S6–O1

INTRODUCTION TO S6:
MONITORING OF ENVIRONMENT IN THE ARCTIC

Atsumu Ohmura
Institute for Atmospheric and Climate Science
Swiss Federal Institute of Technology (E.T.H.)
Universitätstrasse 16
CH-8092 Zurich
Switzerland
ohmura@env.ethz.ch

An awareness of the need and the importance of monitoring in environment science is new, although even today not fully acknowledged. Consequently, monitoring activities must struggle to acquire legitimacy and financial support. However some monitoring activities lack professional expertise in long-term accurate observations. It is essential to clearly formulate the objectives, to identify the appropriate methods and to examine from time to time if the monitoring observations are fulfilling their original goals.

In principle there are two types of monitoring. The first type was intended from the start as monitoring of the environment, the second type was initially not intended for long-term monitoring but later was found to be useful for this purpose. The former is legitimate monitoring work, with a clear object and method, aiming at a long-term observation. Two examples of this category are “Sea ice conditions in Greenland seas” by the Danish Government, going back to 1895, and “Sea ice analysis” by NSIDC, starting in the late 1970s. The second type of monitoring makes use of past data that were obtained before it was known that such observations could later be used for monitoring the environment. A good example of this type of monitoring is air temperature. Measuring air temperature began in mid-17th century and presently occupies the most important position in environment monitoring, but its value for monitoring climate change has only been appreciated since the middle of the 20th century. A great deal of work is necessary to edit and homogenize the past data in order to bring it up to a comparable level with contemporary observations.

Monitoring differs from other observations, mainly owing to its importance in long-term constancy of the measuring scales. The time frame of at least several decades, if possible more than a century is aimed at. The monitoring should ideally start before the advent of the incident to be monitored. The length, method and spatial density depend on an individual object to be monitored. In the Arctic, the objectives range from the exosphere and thermosphere down to the ocean bottom. For example one can consider certain cases in the cryosphere observations, glaciers, ice sheet, sea ice, seasonal snow cover and permafrost. The gravest problems for monitoring these cryospheric sub-systems are the insufficient sampling for glaciers and the short observation period for sea ice, snow cover and permafrost observations, which have data inhomogeneity problems. Fortunately there are at least several decades of observations. It is important to continue these observations long into the future. For the success it is of utmost importance to establish, maintain and apply the traceability of scales in all monitoring works at the earliest stage possible in the Arctic. The following presentations will report concrete examples of the monitoring in the Arctic. The session should deliberate how a successful campaign can be formulated and carried out.

S6–O2

THE RAPIDLY CHANGING ARCTIC SEA ICE EXTENT FROM SPACE BASED AMSR-E AND AMSR2 OBSERVATIONS

Masahiro Hori[1], Keiji Imaoka[1], Kazuhiro Naoki[1], Mieko Seki[2], Josefino C. Comiso[3]
[1]Earth Observation Research Center, Japan Aerospace Exploration Agency,
2-1-1, Sengen, Tsukuba, Ibaraki 305-8505 Japan
[2]Remote Sensing Technology Center of Japan, 1-6-1, Takezono, Tsukuba,
Ibaraki 305-0032 Japan
[3]NASA Goddard Space Flight Center, Code 614.1, Greenbelt, MD, USA 20771
E-mail address of corresponding author: hori.masahiro@jaxa.jp

The extent of the Arctic sea ice is a key parameter for detecting climate change of amplification of warming signals in the region. Since the late 1970's significant negative trend in sea ice extent has been observed using passive microwave (PM) data and has often been discussed as related to the global warming issue. Objective, accurate, and successive monitoring is necessary for the analysis of the Arctic sea ice trend in extent. PM radiometers onboard U.S polar orbiting satellites, such as the SMMR and SSM/I series, are frequently used for that purpose for the period from the 1970's to the present. In May 2002, Japanese Aerospace Exploration Agency (JAXA) launched the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) which has a finer spatial resolution and wider swath than the US PM sensors. The Advanced Microwave Scanning Radiomete-2 (AMSR2) onboard Japanese GCOM-W1 satellite, the successor of AMSR-E, was also launched on 18 May 2012 to continue the time series and has been providing useful data from 3 July 2012. The AMSR series has become the baseline for sea ice studies because of higher resolution and more accurate sea ice concentration and ice extent products. JAXA launched a web-based monitor of the Arctic sea ice extent in the spring 2007 and has been provided near realtime information about the Arctic sea ice extent to the public (http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm). JAXA also provides the historical Arctic BT, ice concentration and sea ice extent data from SMMR, SSM/I, and Windsat radiometers which are all adjusted to be consistent with those of AMSR-E. In particular, the normalization parameters for BT data were derived from data acquired during the overlapped observation period and the sea ice concentration was retrieved using only the Bootstrap algorithm. The sea ice monitor currently has functions to show not only sea ice concentration image but also some PMR raw images (RGB composite of BT 36GHz and 18GHz, Polarization ratio image of 89GHz) and MODIS reflectances. The latter browse images enable us to assess daily sea ice conditions (and also, rough estimation of multi-year ice fraction, ice motion, sky condition etc.). Results of analysis of the web-based monitor of the Arctic sea ice extent shows an unprecedented shrinkage in the Arctic perennial ice cover, as observed during summer 2012 (Fig. 1), and a trend that indicates an acceleration in the decline of the Arctic sea ice cover.

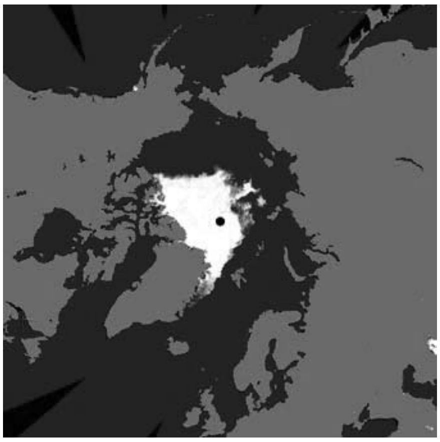

Fig. 1 Arctic sea ice concentration captured by AMSR2 on Sep.16 2012.

S6–O3

ESTIMATION OF ARCTIC SEA-ICE THICKNESS FROM SATELLITE PASSIVE MICROWAVE RADIOMETERS

K. Tateyama [1], R.A. Krishfield [2], W.J. Williams [3] and H. Enomoto [4]
[1] *Kitami Institute of Technology, Kitami, Hokkaido, Japan*
[2] *Woods Hole Oceanographic Institution, Woods Hole, MA, USA*
[3] *Fisheries and Ocean Canada, Institute of Ocean Sciences, Sidney, BC, Canada*
[4] *National Institute of Polar Research, Tachikawa, Tokyo, Japan*
E-mail: tateyaka@mail.kitami-it.ac.jp

To investigate daily large-scale sea-ice thickness distribution in the Arctic and its interannual change, a new algorithm from satellite-based observations was developed by comparing AMSR-E satellite passive microwave data with sea-ice thickness data from shipborne Electro-Magnetic induction ice profiler (EM) and moored Upward Looking Sonar (ULS) of the Beaufort Gyre Observing System in the Canada Basin.

In-situ sea-ice thickness was measured by an EM-31 along with a portable passive microwave radiometer system which has the horizontally and vertically polarized 6, 18, 36 GHz in Joint Ocean Ice Study during summer and autumn 2009 to 2012. As a result, polarization ratio of 6 GHz and gradient ratio between 6 GHz and 36 GHz indicated good sensitivities for thicknesses of second-year and multi-year ice. The penetration depth of 6 GHz is the deepest among the other frequencies. Therefore 6 GHz is more sensitive for information of thicker ice properties than the others.

A sea-ice estimation algorithm was developed using those ratios. This algorithm was applied for AMSR-E and compared with ULS ice draft data during 2003 to 2011. Although AMSR-E sea-ice thickness showed significant under- and overestimation through a year, the error fluctuated cyclically with season. On the other hand, the estimated thickness showed a good agreement with ULS ice draft in March and October. The error assumed to be generated by the seasonal changes of surface salinity, density, temperature, snow cover, and water content (melting). We modified the algorithm to minimize error empirically using a simple approximation of date function.

S6–O4

Monitoring warming in the Eurasian Basin of the Arctic Ocean

Igor V. Polyakov

IARC/UAF

Over the past decade, atmospheric thermodynamic forcing played the increasingly important role in shaping changes of the Arctic multiyear ice. However, analysis of satellite ice motion suggests that the role of ice export through straits connecting the Arctic Ocean with sub-polar basins may be elusive. Available observations suggest a thermodynamic coupling between the heat of the ocean interior and the sea ice. In the Canadian Basin, the impact of Pacific water warmth has been recently documented. While vertical AW heat fluxes are negligible in the Canadian Basin, turbulent mixing may be strong enough in the western Nansen Basin to produce a sizeable effect of AW heat on sea ice. In the eastern Eurasian Basin, double diffusion provides an important alternative to weak turbulent mixing for upward AW heat transport. The relative roles of dynamic and thermodynamic factors in recent changes of the Arctic MYI cover remains to be determined. Quantifying these roles via building a reliable observational monitoring system is a high priority if we are to develop reliable forecasts of the future state of Arctic ice coverage.

S6–O5

OCEAN WARMING, FRESHENING AND CIRCULATION IN THE PACIFIC SECTOR OF THE ARCTIC OCEAN, “POSITIVE FEEDBACK MECHANISMS TO DRIVE THE CATASTROPHIC REDUCTION OF SEA ICE”

Koji Shimada[1], Kohei Mizobata[1], Eri Yoshizawa[1], Daisuke Hirano[1], Tae Wan Kim[2],
Ho Kyung Ha[2], Ho Jin Lee[3], Hyun Jung Lee[2], Kyung Ho Chung[2], Sung Ho Kang[2]
[1] Tokyo University of Marine Science and Technology, Tokyo, 108-8477, Japan
[2] Korea Polar Research Institute, Incheon, 406-840, Korea
[3] Korea Maritime University, Busan, 606-791, Korea
koji@kaiyodai.ac.jp

The Arctic Ocean is not homogenized ocean, but is classified into three types. It means the recent catastrophic reduction of sea ice associated with oceanic changes should be examined taking the regional oceanic properties into consideration.

The first type is the Nansen and Amundsen Basins in the Atlantic sector of the Arctic Ocean. In this region, the surface stress by sea ice motions and winds establishes upwelling favorite condition (i.e. just like as sub-polar gyre), then the warm and saline Atlantic Water affects the fate of sea ice. The second type is the Canada Basin in the Pacific sector of the Arctic Ocean where the clockwise upper ocean circulation (i.e., just like as sub-tropical gyre) and Pacific water dominate the upper ocean. In this region, major heat source to affect the sea ice is not the Atlantic Water but is the Pacific Summer Water. The last type is Makarov Basin where the curl of surface stresses is near zero (i.e. Kuroshio extension) .

Here we focus the warming of the Pacific sector of the Arctic Ocean associated with the catastrophic reduction of sea ice. We also introduce the histories of long-term monitoring in this region since 1990s and recent international challenge for comprehensive understandings of Arctic changes in the missing area, "Makarov Basin", by Korean icebreaker ARAON.

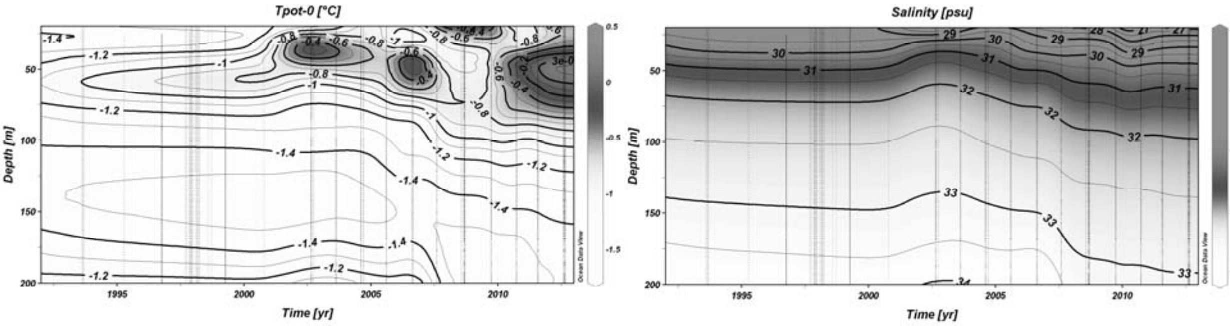

Figure: 20 years time series of potential temperature and salinity in the Pacific Sector of the Arctic Ocean (75-78N,145-165W).

S6–O6

THE OPTIMISM PROJECT (OBSERVING PROCESSES IMPACTING THE SEA ICE MASS BALANCE FROM IN SITU MEASUREMENTS): CURRENT STATUS AND FUTURE PLANS.

Vivier F[1], Lourenco A[1], Bouruet-Aubertot P[1], Cuypers Y[1], Dausse D[1], Eymard L[1], Martin N[1], Weill A[2], Dechambre M[2], Bonnefoy F[3], Ferrant P[3], Gentaz L[3], Rousset J-M[3], Alessandrini B[3], Loisil R[4], Barrois H[4], Amarouche N[4], Panel J-M[5]

[1] LOCEAN-IPSL, Paris, France
[2] LATMOS-IPSL, Paris, France
[3] LMF, Ecole Centrale de Nantes, Nantes, France
[4] INSU, Division Technique, Meudon, France
[5] CEN, Météo-France, Grenoble, France
Frederic.Vivier@locean-ipsl.upmc.fr

Arctic sea ice declines both in extent and volume, at a rate outpacing the most pessimistic climate model predictions. Observations are key not only to assess ongoing changes, but also to improve our understanding and parameterization of physical processes that govern heat exchanges between the ocean, sea-ice, and atmosphere, in order to improve the predictive capabilities of climate models. In situ observations are also critical for the calibration and validation of satellite observations which provide a synoptic view of the Arctic. While sea ice extent is routinely monitored from space, remote sensing of ice thickness is still in its early stage with dedicated missions recently launched (e.g., CryoSat-2) for which in situ data are important to relate raw measurements to geophysical parameters.

The OPTIMISM project, supported by the French National Research Agency (ANR) and the French Polar Institute (IPEV), brings together scientists and engineers from 5 laboratories in France covering the fields of ocean and atmospheric sciences, hydrodynamics, and radar altimetry. A main objective of the project is to develop an autonomous, reasonable cost, system providing real-time measurements not only of ice thickness and heat content, but also of heat fluxes at the ocean-ice-atmosphere interfaces, which are needed to assess the sea-ice mass balance. These challenging technological developments build upon the “Ice-T” (Ice-Thickness) buoy developed at LOCEAN, intended to both thin and thick ice conditions. In particular, a short meteorological mast, dubbed “BEAR” (Budget of Energy for Arctic Region) has been developed to monitor radiative and turbulent heat fluxes, and validated during several field works.

We will present technological developments carried out as part of this project as well as recent or ongoing field experiments. Field works are focused on the study of processes in a coastal polynya of the Svalbard Archipelago where dense water forms, on the one hand, and in the ice pack in the Central Arctic on the other hand. The latter are in particular carried out in collaboration with US and Japanese teams involved in the North Pole Environmental Observatory.

S6–O7

DYNAMICS OF THE GROUND TEMPERATURE REGIME IN EAST SIBERIA

M.N. Zheleznyak
Melnikov Permafrost Institute SB RAS, Yakutsk, Russia
fe@mpi.ysn.ru

In view of recent climate warming observed over the globe, much attention in Earth sciences is given to climate effects on ecosystem response, including permafrost as an ecosystem component.

The ground thermal state and seasonal thaw depth respond most rapidly to environmental changes and anthropogenic disturbances and can serve as permafrost stability assessment criteria.

Development, adaptation and reanalysis of prediction models require reliable baseline data which can only be obtained through establishment of a permafrost monitoring network.

In 2007, the Melnikov Permafrost Institute, with support from the TSP international project, initiated a program to establish a permafrost monitoring network in north-eastern Asia. Long-term (>20 years in length) records of ground temperatures within the depth of zero annual amplitude are available for Yakutsk, Tiksi, Anadyr and Chulman. During the last five years, more than 20 new sites were installed in eight regions of East Siberia, including southern Yakutia, Verkhoyansk Mountains, northern Krasnoyarsk District, north-western Yakutia, and Magadan Province. Ground temperature measurements were resumed in 2007 in several existing boreholes where observations started in the 1980s had been discontinued.

The nature and dynamics of permafrost response to climate change varies between regions and depends on atmospheric circulation patterns, surface heat balance, and soil/rock type. All regions of East Siberia have experienced an increasing trend of 0.3 to 0.6°C/decade in mean annual air temperature during the last 30 years.

Analysis of the ground thermal monitoring data over this period has shown the following:

In Central Yakutia, ground temperatures at the depth of zero annual amplitude exhibit strong interannual variability due to colder (summer) or warmer (winter) periods in some years. However, data obtained by Varlamov et al. indicate no significant warming trend in ground temperatures over this period.

In mountainous regions of southern Yakutia, ground temperatures have increased at most sites, by 0.4 to 1.9ºC depending on local site conditions. Warming is greatest for the subalpine areas and smallest on the slopes and in the valleys.

In Magadan Province, ground temperature warming varies from 0.40ºC on the flat water divide to 0.24ºC in the subalpine zone.

In Chukotka (the Anadyr Lowland), climate warming has resulted in an increase in active layer depth, as well as in ground temperatures at rates of 0.022 to 0.060ºC/yr.

In northern Krasnoyrsk District (Igarka) where permafrost is sporadic with temperatures of – 0.4 to –0.2ºC, its thermal state is stable.