Mass loss of outlet glaciers and ice caps in the Qaanaaq region, northwestern Greenland

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The Greenland ice sheet and peripheral ice caps are rapidly losing mass. Recently, ice mass loss is increasing particularly in northwestern Greenland (e.g. Enderlin and others, 2014). It is urgently important to understand the ongoing changes in this region, but observational data are sparse in northern Greenland. To quantify current ice mass loss in northwestern Greenland and better understand processes driving the mass loss, we studied outlet glaciers and ice caps in the Qaanaaq region as a part of GRENE Arctic Climate Change Research Project. Field and satellite observations were performed to quantify ice surface elevation change of outlet glaciers and ice caps (Saito et al., 2016; Tsutaki et al., 2016). Frontal position and ice speed of outlet glaciers were mapped by satellite data. We also studied processes occurring near the front of outlet glaciers to investigate interaction of the glaciers and the ocean (Ohashi et al., 2016). Our field activities include mass balance monitoring on Qaanaaq Ice Cap since 2012 (Sugiyama et al., 2014), integrated field observations near the calving front of Bowdoin Glacier since 2013 (Sugiyama et al., 2015; Podolskiy et al., 2016), and ocean measurements in front of the glaciers. In this contribution, we present the overview of the results obtained in the GRENE project, and introduce a new project established under the framework of ArCS (Arctic Challenge for Sustainability Project). Our presentation aims to stimulate community discussion on research plan in Greenlnad for Master Plan 2020 called by Science Council of Japan.

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Keywords: Greenland, ice sheet, ice cap, calving glacier

Establishment of a new integrated geodetic observation system in Syowa Station for mm Global Geodetic Reference Frame (GGRF)

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Syowa Station has three independent techniques for space geodetic observation, namely, Very Long Baseline Interferometry (VLBI), Global Navigation Satellite System (GNSS), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS). Observations by the three techniques have been continued for more than 15 years. Hence Syowa Station is one of the most critical geodetic sites in southern hemisphere for maintaining the current International Terrestrial Reference Frame (ITRF).
In addition to these space geodetic observations, continuous gravity observation with superconducting gravimeters have been carried out for more than 20 years as well as repetitive absolute gravity measurements. This means that Syowa Station is a promising site to realize and maintain the GGRF with mm accuracy which is an integrated geodetic reference frame incorporating the ITRF, the International Celestial Reference Frame, the International Height Reference Frame and the Global Absolute Gravity Reference System.
To accomplish mm accuracy of the position coordinates of Syowa Station, we plan the following actions; (1) Replacement of the current VLBI system to the next generation VLBI system, (2) New installation of a next generation Satellite Laser Ranging (SLR) system, (3) Implementation of co-location survey between the space geodetic observation sites and the absolute gravity measurement site with an accuracy of 1 mm, and (4) Realization of gigabit data communication between Syowa Station and Japan.
Establishment of the new space geodetic site can provide co-located position coordinates of 1 mm accuracy combined with the absolute gravity value. The coordinates and gravity value will contribute to realization and maintenance of the mm GGRF. At the same time, the provided temporal variations of the coordinates and the gravity value allow us to investigate solid Earth deformation induced by Glacial Isostatic Adjustment (GIA), plate motion and current change in cryosphere, ocean and atmosphere.

Keywords: GGRF, space geodetic observation, GIA

A perspective for observations on ecosystem response in the Arctic

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Arctic and sub-Arctic ecosystems are exposed to a larger magnitude of warming in comparison with the global average, as a result of warming-induced environmental changes. Understanding the sensitivity of tree growth to climate in these ecosystems is an important factor in the accuracy of future projections of the terrestrial carbon cycle, and also of global climate. However, it is not certain how these ecosystems respond to these changes.
We have conducted research on tree growth response to climate change over the Arctic and sub-Arctic ecosystems using ring width indices (RWI) from a tree-ring width dataset accessed through the International Tree-Ring Data Bank (ITRDB) and found that the responses differed among regions, depending on the characteristics of each region. Tree radial growth decreased with recent rapid warming in southern boreal forests located on continental dry climate region such as inner Alaska and Canada, southern part of Europe, southern part of Lena river basin of eastern Siberia and Mongolia. Conversely, radial growth increased in the Arctic ecosystems. It is clear that spatial heterogeneity in Arctic and sub-Arctic ecosystems response to climate change existed.
However, we still have following questions with regard to advancing our understanding of these ecosystems response; (i) to which extent does the clear spatial heterogeneity in those ecosystems response deduced from RWI data set correspond to that from other kinds of data set?; (ii) what is controlling factor for the spatial heterogeneity in those ecosystems response?; (iii) how can we expect future carbon cycling in the Arctic and sub-Arctic ecosystems?
To answer these questions, we plan to conduct observation-based multilateral study in which we investigate relationship among tree-ring parameters, i.e., ring width (RWI) and stable carbon isotope ratio, remotely sensed spectral vegetation indices, i.e., normalized difference vegetation index (NDVI) and CO_2 flux observations. The comparisons are conducted for linking those data sets each other and for obtaining better estimate of vegetation activity response to climate change over Arctic and sub-Arctic ecosystems. For example, our comparative analysis between RWI and NDVI (Tei et al., in preparation) showed disagreement in their trends over extensive areas; the accelerated RWI trend over some regions did not correlate with greening and, inversely, with browning where tree experienced a slower growth. Comparison of such proxies with direct CO_2 flux observational data set is also useful to know what NDVI and RWI represent at the ecosystem level, how to optimally integrate them each other, and what related challenges need to overcome. Such efforts are expected to improve our understanding of forest carbon cycling in the Arctic and sub-Arctic ecosystems and place current developments into a long-term perspective. It could also help to evaluate the performance of earth system models regarding the simulated magnitude and dynamics of forest carbon uptake, and inform these models about growth responses to climatic drivers.

Keywords: Arctic and sub-Arctic ecosystems, carbon cycle, tree ring, CO2 flux, remote sensing

Characteristics of total ozone measured in the western Antarctica

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To figure out the temporal variation and spatial distribution of Antarctic ozone loss, we investigate the characteristics of long-term (at least longer than 15 years) total ozone columns measured by Dobson or Brewer spectrophotometer at five ground stations in the western Antarctica: King Sejong, Marambio, Belgrano, Halley, and Belgrano stations. All measured total ozone columns, well evaluated through an inter-comparison with OMI total ozone measurements, recently show the recovery pattern, particularly in September. They are generally analogous but often different during the austral springtime when the stratospheric ozone loss strongly occurs. As shown in the comparison of potential vorticity among stations, regional differences of total ozone are attributed to the spatial scale of polar vortex. Additional analyses of other meteorological factors also indicate the large spatiotemporal variations of atmospheric pattern over the western Antarctica. This probably implies that the total ozone variation in this region has higher sensitivity to the large-scale circulation and even climate change compared to the eastern Antarctica. We also find the well-known positive correlation between total ozone and lower stratospheric air temperature all the year round, particularly at 50-100 hPa heights during austral spring. But this positive correlation is not apparent in the upper stratosphere (higher than 10 hPa). Correlation with tropical sea surface temperature is not clear, but the signal looks meaningful and somewhat asymmetry between austral spring and summer. Further analysis will be required for better understanding of this feature.

Keywords: Antarctica, Ozone, Brewer, Dobson

Integrated multidisciplinary study on change in the Southern Ocean and the Antarctic ice sheet

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The Antarctic ice sheet holds 90% of ice, which is equivalent to about 70 m height of sea level. On the other hand, the Southern Ocean produces densest seawater, called the Antarctic bottom water, which drives ocean circulation. The Antarctic ice sheet and the Southern Ocean are the most significant components that control global climate and sea level changes. However, the Antarctic ice sheet and the Southern Ocean are the mostly unknown components in the Earth system due to the difficulties of the observation in these areas, especially in the East Antarctica.
The primary processes and the mechanism of the interactions among the atmosphere, ice sheet, solid earth and ocean should be made clear in the context of the global environmental changes driven by the Antarctic ice sheet and the Southern throughout the various kinds of the interactions. The integrated multidisciplinary study is required with the different fields of the observation data from geological to present time scale together with modeling studies. Furthermore, the developments of the observation instruments are important element to obtain the field observation data in the unexplored under and edge of sea ice. The project of the integrated multidisciplinary study focused on changes in the Southern Ocean and the Antarctic ice sheet are introduced, and the prospects of this program are discussed.

Keywords: Southern Ocean, Antarctic ice sheet, ocean circulation, sea level

Long-term field experiment for detection and study of climatological change in East Antarctica

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This presentation will make a review on the Antarctic climatic change during the last decades and discuss important observation to understand the mechanism of the present situation of Antarctica and the future trajectory.

The observation indicates robust warming of West Antarctica since the middle of the last century as one of the most rapid warming area among the world. In East Antarctica, on the other hand, we have not detected clear temporal tendency in the surface air temperature. The mechanism of the suppression of surface warming of East Antarctica has not been understood yet.

Mass balance of the Antarctic ice-sheet also is one the most important issue because it is the largest source to push the sea level upward. While West Antarctica continues to loss the mass, Droning Maud Land, the western part of East Antarctica, recently, got much accumulation, resulting in increasing the mass of the area. The accumulation may be caused by activity of synoptic-scale disturbances. But the mechanism is still studied and we do not know the future trajectory of the mass balance of Antarctica.

To understand the air temperature change and the surface mass balance in East Antarctica, we need to enhance the observations on the ice-sheet and to keep them for more than ten years, favorably. Thus, we are planning a long-turm field experiment for detection and study of climatological change in East Antarctica.

Keywords: atmosphere, antarctic, arctic

A new perspective on atmospheric and geospace sciences in the Arctic with EISCAT_3D

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The European Incoherent Scatter(EISCAT) radar system in northern Feno-Scandinavia and Svalbard have been playing a pivotal role in advancing cutting edge sciences in various area including atmospheric, ionospheric and geospace studies, space weather and global change. Affiliated in the EISCAT Scientific Association in 1996, the EISCAT user community in Japan has jointly contributed to understanding of the magnetosphere-ionosphere-thermosphere coupling processes using the coordinated ground-based and rocket/satellite simultaneous observations with EISCAT radars.
EISCAT_3D is the major upgrade of the existing EISCAT mainlamd radars, with a multi-static phased array system composed of one central active (transmit-receive) site and 4 receive-only sites to provide us 50-100 times higher temporal resolution than the present system. The core site will transmit radio waves at 233MHz with 10MW power, and all five receiving sites will have sensitive receivers to detect the returned signal using phased-array antenna with 10,000 cross-Yagi elements.
The new radar is expected to overcome current observational difficulties and then open new scientific world that have been never realized. One of the great characteristics is continuous measurements of the space environment-atmosphere coupling in the auroral oval and at the southern edge of the polar vortex. High time resolution data with 3D volume-metric will be obtained by EISCAT_3D. Scientific topics addressed in the Science Case documents (i.e.. McCrea, et al., 2015) are as follows:

1. Atmospheric physics and global change
-a. Vertival coupling between the atmospheric layers
-b. Turbulence and waves in the mesosphere and lower thermosphere
2. Space and plasma physics
-a. Multiple scale interactions in ionosphere-magnetosphere plasmas
-b. Plasma turbulence and active experiments
3. Inflow and outflow of matters in the Earth’ s atmosphere
4. Space debris, near-earth objects and space weather
5. Radio astronomy

In this paper, we will overview scientific subjects to be challenged by the new EISCAT_3D radar facility in the Arctic, as well as the possible inter-hemispheric coupling studies with the PANSY radar in the Antarctic.

Keywords: incoherent scatter radar, bipolar, vertical coupling

