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## The second International Symposium on the Arctic Research (ISAR-2): Brief overview

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The Arctic and the surrounding region of the sub-Arctic represent a key area for the study of global change because the anthropogenic impact, particularly the rate of warming, is projected to be the greatest in any part of the world due to the complicated feedback processes which occur. This Arctic region has undergone very large changes in recent years due to global warming, and accelerated change is predicted. The rapid changes that are occurring in the Arctic, and that have been the topic of the ISAR-1 and ISAR-2 conferences, manifest themselves at a number of scales. The large scales are Arctic-wide changes in key environmental parameters, which are described in a series of papers in this issue. On a more subtle scale we see changes to species and to biological processes in the Arctic. We hope that readers will enjoy the range of papers published in this issue, and will appreciate that phenomena ranging in scale from global radiation balance to clutch size of birds' eggs are actually all related via the central fact of the present-day Arctic, its high rate of warming.

## Present status and variations in the Arctic energy balance

Atsumu Ohmura

The total solar irradiance (TSI, or solar constant) acquired a new value: 1361 W m^<-2> instead of 1365 W m^<-2>. However a long-term variation of TSI was not detected. The solar irradiance at the earth's surface is considerably smaller (170 W m^<-2>) than previously believed (e.g. 198 W m^<-2> of IPCC AR4). The previous overestimation is due to the underestimation of the absorption of solar radiation in the atmosphere. The absorption of solar radiation in the atmosphere at about 90 W m^<-2>, or 25-28% of the primary solar radiation from space. The global mean atmospheric downward terrestrial radiation is much larger (345 W m^<-2>) than previously assumed (325 W m^<-2> of IPCC AR4). The Arctic has regions of negative annual net radiation, a very rare phenomenon on the globe. These regions are the Central Arctic Ocean with its multi-year ice coverage and the accumulation area of the Greenland ice sheet. The energy balance of these regions is presented.

Long-wave incoming radiation has been increasing in the Arctic at a rate of 4-5 W m^<-2>/Decade. The Greenland ice sheet exhibits a large vertical difference in net radiation from the ablation area to the dry snow zone in summer. It ranges from 80 W m^<-2> in the ablation area to 20 W m^<-2> at the equilibrium line and to 10 W m^<-2> in the dry snow zone. This gradient determines the melt gradient on the ice sheet, and is mainly caused by the altitude variation in atmospheric long-wave radiation, seconded by the albedo variation. The effect of albedo in summer for various surfaces is discussed. Simulation capabilities of radiation for many GCMs are investigated.

## Global warming trend without the contributions from decadal variability of the Arctic Oscillation

Yuta Nagato*, H.L. Tanaka

Climate change associated with recent global warming is most prominent in the Arctic and subarctic. The Arctic Oscillation (AO) is a dominant atmospheric phenomenon in the Northern Hemisphere. Decadal variability of surface air temperature (SAT) associated with the AO index shows high correlation with recent global warming trend. In this study, the SAT variability in the Northern Hemisphere is separated in contributions from decadal variability by the AO and remaining components.

The results indicate that the decadal variability of the AO index shows high correlation with the SAT variation until 1990. The AO index and SAT variabilities show a negative trend during 1949-1969, while the trend is positive during 1969-1989. In addition, the spatial distribution pattern of the SAT linear trend during each period shows the same pattern as AO. However, while the AO index indicates a negative trend, the SAT trend is continuously positive also after 1990.This warming pattern appearing after 1990 is caused by the Arctic amplification.

Although the AO has a large amplitude on local scale, the AO is almost dynamically orthogonal to the hemispheric warming component. However, the AO can be related to the decadal variability of the Arctic and subarctic temperature change through the feedbacks by climate sub-systems. /p>

## Analysis of satellite and model datasets for variability and trends in Arctic snow extent and depth, 1948-2006

Hotaek Park*, , Hironori Yabuki, Tetsuo Ohata

This study aims to investigate the spatiotemporal trends in snow depth (SD) and snow cover extent (SCE) for Arctic lands, excluding Greenland, for the period 1948-2006. The investigation not only delineates how the Arctic regions are manifesting significant annual trends in both SD and SCE, but also provides a comprehensive understanding of their historical context. To achieve these objectives, the combined resources of the hydrological and biogeochemical model (CHANGE), National Oceanic and Atmospheric Administration (NOAA) weekly SCE data, and in situ

observations of SD were used. Most regions in the Arctic exhibited a significant negative trend in SD over the 59 years of study. The magnitude of the negative trend was stronger in North America than in Eurasia, where the decrease became more significant, starting from the late 1980s, coinciding well with the temperature rise during that time. During the same period, the warming temperature caused a prominent decrease in deeper SDs (i.e., >35 cm), so that the corresponding SCEs exhibited negative anomalies, with the greatest declines being observed at SDs > 55 cm. In contrast, the SCEs for SD ≤ 35 cm showed increased anomalies during the most recent two decades. The increased anomalies signify a sequential result induced by the decrease in the SCEs with deeper SDs, rather than the expansion of snow to snow-free regions. These changes resulted in a northward shift of the shallow SD line, which took place to a highly significant degree in North America. These results suggest that the Arctic SCE and SD will undergo more intense changes in response to the future climate warming.

## Anomalous sea-ice reduction in the Eurasian Basin of the Arctic Ocean during summer 2010

Yusuke Kawaguchi*, , Jennifer K. Hutchings, Takashi Kikuchi, James H. Morison, Richard A. Krishfield

During the summer of 2010 ice concentration in the Eurasian Basin, Arctic Ocean was unusually low. This study examines the sea-ice reduction in the Eurasian Basin using ice-based autonomous buoy systems that collect temperature and salinity of seawater under the ice along the course of buoy drift. An array of GPS drifters was deployed with 10 miles radius around an ice-based profiler, enabling the quantitative discussion for mechanical ice divergence/convergence and its contribution to the sea-ice reduction. Oceanic heat fluxes to the ice estimated using buoy motion and mixed-layer (ML) temperature suggest significant spatial difference between fluxes under first-year and multi-year ice. In the former, the ML temperature reached 0.6 K above freezing temperature, providing >60-70 W m^<—2> of heat flux to the overlying ice, equivalent to about 1.5 m of ice melt over three months. In contrast, the multiyear ice region indicates nearly 40 W m—2 at most and cumulatively produced 0.8 m ice melt. The ice concentration was found to be reduced in association with an extensive low pressure system that persisted over the central Eurasian Basin. SSM/I indicates that ice concentration was reduced by 30-40% while the low pressure persisted. The low ice concentration persisted for 30 days even after the low dissipated. It appears that the wind-forced ice divergence led to enhanced absorption of incident solar energy in the expanded areas of open water and thus to increased ice melt.

## The structure and behavior of the arctic cyclone in summer analyzed by the JRA-25/JCDAS data

H.L. Tanaka, Akio Yamagami, Shinji Takahashi

In this study, three-dimensional structures and the life-time behavior of arctic cyclones are investigated as case studies, using reanalysis data of JRA-25 and JCDAS. In recent years, arctic region has undergone drastic warming in conjunction with the reduced sea ice concentration in summer. The rapid reduction of the sea ice concentration is explained, to some extent, by a pressure dipole of the arctic cyclone and Beaufort high over the Arctic Ocean. This paper presents some case studies for the structure of the arctic cyclone.

It is found by the analysis of this study that the arctic cyclone indicates many differences in structure and behavior compared with the mid-latitude cyclone. The arctic cyclones move rather randomly in direction over the Arctic Ocean. The arctic cyclone has a barotropic structure in the vertical from the surface to the stratosphere. The arctic cyclone detected at the sea level pressure is connected with the polar vortex at the 500 hPa level and above. Importantly, the arctic cyclone has a cold core in the troposphere and a warm core around the 200 hPa level. The mechanism of the formation is discussed based on the analyzed structure of the arctic cyclones.

## Changing characteristics of arctic pressure ridges

Peter Wadhams, Nick Toberg

The advent of multibeam sonar permits us to obtain full three-dimensional maps of the underside of sea ice. In particular this enables us to distinguish the morphological characteristics of first-year (FY) and multi-year (MY) pressure ridges in a statistically valid way, whereas in the past only a small number of ridges could be mapped laboriously by drilling. In this study pressure ridge distributions from two parts of the Arctic Ocean are compared, in both the cases using mainly data collected by the submarine "Tireless" in March 2007 during two specific grid surveys, in the Beaufort Sea at about 75° N, 140° W (N of Prudhoe Bay), and north of Ellesmere Island at about 83° 20′ N, 64° W. In the Beaufort Sea the ice was mainly FY, and later melted or broke up as this area became ice-free during the subsequent summer. N of Ellesmere Island the ice was mainly MY. Ridge depth and spacing distributions were derived for each region using the boat's upward looking sonar, combined with distributions of shapes of the ridges encountered, using the Kongsberg EM3002 multibeam sonar. The differing shapes of FY and MY ridges are consistent with two later high-resolution multibeam studies of specific ridges by AUV. FY ridges are found to fit the normal triangular shape template in cross-section (with a range of slope angles averaging 27° ) with a relatively constant along-crest depth, and often a structure of small ice blocks can be distinguished. MY ridges, however, are often split into a number of independent solid, smooth blocks of large size, giving an irregular ridge profile which may be seemingly without linearity.

Our hypothesis for this difference is that during its long lifetime an MY ridge is subjected to several episodes of crack opening; new cracks in the Arctic pack often run in straight lines across the ridges and undeformed ice alike. Such a crack will

open somewhat before refreezing, interpolating a stretch of thin ice into the structure, and breaking up the continuity and linearity of the ridge crest. Many such episodes over a number of years can cause the ridge to become simply a series of blocks. This has implications for ridge strength and for permeability to spilled oil. As the percentage of MY ice in the Arctic diminishes, Arctic ridging will be more and more dominated by FY ridges, and we discuss the implications of this change of character of the ice underside in the light of the statistics that we have generated for the two types of ridge.

## Climatic physical snowpack properties for large-scale modeling examined by observations and a physical model

Kazuyuki Saito *, Satoru Yamaguchi, Hiroki Iwata, Yoshinobu Harazono, Kenji Kosugi, Michael Lehning, Martha Shulski

Here we have conducted an integral study using site observations and a model with detailed snow dynamics, to examine the capability of the model for deriving a simple relationship between the density and thermal conductivity of the snowpack within different climatic zones used in large-scale climate modeling. Snow and meteorological observations were conducted at multiple sites in different climatic regions (two in Interior Alaska, two in Japan). A series of thermal conductivity measurements in snow pit observations done in Alaska provided useful information for constructing the relationship. The one-dimensional snow dynamics model, SNOWPACK, simulated the evolution of the snowpack and compared observations between all sites. Overall, model simulations tended to underestimate the density and overestimate the thermal conductivity, and failed to foster the relationship evident in the observations from the current and previous research. The causes for the deficiency were analyzed and discussed, regarding a low density of the new snow layer and a slow compaction rate. Our working relationships were compared to the equations derived by previous investigators. Discrepancy from the regression for the melting season observations in Alaska was found in common.

## The implementation of initial data populations of environmental data and creation of a primary working database

D. Fleischer, M. Bölter, R. Möller

Biological and environmental changes are creating a growing demand for historical and global data sets. Comparing up-to-date ecological and biological findings with historical statements has become a major part of scientific work in the field of ecology. This evaluation and comparison procedure is very time-consuming while the availability of raw data is very low. Comparisons between original findings – if available – require a lot of work from print publication to digitalization or transformation to appropriate data formats. The effective use of working capacity is a general issue and has become important, should the use of information

technologies be invoked to minimize time-wasting copy and paste operations.

In this paper we aim to present a working repository for terrestrial biological data. The implementation of this type of data repository will provide various services to participating scientists as long as the final aim is the publication of these repositories. Furthermore, the security and long-term availability of environmental data is an issue of increasing importance to the scientific community. Unrepeatable sampling events and any data thus obtained are precious in time series analysis. For this reason, a well-structured storage of data is necessary for easy accessibility, retrieval and comparability. This is an important issue for the community of environmental scientists. The need to construct and implement repositories should prevail against all hitches and we are therefore describing our on-going task with the primary population of this kind of data repository. A biological and ecological information system is a matter of public interest and should also be a key issue for ecologists.

## Horizontal distribution of calanoid copepods in the western Arctic Ocean during the summer of 2008

Kohei Matsuno, *, , Atsushi Yamaguchi, Koji Shimada, Ichiro Imai

The horizontal distribution of the epipelagic zooplankton communities in the western Arctic Ocean was studied during August-October 2008. Zooplankton abundance and biomass were higher in the Chukchi Sea, and ranged from 3,000 to 274,000 ind. m—2 and 5-678 g WM m—2, respectively. Copepods were the most dominant taxa and comprised 37—94% of zooplankton abundance. For calanoid copepods, 30 species belonging to 20 genera were identified. Based on the copepod abundance, their communities were classified into three groups using a cluster analysis. The horizontal distribution of each group was well synchronized with depth zones, defined here as Shelf, Slope and Basin. Neritic Pacific copepods were the dominant species in the Shelf zone. Arctic copepods were substantially greater in the Slope zone than the other regions. Mesopelagic copepods were greater in the Basin zone than the other regions. Stage compositions of large-sized Arctic copepods (Calanus glacialis and Metridia longa) were characterized by the dominance of late copepodid stages in the Basin. Both the abundance and stage compositions of large copepods corresponded well with Chl. a concentrations in each region, with high Chl. a in the Shelf and Slope supporting reproduction of copepods resulting in high abundance dominated by early copepodid stages.

## Abundance and diversity of fungi in relation to chemical changes in arctic moss profiles

Takashi Osono, Takeshi Ueno, Masaki Uchida, Hiroshi Kanda

Mosses are a dominant component of high-arctic terrestrial ecosystems, yet little is known regarding the abundance and diversity of fungi associated with these abundant plants. We investigated vertical patterns of abundance and diversity of

fungi and their relationship with chemical properties within profiles of Hylocomium splendens and Racomitrium lanuginosum collected in the Oobloyah Bay area on Ellesmere Island, Canada. The moss profiles were divided into 6 (H. splendens) and 5 (R. lanuginosum) layers according to the color and texture, and hyphal length, fungal assemblages, and contents of organic chemical components (acid-unhydrolyzable residues, total carbohydrates, extractives) and nutrients (N, P, K, Ca, Mg) were measured. Total hyphal length was greatest at the middle layers of H. splendens and at the deepest layers of R. lanuginosum and was significantly affected by moss species and nutrient contents. A total of 18 and 19 fungal taxa was isolated from the profiles of H. splendens and R. lanuginosum, respectively, with 11 taxa being common to both moss species. Moss species significantly affected the species distribution of fungi. Individual fungal taxa showed patterns of vertical distribution within the moss profiles. The contents of acid-unhydrolyzable residues and nutrients increased and the content of total carbohydrates decreased down the profile, which was attributable to the ability of fungi to decompose carbohydrates selectively and to immobilize nutrients in decomposed moss residues.

## High below ground biomass allocation in an upland black spruce (Picea mariana) stand in interior Alaka

Kyotaro Noguchi* Masako Dannnoura, Mayuko Jomura, Motoko Awazuhara-Noguchi, Yojiro Matsuura

The root system of forest trees account for a significant proportion of the total forest biomass. However, data is particularly limited for forests in permafrost regions. In this study, therefore, we estimated the above- and belowground biomass of a black spruce (Picea mariana) stand underlain with permafrost in interior Alaska. Allometric equations were established using 4-6 sample trees to estimate the biomass of the aboveground parts and the coarse roots (roots >5 mm in diameter) of P. mariana trees. The aboveground biomass of understory plants and the fine-root biomass were estimated by destructive sampling. The aboveground and coarse-root biomasses of the P. mariana trees were estimated to be 3.97 and 2.31 kg mˆ<—2>, respectively. The aboveground biomass of understory vascular plants such as Ledum groenlandicum and the biomass of forest floor mosses and lichens were 0.10 and 0.62 kg mˆ<—2>, respectively. The biomass of fine roots

## Effects of sea ice on breeding numbers and clutch size of a high arctic population of the common eider Somateria mollissima

Fridtjof Mehlum

The breeding performance of high-arctic bird populations shows large inter-annual variation that may be attributed to environmental variability, such as the timing of snow melt and break-up of the landfast sea ice that surrounds breeding colonies on islands and along coasts. In the Kongsfjorden area (79° N) on Svalbard, the number

of breeding pairs and the average egg clutch size vary considerably among years. In this study, data on breeding performance are presented from 15 years in the period 1981–2000. The results showed that early break-up of sea ice in Kongsfjorden resulted in larger numbers of nests and larger average clutch sizes than late break-up. Also, individual islands with early break-up of sea ice in a particular year had more nests and larger clutch sizes compared to other islands surrounded by sea ice during a longer period in spring. Thus, the inter-annual variation in the break-up of sea ice in the fjord has considerable implications for the inter-annual variability of recruitment to the population. The results indicate that the effects of global warming on changes in the sea ice melting regime in coastal regions are important for the reproductive output of island-nesting eiders.