As the Arctic changes, so does the world. What kind of future is waiting for us when all the Arctic sea ice disappears?

You too have perhaps heard “Someday there may be ice-free in the Arctic.” Are you aware that this “someday” might come sooner than expected? Satellite observations started in 1979; they show that Arctic sea ice has continued to decrease. What’s more, since about 2000 the Arctic sea ice has been disappearing even faster than before. In the summer of 2012 sea ice decreased to less than half the average area that it covered in the 1980s. With the arrival of winter, once again sea ice forms and covers the Arctic Ocean. But the amount of sea ice is steadily decreasing. It is predicted that if this situation remains unchanged, the Arctic will be totally ice-free in the summer as early as about 2020. The decrease of Arctic sea ice is attributed to the effects of “global warming.” The Arctic is one of the regions that are warming the most in the world. Although global surface air temperature is predicted to increase with an average of 1–3°C, it is said that the surface temperature in the Arctic will increase by 4–12°C. In other words, warming in the Arctic will proceed more than twice as fast as the global average. Such rapid change will not only reduce sea ice, but also alter the flowering of polar plants and the growth of fish and ice seals. Furthermore, this is also impacting on not only the Arctic Ocean and its surrounding regions, but also on countries and animals around the world, including Japan. Over the last few years, Japan has experienced hard winters, with many regions receiving heavy snowfall. It has been found, in fact, that Japan’s heavy snows are related to the decrease in the Arctic sea ice. This new fact, that Japan receives heavy snowfall when Arctic sea ice decreases, is becoming more research. Change in the Arctic climate will probably impact the ecosystems of marine organisms living there. In fact, changes occurring in the Arctic Ocean, where the effects of global warming are quickly manifested, could also be seen in the world’s other oceans. In other words, the path taken by the Arctic Ocean is thought to show the path that other world oceans will follow. For that reason, many people around the world are intensely watching changes in the Arctic.

Further, the Arctic Ocean loses the sea ice that has been dividing the Pacific and Atlantic oceans, a new route for ships would be created that would conceivably have a significant impact on societies, economies, and cultures. Arctic issues are no longer confined to countries bordering the Arctic Ocean, as we must think of these issues as global, affecting the whole world.

In 2013, it was found that in May, Japan had recorded the highest air temperatures in the world, which was related to the decrease in the Arctic sea ice. This new fact, that Japan receives heavy snowfall when Arctic sea ice decreases, is becoming more research. Change in the Arctic climate will probably impact the ecosystems of marine organisms living there. In fact, changes occurring in the Arctic Ocean, where the effects of global warming are quickly manifested, could also be seen in the world’s other oceans. In other words, the path taken by the Arctic Ocean is thought to show the path that other world oceans will follow. For that reason, many people around the world are intensely watching changes in the Arctic.

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It was under these circumstances that, in May 2013, Japan was admitted to the Arctic Council as an observer. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC), which had been conducting Arctic research since the 1990s, established the Institute of Arctic Climate and Environment Research (IACE) in April 2015 to further expedite its Arctic research and to help promote international society. IACE uses its observational expertise and data accumulated over more than a quarter century, as well as its unique facilities and equipment to carry out Arctic studies and research in various fields including physics, chemistry, and biology, while cooperating with researchers in Japan and abroad. IACE is also making efforts to develop observation instruments in a bid to accelerate Arctic research.

What happens when Arctic sea ice disappears? What rules should we follow in using the ice-free Arctic Ocean? There are many problems we must examine when considering the future of the Arctic, and of the Earth. In the IACE we hope to make a contribution to future society by collecting and providing “scientific evidence” that will be useful in making decisions for the Arctic and global issues, and providing those evidences to the world.
As the Arctic changes, so does the world. What kind of future is waiting for us when all the Arctic sea ice disappears?

Introduction

You can have perhaps heard “Someday there may be ice-free in the Arctic.” Are you aware that this “someday” might come sooner than expected? Satellite observations started in 1979; they show that Arctic sea ice has continued to decrease. What’s more, since about 2000 the Arctic sea ice has been disappearing even faster than before. In the summer of 2012 sea ice decreased to less than half the average area that it covered the previous year. With the arrival of winter, once again sea ice forms and covers the Arctic Ocean, but the amount of sea ice is steadily decreasing. It is predicted that if this situation remains unchanged, the Arctic will be totally ice-free in the summer as early as about 2020.

The decrease of Arctic sea ice is attributed to the effects of “global warming.” The Arctic is one of the regions that are warming the most in the world. Although global surface air temperature is predicted to increase with an average of 1°C to 2°C, it predicted that the surface air temperature of the Arctic will increase by about 11°C.

Change in the Arctic climate will probably impact the ecosystems of marine organisms living there. In turn, changes occurring in the Arctic Ocean, where the effects of global warming are quickly manifested, could drive the changes that other world oceans will follow. For this reason, many people around the world are intensely watching changes in the Arctic.

Further, if the Arctic Ocean loses the sea ice that has been dividing the Pacific and Atlantic oceans, a new route for ships would be created that would conceivably have a significant impact on societies, economies, and livelihoods. Arctic issues are no longer confined to countries bordering the Arctic Ocean, as we must think of these issues as global, affecting the whole world.

In the face of these circumstances, Japan was admitted to the Arctic Council as an observer in May 2013. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC), which had been conducting Arctic research since the 1990s, established the Institute of Arctic Climate and Environment Research (IACE) in April 2015 to further expedite its Arctic research. JAMSTEC uses its observational expertise and data accumulated over more than a quarter century, as well as its unique facilities and equipment to carry out Arctic studies and research in various fields including physics, chemistry, and biology, while cooperating with researchers in Japan and abroad. At present, JAMSTEC is making efforts to develop observation instruments in a bid to accelerate Arctic research.

“Since the Arctic sea ice disappears?” “What rules should we follow when using the ice-free Arctic Ocean?” There are many problems we must examine when considering the future of the Arctic, and of the Earth. As the Arctic sea ice disappears, what problems will appear in the future, and what problems will we face then? These are some of the issues that we are trying to address, and the problems that we are trying to solve. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is working to solve these problems and to make the Arctic a safer place for everyone who lives there.

IACE
Institute of Arctic Climate and Environment Research

Director, Institute of Arctic Climate and Environment Research

Takeshi Kawano

IACE
Institute of Arctic Climate and Environment Research

河野 俊
The Arctic Ocean used to be covered with sea ice almost all of the year, so it was a “quiet ocean”. But because of global warming there is now less ice and the ocean is exposed to the atmosphere, allowing it to be directly affected by the wind; consequently, the Arctic Ocean is becoming an active ocean. Melting of the sea ice is also associated with ocean warming, freshening, and acidification, which is greatly changing the environment. Additionally, because the sea ice is now more directly exposed to the atmosphere, the Arctic Ocean is exposed to the influences of marine organisms. Such changes are not confined to the ocean; there are changes in soil and the land surface. For example, the amount of snow and ice on the land has been decreasing in the Arctic region, more noticeably in the years from 1950 to 1990. As a result, the ground becomes warmer, and the snow and ice cover thin. This is believed to have been caused by increased sunlight, which is more intense due to the decrease in the Arctic ice, more noticeably earlier in the year than before. Land that has warmed to the point where there are no ice cover will have lower soil temperatures. This is believed to have caused the ground to become warmer, and the soil to melt. This is a real phenomenon.

As the ocean becomes an active ocean, various rapid changes of the environment in the Arctic and its surrounding regions are occurring. But what is happening in the ocean, land, and atmosphere? How fast are we facing these changes, and what should we do to address them? At this time, we do not have enough data to quantitatively assess these changes. As such, our goal at the Arctic Ocean and Climate System Research Unit is to ascertain the status and trends of Arctic environmental changes, and to protect the impacts of Arctic changes on the global climate system. Furthermore, for each phenomenon occurring in the Arctic, it is important to determine the processes which cause the changes, “Why do these things happen?”

We are conducting expeditions in the Arctic using the research vessel (R/V) Mirai to measure ocean and atmospheric conditions, collect samples of seawater and sediments, and perform other tasks. We are installing ocean observation systems to collect data year round, and at various depths that can be related to the seasonal changes of hydrological cycles. We are also collecting data on land around the Arctic to investigate changes of vegetation, soil, and underground temperatures, and other factors. We believe these studies are important in building the foundation of Arctic research. Modeling experiments using the Earth Simulator supercomputer are also essential for a detailed understanding of the current and future status and trends.

In recent years, reduction of the Arctic sea ice in summer has enabled R/V Mirai to sail in areas that were previously covered by ice, and have obtained new data. These data will be used to understand the Arctic’s current and future status and trends.
The Arctic Ocean used to be covered with sea ice almost all of the year, so it was a “quiet ocean.” But because of global warming there is now less ice and the ocean is exposed to the atmosphere, allowing it to be directly affected by the wind; consequently the Arctic Ocean is becoming an active ocean. Melting of the sea ice is also associated with ocean warming, freshening, and acidification, which is greatly changing the environment. Additionally, because the ice cap shrinks, more cold water is exposed to the winds, which are the primary cause of the changes in the Arctic. The Arctic is warming more rapidly now than in the past, and the Arctic is warming more rapidly than other regions. As a result, the Arctic is becoming an active ocean.

Finding the Current Status and Trends of the Arctic Environmental Change

The Arctic Ocean would be covered with sea ice almost all of the year, so it was a “quiet ocean.” But because of global warming there is now less ice and the ocean is exposed to the atmosphere, allowing it to be directly affected by the wind; consequently, the Arctic Ocean is becoming an active ocean. Melting of the sea ice is also associated with ocean warming, freshening, and acidification, which is greatly changing the environment. Additionally, because the ice cap shrinks, more cold water is exposed to the winds, which are the primary cause of the changes in the Arctic. The Arctic is warming more rapidly now than in the past, and the Arctic is warming more rapidly than other regions. As a result, the Arctic is becoming an active ocean.
How are changes in the Arctic Ocean affecting marine life? We are seeing greater activity by organisms in a marine region that was formerly covered by ice for almost the entire year. Because a larger marine region is now open in the summer, sunlight penetrates into the ocean over a larger area, and phytoplankton are able to actively photosynthesize there. Furthermore, when the ice that isolates the ocean from the atmosphere disappears, the ice is directly affected by the wind, mixing, circulation, and other processes are more active, and the region that was separated deeply in the ocean is being transported to the surface area, where they mix with the production of the atmosphere, and that region will make a lot of marine life in the Arctic Ocean. Arctic ocean changes are beneficial in a variety of ways. But how long will these favorable effects last?

Although on the one hand there are marine areas where organisms are more active, ocean acidification is happening all over the world, but in the Arctic, melting of the ice is diluting the concentration of carbonate in seawater, making the Arctic Ocean the fastest-acidifying ocean. Advancing acidification might affect the growth of plankton and juvenile shellfish. It is likely that their growth is inhibited, which impacts specific zooplankton, which feed on phytoplankton, and fish, which feed on zooplankton. There may also be impacts on people in the fishing and marine products industry, and on our diets, as fish no longer be caught in some marine areas but will require to find new areas.

Despite ocean acidification, the oceans have originally been weak basic, so acid won’t dissolve shellfish shells. Plankton and shellfish make their own skeletons and shells with calcium carbonate. But higher atmospheric CO2 leads to more CO2 dissolved in seawater, and that CO2 reacts with water to produce hydrogen ions. The oceans have a buffering system that controls the increased hydrogen ions by combining them with carbonate ions, becoming bicarbonate ions. Calcium carbonate in organisms dissolves to compensate for the decrease in carbonate ions caused by the reaction with hydrogen ions. In other words, it’s a matter of grave importance to organisms whether seawater is rich in carbonate ions (saturated) or not (under saturated), because in under saturated state there are not enough carbonate ions, which are necessary for the growth of organisms. Understanding the acidification happening in the Arctic Ocean and its impacts on organisms and ecosystems can help predict changes in other world oceans.

To answer the question “How do global warming and acidification affect zooplankton and phytoplankton?” the Arctic Marine Ecosystem Research Unit conducts field studies and collects samples in the Arctic Ocean. Additionally, research taking advantage of expertise in measuring the carbonate density of these marine carbonate organisms, in which JAMSTEC leads the world, has confirmed that the zooplankton living in oceans with advanced acidification have low shell density. We are also working on building an “Arctic Ice-Ocean Ecosystem Model” using a supercomputer to predict the future impacts of global warming and acidification on ecosystems. We hope that by understanding these feedbacks of marine ecosystem models, we can obtain predictions with lower uncertainty.
How are changes in the Arctic Ocean affecting marine life? We are seeing greater activity by organisms in a marine region that was formerly covered by ice for almost the entire year. Because a larger marine region is now ice-free in the summer, sunlight penetrates into the ocean over a larger area, and phytoplankton are able to photosynthesize there. Furthermore, when the ice that isolates the ocean from the atmosphere disappears, the ice is directly affected by the wind, ocean mixing, circulation, and other processes. In the Arctic, the ice that was separated deep in the ocean is being transported to the surface again, where they mix with the production of carbon dioxide, resulting in increased and enhanced light penetration into the water column. In Arctic regions, marine life is diverse in many ways, but it has long been these focuses that are salient.

Although the ice is from melted at certain areas where organisms are more active, ocean acidification is happening all over the world, but in the Arctic, melting of the ice is altering the concentration of carbon dioxide in seawater, making the Arctic Ocean the fastest-acidifying ocean. Advancing acidification might affect the growth of planktonic and juvenile shellfish. It is likely that their growth is inhibited, the impacts will spread to zooplankton, which feed on phytoplankton, and to fish, which feed on organisms. There are also impacts that people in the fishing and marine products industry, and on our diets, as fish will no longer be caught in some regions, and will require other. Despite these, acidification, the sources have originally been weak acids to start, and won’t dissolve shellfish. Plankton and shellfish make their own skeletons and shells with calcium carbonate. But higher atmospheric CO2 leads to more CO2 dissolved in seawater, and that CO2 reacts with water to produce hydrogen ions. The carbon have a buffering system, that controls the increased hydrogen ions; by combining them with calcium ions, becoming bicarbonate ions. Calcium carbonate in organisms dissolve to compensate for the decrease in carbonate ions caused by the reaction with hydrogen ions. In other words, it’s a matter of grave importance to organisms whether seawater is rich in carbonate ions (saturated) or not (under saturated), because in under saturated state there are not enough carbonate ions, which are necessary for the growth of organisms. Understanding the acidification happening in the Arctic Ocean and its impacts on organisms and ecosystems can help predict changes in other world oceans.

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How Advancing Acidification of the Arctic Ocean Affects Organisms

Arctic Marine Ecosystem Research Unit Naomi Harada

Research Unit Leader Naomi Harada
Although it is well known that carbon dioxide (CO₂) is the main cause of global warming, in fact various other substances are also involved in global warming. In particular, the effects of methane and black carbon are estimated to be important.

Methane is the main constituent of natural gas; it is emitted in the burps of cattle and other animals, and also from rice paddies. In Siberia, where in recent years the permafrost is thawing because of global warming, it is possible that methane trapped within the permafrost will be released.

Black carbon, which is in aerosol form, has a large impact on global warming. Unlike methane, it is not a greenhouse gas, but can cause global warming. It is formed by the incomplete combustion of fossil fuels and biomass. Black carbon absorbs sunlight; when it attaches to snow while being carried by the wind, it turns the snow black. As a result, the snow more readily absorbs sunlight, and the ground is warmed and its temperature rises, which in turn further speeds up global warming.

Although we know that methane and black carbon have large impacts on global warming, there is still a great deal of uncertainty. In this context, conducting studies and research mainly in the Pan-Arctic region, where global warming is proceeding faster than anywhere else on the Earth, may provide clues for understanding the connection of methane and black carbon with global warming.

One of our current tasks is to build a more precise simulation model. For example, black carbon is actually composed of particles differing greatly in size and shape. How do differences in particles affect the differences in movement and transport route in the atmosphere? We will use the observation data we are starting to collect and our simulation technology to create a more accurate model.

Research institutes around the world are running simulations to predict global climate change; however, in answer to questions like “How high will global temperatures have risen 100 years from now?”, there are wide differences in the results of these simulations. Further clarification of these models is needed to sufficiently include the exchange of substances such as methane and black carbon with the atmosphere, oceans, snow, and ice. Refining the models for these substances should increase the precision of global climate change predictions.

Shedding Light on the Transport and Transformation Mechanisms for Short-lived Climate Pollutants
Although it is well known that carbon dioxide (CO₂) is the main cause of global warming, in fact various other substances are also involved in global warming. In particular, the effects of methane and black carbon are estimated to be important. Methane is the main constituent of natural gas; it is emitted in the burps of cattle and other animals, and also from swamps, rice paddies, and Siberia, where in recent years the permafrost is thawing because of global warming, it is possible that methane trapped inside the permafrost will be released. Black carbon, which is composed of a large amount of soot, is the soot arising from fossil fuel combustion and forest fires. Black carbon itself absorbs sunlight; when it attaches to snow while being carried by the wind, it causes the snow to become darker, which in turn further enhances global warming. Although we know that methane and black carbon have large impacts on global warming, there is much uncertainty. In this context, conducting studies and research mainly in the Pan-Arctic region, where global warming is proceeding faster than anywhere else on the Earth, may provide clues for understanding the connection of methane and black carbon with global warming.

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Research institutions around the world are running simulations to predict global climate change; however, in answering questions like “How high will global temperatures have risen 100 years from now?” there are wide differences in the results of these simulations. Further, many models do not sufficiently include the interchange of substances such as methane and black carbon with the atmosphere, oceans, snow, and ice. Refining the models for these substances should increase the precision of global climate change predictions.

When the Arctic Ocean ice melts in the future and ships sail that ocean, the black carbon emitted by those ships will likely be a problem. It is our intent to use the findings of our research in the Pan-Arctic region to provide grounds for scientific decision-making to help consider the connection of methane and black carbon with global warming.

Our Arctic Geochemical Cycle Research Unit collaborates with research groups in Japan and other countries to conduct measurements in various locations and investigate atmospheric methane and black carbon. How do these substances enter in the atmosphere, how are they transported, and how do they deposit? Our current basic task is to build a more precise simulation model. For example, black carbon is actually composed of particles that differ greatly in size and shape. How these differences in particle size and shape affect the differences in movement and transport routes in the atmosphere? We will use the observation data we are gathering and our simulation technology to create a more accurate model.
Under the overarching theme of ‘prediction’, our Pan-Arctic Climate Change Projection Research Unit is using JAMSTEC’s ‘Earth Simulator’ supercomputer as an effort to develop a highly accurate numerical model for the Pan-Arctic region. When will the Earth, or Japan, be like 10, 20, or 50 years from now owing to global warming and other climate change? To find out, it’s important to increase our understanding of the Arctic and its surrounding regions.

The Arctic is a region where climate change impacts are most pronounced, as exemplified by the rapid decrease in the sea ice that covered the Arctic Ocean. Over the last few years, attention has focused on questions such as, “How will the melting of the ice affect other regions?” The Arctic is strongly affected by climate change, but because of the great magnitude of change, it could at the same time have strong impacts on other regions, including Japan. For that reason we are building a model that covers not only the Arctic, but also the Pan-Arctic region, which includes the peripheral regions around the Arctic.

Models for global-scale, long-term simulations, called climate models, have been created at research institutions in many countries with collaboration by many researchers. The results of these models have been collected, examined, and released through international frameworks such as the Intergovernmental Panel on Climate Change, an organization that assesses research results on global warming and other climate changes caused by human activities. But because performing simulations for the entire Earth requires enormous computing resources, there is a limit to detail even with the power of a supercomputer. For example, many of the climate models provided for the IPCC’s most recent report performed their calculations by covering the Earth with grids about 100 km on a side. Although climate models provide an indicator for understanding changes over the Earth as a whole, 100-km grids are too big to reproduce local changes and meteorological events. We will therefore create a model that uses large grids for everywhere except the Pan-Arctic region, which is divided into grids about 5 km on a side, to obtain results that are highly accurate for the Pan-Arctic region despite limited computational resources. Considering the fact that rapid changes in the Arctic are greatly affecting other regions of the Earth, it is our expectation that the results obtained from such models will lead to new understanding of, and more detailed predictions for, climate change not only in the Arctic but also on the entire planet.

One more thing that distinguishes our unit is the modeling of the ice sheets in Greenland and other places. Even Greenland with its vast ice sheet is beginning to experience previously unseen phenomena, such as the large scale and rapid melting of ice in summer. Melting of the Greenland ice sheet feeds immense volumes of fresh water into the ocean, which could affect the entire planet. Our incorporation of a Greenland ice sheet model into our climate model is internationally cutting-edge research through which we hope to be helpful in further improving the accuracy and reliability of predictions from the Pan-Arctic to mid-latitude regions.

Pan-Arctic Climate Change Projection Research Unit

Yoshiki Komuro
Research Unit Leader
Under the overarching theme of “prediction,” our Pan-Arctic Climate Change Projection Research Unit is using JAMSTEC’s “Earth Simulator” supercomputer as an effort to develop a highly accurate numerical model of the Pan-Arctic region, which will help us understand how the earth, or rather the Earth, will be like 10, 20, or 50 years from now as a result of global warming and climate change. To find out, it’s important to increase our understanding of the Arctic and its surrounding regions.

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Using New Observation Technologies to Pioneer a World Never before Seen

JACE not only performs research, studies, and simulations in a variety of fields, but also devotes efforts developing measurement instruments and observation technologies in order to conduct trouble-free observations and collect even more data and samples in the Arctic, which has barriers to performing observations there. Which country will be the first to achieve it? Developers around the world are gearing up for the challenge. The development of instruments would make it possible to perform measurements and safely will surely better our understanding of the Arctic.

Arctic Observation Technology Development Unit

Research Unit Leader
Yasuhisa Ishihara

Earth Simulator

The supercomputer “Earth Simulator,” which performs large-scale simulations of the full Earth system, was developed by bringing together Japan’s most advanced technologies. It began operating in March 2002. We have built a number of similar (called “numerical simulations”) which involves using the models to conduct experiments. In particular, the “Earth Simulator” conducts high-resolution simulations in the earth science field, such as global prediction experiments using climate models. In June 2015 the third-generation system began operating; some of the world’s best computational performance is being used to conduct a series of advanced numerical models for understanding the Arctic’s current state and predicting its future state. These tasks include the five Arctic models with improved resolution, chemical transport models, and Arctic ecosystem models. The “Earth Simulator,” which is operated in JMA’s Institute for Earth, Sea and Space, is a research in Arctic, Ocean, and Environmental Research.

Oceanographic Research Vessel Mirai

Our research vessel Mirai is active in the North Pacific Ocean, but also in other world oceans including the Pacific and Indian Oceans. Sailing the world oceans, Mirai makes observations of ocean current, water properties, such as temperature, salinity, and chemical compositions, and marine organisms such as phyto- and zooplankton. We can perform meteorological observations including cloud, storms, waves, and wind, and chemical component, such as greenhouse gases. Furthermore, various samples of the broad ecosystem in the ocean were collected. Additionally, it carries many observation instruments such as the “Ocean Weather buoy,” called “numerical simulation,” which involves using the models to conduct experiments, especially in the Earth science field, such as global prediction experiments using climate models. In June 2015 the third-generation system began operating; some of the world’s best computational performance is being used to conduct a series of advanced numerical models for understanding the Arctic’s current state and predicting its future state. These tasks include the five Arctic models with improved resolution, chemical transport models, and Arctic ecosystem models. The “Earth Simulator,” which is operated in JMA’s Institute for Earth, Sea and Space, is a research in Arctic, Ocean, and Environmental Research.
Using New Observation Technologies to Pioneer a World Never before Seen

Arctic Observation Technology Development Unit

Yasuhisa Ishihara
Research Unit Leader

Why not perform "smarter" observations; however, doing this requires monitoring floats in an attempt to develop a technology that can take photographs from below the ice, but this raises the problem of how to recover the data. The Arctic requires various barriers to performing observation there.

But if the project involves many difficulties that make the effort worthwhile, the World Ocean Research Program announced a project this year called "Polar Challenge," which involves crossing the Arctic under the ice for 2000 km while making observations. Why exactly will it be the first time a team of developers around the world are gearing up for the challenge. The development of instruments would make it possible to monitor environmental and safety issues such as the change in sea ice, oceanography, and biological activity, and things that no one has studied. The development of instruments that can be used by researchers is a prerequisite for any request from any researcher. Therefore, the advantage we find in supporting Arctic research with new technologies.

In the operation of some early-model buoys required about six people and heavy equipment. However, with the installation of global warming, these units have become lighter and easier to install. With more stable equipment, the installation of marine areas where ice disappears in the summer because of weather buoy, which can make highly accurate environmental observations. And, since 1998, R/V Mirai has made voyages at a pace of about twice in three years to the Arctic Ocean; there are expectations for the ship's excellent navigational performance, R/V Mirai has laboratories and system," the "subsurface moored monitoring system," and the "Argo observation instruments such as the "ocean weather observation system,"

Oceanographic Research Vessel Mirai

The Research Vessel and Supercomputer Supporting IACE’s Arctic Research

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Domestic Collaboration

The Arctic environmental changes due to global warming are having a greater impact on a wider range of fields. It is essential that the Arctic be considered in the spotlight, and the Arctic Council is aiming to address the question of “Why does the Arctic Ocean covered with ice almost all of the year.” To address this question, we started Arctic expeditions. R/V Mirai, which is an ice-strengthened ship, can perform research on the Arctic Ocean, which was covered with ice almost all of the year. Accumulating observation data has enabled us to understand the rapid environmental changes in the Arctic, its impacts, and ways to address them. The 1990s marked the beginning of the research cooperation and collaboration in Japan, with the purpose of understanding the Arctic environmental changes due to global warming. Since 2002, the observation data have increased significantly, and we have performed modeling experiments with the “Earth Simulator.” Meanwhile, the Institute of Arctic Climate and Environment Research was established on April 1, 2015. Global research achievements including observation research from R/V Mirai and simulation research with the “Earth Simulator” have contributed to climate research, for not only the Arctic region but also the global scale, by means of diverse research institutions in Japan.

International Collaboration

The Arctic has long attracted the attention of researchers, as well as the Arctic Circle countries, given its unique characteristics. Understanding the impact of the Arctic environmental changes on the Earth, their impacts, and ways to address them. Research cooperation and collaboration involving Arctic countries and research institutes, and making advantageous use of their respective characteristics in that we are capable of conducting research with the most suitable methods in the world. Along with the Arctic Circle countries, our research has expanded the major purposes of our Arctic research. In conjunction with such changes, the observation data that JAMSTEC has conducted interdisciplinary research on the Arctic, and has contributed to the Arctic research.

Network for National and International Cooperation and Collaboration

The International Collaboration Network for National and International Cooperation and Collaboration (NASC), as established in 2009, has cross-country collaboration, and is performing interdisciplinary research on the Arctic. JAMSTEC is performing interdisciplinary research on the Arctic from a broad array of fields in order to make greater contributions.

The History of JAMSTEC’s Arctic Research

JAMSTEC has contributed to climate research, not only for the Arctic region but also at the global scale. By means of diverse research achievements including observation research from R/V Mirai and simulation research with the “Earth Simulator,” the Arctic Marine Environmental and Oceanographic Research System was established on April 1, 2015. Global research achievements including observation research from R/V Mirai and simulation research with the “Earth Simulator” have contributed to climate research, for not only the Arctic region but also the global scale, by means of diverse research institutions in Japan.

LACE

Director, Institute of Arctic Climate and Environment Research

Deputy Director, Institute of Arctic Climate and Environment Research

Arctic Ocean and Climate System Research Unit

Arctic Marine Ecosystems Research Unit

Arctic Oceanographic and Chemical Cycle Research Unit

Arctic Ocean Observation Technology Development Research Unit

Arctic Geophysical Ocean Research Unit

Arctic Sea Ice Change Propagation Research Unit

Arctic Oceanographic and Chemical Cycle Research Unit

Arctic Geophysical Ocean Research Unit

Arctic Ocean Observation Technology Development Research Unit

Arctic Ocean and Climate System Research Unit

Arctic Marine Ecosystems Research Unit

Arctic Oceanographic and Chemical Cycle Research Unit

Arctic Ocean Observation Technology Development Research Unit
Domestic Collaboration

The Arctic environmental changes due to global warming are leading to greater public interest and concern. Responding to this interest and concern, collaboration by researchers in a broad range of fields to investigate the Arctic issue now in the spotlight. We are to provide clear and reliable evidence that might lead to solutions for the problems facing the Arctic region, so we are formerly accompanied by vigorously expanding research cooperation and establishing a broad-based Arctic-related research institutions in Japan.

International Collaboration

The Arctic is a region comprising the Arctic Circle, as well as the Arctic Circle countries and surrounding areas. To understand the rapid environmental changes in the Arctic, their impacts, and the causes of their changes, we need international research cooperation and collaboration including Arctic research essential to understanding "the rapid loss of sea ice, and other causes of Arctic warming" and "the impacts of Arctic warming" became more clearly understood in recent years. Global warming is proceeding faster in the Arctic than in any other region of the world. Along with this new knowledge, the years 2002, 2005, 2007, and 2012 set new records for the minimum extent of summer sea ice in the Arctic Ocean. As a result, the satellite observation started in 1979. Ice decreases were greater than ever before: it became widely known that the sea ice is reducing at an unprecedented rate.

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