NOAA SEARCH INITATIVE: ELEMENT 9
FY03 Progress Report

Title: Monitoring the Eurasian Basin of the Arctic Ocean

P.I.: Ignatius G. Rigor (University of Washington)

Co-Investigators and Collaborators: Andy Heiberg, University of Washington; Magda Hanna, National Ice Center; Igor Dmitrenko, International Arctic Research Center; Igor Polyakov, International Arctic Research Center; and Sergey Priamikov, Arctic and Arctic Research Institute, St. Petersburg, Russia. This project is coordinated with the NOAA/SEARCH project "Monitoring Ice Thickness in the Western Arctic Ocean".

Rationale: Dramatic changes in Arctic climate have been noted during the past two decades. Observations from the International Arctic Buoy Programme (IABP) have played a significant role in the detection of this change over the Arctic Ocean. For example, using IABP data, Walsh et al. (1996) showed that sea level pressure (SLP) has decreased; Rigor et al. (2000) showed that surface air temperature (SAT) has increased; and in concert, the circulation of sea ice and the ocean have changed so as to flow less clockwise (Steele and Boyd, 1998; Kwok, 2000; and Rigor et al. 2002). In addition to studies of Arctic climate and climate change, observations from the IABP are also used to validate satellites, for forcing, validation and assimilation into numerical climate models, and for forecasting weather and ice conditions.

Monitoring the Eurasian Basin is important since this is the center of many of the changes in Arctic climate. For example, the decrease in SLP noted by Walsh et al. (1996), the warming in SAT noted by Rigor et al. (2000), and the thinning of Arctic sea ice noted by Rothrock et al. (1999) are most significant in this area. One could ask, did the increase in SAT act to thin sea ice, or did the thinner sea ice allow more heat to flux from the ocean to warm the atmosphere? It has been hypothesized that the dynamic thinning of sea ice driven by the changes in atmospheric circulation causes the increasing trends in SAT (e.g. Rigor, et al. 2002).

We propose to deploy enhanced buoys in the Eurasian Basin of the Arctic Ocean (Fig. 1), designed to monitor and attribute changes in the thickness of sea ice, to verify this hypothesis. Establishing a record of climate-induced changes in the thickness of the sea ice cover is essential to understanding the role of the sea ice cover in the global climate system and to the application of the sea ice cover as an early indicator of climate change in the Polar Regions. As explained in the recent report on the SEARCH Workshop on Large-Scale Atmosphere/Cryosphere Observations (Overland et al., 2002), buoys within the IABP network can play an important role in monitoring changes in ice thickness by enhancing their measurement system.

Accomplishments to Date:

1. Ice Mass Balance (IMB) Buoy Deployments

   1.1. IARC/AARI NABOS Deployment
   Collaborated with the International Arctic Research Center (IARC) Nansen and Amundsen Basins Observational Systems (NABOS) researchers to deploy a CRREL IMB buoy north of the Laptev Sea (80.1N 146.1E) from the *Kapitan Dranitsin* in September 2003. This buoy was deployed in a 300km array with meteorological buoys of the IABP (see Figure 2 in companion progress report on Element 8, "Ice Thickness in the Western Arctic Ocean").

1.2. IOS/JAMSTEC/WHOI CCG Deployment
Collaborated with the Institute of Ocean Sciences researchers to deploy a CRREL IMB buoy in the Beaufort Sea (78.3N 146.5W) from the *CCGS Louis St. Laurent* in September 2003 (see Figure 2 in companion progress report on Element 8, "Ice Thickness in the Western Arctic Ocean"). This buoy was collocated with a Japan Marine Sciences and Technology (JAMSTEC) ocean buoy.

2. Publications

2.1. Rigor, I.G. and J.M. Wallace, Variations in the Age of Sea Ice and Summer Sea Ice Extent, *Geophys. Res. Lett.*, submitted, 2004.

3. Data Collection and Analysis

We have begun processing and quality control of the data collected from the buoys. These data are being archived at the World Data Center for Glaciology.

4. Presentations

4.1. Rigor, I.G., and Jamie Morison, Climate Observing System for Arctic Ocean, *Proc. Marine Science in Alaska: 2004 Symposium*, Anchorage, Jan. 2004.
4.2. Rigor, I.G. (invited), Variations in the Age of Sea Ice and Summer Sea Ice Extent, *Proc. Lamont Mini-conference, Central Arctic: Battleground of Natural and Man-Made Climate Forcing*, Lamont Doherty Earth Observatory of Columbia University, New York, Jan. 2004.
4.3. Rigor, I.G. (invited), and J. M. Wallace, Predicting the Extent of Sea Ice in the Arctic, *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract OS11B-06, Dec. 2003.
4.4. Rigor, I.G., and M. Ortmeyer, The International Arctic Buoy Programme (IABP), *Proc. Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract C41C-0987, Dec. 2003.
4.5. Perovich, D.K., J.A. Richter-Menge, I.G. Rigor, C.L. Parkinson, J.W. Weatherly, S.V. Nghiem, A. Proshutinsky, and J. Overland, Assessing, understanding, and conveying the state of the Arctic sea ice cover, *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract C41C-0990, Dec. 2003.
4.6. Rigor, I.G., J. Richter-Menge, and J. Morison, Study of Environmental Arctic Change (SEARCH): An Arctic Ocean Observing System: Ice and Ocean Components, *Climate Observation Program Workshop Report*, May 2003.

5. Outreach

5.1. Assisted with the development of graphics describing Arctic change in the National Geographic Article, Arctic Ice (2004).
5.2. Poster presented in item 3.6 was also displayed by Diane Stanitski at the Earth Observation Summit as an outstanding example of Arctic Ocean research.

Plans for the Coming Year:
1. Ice Thickness Buoy Deployments
2. Data Collection and Analysis
3. Presentations

Summary of Financial Expenditures:

Salary & Benefits	$54,516
Travel	$4,696
Logistics (aircraft)	$72,000
ARGOS	$19,500
Ice Augers	$7,000
Materials & Supplies	$4,362
APL Prorated Expense	$19,312
UW F&A	$18,597
TOTAL	**$199,983**

Budget for Coming Year: $200,000 Grand Total

UW: $60,000

Salary & Benefits	$35,032
Travel	$1,700
ARGOS	$ 5,000
Materials & Supplies	$ 820
APL Prorated Expense	$10,380
UW F&A	$ 7,068
TOTAL	**$ 60,000**

CRREL: $70,000

Salary	$16,745
Equipment	$25,765
Overhead	$27,490
TOTAL	**$ 70,000**

PMEL: $70,000

Equipment	$70,000
TOTAL	**$ 70,000**

References:

Kwok, R., Recent changes in Arctic Ocean sea ice motion associated with the North Atlantic Oscillation, Geophys. Res. Lett., 27(6), pp. 775-778, 2000.

Overland, J., F. Fetterer, D. McGuire, J. Richter-Menge, and J. Walsh, SEACH Workshop on Large-Scale Atmosphere / Cryosphere Observations, Contribution 2452 from NOAA/PMEL, 2002.

Rigor, I.G., J.M. Wallace, and R.L. Colony, Response of Sea Ice to the Arctic Oscillation, J. Climate, v. 15, no. 18, pp. 2648 - 2668, 2002.

Rigor, I.G., R.L. Colony, and S. Martin, Variations in Surface Air Temperature in the Arctic from 1979-1997, J. Climate, v. 13, no. 5, pp. 896 - 914, 2000.

Rothrock, D.A., Y. Yu, and G.A. Maykut, Thinning of Arctic sea-ice cover, Geophys. Res. Lett., 26, pp. 3469-3472, 1999.

Steele, M. and T. Boyd, Retreat of the cold halocline layer in the Arctic Ocean, J. Geophys. Res., 103 (C5), 10,419-10,435, 1998.

Walsh, John E; Chapman, William L; Shy, Timothy L, Recent decrease of sea level pressure in the central Arctic, Journal of Climate, Boston, MA. Vol. 9, no. 2, pp. 480-486, 1996.

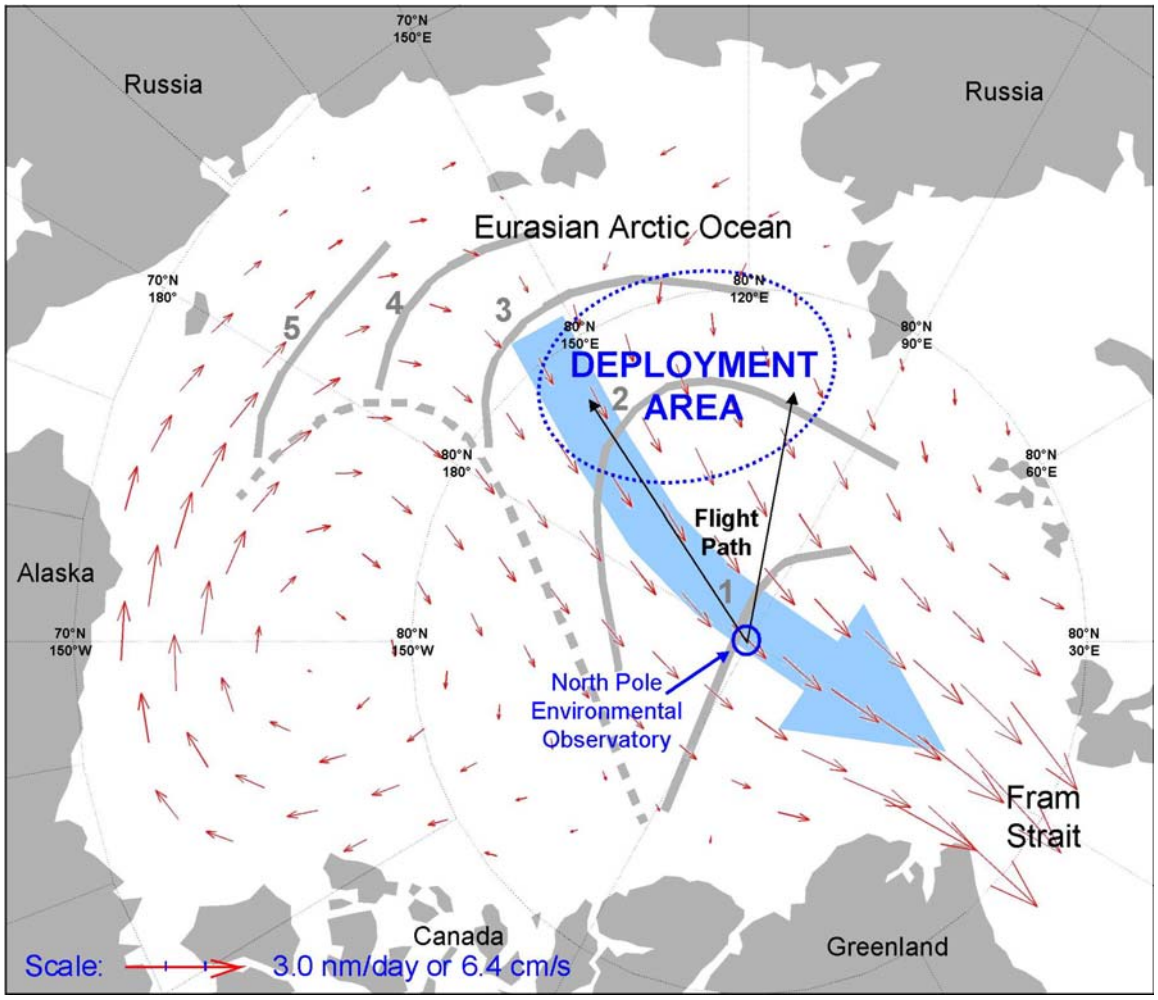

Figure 1. This map shows the area of the Eurasian Arctic Ocean where we plan to deploy enhanced buoys from the North Pole Environmental Observatory. This map also shows the mean field of ice motion analyzed from buoy data (red arrows); the residence time of sea ice (gray lines, these contours show the number of years that ice along each line would take to drift across the Arctic Ocean and exit through Fram Strait); the boundary between ice that will exit Fram Strait or recirculate in the Beaufort Gyre (dashed gray line); and the Transpolar Drift Stream (thick blue arrow).