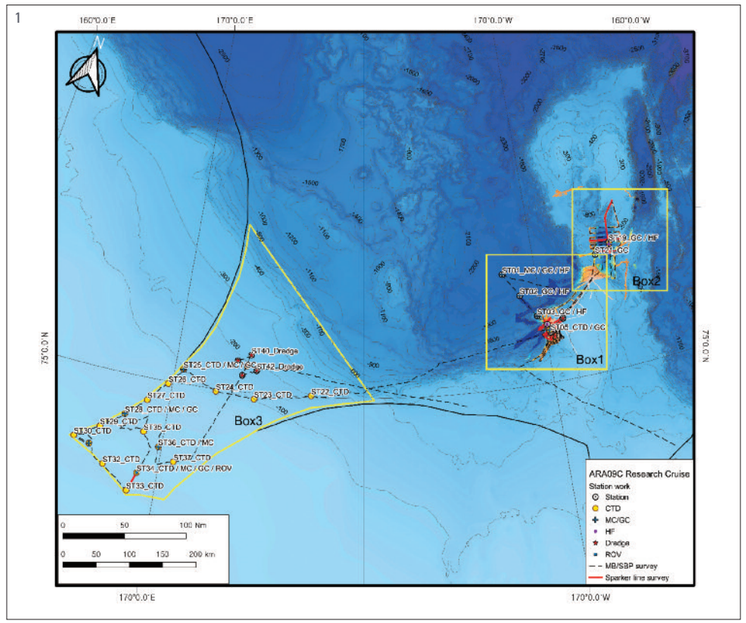


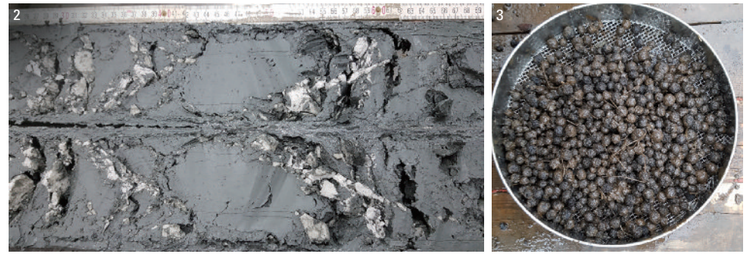
Figure 1. Overview map that shows the survey areas and activities of Araon cruise ARA08C

The Arctic is known to possess about 20% of the world's undiscovered energy resources. It is expected that there is about 15% of gas hydrates named 'fiery ice' as future energy resources. As the Arctic warms and the sea ice dramatically decreases, people's activities and exploration become easy in the Arctic Ocean, which has been difficult to approach. This study is being conducted as an R&D project of the Ministry of Maritime Affairs and Fisheries from 2016 to 2020 to investigate the seabed resource environment and the methane release phenomena from the melting seabed of the Arctic Ocean.

The 2018 Arctic ARA9C Cruise of the ice-breaking RV, Araon (Chief Researcher: Dr. Keun Young Jin), was undertaken in the Chukchi Sea and the East Siberian Sea. A total of 39 researchers (30 from Korea, 5 from Japan, 2 from Russia, and 2 from China) participated in the Korea–Japan–Russia international research cruise. The Korean team consisted of the Korea Polar Research Institute, the Korean Institute of Geoscience and Mineral Resources, Gangwon National University, Hanyang University, Sejong University, Gyeongsang University, the Ulsan National Institute of Science and Technology, and the Gwangju Institute of Science and

Figure 2. 'Fiery ice' gas hydrates retrieved in the continental slope of the Chukchi Plateau

Figure 3. Manganese nodules collected at 200 m water depth in the continental slope of the East Siberian Sea



Technology. The Kitami Institute of Technology from Japan, the Institute of Ocean (RAS) from Russia, and Hohai University from China participated as the international team. The cruise period was 23 days (August 29 – September 20).

The 2018 cruise focused on in-depth surveys to intensively explore three key findings (gas hydrates in the Chukchi Plateau, manganese nodules, and high methane concentration in the East Siberian Sea) identified in the Chukchi Sea and the Siberian Sea in the first 2016 cruise. The Central Basin in the Chukchi Plateau, which remains an unexplored area, was also first surveyed.

The highlights of this cruise include 1) the first discovery of the Bottom-Simulating Seismic Reflector (BSR), which is an indicator of the regional existence of gas hydrates, and the recovery of gas hydrate samples from the top of two submarine mound structures; 2) the collection of about 2,000 manganese nodules in a large area of about 80 km distance and around 200 m water depth in the Eastern Siberian Sea; and 3) the grid-style dense measurement in the East Siberian continental shelf, where very high methane concentration anomaly (several tens of magnitude higher than the global average) was first detected in the 2016 cruise.

Circum-Arctic Permafrost Environment Change Monitoring - Future Prediction and Development Techniques of Useful Biomaterials (CAPEC Project)

A Leading Study on the Environmental Change in the Circum-Arctic Permafrost Region through Establishment of International Joint Research Network

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The Arctic Circle means land and sea 66° 33 min north of the latitude. As the Earth's axis of rotation is tilted by 23.4°, the Arctic is an area that has a white night that does not last at least once a year and has an open night. This has greatly increased the interest in the Arctic since the former Soviet secretary, Gorbachev, made a speech in Murmansk in 1987. In addition, the Arctic has been rapidly melting sea ice and permafrost, and the ecosystem is rapidly changing, raising scientific interest in diagnosing changes and analyzing ripple effects and responding to them.

However, as accurate monitoring and prediction of environmental changes in the Arctic is still insufficient, systematic observation is needed to understand the interrelationships between the patterns, causes, and changes of environmental change in the Arctic. Therefore, Korea is also trying to better diagnose and analyze the trends of these environmental changes in the Arctic.

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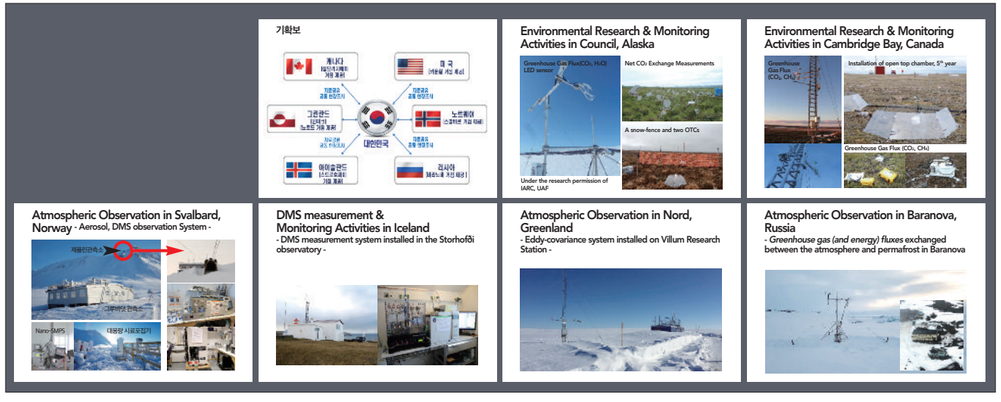
As part of this, the Korea Polar Research Institute (KOPRI) (supported by the Ministry of Science and ICT, the National Research Foundation of Korea) secured six observational nodes, and established measuring systems in the permafrost area of six Arctic Council countries including the United States, Canada, Norway (Svalbard), Greenland, Iceland, and Russia. In Korea, high-quality human resources, such as the Gwangju Institute of Science and Technology, Kyungin Women's University, Korea University, Seoul National University, Sookmyung Women's University, Yonsei University, Hanyang University, and the Korea Institute of Construction Technology, are participating. Based on these nodes, long-term monitoring of weather, atmospheric, and ecological environments is carried out to secure environmental factors and analyze their characteristics. Furthermore, through the simulation of changes in the Arctic environment, research on how Arctic changes will affect our environment in the long term as well as development of technology that can be discovered and utilized by finding useful substances in the Arctic have been conducted, and the team has been working as a representative for important Arctic-related meetings in the international community.

Ultimately, it is expected that environmental factors, such as climate, soil, and ecosystem, can be listed on a database to understand the process of greenhouse gas exchange between climate, ecosystem, and frozen soil, and combined with satellite exploration to improve the accuracy of environmental change forecast across the entire scale of the Circum-Arctic regions. Furthermore, such research activities on the Arctic could serve to enhance the image of Korea in the international community by presenting the findings to the Arctic Council and International Arctic Science Committee (IASC) working groups. Securing networks with Arctic countries through international joint research could be provided as a scientific basis for the future exploration of Arctic resources. Increasing the predictability of changes in the polar environment could also increase the responsiveness of future changes in the environment.

In carrying out this project, the team published 15 foreign SCI-class journals (average mrnIF of 72 or more) in 2018 and applied for a domestic patent for the discovery of useful protein using plants in the Arctic. Moreover, 22 environmental factors have been accumulated such as greenhouse gases, soil microorganism genes, carbon dioxide flux, and so on.

Fig. 1. Operation of the international collaborative research network and environmental change measurement system by each observation node



Changes in environments and coastal geomorphology of Svalbard fjords, Arctic

Exploring the fjords of Svalbard, the Barometer of Climate Change

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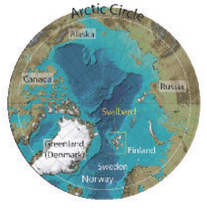


Figure 1. Map of the Arctic showing the location of the Svalbard archipelago

The Svalbard archipelago is located east of the Fram Strait, where warm Atlantic water intrudes the Arctic Ocean - the gateway to the Arctic. Fjords that shape the coastlines of Svalbard host sediments eroded and transported by glaciers and glacier meltwater that record changes in environmental processes including ocean circulation, glacier advance and retreat, sea level, and coastal erosion. As 62% of the area is currently covered by glaciers that are known to be vulnerable to climate changes, the Svalbard fjords provide an excellent setting for investigating environmental consequences of past, current, and future climate changes in northern high latitudes. The Korea Polar Research Institute has been working on the research project, "Changes in environments and coastal geomorphology of Svalbard fjords, Arctic (2015–2020)," funded by the Ministry of Science and ICT (Korea Research Foundation). We aim to 1) build a map based on the observation of the Svalbard fjord coastal changes, 2) reconstruct the environmental changes of the fjords since the last deglaciation, and 3) develop and apply organic and inorganic paleoenvironmental proxies. In 2018, the changes in depositional environments in an unglaciated fjord system have been successfully reconstructed, and the alkenone biomarker proxy was applied to the fjord sediment to unravel the enhanced marine primary productivity fueled by Atlantic water intrusion during the Late Holocene using data and sediment cores collected during the Korea–Norway joint expeditions (2016 and 2017). Furthermore, a metal-free clean laboratory for analyzing neodymium isotopes, which is a proxy for sediment provenance and water mass changes, was established. Efforts to probe the impacts of global climate changes in the Svalbard fjords will be pursued.

Figure 2. Tidewater glacier in Woodfjorden, northern Svalbard

Figure 3. Analytical procedures for detrital Nd isotopes and their spatial variation in Svalbard surface sediments

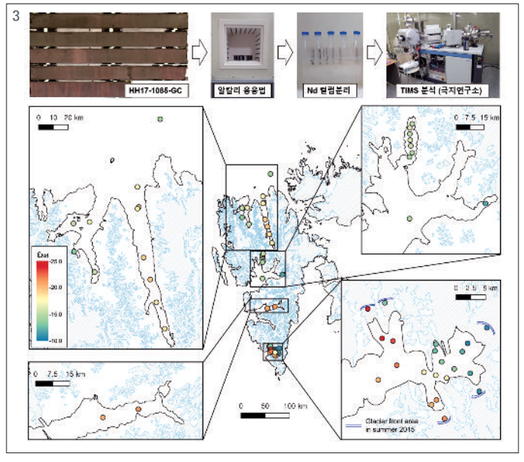
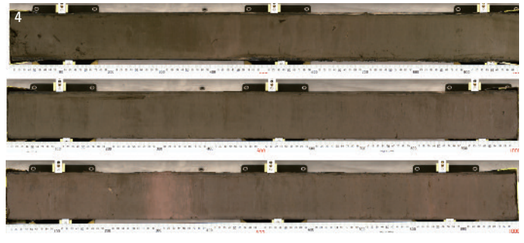


Figure 4. Image of a sediment core from Wijdefjorden, northern Svalbard



Research on the Analytical Technique for Satellite Observation of Arctic Sea Ice

Near Real-Time Monitoring of Arctic Sea Ice through Remote Sensing

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Arctic sea ice is one of the most visible indicators of climate change. It also plays a key role in the development of the new Northern Sea Route (NSR). Satellite remote sensing technology is a useful tool for conducting observations of sea ice in the Arctic Ocean. Therefore, developing appropriate techniques for processing and analysis to retrieve precise sea ice characteristics from satellite data is necessary. "Research on the analytical technique for satellite observation of Arctic sea ice," a project launched in 2017 at KOPRI to be completed in 2019, consists of three objectives: 1) developing a prototype satellite data archive/manage system for Arctic sea ice monitoring, 2) advancing sea ice remote-sensing data processing and analysis techniques, and 3) contributing to the efforts of the international satellite observation network for the Arctic. For a successful accomplishment of sea ice satellite data analysis, collaboration with various research groups, industries, and the academia will be continued.

This project will establish the Satellite Remote-Sensing Team for Arctic and Antarctic Research (STAR) system, which will archive and manage near real-time masses of remote-sensing data acquired by various sensors such as synthetic aperture radar, high-resolution optical imaging sensors (multispectral and hyperspectral), ocean color / sea surface temperature sensor, passive microwave sensor, altimeter, unmanned aerial vehicle (UAV), and so on. Moreover, through the development of a sea ice satellite data processing and analysis technology, this project will generate sea ice data necessary for climate change research and the development of the NSR, and verify satellite-based sea ice data through field surveys carried out on the icebreaking research vessel, ARAON. Finally, this project will establish a data-receiving system of Korea Multi-Purpose Satellites (KOMPSATs) for polar regions by collaborating with the Korea Aerospace Research Institute (KARI) and, in so doing, lay the foundation for the international satellite observation network.

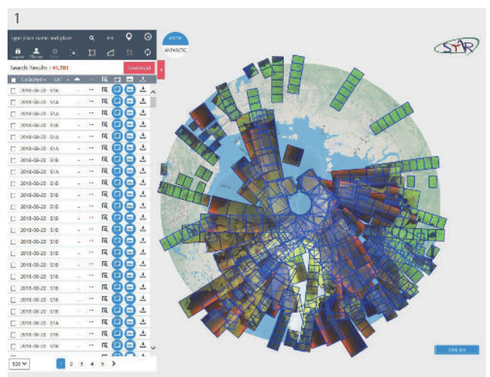

Figure 1. User interface of the satellite data archive/manage system for Arctic sea ice monitoring

Figure 2. International Arctic field observation for sea ice in the Alaska. Korea, Norway, Canada, and USA are participated for study of processes of the Arctic coastal environment at the interaction between the marine, terrestrial, atmosphere and cryospheric environments using ground-based and remote sensing observation

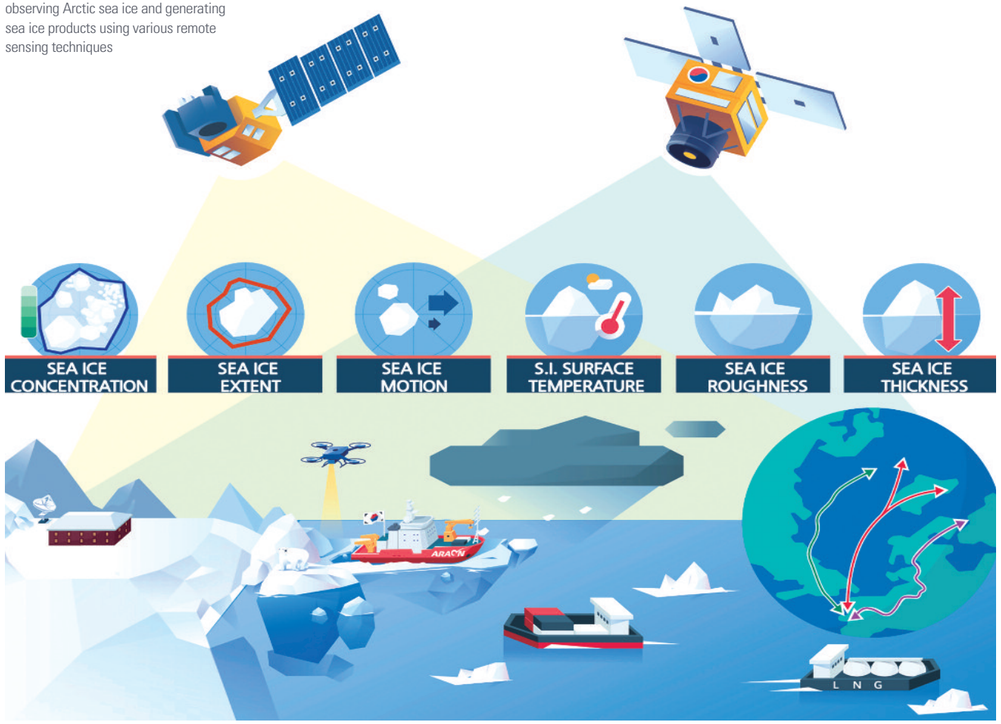

Figure 3. Schematic diagram of observing Arctic sea ice and generating sea ice products using various remote sensing techniques

Development and Application of the Korea Polar Prediction System (KPOPS) for Climate Change and Disastrous Weather Events

Applying the Korea Polar Prediction System to the Study of the Arctic-midlatitude Weather Linkage

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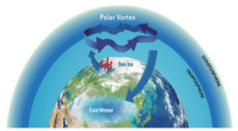
Figure 1. Schematic of Eurasian cold winter induced by sea ice melting in the Arctic



Rapid changes in cryospheric climate components, such as sea ice and snow, are emerging due to an accelerated Arctic climate change. Recent studies have revealed that the effects of the rapid changes are not limited to the Arctic but extended to weather extremes in mid-latitudes. Moreover, previous studies show that the Korea Polar Research Institute (KOPRI) has developed its own polar prediction system, which uses sea ice and snow covers as major predictors, and carries out winter seasonal forecast in Korea. This year, the polar prediction system was improved by focusing on enhancing its capability in Arctic cloud simulation and also by substituting the dynamic core of the original prediction system with that more appropriate for polar regions. On the other hand, to establish the test bed for continuous model improvement in the future, the observation of cloud particles and the atmospheric boundary layer was started all year round at the Arctic Dasan Station. The accumulated data will be used to verify the model performance of Arctic cloud simulation.

The absence of regular upper-air meteorological observations in the high-latitude Arctic Ocean is often pointed to as a cause of failure of meteorological forecasting. The KOPRI has conducted relevant research about the usefulness of temporarily enhanced upper-air radiosonde observations in the Arctic Ocean to numerical weather prediction. Based on these background research, the project has been regularly carrying out radiosonde upper-air observations in the Araon Ocean. In cooperation with the Korea Meteorological Administration, real-time data are transmitted to the World Meteorological Organization (WMO), which makes our data available to international forecasting agencies. This is an official activity approved by the WMO's "Year of Polar Prediction (YOPP)" program.

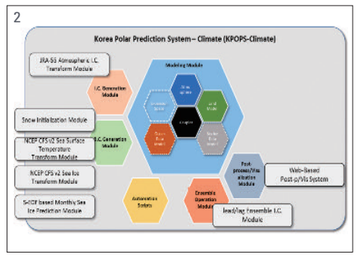


Figure 2. Schematic diagram of the Korea Polar Climate Prediction System (KPOPS-Climate)

Figure 3. Arctic cloud observation network at the Dasan Station in Ny-Alesund

Figure 4. (Left) Upper-air observation in the Arctic Ocean by the radiosonde balloon launch on the IBRV Araon (Right) Introduction of the KOPRI activity for upper-air radiosonde observations in the Arctic Ocean to the WMO's "Year of Polar Prediction (YOPP)" Newsletter

Carbon Assimilation Rate of the Sea Ice Ecosystem in Kongsfjorden MIZ, Arctic

Take a stock of carbon absorption and the behavior of the Arctic sea ice ecosystem

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The Arctic Ocean has been evaluated as having a low primary production due to extreme environmental conditions. However, based on recent research, it was reported that the Arctic sea ice ecosystem was found to have a very high carbon assimilation rate. In the past, studies on the sea ice ecosystem were carried out mainly by Arctic countries. In the Arctic Ocean, the range of the contribution of sea ice algae to the total primary production is approximately 15%–20%. In the future, the change in the production of sea ice algae is expected to increase with the first year ice, and the necessity of reevaluation will be emphasized. This project will focus on understanding the carbon assimilation rate of the sea ice ecosystem as well as the carbon behavior depending on the growth stage in the Kongsfjorden marginal ice zone around the Arctic Dasan Station in 2017–2019 (Phase 1). During the study period, species diversity and the contribution of the organic matters of the marine ecosystem in the Kongsfjorden marginal ice zone as well as the carbon assimilation rate of sea ice algae will be evaluated and analyzed. Therefore, in this project, it is expected that the change of the carbon assimilation rate according to the variation of the sea ice ecosystem and the carbon behavior based on the sea ice – ocean pCO_2 continuous observation system with the sea ice growth stage will be understood.

Figure 1. Photograph of the Dasan Station

Figure 2. Photograph of sea ice core sampling

Figure 3. Sea ice algae in-situ incubation

Early Animal Evolution and the Primitive Earth System of North Greenland

Internal structures of 520 million-year-old stem arrow worms are seen by EPMA

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Most of the organisms that we call 'animals' arose in the fossil record about 540 million years ago at the beginning of the Cambrian Period. and underwent a radical morphological evolution to attain the great variety of morphological blueprints that are seen today. The morphological origin of modern animals thus lies in Early Cambrian animal fossils. However, only the hard part of the animals, such as bones and shells can get fossilized in a normal condition, and less than 14% of animal species have hard parts in their bodies, which means that about 86% of the animals usually do not leave a hint in the fossil record. Nevertheless, there are several fossil localities around the world that yield fossils preserving details of soft parts such as eyes, guts, and appendages. These localities include the Burgess Shale of Canada, the Chengjiang biota of China, and the Sirius Passet of North Greenland.

To solve the mystery of early animal evolution, the Korea Polar Research Institute has carried out field expeditions to Sirius Passet, North Greenland, and has collected more than 10,000 specimens of diverse animal fossils from the Early Cambrian. The main research focus of this year was on the reconstruction of the internal structures of the Cambrian stem-group chaetognaths. Chaetognaths form one of the main components of the modern marine plankton and are considered to retain a primitive early animal morphology. Therefore, elucidating the morphology of the Cambrian stem-group chaetognaths is critical in understanding the earliest animal evolution. The internal structures of the stem-group chaetognath have been identified, such as muscle bundles, guts, and fin rays, by applying EPMA on the fossils (Fig. 1),

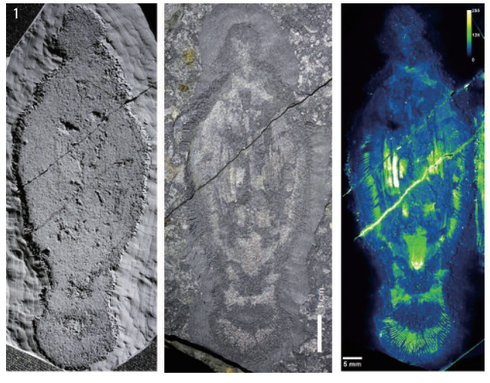

Figure 1. Stem-group chaetognath fossils from North Greenland (Left, Middle) and its carbon elemental map, in which muscle bundles, guts, and fin rays are well expressed

Figure 2. 2018 season KOPRI field camp at Sirius Passet, North Greenland

an original method that the Korea Polar Research Institute has developed.

North Greenland is the northernmost terrestrial area in the world, located above 82°N. Most of the area remains unstudied so that various polar research can be carried out in the future. The largest camp in the history of North Greenland was set up in the 2018 season (Fig. 2), with the establishment of some key infrastructures. A newly built polar igloo is storing the field gears for the non-field season. The very first AWS in this area has been installed, which sends weather information via satellite every day (Fig. 3).

Figure 3. Polar igloo (Left) and AWS (Right) at Sirius Passet, North Greenland

Future Values and Technology from Polar Resources

01

Characterizing Mantle Domain beneath West Antarctic Rift System and Antarctic Mid-Ocean Ridges

Constructing a Unique Seismic Network in Antarctica Consisting of Land-Based and Ocean-Bottom Seismographs

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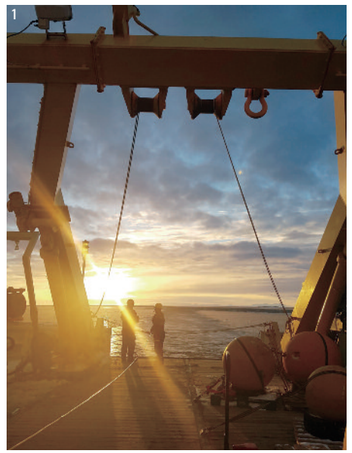

Figure 1. The picture of deploying a magnetometer to measure magnetic anomalies in the Antarctic Mid-ocean Ridges on RV Araon.

Figure 2. The picture of retrieving the Ocean Bottom Seismograph (OBS) installed on the site O181 during 2018-19 Antarctic summer fieldwork period.

Figure 3. The picture of deploying the OBS on the site of O184 during 2018-19 Antarctic summer fieldwork.

The West Antarctic Rift System (WARS) is one of the largest active rift valley lying between East and West Antarctica. The origin and development of the WARS should be related with the formation of the Transantarctic Mountains, which stretches between the Ross Sea and the Weddell Sea—the entire length of Antarctica with a total range of about 3,500 km. To understand the origin and development of the WARS, the Division of Polar Earth-System Sciences at KOPRI has performed the phase II of the research titled "Characterizing Mantle Domain beneath West Antarctic Rift System and Antarctic Mid-Ocean Ridges." In the period of phase II starting from 2017, the Terror Rift was the subject of the study because of its high occurrence of tectonic earthquakes and already well-established seismic and GPS networks based on the Jang Bogo Station (JBG). The three-dimensional P-wave seismic velocity model beneath the Terror Rift and JBS was computed using teleseismic events, and two low-velocity anomalies beneath the Terror Rift, Mount Melbourne, and Mount Rittman areas were found. The rifting process on the surface has the lower mantle material up-going, which was then partially melted through decompression melting. Five more ocean bottom seismographs will be deployed during the 2018-19 summer Antarctic field season to compute a 3D velocity model with higher resolution and measure tectonic activities at the Terror Rift, and year-round data will be retrieved during the 2019-20 summer Antarctic field season. The retrieved year-round seismic data will provide a better understanding of the tectonics of the WARS by constraining better 3D velocity models, locating precise tectonic events and their frequency, visualizing seasonal seismic noise patterns and so on.

Future Values and Technology from Polar Resources

02

Understanding polar upper atmospheric changes by energy input from the space environment and the lower atmosphere

A Way of Looking at the Polar Upper Atmosphere: Radar and Camera

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Studies on the polar upper atmosphere, which is directly affected by the interaction between space environment like the sun and the Earth's magnetosphere, are lacking because of very limited observations. The space environment research group in the Korea Polar Research Institute (KOPRI) has built ground-based observational systems at both Arctic and Antarctic areas and studied the physical characteristics of the polar upper atmosphere under the influence of the space environment. Recently, KOPRI joined EISCAT's (European Incoherent Scatter) observational radar network as an attempt to study upper atmospheric changes in both space and time with ground-based observations at Dasan Arctic Stations—as well as at Kiruna observatory in Sweden. In particular, the National Center for Atmospheric Research (NCAR) performed the HiWind mission, which is a balloon-based Fabry-Pérot Interferometer (FPI) observation for the daytime thermospheric wind measurement in summer at the stratosphere. KOPRI participated in this mission as a collaborator with EISCAT ionospheric observations in Kiruna. The HiWind mission plays an important role to extend our observational scope for the study of the interaction between space environment and upper atmosphere from nighttime to daytime. Simultaneously observing plasma motion from the EISCAT and neutral wind at thermosphere from the FPI, this study aims to tackle the kinetic properties of the polar upper atmosphere as a result of the physical interaction between neutrals and plasmas during the daytime.

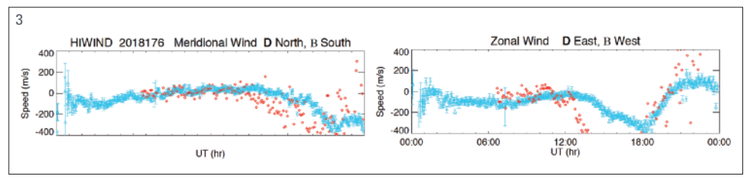

Figure 1. EISCAT radar antenna in Tromsø, Norway, which is one of the EISCAT radar networks across the Arctic. It monitors the polar upper atmosphere to study the influences of the space environment (courtesy of EISCAT).

Figure 2. HiWind mission enables us to monitor the polar thermospheric winds during the daytime in summer by placing the FPI instrument into the stratospheric height.

Figure 3. Polar thermospheric winds and ion drifts observed from HiWind and EISCAT, respectively, on day 176 in 2018. They will be utilized to study their coupling in the polar region.

Future Values and Technology from Polar Resources

03

Polar Genomics 101 Project: Genome analysis of polar organisms and establishment of application platform

Unlock the secrets of adaptation and evolution by Antarctic genomics

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Since the advent of continental glaciation and the cooling of the Southern Ocean 38 million years ago (Mya), the Southern Ocean became thermally isolated and attained its present frigid temperatures (-2 to +2°C) by the mid-Miocene (14-10 Mya). Given this long, unique evolutionary history and current environmental setting, the Antarctic biota provides many opportunities to address fundamental biological problems, in particular, the links from genome to the survival of organisms.

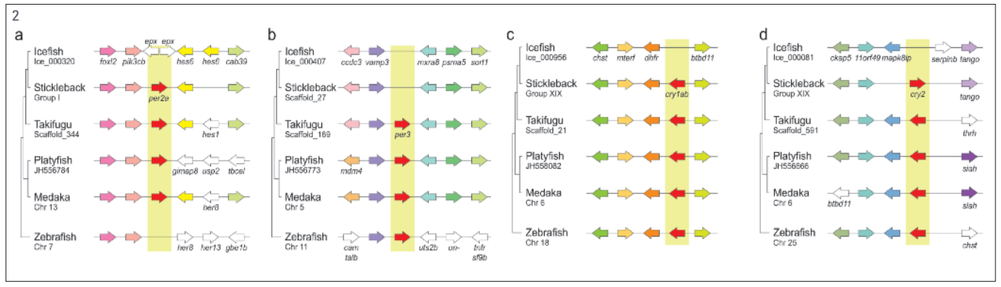
Antarctic icefish are the only vertebrate species that lacks functional hemoglobin genes and red blood cells. Here, a high-quality genome assembly and linkage map are reported for the blackfin icefish, *Chaenocephalus aceratus*, highlighting evolved genomic features for their unique physiology. Phylogenomic analysis revealed that Antarctic fish of the teleost suborder Notothenioidei, including icefish, diverged from other teleosts about 77 million years ago, and subsequently evolved into cold-adapted phenotypes as the Southern Ocean cooled to subzero temperatures. Results show that genes involved in protection from ice damage, including those encoding antifreeze glycoprotein (AFGP), and zona pellucida (ZP) proteins, are highly expanded in the icefish genome. Furthermore, genes that encode enzymes that help to control the cellular redox state, including members of the *SOD3* and *NQO1* gene families, are expanded—probably as evolutionary adaptations to the relatively high concentration of oxygen dissolved in cold Antarctica waters. In contrast, some crucial regulators of circadian homeostasis (*cry* and *per genes*) are absent in the icefish genome, suggesting compromised control of biological rhythms in the polar light environment. The availability of the icefish genome sequence will advance understanding of adaptation to extreme Antarctic environments.

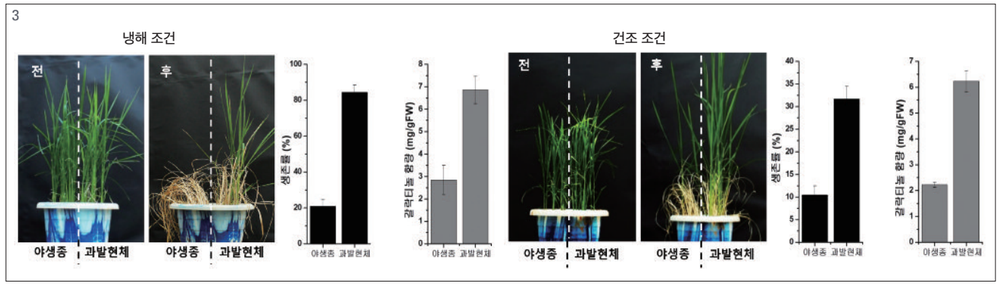
Figure 1. The genetic linkage map for the blackfin icefish.

Figure 2. Genomic evidence supporting gene loss events for blackfin icefish circadian rhythm-related genes. Genomic structures and syntenic comparisons of a. *cryptochrome* gene *cry1ab* and b. *cry2* c. *period* gene *per2* and d. *per3* gene clusters are shown within representative sequenced teleost genomes.

Figure 3. The cold (Left) and drought (Right) resistance phenotype of transgenic rice over-expressing *DaGolS2* originated from *Deschampsia antarctica*. *DaGolS2* over-expressing rice plants showed about threefold higher survival rate and galactinol contents than wild-type rice plants, under cold and drought stress conditions, respectively.

Finally, the representative Antarctic flowering plant *Deschampsia antarctica* is an attractive extremophile with important genetic resources for crop engineering for enhancing tolerance to environmental stresses. To elucidate the function of stress-responsive genes, *DaGolS2* gene related to the tolerance to cold and drought of *Deschampsia antarctica have been isolated* and used a transgenic approach to investigate its function in planta. The transgenic plants over-expressing *DaGolS2* showed about threefold higher survival rate and galactinol content under cold and drought stresses, compared to wild-type rice plants. These results indicate that *DaGolS2* plays a crucial role in response to drought and cold stress via the accumulation of galactinol in plants, and suggest the potential values of genetic resources from polar plant organisms for agricultural applications.





Future Values and Technology from Polar Resources

04

Commercialization of useful metabolites from polar organisms

Secure a pool of indigenous polar organisms, and develop a library for its popularization

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To commercialize the metabolites, polar organisms were collected, the extract and metabolite libraries were prepared, and the activities of the new metabolites were measured. In 2018, 15 species of organisms around Sejong Station in Antarctica, 35 samples of biological samples around the Arctic Dasan Base, and 12 samples of seawater were collected, and the shapes and collection sites were collected. Marine agar (150), actinomycetes (ISP1: 4), fungi (GYA / YPG: 127), and DB construction (277) were established. 10 of the isolated microorganisms were deposited with KCTC. In addition, 33 genes related to immune and detoxification of polar copepods were identified to understand the metabolic pathways of the polar environment adaptive organisms.

A total of 117 isolates from polar organisms–derived extracts and 1,023 MS-library DBs were obtained. In particular, a total of 102 polymorphic microbial extracts were analyzed by liquid chromatography–mass spectrometry (LC-MS) analysis using MS-library, and structural studies were conducted through chemical DB search (Fig. 1). The separation and chemical structure of the secondary metabolites were determined from an Antarctic soil microorganism, *Pseudorhodobacter psychrotolerans* sp. nov. IC_{50} values were determined by measuring the antimicrobial activities (6 kinds) and antibiotic activities (37 kinds) of *Candida albicans, Staphylococcus* aureus, and *Escherichia coli* in the extracts of lichens and fungi for securing the usefulness of new metabolites. The anti-inflammatory activity against the metabolites isolated from the culture extracts of the marine fungus SF 5929 strain was confirmed. In the cancer cells of 5 parts (cervical cancer, colon cancer, liver cancer, skin cancer) treated with 66 materials of extracts, 9 kinds of extracts with a decreasing ratio were selected. In addition, antibiotics, immunological activity, and so on, as well as low-temperature enzymes and biopolymer production strains were obtained. In 2018, the commercialization of the p-CY01, a blood-assistant anti-freezing agent, was completed. In addition, the mechanism of action of the Alzheimer's treatment (Ramalin), the synthesis before the commercialization of anti-diabetic drugs (Lobarstin) and the production of industrial low, and commercialization data for the transfer of technology.

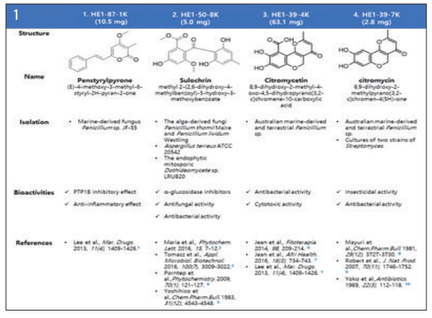

Figure 1. Development of a Metabolome DB

Future Values and Technology from Polar Resources

05

Geological evolution of Victoria Land, Antarctica, and the formative process of planets

Establishing the Basis for Geologic and Meteoritic Fieldworks and Researches in Victoria Land, Antarctica

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Antarctica is the least-known continent with its geological past beneath the ice. KOPRI has been conducting geologic and meteoritic expeditions to the continent since the opening of the Jang Bogo Station. These expeditions resulted in rare and high-quality geologic and meteoritic field data and materials that enable research on the past and present geological activities of Antarctica and the formative processes of planets. In 2018, detailed geochronology and the metamorphic process of the Ross orogeny ruled the assembly of Antarctica—500 million years ago. Depositional environments and sediment provenance of sedimentary basins in the active margin were interpreted from the Ross-age sedimentary strata.

Two hundred million years ago, diversity of vegetation in Antarctica was reconstructed based on new fossil woods. Expeditions to recent volcanoes allow new research to trace past eruptions and monitor current volcanic activities. Continuous recovery of Antarctic meteorites, including those from new blue-ice fields in Allan Hills, resulted in Korea being one of the top five meteorite research countries. The analytical data from these meteorites revealed the ages and inhomogeneity of the materials of the early solar system and thermal history of the meteorites, which provided the basis for understanding the formation of planets. KOPRI has completed securing four strategic footholds of Victoria Land that enable long-range fieldworks all over the Victoria Land. Continuous geological and meteorite expeditions to the Antarctic continent are planned for gathering geological information and meteorites, aiming at understanding geological processes of past Antarctica, and history of solar systems. New expeditions to active volcanoes are to be the basis for accessing the geological processes of present Antarctica. All these results are expected to help prepare the future of Antarctica for humankind.

Figure 1. Geological field camp at Neall Massif, Northern Victoria Land

Figure 2. Fieldwork for 500 million-year-old sedimentary rocks near the campsite

Figure 3. Searching for Antarctic meteorites from the blue-ice field near Elephant Moraine

Figure 4. The map showing the location and coverage of four strategic footholds of Victoria Land

Future Values and Technology from Polar Resources

06

Antarctic Korean Route Expedition and Development of Technologies for Deep Ice Coring and Hot Water Drilling

Antarctic Inland Traverse for a New Polar Scientific Frontier

Jong Ik Lee jilee@kopri.re.kr

Figure 1. K-route Antarctic traverse fleet

Figure 2. K-route Antarctic traverse

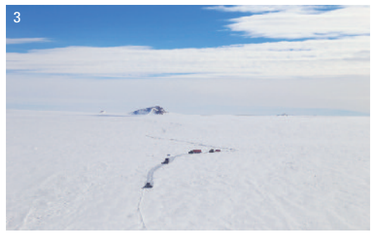

Figure 3. K-route crossing crevasse

Recently, large international scientific interests have been focused on the Antarctic inland for the global issues of climate and environmental changes. For example, the Antarctic deep ice core drilling project in a quest to recover a block of 1.5 million–year-old ice is selected as one of the ten scientific issues in 2019.

In 2014, the Korea Polar Research Institute (KOPRI) built the Antarctic Jang Bogo Station on Victoria Land, East Antarctica, and launched the K-route project for Antarctic inland research in 2017. The purposes of the K-route project are 1) expedition of traverse route into the Antarctic inland, 2) the development of polar research facilities and technologies for inland research activities, and 3) the sampling of deep ice core and subglacial lake water and sediments.

For the last two years, KOPRI has set up the traverse fleet with six snow vehicles, two tractors, five fuel tank sledges, seven cargo sledges, two snowmobiles, and eight flexible fuel tanks. In addition, two sets of living cabin container, four Arctic trucks for high-speed ice sheet exploration, and one mobile bridge for crossing a crevasse have been developed. In the 2018/2019 field season, the traverse advanced 700 km from the Jang Bogo Station via the D2 site, the most suitable place for subglacial lake drilling, and established two supply bases on the route. As for scientific issues, geophysical surveys of the subglacial lake were carried out at the D2 site using an ice-penetrating radar equipped on a helicopter and through satellite observation. With this research, the bedrock topography beneath the 2,000 m–thick glacier was reconstructed.

Subsequently, the K-route project will continue to enforce the traverse fleet with several snow vehicles, sledges, and other equipment, and will prepare inland research such as ice sheet flow monitoring, and subglacial lake and deep ice core drilling.

Figure 4. K-route expedition crews

Future Values and Technology from Polar Resources

07

Investigation and mass production of functional materials from polar microalgae

Make a continuous effort to develop and industrialize the new materials found in polar microalgae

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This is the first commercialization project using polar microalgae that started in 2017. Beginning with the development of "cosmeceuticals" (cosmetics + pharmaceuticals) with low-entry barriers, development of new medicines in the future will continue and the practical application of "polar biological resources" will be highlighted.

Last year, cell-protective pharmacological functions were observed in polar microalgae, and this year, the discovery of newly active substances was observed on by isolating metabolizing activities that show the efficacy to reduce cell damage and wrinkles from ultraviolet rays.

In Arctic microalga *Micractinium* sp. KSF0031, seven compounds were isolated. Among them, two single compounds with efficacy in the anti-allergic test were recently identified using Jurkat T-immune cells. Given this, a single compound (#8) that has the effect of reducing wrinkles caused by ultraviolet rays was also found, and its mass synthesis is underway for industrialization.

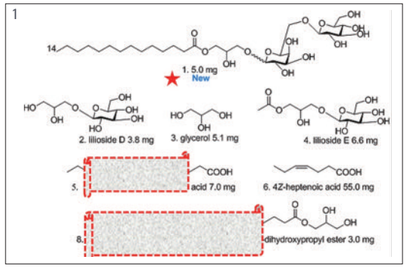
As a preliminary work for commercialization, eight polar samples were registered in the International Cosmetic Ingredient Collection (ICID). The skin safety evaluation of efficacy component of skin damage prevention by ultraviolet rays, confirmed by hot water extract of *Micractinium* sp. KSF0031, was executed, and the stability evaluation will be performed again this year with a single compound responsible for the efficacy.

To overcome the limitation in laboratories wherein it can only grow up to 2 liters in a culture flask, a new 4°C culture room of about 27 cubic meters in size where microalgae of 200 liters can be cultured will be launched.

Figure 1. The molecular formula of seven compounds isolated from polar microalga KSF0031

Figure 2. ICID registration and clinical skin stimulation test report of KSF0031 extract

Figure 3. Polar microalgae collection and mass cultivation in low-temperature room



Future Values and Technology from Polar Resources

08

Development of Potential Candidates as Antibiotics Based on Polar-Genetic Resources

Develop next-generation antibiotics candidate materials using polar-genetic resources

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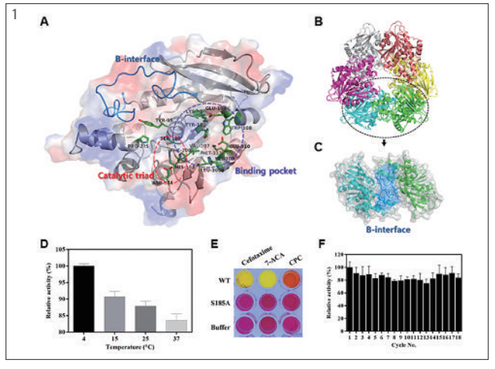

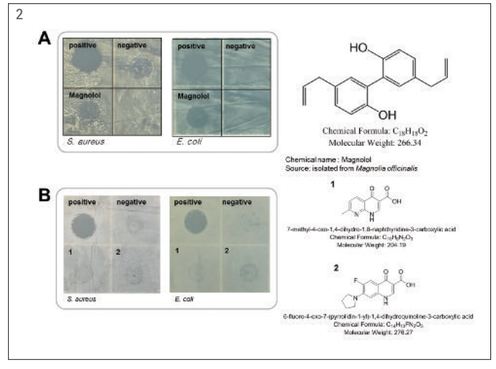

Figure 1. Structural analysis and biochemical properties of PbAcE, an enzyme derived from low-temperature aapted microorganisms in the Arctic Alaska

Figure 2. Antibacterial activity assay of new antibiotics compound

The objective of this study is to find next-generation antibiotic candidates that can overcome the antibiotic resistance problem using new, useful gene information from polar organisms. Major research methods include finding a useful antibiotic-compound modifying enzyme and producing recombinant proteins to identify biochemical properties and tertiary structures. The next step is to generate various structural variants of the existing antibiotic backbone compound using the modifying enzyme and then measure its antibacterial activity.

As a major result in 2018, 20 recombinant proteins of the antibiotic compound modifying enzyme were produced, and biochemical property and tertiary structure analysis were completed for 4 of them. Among them, the research group has determined the tertiary structure and functional characteristics of the acetylesterase (PbAcE) enzyme from the *Paenibacillus* sp. found in the eastern soil of Arctic Alaska. The results have been published in the PLOS ONE journal and were applied for a domestic patent. The structural analysis of the PbAcE enzyme revealed that it has a low-temperature activity and a broad substrate specificity by flexible subunit movements as well as more wide substrate binding pockets. The biochemical properties of PbAcE can be utilized in the development of the acetyl xylan hydrolysis enzyme and various antibiotic variants. In particular, PbAcE has been experimentally proven to be functional in removing the acetyl group of beta-lactam antibiotics such as cefotaxime, 7-Aminocephalosporanic acid (7-ACA), and cephalosporin C. Furthermore, the commercial availability of PbAcE was assessed by ensuring that the activity is maintained by more than 80% even after immobilization and 18 times are being reused. In addition, marine natural substances, quinolone-type antibiotics, and magnolol substances have been studied to be used as a backbone of new antibiotics.

PAP & PIP

01

Overview of Domestic Polar Academic Program (PAP)

Expand the Base for Polar Research and producing outstanding Professionals

To promote polar scientific research in Korea, KOPRI launched the Polar Academic Program (PAP) through which a research fund of KRW 1 billion is granted to Korean universities for joint collaborative research to be conducted between academia and research institutes.

The goals of the PAP include : discovering creative ideas for polar research; conducting field-based polar research by allowing accessibility and joint use of polar infrastructure (Antarctic and Arctic research stations and icebreaker Araon); and fostering the next generation of researchers specializing in polar science.

Since 2010, this program has supported a total of 22 universities and two research institutes in Korea for research. In addition, 76 students in master's programs and 62 in doctoral programs participated in PAP over the past three years (2016-2018), thereby solidifying the foundation for polar research and polar experts. The program also generated outstanding results in terms of academic papers in polar science: 16 out of 35 SCI-level papers obtained a standardized impact factor of 80 points or higher.

In 2018, a total of 16 polar research projects drew the participation of 97 researchers (16 doctoral degree holders; 35 master's degree holders; and 46 bachelor's degree holders) from twelve universities across Korea.

<Timeline for New PAP Project>

February–March
Announcing a new project and receiving applications

April
Selecting and assessing the new project

By 1 May
Entering into an agreement for the new project and launching the project

<Areas of Recruitment in a New PAP Project>

Category	Major Content
Polar GeoScience	Area related to polar geoscience, including rocks, geological features, and Antarctic meteorites in polar regions.
Polar BioScience	Area related to polar bioscience, including polar ecosystems and life in polar regions.
Polar-Ocean Science	Area related to polar marine science, including sea ice and atmosphere in polar regions.
Polar-aleo/ CryoScience	Area related to paleoclimate and permafrost in polar regions, including polar glacier, submarine sediment, and restoration of the paleoenvironment.
Polar-Atom/ Cosmo Science	Area related to polar climate and space science, including lower/upper atmosphere, space environment, and satellite science.

<PAP Research Project in 2018>

Research Project Tilte	Project Investigator	Period
Highly precise and assured navigation system for unmanned explorations in the polar regions	Jiyun Lee(KAIST)	2018.06.01.~2019.05.13.
The impact of climate change on the life of Inuit in case of Nunavut, Canada	Seung Ho Lee(Konkuk Univ.)	2018.06.01.~2019.05.31.
Understanding the process of polar shrub expansion using the Ecosystem Demography Model	yeonjoo kim(Yonsei Univ.)	2018.06.01.~2019.05.31.
Study on behavioral characteristics of tardigrade using microfluidic chip	Sung hyung jin(KAIST)	2018.06.01.~2019.05.31.
Establishment of CSF expression in arctic Chlorella sp. via genetic transformation	Kim sung ryong(Sogang Univ.)	2018.06.01.~2019.05.31.
Identyfying sources of methylmercury in arctic Sea using a mass flus model	Seunghee Han(GIST)	2018.06.01.~2019.05.31.
Test of underwater obsevation data transfer system using a pop-up buoy in extremely severe environment	Jae-Hun Park(Inha Univ.)	2018.06.01.~2019.05.31.
Study of radioactive isotopes for environmental samples from Antarctica	Hahn In sik (Ewha Womans Univ.)	2018.06.01.~2019.05.31.
Understanding the characteristics and accumulation process of microplastics in the Antarctic coast and oceans	Hwang Jin-hwan(Seoul National Univ.)	2018.07.02.~2018.12.31.
Hydrogeological characteristics of active layers near King Sejong Station	Jin Seong-wook(Chonbuk National Univ.)	2018.07.02.~2018.12.31.
The study of membrane fluidity change in Arctic bacteria by global warming through microbial phospholipid fatty acid analysis	Yang Yeong-heon(Konkuk Univ.)	2018.07.02.~2018.12.31.
What to edit: Rapid Evolution Through Analysis on Functional Evolution of Polar Genetic Resources	LEE Byeong-ha(Sogang Univ.)	2018.07.02.~2018.12.31.
Study on historical record and environmental behavior of emerging contaminants in polar environments using target and non-target analysis	Moon Hyo-bang(Hanyang Univ.)	2018.07.02.~2018.12.31.
Anti/De-icing materials to ensure function of equipment in polar environment	Kwak Min-seok(Pukyong National Univ.)	2018.07.02.~2018.12.31.
Arctic Development in Russia and Its Impacts on Local Communities	Choi Woo-ik(Hankuk Univ. of Foreign Studies)	2018.11.01.~2019.10.31.
The Effects of Abnormal Behavior of Jet Streams Induced by Polar Warming on Air Quality Changes in East Asia	Choi Won-sik(Pukyong National Univ.)	2018.11.01.~2019.10.31.

PAP & PIP

02

Overview of Domestic Polar Industrial Program (PIP)

Develop the System Best Fit for Polar Research in Collaboration with Specialist Companies

KOPRI has been conducting the Polar Industrial Program (PIP) with an annual research fund of KRW 700 million. The purpose of this industry-research institute collaborative research program includes: ensuring research excellence in Polar regions by developing equipment and technology necessary to conduct Polar research; commercializing such equipment and technology to create new Polar industries and support small and medium-sized enterprises.

The two projects carried out in 2018 were promoted by small businesses to develop systems and equipment required by KOPRI and to utilize them in polar regions.

<Timeline for New PIP Project>

Feb.
Selecting technology items

Mar.
Conducting planning Research

April
Preparing a request for proposal (RFP)

May
Announcing the project; selecting participants, and launching the project

<PIP Research Projects in 2018>

Research Project Title	Participating Institution	Research Period
A development of ice-penetrating radar (IPR) for internal ice structure analysis	U-Tel Co., Ltd. (General Manager Shin and other participants)	2018.11.01.~ 2019.10.31.
Development of advanced technology for underwater rock drilling and obtaining a rock core in deep sea(1,000M)	Shinyang Technology Co., Ltd. (President Jeon and other participants)	2018.12.29.~ 2019.12.28.

Part. 02

RESEARCH INFRASTRUCTURE

Marking Its 30th Anniversary, the Antarctic King Sejong Station to Make a New Leap Forward

Leader of the 31st overwintering Team
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King Sejong Station

- King George Island, South Shetlands, Antarctic Peninsula ((62°13'S / 58°47'W))
- Established in February 1988

To become a member of the Antarctic Treaty in November 1986, South Korea established the Antarctic King Sejong Station in the King George Island of the South Shetlands in February 1988. Overwintering team composed of 17 members stayed in the station for a year, and a summer research team of 100 members was dispatched to the station to conduct diverse studies from November to February of the following summer in Antarctica.

<Mission>

❶ Research on Climate change, Marine system, Atmosphere, Ozone layer, and Paleoclimate
❷ Transmitting data to the World Meteorological Organization, and sharing data with the Korea Meteorological Administration, other research institutions and universities
❸ Ecosystem monitoring for Antarctic birds

The 31st overwintering team of 17 members was officially launched on October 18, 2017. From the 19th to 27th of the same month, there was a training program to learn how to manage facilities of the King Sejong Station and how to work and operate safely. The team left Incheon International Airport on November 28 and arrived at the Antarctic King Sejong Station on December 1. After a week of duty handover, the mission of the overwintering team began on December 8 (Fig. 1).

For the summer season of 2017–2018, a range of construction and maintenance works were completed to build up a new research building and a history museum, replacing power generators as well as repairing the wastewater treatment and recycling system, and the fresh water reservoir. In addition, researchers from Korea and other countries visited the station to study in diverse research areas including the terrestrial and coastal ecosystem and the atmosphere. To finalize the construction and maintenance for the coming 30th anniversary ceremony of the King Sejong Station, the overwintering team and construction team cooperated in speeding up the works. There was a sort of tension because of the delayed supply of food and construction materials; however, the problem was solved by very fast unloading of supply directly from the ship to pier using a crane. Despite the tight construction schedule, the new research building, where laboratories and research equipments were moved from the old building, was prepared in a short period for diverse research projects to be implemented according to their supposed plan (Fig. 2).

The team also saw a risky moment during replacing the old power generators; however, they completed a safe work to install the three new power generators that are now connected to an emergency unit and an independent standby unit to construct an electricity supply system that is flexible to diverse situations. In addition, the waterproof cloth of the fresh water reservoir was replaced to secure abundant water for one year and stable drinking water supply. The sewage treatment system was repaired and readied for normal mechanical operation; however, some further improvements need to be made for enhancing practical treatment efficiency. Both laboratory testing and treatment facility check were conducted to identify the cause of low efficiency and revealed that the inflow of sewage intermittently exceeded the treatment capacity. The table tennis room that had an accident risk because of its small space was renovated to a gym. Repair works were also done for the varieties of storage facilities in the station. More storage space was secured by systematically arranging old equipment and materials (Fig. 3).

Fig. 3. The landscape of the Antarctic King Sejong Station

In 2018, the weather was characterized with a high winter temperature and frequent winter rain episodes. Monthly average temperature showed a similar pattern with the previous years, but the temperature from July to August was relatively high, which led to a high frequency of rain. Accordingly, there was a wide range of ice covering the ground surface. Although there was a period where the Marian Cove was almost entirely covered with floating ice and sea ice during winter, the sea ice was not densely structured. In the winter period, the crew for marine science conducted regular monitoring works and survey at the marine observation station in front of the King Sejong Station. Two crews for biological science took soil and vegetation samples and monitored quality of drinking water, efficiency of sewage treatment system, and population size of introduced species (gnats). In addition, small-scale laboratory study was carried out to find out the conditions to get the wastewater treatment and recycling system under normal operation. Crews for atmospheric and upper atmospheric sciences managed the monitoring of data and equipment (Fig. 4).

The 30th anniversary ceremony of the Antarctic King Sejong Station was successfully held and attended by a number of members of the Ministry of Oceans and Fisheries, the national Assembly, and other senior government officials. For the foundation day event, more than 50 members from nearby stations visited King Sejong Station, and enjoyed the shiny weather and festivity. In addition, a variety of international groups, including governmental officials from China and Colombia, students from Chile, and Antarctic researchers from Turkey, visited the station. With other nearby stations, there were frequent mutual visits and exchanges for close partnership (Fig. 5).

Figure 1. The 31st overwintering Team

Figure 2. Move to research Facility

Figure 4. Survey at the Marine Observation Station

Figure 5. Foundation Day Event

Stabilize the Facility System for Operation and Maintenance to Be the Base Camp for International Joint Research

Leader of the 5th overwintering Team
Kyu-chul Yoo kcyoo@kopri.re.kr

Jang Bogo Station

- Terra Nova Bay, Northern Victoria Land, Antarctic (74°37'S / 164°12'E)
- Established in February 2014

Following the completetion of the Antarctic King Sejong Station, Korea built the second Antarctic Station called Jang Bogo Station in 2014. This station is located on the coast of Terra Nova Bay in Northen Victoria Land providing better access to the center of the Antarctic continent. The center and coast of Antarctica has become more easily assessible by the Antarctic Jang Bogo Station, further enabling research and collection of various data regarding climate change, topography and geography surveys, upper atmosphere and space science research

<Mission>
❶ Space, Astronomy, Glacier, Meteorite Study
❷ Study of Climate Change through Prediction of the Cryosphere Change
❸ Testbed for multidisciplinary study, application oriented research

In 2017, the 5th overwintering team to the Antarctic Jang Bogo Station was organized, consisting of 17 researchers including the team leader, and members of the general affairs group, maintenance group, and research group. The unit completed an orientation training at Busan, Korea, and had a launching ceremony at the Korea Polar Research Institute in September and October of the same year, respectively. It left Incheon International Airport on October 25 and arrived in Antarctica on October 27 to start its journey. The first to 4th overwintering Team were responsible for stabilizing and reinforcing the facilities and maintenance system, and the 5th overwintering team was committed to further upgrading some of the advanced equipment and facilities as well as securing the safety of the infrastructure and station, having been constructed and operated for the past four years.

In the 2018 summer season, more than 100 Korean and international experts stayed at the station to conduct polar research on a nearby land, while the overwintering Team expended the three months on maintaining the station and supporting the research of the summer unit. During the fifth winter research period, the supplies by the Korean Research Icebreaker, Araon, were important in addition to those by regular aviation. Compared to the fourth unit, who made three times of Araon supply, the fifth unit could visit the station only twice for loading and landing (first from December 6 to 8, 2017, and second from March 2 to 4, 2018). In particular, as sea ice on the offshore of the station did not flow back during the summer season, loading and landing could be made only for small-sized goods and equipment with shipping by air, not by marine routes. Due to such freezing condition, it was not possible to conduct marine research using rubber boats offshore.

Figure 1. The 5th overwintering Team to Jang Bogo Station

Figure 2. Second landing and loading by helicopter

Figure 3. Surgical simulation in the virtual environment

The researchers upgraded some of the weather, atmosphere, and space observation equipment; retrieved data; replaced parts of biological observation equipment; took ocean samples; and carried out the diverse activities required for the research. The maintenance group focused on retrofitting and repairing the devices of different facilities for their stabilization. Supported by this effort, the Jang Bogo Station, which marks its fifth anniversary this year, became known for the best fit for Antarctic research, and attracted unprecedented participation and interest from across the world. Many countries, including the United States and New Zealand, visited or stayed at the station for the international joint Antarctic research. In particular, China, which plans to construct a station at the nearby Inexpressible Island, dispatched researchers of the Chinese research icebreaker vessel, Xue Long, and the government inspection teams of the Chinese Arctic and Antarctic Administration (CAA) and the Polar Research Institute of China (PRC) to the Jang Bogo Station, of which facility operation and maintenance system drew their interest.

To protect the researchers exposed to extreme mental stress due to the strong downhill winds and cold (-30°C or less) as well as the lack of sunlight during polar nights without midnight sun in winter, a webcam system for psychological counseling, on a calendar quarter basis, was introduced in collaboration with the Gachon University Gil Medical Center. In addition, the first trial of surgical simulation in a virtual environment was conducted in response to emergencies in winter and under the station's condition of vastly insufficient medical apparatus. Accordingly, the first step for establishing a remote medical system in the polar region was taken with two times of surgical simulation based on the design of performing a surgery, including general anesthesia, and training unit members for operation assistance. A mock exercise for firefighting was also practiced on a calendar quarter basis, and an alarming system was established to prevent risks of electrical fire.

The Arctic Dasan Station

Provide the Best Environment to Encourage Arctic Research

Station Support Team

The Arctic Dasan Station

- Ny-Ålesund, Svalbard, Spitsbergen(78°55'N / 11°56'E)
- Opened in April 2002

Korea was established the First Arctic Dasan Research Station in Ny-Ålesund of Svalbard, Spitsbergen, in April 2002 for research of the Arctic environment and climate change. KingsBay AS of Norwegian company is ins charge of the operation and management of all the facilities of the station. The Korea Polar Research Institute (KOPRI) operates the Arctic Dasan Research Station as summer station and around 60 international researchers visit to the Arctic Dasan Research Station to conduct field research activity in summer season.

<Mission>

❶ Arctic Sea Ice Research
❷ Environmental Change Survey on Upper Atmosphere and Space, Marine and terrestrial Ecosystems

For the year of 2018, the Arctic Dasan Station was visited by 61 researchers from 20 institutes including KOPRI (30 researchers from external agencies) and conducted on-site research for the summer season. The first research began on March 15. Before the summer season started, the team checked a list of required goods for regular supply to select and support items essential for operating the station. In particular, starting from the summer season of this year, a part of the cost for using the camp town facilities is supported to visitors to encourage research at the Dasan Station.

Category	Details	Note
Support items	• Cost for staying at the camp town (board and lodging)	Including the guesthouse in KingBay
	• Cost for firearm education and rent	Safety requirements in the field
	• Cost for using the warehouse in KingBay	Support of the institute responding to the lack of space in the camp
	• Research facilities at the camp town(Teisten/FRP boat, Marine Lab, etc.)	To encourage the use of research facilities at the camp
	• Rent for the Zeppelin Observatory and other fees	Arctic climate change and Ny-Alesund camp town monitoring

In addition, the team rented a warehouse in the Ny-Alesund camp, on a long-term basis, to secure more space for the installation and operation of research equipment and apparatus in the Dasan Station. Moreover, efforts were made to crease a pleasant research environment by zoning and rearranging the station's research place from four research rooms and two warehouses to three research rooms and three warehouses that considered spatial usage conditions and purposes.

Lastly, in September, the end of the summer season of the year, four members of the staff (two from the Station Support Team, one from the General Affairs & Purchasing Team, and one from the Infrastructure & Security Team) were dispatched to the station to check the asset, dispose unused on-site equipment, maintain facilities, and arrange and take out unnecessary goods.

Figure 1. Space zoning (Before > After)

Figure 2. Asset check and disposal of unnecessary items

Figure 3. Wrapping of items for takeout

The Ice-Breaking Research Vessel(IB/RV) Araon

Provide the Foundation for Polar Research and Supplies Support to the Stations

Station Support Team

Ice-breaking Research Vessel, Araon

- Gross tonnage: 7,507 T
- Size(m) : (L)111×(W)19×(H)9.9
- People on board: 85
- Built in November 2009 (first sailing on Antarctica in December 2009)

An ice breaker is a ship that is able to break ice to sail on freezing waters such as areas near Antarctica and the Arctic sea covered with ice. The Araon is responsible for its own polar research on freezing waters and missions such as supplying goods and carrying passengers to polar regions.

<Mission>

❶ Conduct independent polar research in the harsh Arctic region

❷ Support stations in the South and North Pole and construct the Antarctic Jang Bogo Station

In 2018, the ice-breaking research vessel Araon was operated for a total of 294 days (220 in Antarctica and 74 days in the Arctic) for research cruise and station supply support.

For the second round (2017–2018) of the Antarctic expedition, the Araon departed the Lyttelton Harbor in New Zealand on December 21, 2017, heading to Amundsen Sea, Antarctica, where three research projects were completed before it traveled back to the Lyttelton Harbor on February 12, 2018: "Research on the Melting Rate of Amundsen Ice Shelves and the Changing Trend of the Sea," "Identification of Factors Driving Regional Differences in Climate Change at the Antarctica," and "Cause Analysis and Forecast of Changes in the Cryosphere Near the Antarctic Jang Bogo Station." The Araon then departed the Lyttelton Harbor again on February 16, 2018, to complete the third round of the expedition for the four research topics at Ross Sea: "Research on the Ecosystem Structure and Function of the Marine Protected Area of the Antarctic Ocean," "Restoration of the 2 Million Years of the Antarctic Cryosphere and Ocean Changes Using Sediments," "Cause Analysis and Forecast of Changes in the Cryosphere Near the Antarctic Jang Bogo Station," and "Identification of Relations between the West Antarctic Rift System (WARS) and the Mantle under the Antarctic Mid-Ocean." On March 20, 2018, it entered back into the harbor. For the fourth round, the vessel left the same harbor to carry out three research projects at the Bransfield Basin and the sea area near the Sejong Station: "Prediction of 2050 Changes in the Marine Ecosystem of the Antarctic Pen Sea Area," "Restoration of the 2 Million Years of the Antarctic Cryosphere and Ocean Changes Using Sediments," "Identification of Natural Phenomenon at Polar Regions and Development of Applied Technologies Using the Analysis of Ice Chemical Characteristics." After the completion of the research, the Araon fulfilled its last mission - to supply support to the Sejong Station before departing Punta Arenas, Chile, and traveling back to Korea.

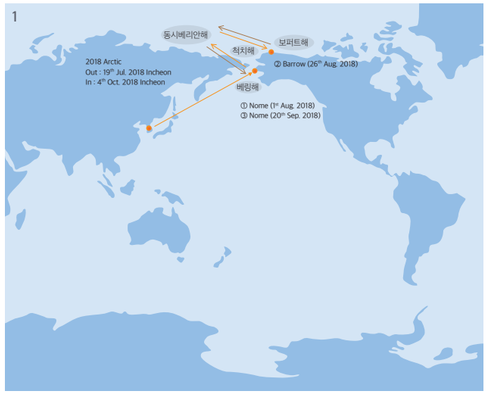


Figure 1. 2018 Arctic Cruises

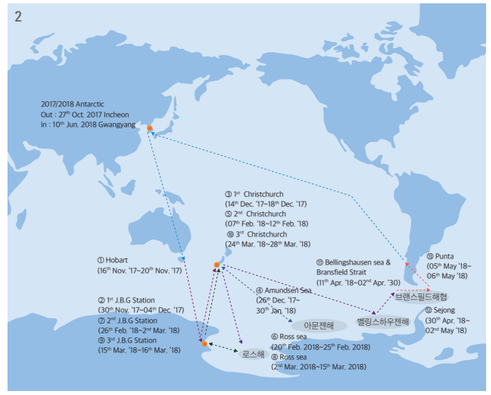
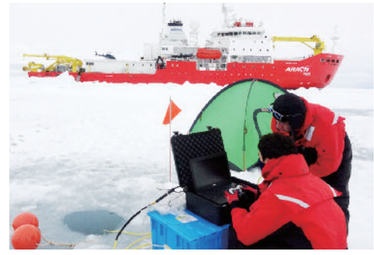


Figure 2. 2017/2018 Antarctic Cruises

Finishing the 220 days of the Antarctic expedition, the Araon went into the dock at the Yeosu Sea shipyard for repair for 16 days before the pilot operation for the performance check of research equipment for 10 days at the Ulleung Basin of the Korean East Sea. Then, it stayed at the Incheon Harbor from July 11 to 19, 2018, for preparations for its navigation to the Arctic, such as the loading of research equipment and food supplies, and general maintenance. It was operated on the Arctic sea for 74 days from July 19 to October 1, 2018.

On the Bering Sea, Chukchi Sea, and East Siberian Sea, the first round of Araon Arctic expedition was made for three research topics: "Research on Integrated Monitoring and Application of Environmental Changes in the Arctic Sea," "Development of Analysis Technologies for the Satellite Observation of Arctic Sea Ice," and "Development and Application of the Polar Climate Change and Weather Disaster System (Korea Polar Portal Service [KPOPS])." For the second round, research was carried out on the "Environmental Expedition on the Submarine Resources of the Arctic Sea and the Submarine Methane Release Phenomenon." Then, the Araon had a month of preparation for the Antarctic expedition for 2018–2019 that started on October 31, 2018.

The major missions of its first round include supply support to the Jang Bogo Station, with the schedule where it departed the Lyttelton Harbor and arrived at the station. As a result, it supplied goods and personnel for the winter team and safely traveled back to New Zealand. For the second round, it is headed to Antarctica again on December 22 for Ross Sea research and second supply support to the Jang Bogo Station. The third round, the last one for 2018 and 2019, is planned for the same research and supply support, and its return date to Korea is April 14, 2019.



International Cooperation Centers-NPI

Producing Outstanding Research Achievements from the Cooperation between Korea and Norway

KOPRI–NPI Cooperative Polar Research Center

Celebrating its fifth year, the achievements of the KOPRI–NPI Cooperative Polar Research Center continued in 2018. The center published a follow-up paper that focuses on the data obtained during the joint research cruise "N-ICE 2015," aboard the Norwegian research icebreaker, RV Lance. A research paper on the relationship between the salinity of the Arctic sea ice-melt pond and the properties of Arctic sea ice was also produced. In collaboration with the Norwegian Polar Institute (NPI), KOPRI carried out an on-site expedition regarding the biological toxicity of Arctic environmental pollutants through which the researchers were able to publish two research papers on such pollutants. As part of the joint efforts of the KOPRI–NPI Cooperative Polar Research Center, KOPRI and the Norwegian Embassy in Korea co-organized the "Arctic Science Cooperation Seminar" at the BEXCO in Busan, South Korea, on December 12, 2018. The seminar was held as a side event of the 2018 Arctic Partnership Week's Science and Technology Day, and 170 experts from governments, universities, and research institutes gave presentations and contributed to lively discussions under the theme "Arctic Science: Innovation, New Frontiers, and Partnership."


1

Figure 1. The landscape of NPI's Fram Centre in Tromsø, Norway, where the KOPRI–NPI Cooperative Polar Research Center is located.

International Cooperation Centers-Chile

Enhancing Collaborative Research with Chilean Research Institutes and Universities

Korea–Chile Antarctic Cooperation Center


1

Figure 1. The landscape of INACH's Research Centre where Korea–Chile Antarctic Cooperation Center located.

The Korea–Chile Antarctic Cooperation Center is located within the Instituto Antártico Chileno (INACH) at Punta Arenas, a Chile's gateway city to Antarctica. The center is devoted to supporting the diverse activities of the King Sejong Station, including on-site research on the Antarctic Peninsula, and developing and carrying out joint research with its South American partners. In 2018, the Cooperation Center supported the research project "Studies on the Changes in Coastal Marine Systems of the Antarctic Peninsula: A 2015 Outlook," in collaboration with the Research Center: Dynamics of High Latitude Marine Ecosystems (Centro de Investigación: Dinámica de Ecosistemas marinos de Altas Latitudes, IDEAL). The Center has also supported research cooperation with the University of La Frontera (UFRO) in forecasting the biological response of major terrestrial organisms on King George Island to the changes in the Antarctic environment. This provided an opportunity for the Center to contribute to publishing research papers—one for the relationship between climate change at the Antarctic Ocean and soil microbes, and another for the newly found lichens at King George Island. Cooperation with UFRO has also contributed to the analysis of polar organisms' genome information, by collaborating in the joint sampling for gene expression analysis of Antarctic vegetation under different environmental conditions.

International Cooperation Centers-New Zealand

Bridging the Active Antarctic Cooperation between Korea and New Zealand

Korea-New Zealand Antarctic Cooperation Center

In November 2014, the Korea-NZ Antarctic Cooperation Center was established within the International Antarctic Center of Christchurch to support the Jang Bogo Station that was inaugurated in February 2014 in the Terra Nova Bay, in the western Ross Sea. Major tasks include identifying and promoting potential collaborative projects between Korea and New Zealand, exchange of human resources, expanding international cooperation in Antarctica and supporting research activities and logistics for the Jang Bogo Station. The Antarctica New Zealand is the key counterpart for Antarctic cooperation between Korea and New Zealand. Once or twice a month, meetings are held to share information, such as the status of ongoing cooperative activities, including those supporting research; facility and aircraft use; and station building and operation. Since the opening of the Center, areas of collaboration have expanded to include glaciology, paleoclimate, Ross Sea ecology and hot water drilling technology.

During the 2017/18 season, a penguin observatory was successfully built at Cape Hallett as a part of Ross Sea ecological study for the use by scientists of both countries. In addition, as a part of collaboration between KOPRI and New Zealand's National Institute of Water and Atmospheric Research (NIWA), seabed moorings were recovered from the Terra Nova Bay by KOPRI's IBRV Araon, and a KOPRI scientist joined in the Tangaroa cruise in the Southern Ocean.

The Cooperation Center maintains a strong cooperative relationship with the Antarctic Office of Christchurch City. On September 28, 2018, the Director of the Korea-New Zealand Antarctic Cooperation Center delivered a congratulatory speech at the 2018/19 Antarctic season opening reception in Christchurch, attended by over 300 persons, including key government and businesses figures. Korean Antarctic activities were also introduced to the New Zealander public as part of the "Air Day" on the following day. The Center's activity and its role will be strengthened and further expanded to provide efficient support for research activities based at the Jang Bogo Station, including the K-route Project.

Figure 1. Congratulatory speech on behalf of KOPRI at the 2018/19 Antarctic season opening reception in Christchurch (September 28, 2018).

Figure 2. During "Air Day", many Christchurch residents visited the KOPRI booth, introducing the Korean Antarctic Program (September 29, 2018).

1

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Part. 03

RESEARCH SUPPORT

Committed to Enhancing International Cooperation, Securing Facilities, and Constructing the Remote Medical Collaboration

Station Support Team

Figure 1. Quid pro quo signed with the United States Antarctic Program (USAP)

In 2018, the operation of Arctic and Antarctic stations focused on three missions: (1) strengthening the international cooperation and regularly concluding agreements for the Antarctic Jang Bogo Station; (2) building two small-sized vessels (5 tons) new to the Antarctic King Sejong Station and preparing the construction of a building for their storage; and (3) establishing the remote medical collaboration system between the Antarctic science station and the Gachon University Gil Medical Center.

First of all, it held the Korea–Italy Bilateral Meeting (April 2018) and the Korea–China Bilateral Meeting (May 2018) to come up with a practical opportunity to strengthen the international collaboration in operation of and supply to the Jang Bogo station that was realized during the 2018–2019 summer season of Antarctica. In addition, on the occasion of the Council of Managers of National Antarctic Programs (COMNAP) meeting (June 2018) held in Garmisch-Partenkirchen, Germany, bilateral and multilateral working-level meetings were held with countries, such as the US, Italy, New Zealand, China, Uruguay, and Chile, who have kept a close partnership with Korea. The meetings aimed at enhancing the efficiency of Antarctic research by discussing the joint use and operation of aircraft and ships, mutual transportation support of supplies, sharing of infrastructures between countries, transportation of personnel, and Korean researchers' activities at other countries' stations.

Particularly in this year, bilateral agreements and their protocols were concluded in accordance with the quid pro quo on international collaboration. This step will continue to be taken, on a regular basis, prior to the start of Antarctic summer season, annually.

Second, in 2018, two small-sized vessels were constructed for the Sejong station, based on the plan formulated by the Department of Polar Technology. Construction of a building to safely keep a total of four of such vessels started in this year as well. Its working design was produced in July, and the builder (Hansol Engineering and Construction Corporation) was nominated in August to prepare for the construction materials. Small-sized vessels, goods and materials, and regular supplies were shipped at the Port of Pyeongtaek-Dangjin in November and arrived in the Sejong station on 26th December via Valparaíso, Chile. The shipbuilding and construction works will be completed on March 2019 and compared to the past practice using rubber boats (Zodiac MK-6 HD) to ship personnel and goods; the new small-scale vessels will secure safer and more efficient transportation and research activities on the sea.

Lastly, a remote medical collaboration system was introduced to allow connection between the station in Antarctica and the Gachon University Gil Medical Center in Korea at any time, if needed. In particular, data from different medical check equipment (ultrasonic waves, X-ray, electrocardiogram) is now sent to the medical team in Korea, on a real-time basis. This system enables more accurate diagnoses and advice connected to software designed for managing medical records, such as the history of treatment and prescriptions to provide a solid foundation for patient care. It is also planned for 2019 to interlink such system with the software of mobile phones with which the medical team in Korea can get access to the data sent from the station, on a real-time basis. This advanced system of Korea is exemplary to other countries and plays an essential role in ensuring the health of all researchers on the field including winter team members.

Figure 2. Two new small-scaled vessels Sejong 1 and 2 for the Antarctic King Sejong Station

Figure 3. Unloading of the regular supply ship (Shinsung Ever)

Figure 4. Current installation status of the remote medical system (The Antarctic Jang Bogo Station)

Proactive Engagement in Building Mid- and Long-Term Polar Visions and Establishing Polar Policy

Department of Polar Policy

Figure 1. Declaration of the Blueprint on Polar Activities at the "Arctic Partnership Week 2018"

Figure 2. 27th Research Group on Polar Law (2018)

Figure 3. KoARC Seminar at Arctic Partnership Week 2018

KOPRI, as the only public research institute of Korea devoted to polar sciences, contributes to the establishment and implementation of the nation's polar policy as well as the promotion of international cooperation on polar regions by participating in international meetings and conferences dedicated to the Antarctic and Arctic.

KOPRI has made continuous effort to develop and strengthen Korea's Antarctic and Arctic policy. Following up on the establishment of the "3rd Antarctic Master Plan (2017~2021)," the institute has developed the "2018 Implementation Plan" in April 2018, and for the Arctic, "The Arctic Master Plan for 2018–2022" was put in place.

KOPRI organized a joint task force team to support establishing the "Blueprint on Polar Activities (2050 Vision)" with the Korea Maritime Institute, to come up with a mid- and long-term development strategies to proactively deal with issues under the frame of the international polar governance. The TF team was officially launched in August 2018 and produced a report later in the same year, which provided the basis for the "Blueprint on Polar Activities" that the Minister of Oceans and and Fisheries announced on December 2018 at the opening ceremony of the 2018 Arctic Partnership Week.

KOPRI has actively participated in the forum of international discussions on polar issues as a part of the Korean delegations to a range of international conferences. At the 41st Antarctic Treaty Consultative Meeting (ATCM), which was held in Buenos Aires, Argentina, on May 2018, KOPRI played a leading role in agenda proposal and follow-up discussion, which was a first in the history of Korea's participation to the ATCM. It also contributed to the enhancement of the accessibility of the data required for Antarctic observations by carrying out follow-up actions in accordance with ICG's recommendations such as the construction of a web-based database.

In addition, during the Commission of the 37th Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Science Committee (SC) meeting held in Australia on October 2018, KOPRI raised the international awareness of Korea's commitment toward contributing to the policy for the preservation of Antarctic marine organisms, based on its "Ross Sea MPA Marine Ecosystem Research."

KOPRI continues to strengthen its cooperation with other Arctic-related research institutes in Korea by operating the Secretariat for the Korea Arctic Research Consortium (KoARC), which has provided a consultation forum for about 30 Arctic related institutes since 2015. In particular, 2018 saw a remarkable outcome by the collaboration of its science, industry, and policy working groups for the "Analysis Research on Change in Arctic Sea Ice and Navigation Conditions of the Northern Sea Route." In addition, it organized KoARC international seminars titled "The Disappearing Arctic sea ice and Uncharted Oceans of opportunities: Satellite, Shipping and Sustainability" at the 2018 Arctic Circle Assembly held in Iceland in May and titled "Changing Arctic Sea-ice Dynamics and NSR Developments" the 2018 Arctic Partnership Week in Busan, Korea, in December, to introduce its major activities to Korean and international experts.

KOPRI has widened its focus from polar science research to polar laws. In particular, efforts are being made to strengthen the national research capacity and responsive ability in such areas, with active participation in the "Research Group of Polar Law" which is composed of experts from Korean and international academia, the government, and research fields. The group is divided into two subgroups—one for Antarctic and the other for Arctic law. Each of the subgroups shares information and has discussions on polar law issues. In 2018, it dealt with 10 presentation topics through 4 different meetings.

Expanding the International Network through a Wide Range of Collaboration Activities

International Cooperation Team

Figure 1. Renewal of the Agreement of Cooperation on Polar Research between the KOPRI and the PRIC

Figure 2. The Arctic Circle Korea Forum

Figure 3. The 24th International Symposium on Polar Sciences

KOPRI continues to strengthen its international cooperation through extending its collaboration with partner institutes, enhancing the Korea's representation in international organizations and conferences, and exploring activities to expand its future network.

In 2018, KOPRI facilitated bilateral meetings and videoconferences to accelerate research and logistics cooperation with its partner institutions. As a result, KOPRI renewed cooperation agreements with leading international institutes, including the National Institute of Polar Research (NIPR) of Japan, the Polar Research Institute of China (PRIC), and Chilean Antarctic Institute (Instituto Antártico Chileno, INACH). It also formed new official partnerships with the Northern (Arctic) Federal University (NArFU) in Russia and the Arctic Research Centre (ARC) at Hokkaido University, Japan.

KOPRI also engaged in continuous efforts to solidify Korea's role in Arctic and Antarctic organizations and conventions by jointly hosting and organizing international conferences, such as the Arctic Circle Korea Forum, the International Seminar in Commemoration of 30th Anniversary of Korean Polar Research, and the International Symposium on the "Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean." In addition, experts from KOPRI joined the Korean delegations and participated in intergovernmental meetings, including the 48th General Assembly of the Intergovernmental Panel on Climate Change (IPCC) and the 2nd Arctic Science Ministerial (ASM2), and contributed to producing meaningful outcomes regarding Korea's polar agenda.

In 2018, KOPRI hosted two invitation programs, namely the "Asia Polar Science Fellowship Program" and "Arctic Fellowship Program". For the former, six polar scientists from four Asian countries including China, Japan, Turkey, and Vietnam were invited for research visits. The Arctic Fellowship was newly launched to invite early career researchers from the Arctic region and expand the research network in the region. In its inaugural year, one researcher from Denmark and two from Russia participated in the program. Marking the 30th anniversary of the King Sejong Station, the 24th International Symposium on Polar Sciences was held under the theme "30 years of footsteps in Antarctica: Looking back and looking forward." A total of 300 experts participated in the symposium, including the director of the Scientific Committee on Antarctic Research (SCAR), to present their research outcomes (36 oral presentations and 60 posters).

Marking the 30th Anniversary of the Antarctic King Sejong Station with the Public

Public Relations Team

Marking the 30th anniversary of the Antarctic King Sejong Station, which has played a critical role throughout the history of South Korea's polar research, the Korea Polar Research Institute (KOPRI) encouraged communication with the public in diverse ways to build a consensus and create common understanding of polar studies.

Taking the 30th anniversary ceremony held at the King Sejong Station as an opportunity, KOPRI carried out a series of outreach programs through diverse platforms to inform the public of the Station's 30 years of history and enhance their understanding of the polar regions. In particular, KOPRI organized different events to satisfy the public's curiosity, which includes "Antarctic Forum 2018," which served as an introduction to the Antarctic scientific research, culture, and expedition, and the special lecture "Creating a Future at the Place of Unknown," within the popular lecture program "The 15 minutes that changes the world ."

In addition, KOPRI focused on introducing the progress Korea has made during the last three decades, by participating in large-scale international events related to the polar regions. During the Polar 2018 (Davos, Switzerland), National Institute of Polar Research (NIPR) Open House Day (Tokyo, Japan) and Antarctica Air Day (Christchurch, New Zealand), KOPRI has set up a side-event booth to raise the public awareness of Korea's polar research based on 30 years of infrastructure operation and scientific activities.

A remarkable change was made in the "21C Dasan Junior," a renowned educational program provided by KOPRI. Moving away from the conventional evaluation mechanism that focused on the trainees' research plans, this year's program selected participants through a quiz competition on polar regions so that high school students could easily solve. Students with a wide range of backgrounds and interests, such as art, music, and science actively participated in the competition.

In addition, acknowledged for its various activities for spreading science culture, including site-visiting programs, lectures, Open Day on the IBRV Araon , and Polar Academy program, the institute won the "2018 Grand Prize for Educational Donation."

In this year as well, having been globally reported, KOPRI achieved notable research outcomes as it identified the cause-and-effect relationship between sea level rising and Antarctic ice shelves for the first time in the world, and developed a system for forecasting changes in Arctic sea ice. It also reported continuous research outcomes that can be applied to our daily lives, such as the development of a blood-freeze preservative using microorganisms in the Southern Ocean, and research of polar ice for identifying removal mechanisms of pollutants and toxic substances in the environment. Such research outcomes in the field of polar regions has caught the world's attention.

These research activities were posted on KOPRI's Social Networking System in the public-friendly form of Card News and infographics. In particular, the institute opened an official blog to introduce its research methods, objectives, and values in simple terms based on an interview with researchers. The blog was highly appreciated by the visitors and received Web Award Korea's 2018 Grand Prize for "Blog in the Public Sector" only six months since its opening.

Figure 1. Antarctic Forum 2018

Figure 2. The Window (Documentary TV Program)"30 Years of Antarctic Expedition: The Collapsing Ice Continent"

Figure 3. The participants of "2018 21C Dasan Junior"

Korea's Only Polar Library igloo Library

Department of Knowledge & information

Figure 1. Landscape of the igloo

Polar library "igloo"

Korea's only polar library "igloo" was founded in 2010 by KOPRI. The library collects a wide range of specialized materials on polar science, such as separate volumes, serials, an academic database, and data from Korean and international institutes to promote expertise in such field. In addition, it makes a continuous effort for publication to raise public awareness on polar expeditions and science. Its focus is also given to publishing abstract collections, which briefly introduce KOPRI's research papers and annual reports to better inform research outcomes.

In 2017, it restructured the E-library to provide up-to-date digital services and developed an advanced Institutional Repository(IR) to secure the efficient archiving of research performances of the institute.

Figure 2. E-Library & Repository websites

Figure 3. 55th KLA General Conference

Outstanding library recognized by the 2018 KLA General Conference

The igloo was acknowledged for its dedicated role and function as a polar library, receiving the Chairperson's Special Prize in the technical library category of the "2018 KLA General Conference", which was organized by the Library Information Policy Committee under the President's Office and the Ministry of Culture, Sports and Tourism.

It received excellent marks particularly for supporting polar research by operating its own E-library and Repository and providing the academic database and e-journals for visitors to easily access diverse information. Moreover, it was also credited for running and enhancing customer-friendly services for the copy of original texts and multifunctional space.

Publication for raising public awareness of polar sciences

The Igloo publishes individual polar books to popularize polar science. Since 2012, it has planned and published polar expedition series and collections. Up until today, a total of nine collections and two expedition series have been introduced. Starting from "Discover the Antarctica" in 2014, a total of three separate volumes were published.

In addition, a new handbook series on Antarctic living things were seen in 2018. Unlike the prior examples, it contains a range of visual information on biological roles and characteristics of polar lives and geological structure. Its first volume was titled "The Private Life of Antarctic Wildlife - King George Island" to relay the importance and aesthetic value of Antarctic organisms.

The 8 out of 14 polar science books by the igloo were selected as outstanding science books, which were recognized for its excellence and distinctiveness. Efforts will continue in various ways, such as publishing books and organizing lectures provided by authors in connection with local communities, for spreading polar information.

Figure 4. Book publications

Catch the Dynamic Scenes in Antarctica and the Arctic

8th The Polar Photo Contest

KOPRI held the "8th Polar Photo Contest" to provide an opportunity to secure excellent photo materials and encourage communication with staff and polar-customers. The photos taken by researchers in Antarctica and the Arctic were posted on the "Public SNS Poll Event (June 20–25, 2018)" to select the best photo.

Grand Prize

Kim Yeon-tae Polar bear staring at the sky

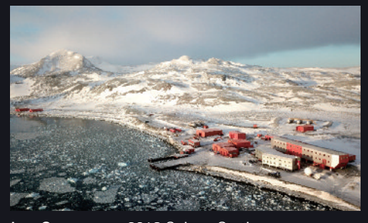
Excellence Award

Jeon, Sung-jun K-route crevasse explorer

Lee, Won-seok New research facility visited by penguins

Runner-up

Joo, Hyung-min Look forward to the year after



Lee,Sang-woo 2018 Sejong Station

Kang, Shin-joon The Jang Bogo Station at midday of a polar night

APPENDIX

List of Main Projects

In-house Project

Project Title	Project Investigator	Period	Sponsor
Investigation for the cause of east-west different climate responses in Antarctica	Seong-Joong Kim	'18.01.01 ~'18.12.31	KOPRI
Understanding polar upper atmospheric changes by energy inputs from the space environ-ment and the lower atmosphere	Geonhwa Jee	'18.01.01 ~'18.12.31	
KOPRIReconstruction of Antarctic ice sheet and ocean history for the past two million years using sediment records	Jae Il Lee	'18.01.01 ~'18.12.31	
Reconstruction of Antarctic ice sheet and ocean history for the past two million years using sediment records	Soon Do Hur	'18.01.01 ~'18.12.31	
Characterizing mantle domain beneath West Antarctic Rift System and Antarctic mid-ocean ridges	Yongcheol Park	'18.01.01 ~'18.12.31	
Ocean-to-Ice Interactions in Amundsen Sea: Ice shelf melting and its impact on ocean processes	Tae-Wan Kim	'18.01.01 ~'18.12.31	
Studies on the Changes in Coastal Marine Systems of the Antarctic Peninsula: A 2050 Outlook	In-Young Ahn	'18.01.01 ~'18.12.31	
Polar Genomics 101 Project: Genome analysis of polar organisms and establishment of application platform	Park Hyun	'18.01.01 ~'18.12.31	
Modeling responses of terrestrial organisms to environmental changes on King George Island	Lee, Hyoungseok	'18.01.01 ~'18.12.31	
Commercialization of useful metabolites from polar organisms	Yim, Joung Han	'18.01.01 ~'18.12.31	
The Antarctic Korean Route Expedition and Development of Technologies for Deep Ice Coring and Hot Water Drilling	Jong Ik Lee	'18.01.01 ~'18.12.31	
Research on analytical technique for satellite observation of Arctic sea ice	Hyun-cheol Kim	'18.01.01 ~'18.12.31	
Development and Application of the Korea Polar Prediction System (KPOPS) for Climate Change and Disasterous Weather Events	Joo-Hong Kim	'18.01.01 ~'18.12.31	
Developments of Analytical Methods for Climate Regulating Components and its application to Polar Environment	Ki-Tae Park	'18.01.01 ~'18.12.31	
The Jang Bogo Long-term Ecological Research (JBG-LTER) - Korea·New Zealand·Italy Joint platform construction	Han-Gu Choi	'18.01.01 ~'18.12.31	
Early animal evolution and the primitive Earth system of north Greenland	Park Tae-yoon	'18.01.01 ~'18.12.31	
Carbon assimilation rate of sea ice ecosystem in the Kongsfjorden MIZ, Arctic	Sun-Yong Ha	'18.01.01 ~'18.12.31	
Large-scale production and Clinical evaluation of CPS (Cell-Protecting Substance) from polar microalgae	Kim Sanghee	'18.01.01 ~'18.12.31	
Investigation of ice chemistry for understanding of environmental processes in polar region and its applications	Kitae Kim	'18.01.01 ~'18.12.31	
Development of potential candidates as antibiotics based on polar genetic resources	Lee, Jun Hyuck	'18.01.01 ~'18.12.31	

National Research & Development Project

Project Title	Project Investigator	Period	Sponsor
Investigating Cryospheric Evolution of the Victoria Land, Antarctica -ICE-	Won Sang Lee	'18.06.01 ~'19.05.31	Ministry of Oceans and Fisheries
Crustal evolution of Victoria Land, Antarctica, and the formative process of planets	Jong Ik Lee	'18.06.01 ~'19.05.31	
Korea-Arctic Ocean Observing System(K-AOOS)	Sung Ho Kang	'18.05.01 ~'19.04.30	
Investigation of submarine resource environment and seabed methane release in the Arctic	Young Keun Jin	'18.05.01 ~'19.04.30	
Ecosystem Structure and Function of Marine Protected Area (MPA) in Antarctica	Jeong-Hoon Kim	'18.06.01 ~'19.05.31	
Study on geochemical proxies for understanding Ross Sea ocean-ice sheet interactions at IODP Exp. 374	Sunghan Kim	'18.04.01 ~'19.02.28	
Genome Analysis of Marine Animals	Park Hyun	'18.09.01 ~'19.06.30	
Circum Arctic Permafrost Environment Change Monitoring, Future Prediction and development Techniques of useful biomaterials(CAPEC)	Bang Yong Lee	'18.01.01 ~'18.12.31	Ministry of Science and ICT
Changes in environments and coastal geomorphology of Svalbard fjords, Arctic	Seung Il Nam	'18.05.01~'19.02.28	

Entrusted Project by Government Agency

Project Title	Project Investigator	Period	Sponsor
Bathymetric survey for mapping and undersea feature names near Jang Bogo station in Antarctica	Joohan Lee	'18.07.10 ~'19.05.31	Korea Hydrographic and Oceanographic Agency (Service Business)
Changing Arctic Sea Ice Dynamics and Northern Sea Route Developments: Retrospective Analysis	Hyoung Chul Shin	'18.07.27 ~'19.01.31	Ministry of Oceans and Fisheries(Service Business)
Environmental Management and Monitoring of Antarctic Specially Protected Area(5)	Ho Sung Chung	'18.09.12 ~'19.05.31	Ministry of Environment (Service Business)
Development of damage monitoring system and evaluation of health monitoring	Bang Yong Lee	'18.01.01 ~'18.12.31	Ministry of Land, Infrastructure and Transport
Organic carbon transfer across the river-sea interface: a case study in Geum and Sumjin river systems	Jung-Hyun Kim	'18.04.01 ~'19.02.28	National Research Foundation of Korea
Structural and functional characterization of Arctic soil microbiome	Yoo Kyung Lee	'18.01.01 ~'18.12.31	
Study on micro-invertebrate communities and relationships to environmental condition in Antarctica	Kim Sanghee	'18.01.01 ~'18.12.31	
Noble gas study of the differentiated meteoites, Moon and Martian meteorites	Jong Ik Lee	'18.01.01 ~'18.12.31	
Development of in vitro 3D cell culture and in vivo zebrafish model for studying pathogenesis and drug target of schizophrenia	Min, Seul Ki	'18.09.01 ~'19.06.30	
A preliminary study of core technology development for unmanned underwater vehicle exploration in the polar regions	Sukyoung Yun	'18.05.01 ~'18.12.31	Korea Research Institute Of Ships & Ocean Engineering

List of Main Projects

Polar Academic Program (PAP)

Project Title	Project Investigator	Period	Sponsor
Highly precise and assured navigation system for unmanned explorations in the polar regions	Jiyun Lee (KAIST)	'18.06.01 ~'19.05.31	KOPRI
The impact of climate change on the life of Inuit in case of Nunavut, Canada	Seung Ho Lee (Konkuk University)	'18.06.01 ~'19.05.31	
KOPRIUnderstanding the process of polar shrub expansion using the Ecosystem Demography Model	Yeonjoo Kim (Yonsei University)	'18.06.01 ~'19.05.31	
KOPRIStudy on behavioral characteristics of tardigrade using microfluidic chip	Sung hyung jin (KAIST)	'18.06.01 ~'19.05.31	
KOPRIEstablishment of CSF expression in arctic Chlorella sp. via genetic transformation	Kim sung ryong (Sogang University)	'18.06.01 ~'19.05.31	
KOPRIIdentyfying sources of methylmercury in arctic Sea using a mass flus model	Seunghee Han (GIST)	'18.06.01 ~'19.05.31	
KOPRITest of underwater obsevation data transfer system using a pop-up buoy in extremely severe environment	Jae-Hun Park (Inha University)	'18.06.01 ~'19.05.31	
KOPRIStudy of radioactive isotopes for environmental samples from Antarctica	HAHN INSIK (Ewha Womans University)	'18.06.01 ~'19.05.31	
KOPRIUnderstanding the characteristics and accumulation of microplastics in the Antarctic coast and ocean	Jin Hwan Hwang (Seoul National University)	'18.07.02 ~'18.12.31	
KOPRIHydrogeological characteristics of active layers near King Sejong Station	Sung-Wook Jeen (Chonbuk National University)	'18.07.02 ~'18.12.31	
KOPRIThe study of membrane fluidity change in Arctic bacteria by global warming through microbial phospholipid fatty acid analysis	Yung-Hun Yang (Konkuk University)	'18.07.02 ~'18.12.31	
KOPRIWhat to edit: Rapid Evolution Through Analysis on Functional Evolution of Polar Genetic Resources	Byeong-ha Lee (Sogang University)	'18.07.02 ~'18.12.31	
KOPRIStudy on historical record and environmental behavior of emerging contaminants in polar environments using target and non-target analysis	Hyo-Bang Moon (Hanyang University)	'18.07.02 ~'18.12.31	
KOPRI Anti/De-icing materials to ensure function of equipment in polar environment	Minseok Kwak (Pukyong University)	'18.07.02 ~'18.12.31	
KOPRIArctic Development in Russia and Its Impacts on Local Communities	Woo ik Choi (Hankuk University of Foreign Studies)	'18.11.01 ~'19.10.31	
KOPRIThe Effects of Abnormal Behavior of Jet Streams Induced by Polar Warming on Air Quality Changes in East Asia	Won sik Choi (Pukyong University)	'18.11.01 ~'19.10.31	

Polar Industrial Program(PIP)

Project Title	Project Investigator	Period	Sponsor
A development of ice-penetrating radar (IPR) for internal ice structure analysis	Seung-Ha Shin (U-Tel Co., Ltd.)	'18.11.01 ~'19.10.31	KOPRI
Development of advanced technology for underwater rock drilling and obtaining a rock core in deepsea(1,000M)	Ho Kyung Jeon (Shingyang Technology Co., Ltd.)	'18.12.29 ~'19.12.28	

List of Published Articles

*Only papers that have as its SCI/SCI(E) principal authors from KOPRI research projects are listed here.

NO.	Articles
1	Byun, M. Y., L. H. Cui, et al. (2018). "Identification of Rice Genes Associated With Enhanced Cold Tolerance by Comparative Transcriptome Analysis With Two Transgenic Rice Plants Overexpressing DaCBF4 or DaCBF7, Isolated From Antarctic Flowering Plant Deschampsia antarctica." *Frontiers in Plant Science* 9.
2	Cho, B. C., S. C. Hardies, et al. (2018). "Complete genome of streamlined marine actinobacterium Pontimonas salivibrio strain CL-TW6(T) adapted to coastal planktonic lifestyle." *Bmc Genomics* 19.
3	Cho, M. H., A. R. Yang, et al. (2018). "Vegetation-cloud feedbacks to future vegetation changes in the Arctic regions." *Climate Dynamics* 50(9-10): 3745-3755.
4	Cho, S. M., H. Lee, et al. (2018). "Comparative transcriptome analysis of field- and chamber-grown samples of Colobanthus quitensis (Kunth) Bartl, an Antarctic flowering plant." *Scientific Reports* 8.
5	Choe, Y. H., M. Kim, et al. (2018). "Comparing rock-inhabiting microbial communities in different rock types from a high arctic polar desert." *Fems Microbiology Ecology* 94(6).
6	Choi, Y., H. I. Yoon, et al. (2018). "Activation of Periodate by Freezing for the Degradation of Aqueous Organic Pollutants." *Environmental Science & Technology* 52(9): 5378-5385.
7	Gal, J. K., J. H. Kim, et al. (2018). "Assessing the saponification effect on the quantification of long chain alkenones and the U-37(K ') paleothermometer." *Geochemical Journal* 52(6): 497-507.
8	Gal, J. K., J. H. Kim, et al. (2018). "Distribution of long chain alkyl diols along a south-north transect of the northwestern Pacific region: Insights into a paleo sea surface nutrient proxy." *Organic Geochemistry* 119: 80-90.
9	Ha, S. Y., J. O. Min, et al. (2018). "Synthesis of mycosporine-like amino acids by a size-fractionated marine phytoplankton community of the arctic beaufort sea." *Journal of Photochemistry and Photobiology B-Biology* 188: 87-94.
10	Han, D., Y. J. Joe, et al. (2018). "Application of laser-induced breakdown spectroscopy to Arctic sediments in the Chukchi Sea." *Spectrochimica Acta Part B-Atomic Spectroscopy* 146: 84-92.
11	Han, H. and H. C. Kim. (2018). "Evaluation of summer passive microwave sea ice concentrations in the Chukchi Sea based on KOMPSAT-5 SAR and numerical weather prediction data." *Remote Sensing of Environment* 209: 343-362.
12	Han, H. and H. Lee. (2018). "Glacial and tidal strain of landfast sea ice in Terra Nova Bay, East Antarctica, observed by interferometric SAR techniques." *Remote Sensing of Environment* 209: 41-51.
13	Han, S. J., J. H. Yim, et al. (2018). "Effect of Temperature on the Yield, Activity, and Stability of a Cold-Active Protease from Pseudoalteromonas arctica PAMC 21717." *Romanian Biotechnological Letters* 23(5): 14051-14055.
14	Hong, J. M., S. S. Suh, et al. (2018). "Anti-Cancer Activity of Lobaric Acid and Lobarstin Extracted from the Antarctic Lichen Stereocaulon alpnum." *Molecules* 23(3).
15	Hong, S. B., S. J. Jun, et al. (2018). "Improvement and performance testing of melting system for measurement of trace elements in firn core drilled at NEEM site, Greenland." *International Journal of Environmental Analytical Chemistry* 98(8): 725-742.
16	Jang, G. I., C. Y. Hwang, et al. (2018). "Effects of heavy rainfall on the composition of airborne bacterial communities." *Frontiers of Environmental Science & Engineering* 12(2).
17	Jang, K., Y. Huh, et al. (2018). "Diagenetic overprint on authigenic Nd isotope records: A case study of the Bering Slope." Earth and Planetary Science Letters 498: 247-256.
18	Jogo, K., M. Ito, et al. (2018). "Redistribution of Sr and rare earth elements in the matrices of CV3 carbonaceous chondrites during aqueous alteration in their parent body." *Earth Planets and Space* 70.
19	Joo, Y. J., A. M. Soreghan, et al. (2018). "Quantification of particle shape by an automated image analysis system: a case study in natural sediment samples from extreme climates." *Geosciences Journal* 22(4): 525-532.
20	Jun, S. Y., S. J. Choi, et al. (2018). "Dynamical Core in Atmospheric Model Does Matter in the Simulation of Arctic Climate." Geophysical Research Letters 45(6): 2805-2814.
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22	Jung, J. H., J. H. Moon, et al. (2018). "Novel insights into the genetic diversity of Parafavella based on mitochondrial CO1 sequences." *Zoologica Scripta* 47(6): 743-755.
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NO.	Articles
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Registration of Patent

States	Registration Date	Patent Number(Registration No.	Title
Europe	2018-03-07	3000879	Cold-adapted Protease Derived from Pseudoalteromonas arctica PAMC 21717 and Uses Thereof
Republic of Korea	2018-01-03	10-1816802	Low molecular cryoprotective exopolysaccharide (LM CY01) from Arctic bacterium Pseudoalteromonas sp. strain CY01
Republic of Korea	2018-11-28	10-1924808	two antimicrobial peptides from Antarctic fishes (Notothenia coriiceps and Parachaenichthys charcoti)
Republic of Korea	2018-05-17	10-1860902	Stearoyl-CoA Deasaturase Derived from Tigriopus kingsejongensis and Use Thereof
United Kingdom	2018-01-24	2626070	PHARMACEUTICAL AND FOOD COMPOSITION FOR PREVENTING OR TREATING DIABETES OR OBESITY
France	2018-01-24	2626070	
Germany	2018-01-24	60 2011 045 380.7	
China	2018-03-13	ZL201510552764.6	
Europe	2018-01-24	2626070	
Japan	2018-09-07	6398014	Composition for Preventing or Treating Degenerative Brain Disease Comprising Ramalin
USA	2018-05-15	9,968,576	
Republic of Korea	2018-08-21	10-1892078	Pharmaceutical Composition for Prevention or Treatment of Brain Cancer Comprising Robarstin and Combination Therapy in the Treatment of Brain Cancer Using the Same
Republic of Korea	2018-02-07	10-1829048	Omega-6 Fatty Acid Desaturase from Arctic Chlamydomonas sp. and use thereof
Republic of Korea	2018-02-05	10-1828080	Cold-active lipase from Psychrobacter sp.
Republic of Korea	2018-03-05	10-1837344	How to determine the origin tidal utilizing the complexstable isotopic analysis of bivalves
Republic of Korea	2018-06-08	10-1867799	Degradation of heterocyclic organic compounds usingiodate and freezing
Republic of Korea	2018-04-12	10-1850247	DRILLING APPARATUS OF SUBMARINE CORE

KOPRI New Staffs (2018)

Type	Name	Degree	Speciality	Name of Ph.D Thesis	Department
Research Staff	Emilia Kyung Jin	Ph.D.	Earth and Environmental Sciences	Local and Remote Process in the Atmosphere–Ocean Coupled System and Associated Climate Predictability	Unit of Ice sheet and Sea Level Changes
	Yong Han Choi	Ph.D.	Earth and Environmental Sciences	Radar Data Assimilation for the Simulation of Heavy Rainfall Cases over the Korean Peninsula Using Adjoint-Based Methods	Unit of Arctic Sea-Ice Prediction
	Hoje Kwak	M.S.	Ocean Science	-	Unit of Antarctic K-Route Expedition
Technical & Administrative Support Staff	Sunbin Kim	M.A.	Public Administration	-	Department of Polar Policy
	Changhyun Chung	Ph.D	Mechanical and Environmental Informatic	Development of a Swimming Humanoid Robot for Research of Human Swimming	Department of Polar Technology
	Hyoung-kwon Kim	M.S.	Mechatronics Engineering	-	Department of Polar Technology
	Jaechun Lee	B.S.	Navigation System Engineering	-	Ship Operation Team
	Ohin Kwon	B.S.	Architectural Engineering	-	Infrastructure & Security Team

Overwintering Research Team Members of the Antarctic Station

List of the 5th Overwintering Research Team Members of the Antarctic Jang Bogo Station

Area	Position	Name	Responsibilities	Note
Operation and Management	Station Leader	YU Kyu-chul	- General management of station operation in charge - International cooperation with foreign stations	- KOPRI
	Station Manager	HAN Ji-hyun	- Managing practical tasks of station operation - Managing overwintering team task schedule - Managing communication task, overwintering report and other general affairs	
Research	Atmosphere Scientist	YOO Jae-il	- Operation of the observation equipment to monitor atmospheric constituents(greenhouse gas and aerosol), data collection, quality control, and processing - Periodic air sampling for the analysis of the atmospheric composition	- Member of the 2nd overwintering team to the Jang Bogo Station
	Upper Atmosphereric Scientist	KWON Jong-woo	- Operation of the upper atmosphere observation equipment including meteor radar, SATI and cloud camera, and data collection, analysis, and processing	
	Biologist	KIM Hyun-joong	- Soil and seawater monitoring around the station	
	Geophysicist	LEE Dong-wook	- Operation of the observation equipment, such as seismometer, terrestrial magnetism sensor and gravimeter and data collection, analysis, and processing	
	Oceanographer	PARK Sang-hoon	- Operation of Oceanographic research equipment and data collection, analy-sis, and processing	
	Meteorologist	KIM Jun-hyung	- Meteorological observation and forecasting, data processing, and observation device management	- Dispatched from the Korea Mete-orological Administration
Medical Service	Medical Doctor	CHAE Byeong-do	- Patient treatment and the urgent escort plans, in case of medical emergencies	- Dispatched from the Gachon University Gil Medical Center
Facility Maintenance	Mechanical Engineer	KIM Seung-gu	- Operation and maintenance of machinery	- Member of the 2nd overwintering team to the Jang Bogo Station
	Mechanical Engineer	NOH Ki-young	- Operation and maintenance of refrigerators and desalinators	- Member of the 2nd overwintering team to the Jang Bogo Station
	Heavy Equipment Operator	CHOI Ji-nyun	- Operation of heavy equipment, such as crane, excavator, and forklift	
	Communication Officer	Jang Jae-won	- Operation of satellites, communication equipment, electronic equipment,and external communication	- Menber of the 2nd overwintering team to the Jang Bogo Station
	Electric Engineer	KWON Tae-gyun	- Operation of electrical equipment, electric wiring, and repair of electronic products	
	Generator Engineer	Jang Chang-won	- Operation, repair, and maintenance of power-generation facilities	
	Safety Officer	KANG Shin-jun	- Safety for all researchers and staffs in the station	- Dispatched from the National Fire Agency
	Chef	LEE Hee-young	- Cooking, maintaining kitchen and food materials	- Member of the 2nd overwintering team to the Jang Bogo Station

The list of 31st Overwintering Research Team Members of the Antarctic King Sejong Station

Area	Position	Name	Responsibilities	Note
Operation and Management	Station Leader	HONG Soon-kyu	- General management of station operation in charge - International cooperation with foreign stations	- KOPRI
	Station Manager	PARK Ha-dong	- Managing practical tasks of station operation - Managing overwintering team task schedule - Managing communication task, overwintering report and other general affairs	
Research	Atmosphere Scientist	PARK Sang-jong	- Operation of the observation equipment to monitor atmospheric constituents(greenhouse gas and aerosol), data collection, quality control, and processing - Periodic air sampling for the analysis of the atmospheric composition	
	Biologist	LEE Kyung-ha	- Soil and seawater monitoring around the station	
	Biologist	PARK Ji-gang	- Soil and seawater monitoring around the station	
	Upper Atmosphereric Scientist	LEE Sang-woo	- Operation of upper atmosphere observation equipment including meteor radar, SATI and cloud camera, and data collection, analysis, and processing	
	Oceanographer	CHOI Bong-su	- Marine environmental research of Marian cove	
	Meteorologist	CHO Gab-hwan	- Meteorological observation and forecasting, data processing, and observation device management	- Dispatched from the Korea Meteorological Administration
Medical Service	Medical Doctor	CHO Hanna	- Patient treatment and the urgent escort plans, in case of medical emergencies	- Dispatched from the Gachon University Gil Medical Center
Facility Maintenance	Mechanical Engineer	LEE Sang-soon	- Operation anintenance of machinery	- Member of the 25th and 27th overwintering team to the King Sejong Station
	Mechanical Engineer	YOON Young-woon	- Operation and maintenance of refrigerators and desalinators	
	Heavy Equipment Operator	PARK Won-seok	- Operation of heavy equipment, such as crane, excavator, and forklift	
	Communication Officer	LEE Sang-hoon	- Operation of satellites, communication equipment, electronic equipment, and external communication	- Member of the 19th and 23th overwintering team to the King Sejong Station - Member of the 1st and 3rd overwintering team to the Jang Bogo Station
	Electric Engineer	LEE Seung-chul	- Operation of electrical equipment, electric wiring, and repair of electronic products	
	Generator Engineer	JIN Hee-sung	- Operation, repair, and maintenance of power-generation facilities	
	Marine Safety Officer	SON Young-ik	- Safety for all researchers and staffs in the station	- Dispatched from the Ministry of National Defense (Navy)
	Chef	KONG Min-kyu	- Cooking, maintaining kitchen and food materials	

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