Russian-American Initiative on Land - Shelf Environments in the Arctic (RAISE)

Supported by the U.S. National Science Foundation and the Russian Foundation for Basic Research

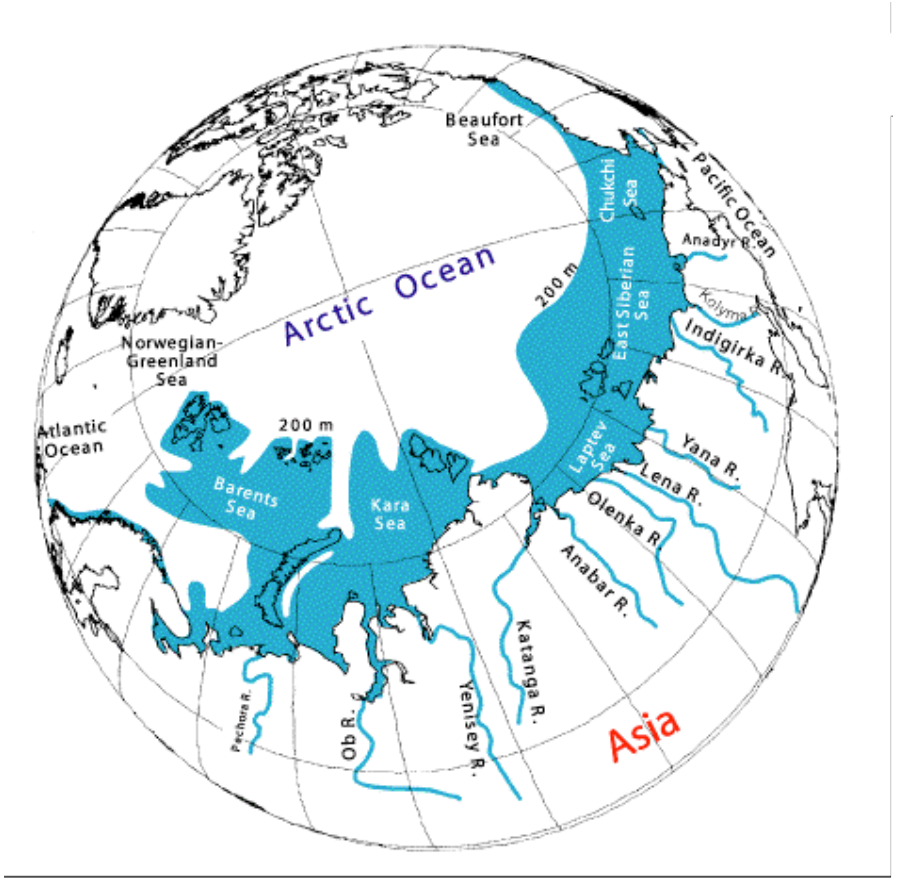
http://www.raise.uaf.edu

http://arctic.bio.utk.edu

(Download this presentation)

Little Diomede, U.S.A.

Big Diomede, Russia



The RAISE program provides a research umbrella for joint U.S. - Russian research on environmental change in the Eurasian Arctic

Key RAISE research topics

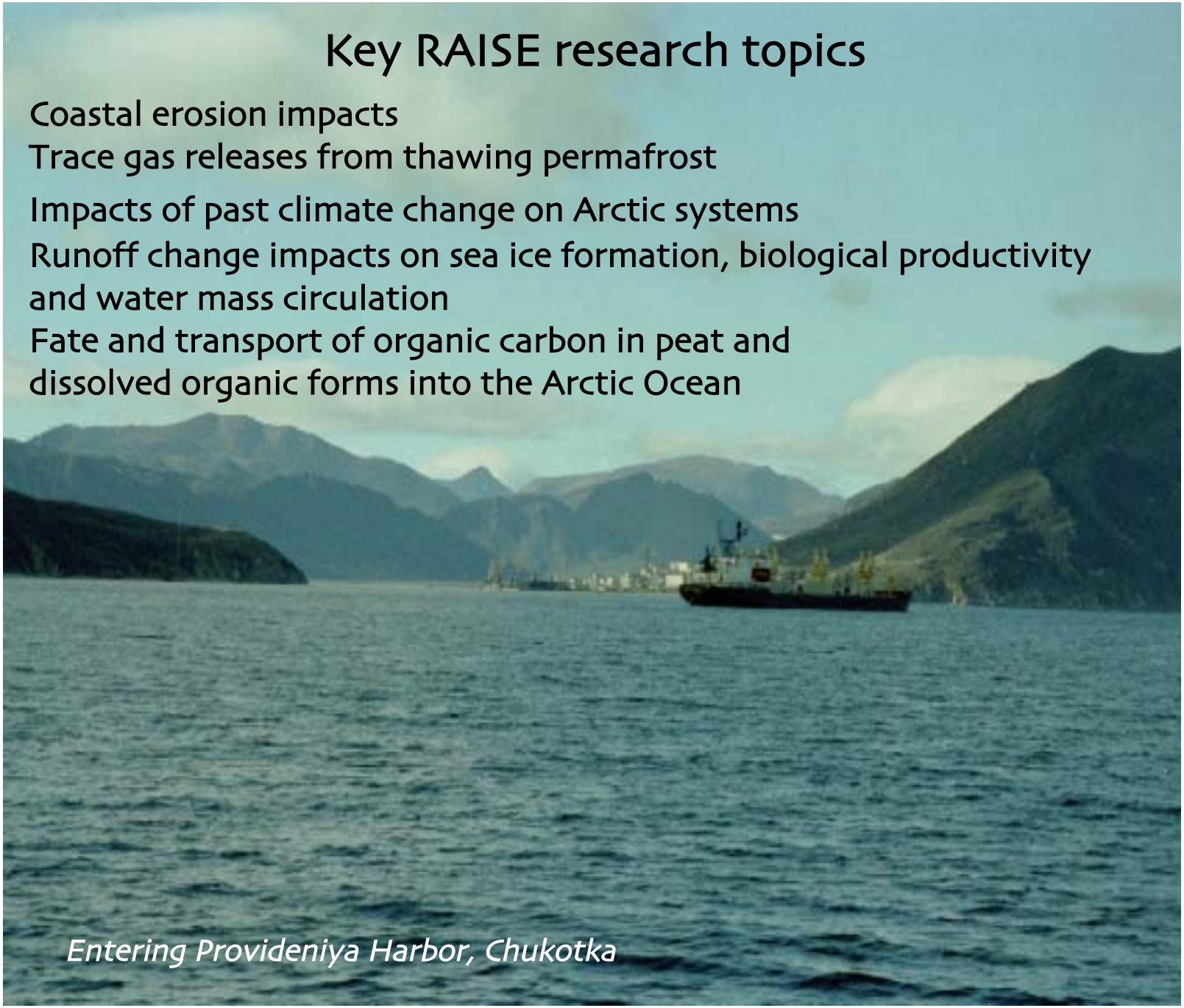
Coastal erosion impacts

Trace gas releases from thawing permafrost

Impacts of past climate change on Arctic systems

Runoff change impacts on sea ice formation, biological productivity and water mass circulation

Fate and transport of organic carbon in peat and dissolved organic forms into the Arctic Ocean



Entering Provideniya Harbor, Chukotka

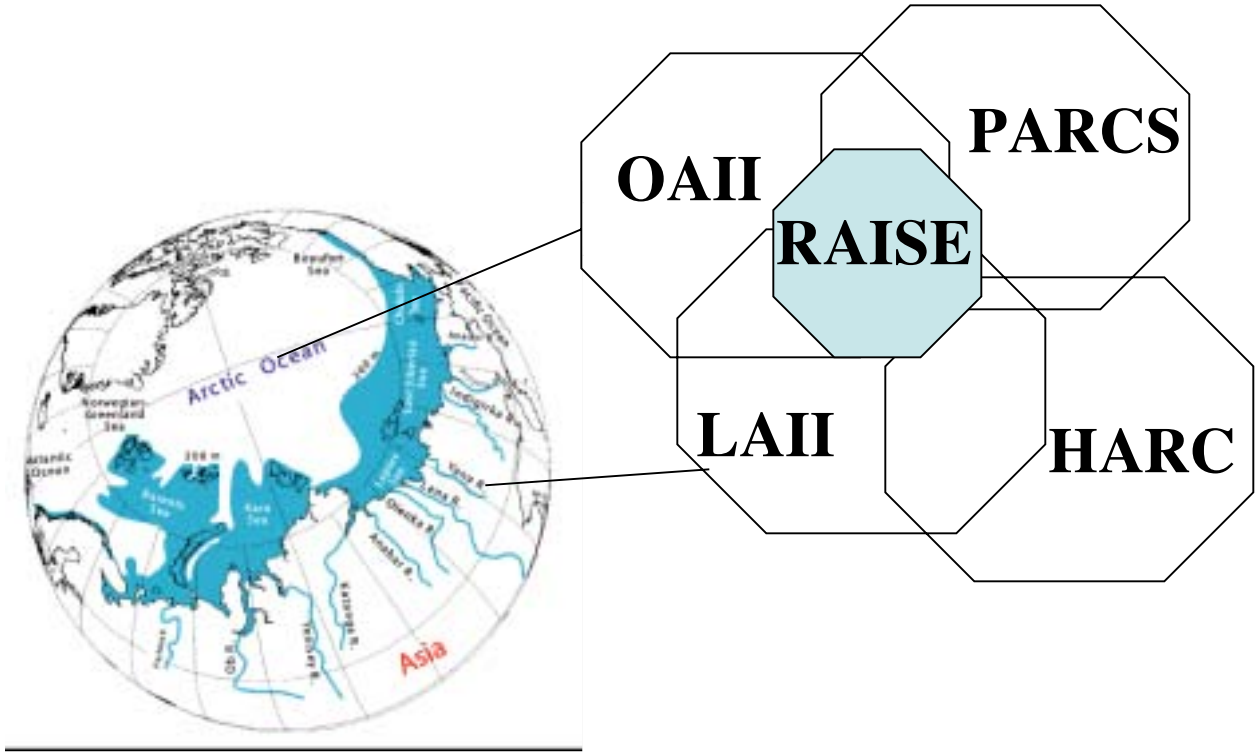
RAISE is unique among ARCSS components

1. **RAISE is explicitly international (and thus pan-Arctic or at least cross-Arctic) in implementation.**

2. **RAISE supports research within terrestrial and marine systems and across the land-sea margin**

3. **RAISE supports global change research from the Last Glacial Maximum to the present**

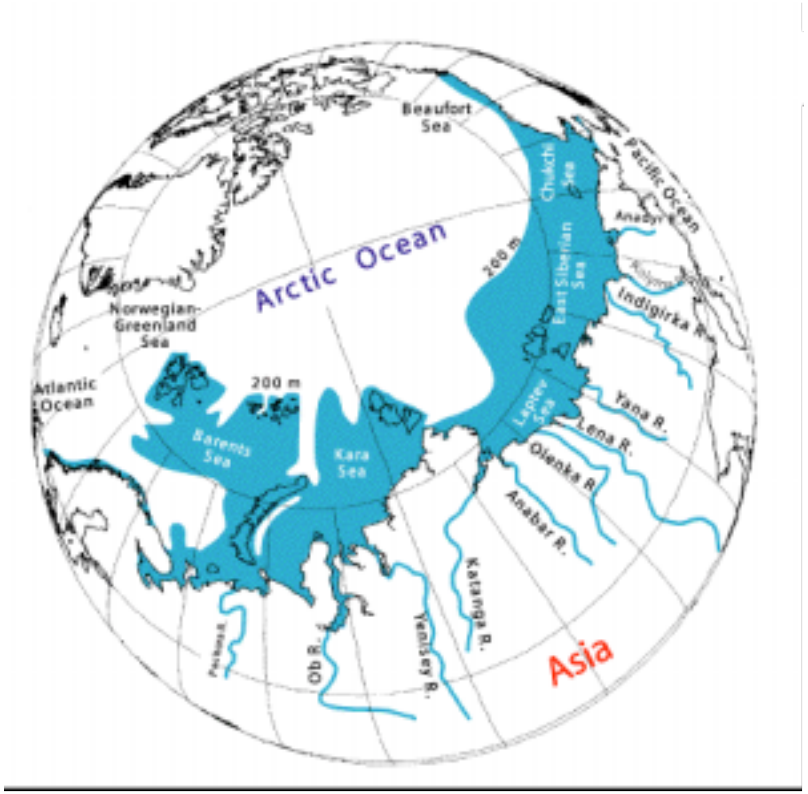
4. **RAISE has a human dimensional element**



Russian-American Initiative for Land-shelf Environments in the Arctic

Current U.S. RAISE projects

- *"Sensitivity of the West Siberian Lowland to Past and Present Climate Change"*
- *"Contemporary Water and Constituent Balances for the Pan-Arctic Drainage System: Continent to Coastal Ocean Fluxes*
- *"Arctic Coastal Dynamics"*
- *"Linkages between riverine freshwater dispersal, sea-ice formation and large-scale sediment transport in the Central and East Siberian Arctic"*
- *"The Late Pleistocene Glacial and Sea Level History of Wrangel Island, Northeast Siberia"*
- *"A Measurement Program in Siberia to Assess Disturbance-Driven Changes in Arctic Carbon Fluxes"*



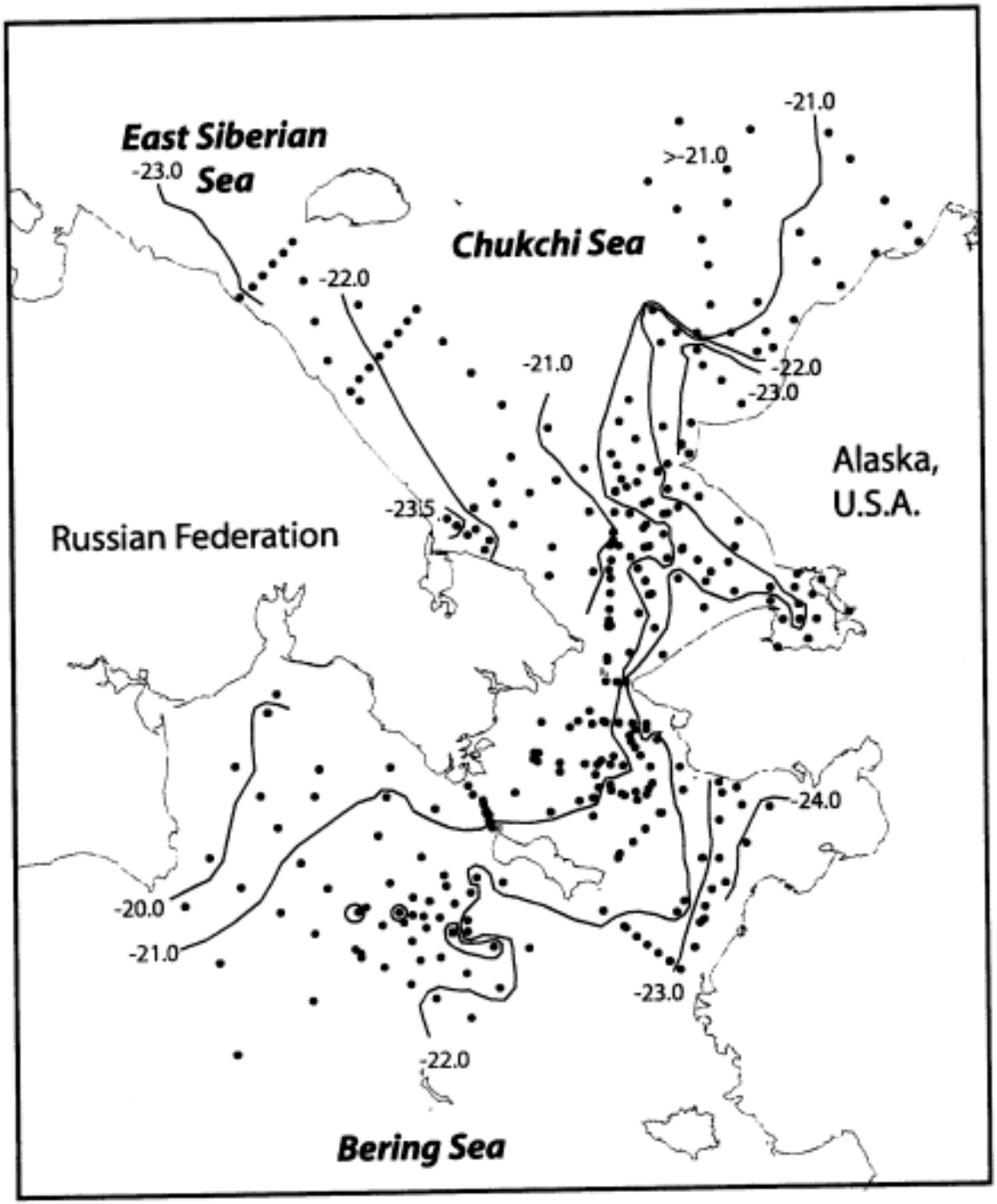
Russian projects: see RAISE web site

The Arctic "half hemisphere" showing oceans, shelf-seas, and catchment areas for Pan-Arctic rivers. Blue line represents relative river run-off.

Complex Systems Research Center
Institute for the Study of Earth, Oceans and Space
University of New Hampshire
Durham, New Hampshire

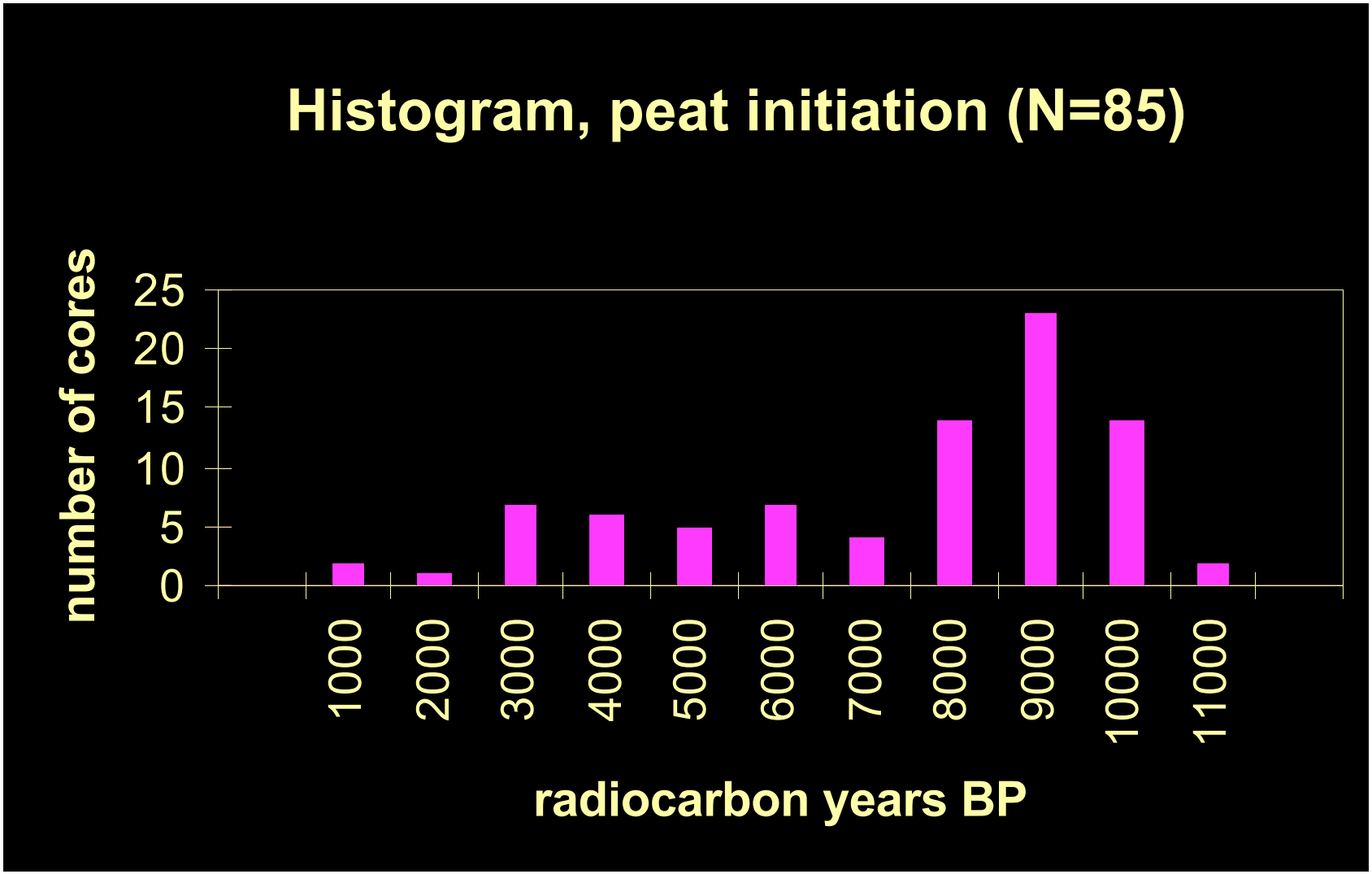
Ecosystems Center
Marine Biological Laboratory
Woods Hole, Massachusetts

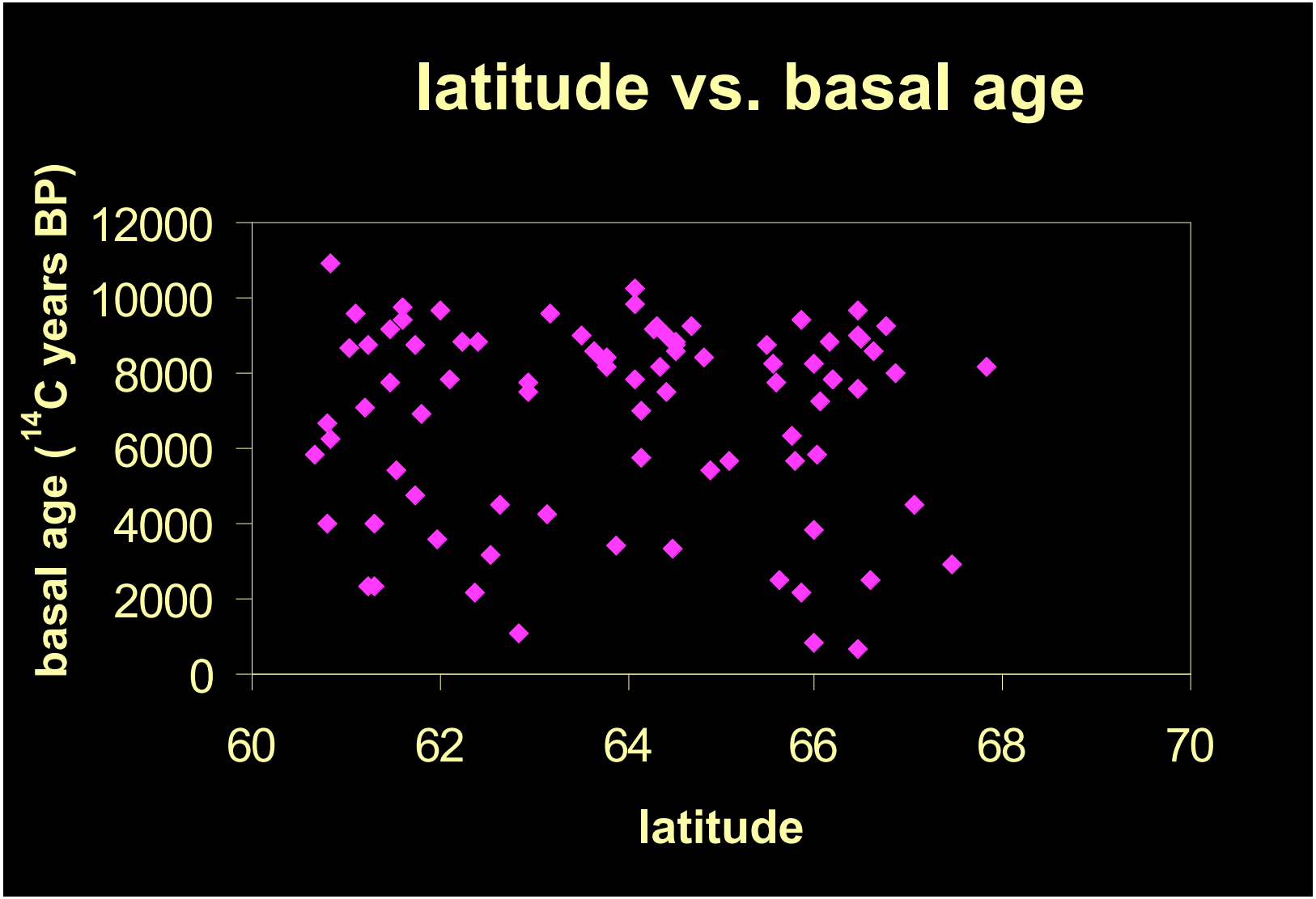
Global Hydrological Archive and Analysis System

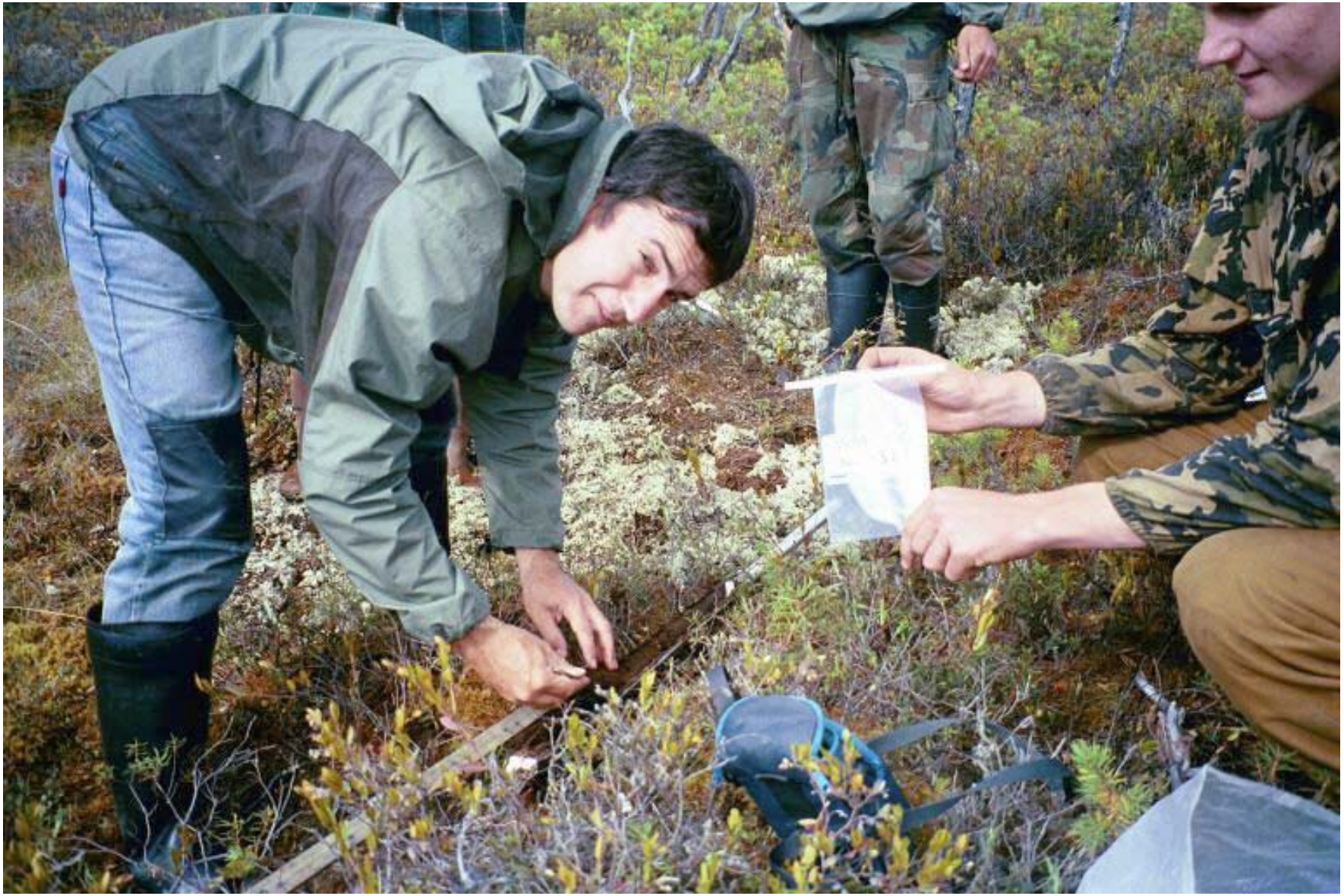


Carbon -13 in organic carbon of surface sediments

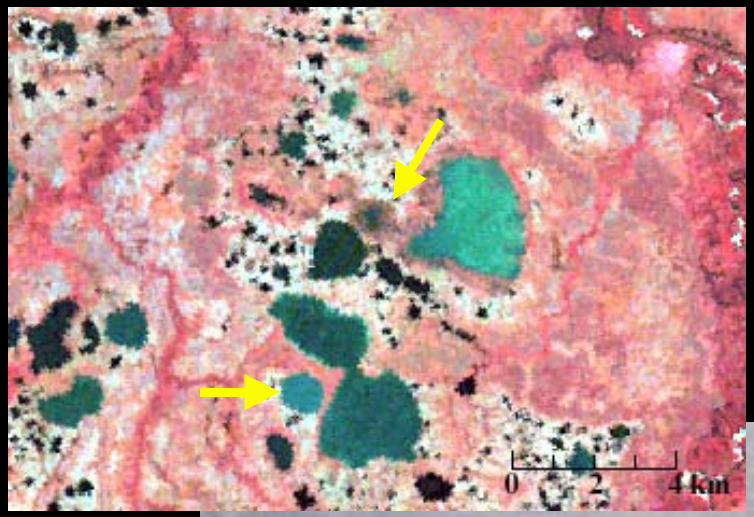
From Cooper et al. (2002)Marine Ecology Progress Series


Histogram, peat initiation (N=85)
number of cores
25
20
15
10
5
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
radiocarbon years BP

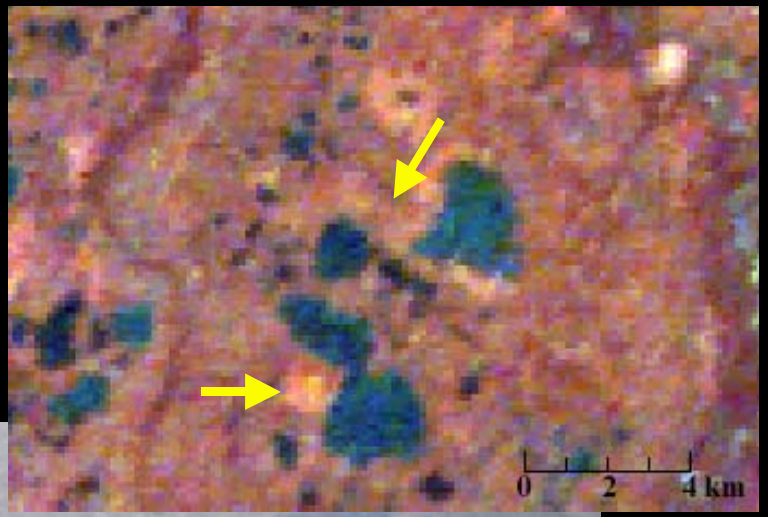

latitude vs. basal age
basal age (^{14}C years BP)
12000
10000
8000
6000
4000
2000
0
60
62
64
66
68
70
latitude

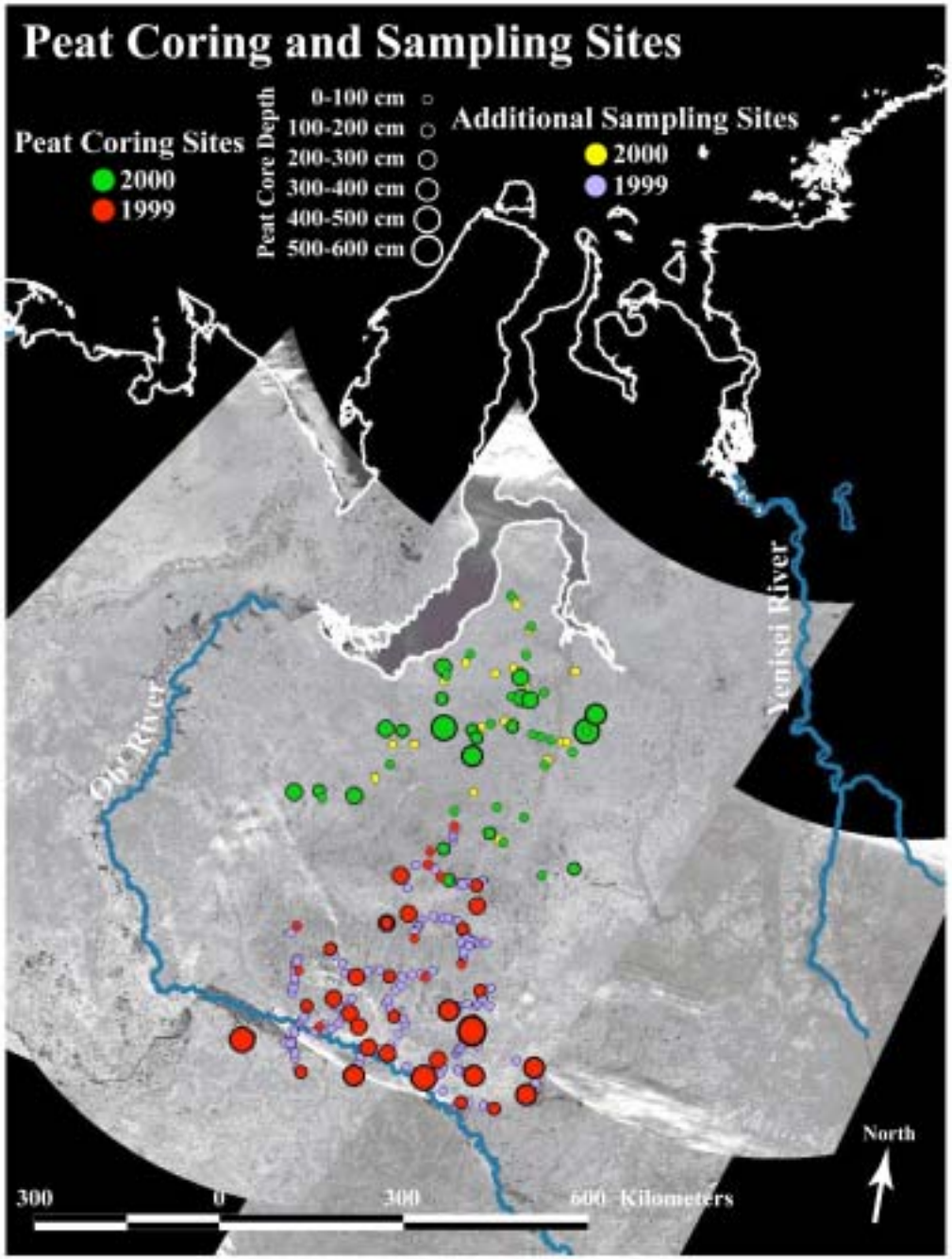


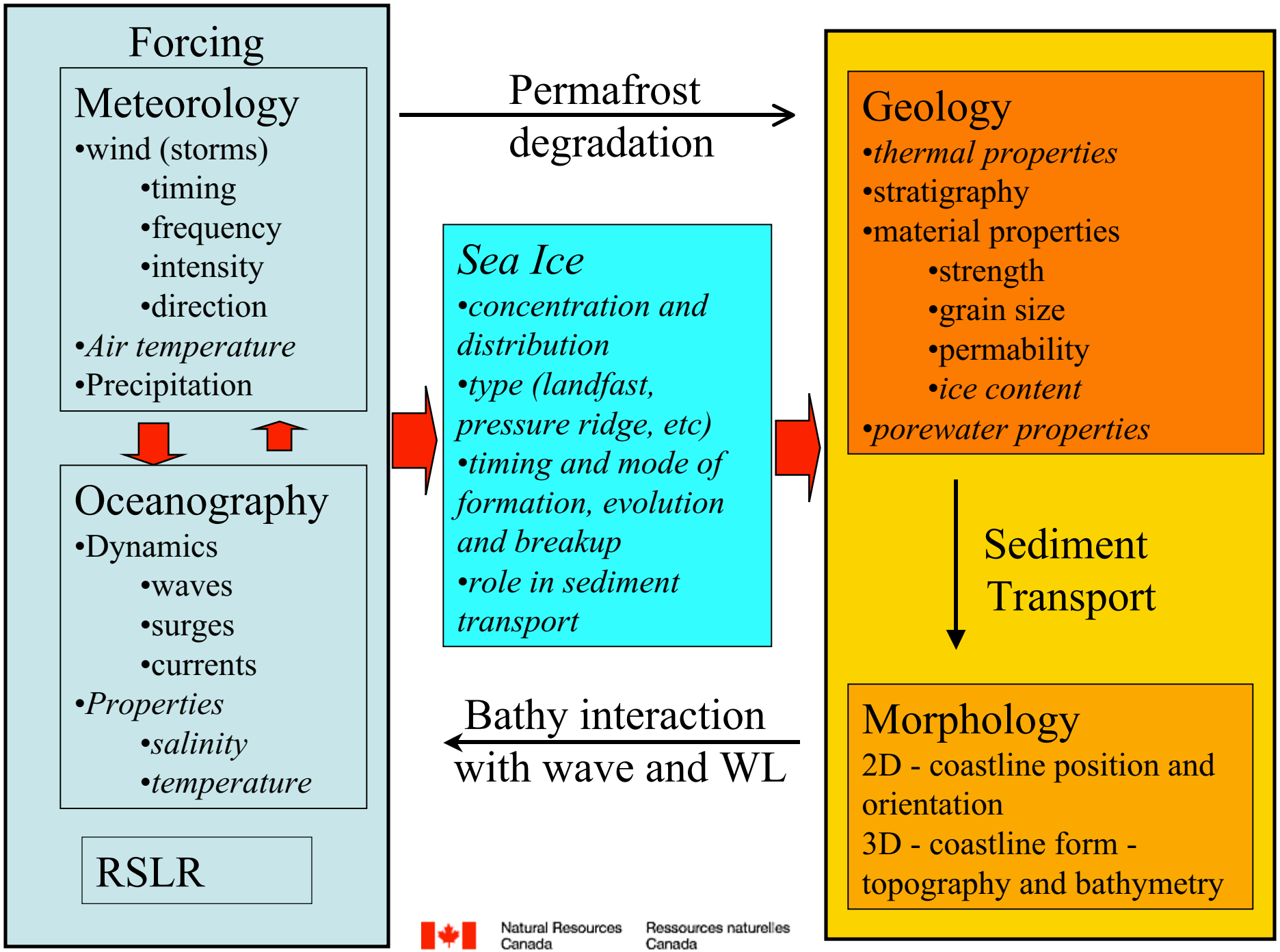
Landsat MSS 1973



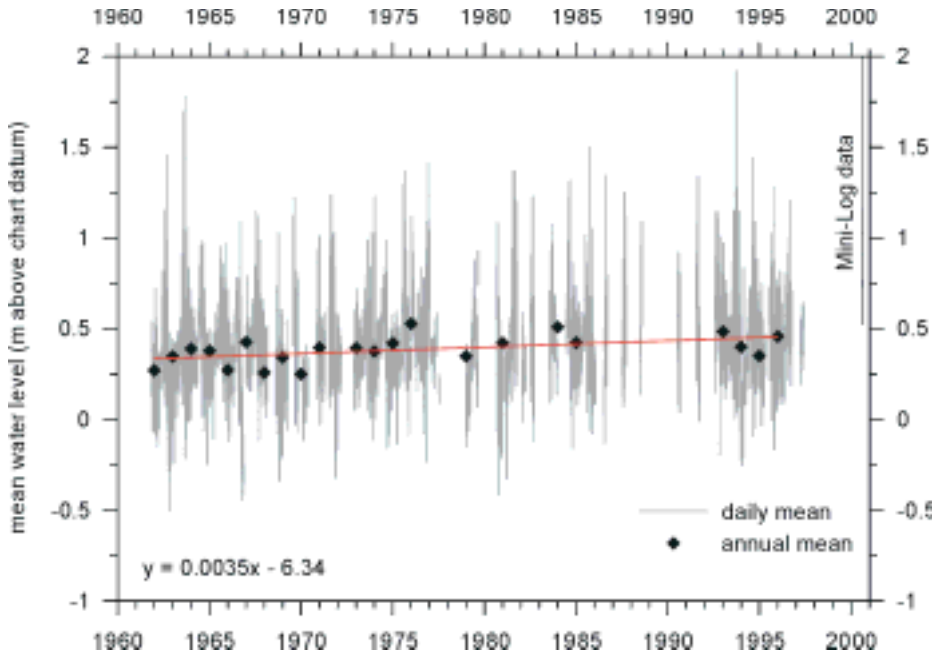
RESURS MSU-SK 1998



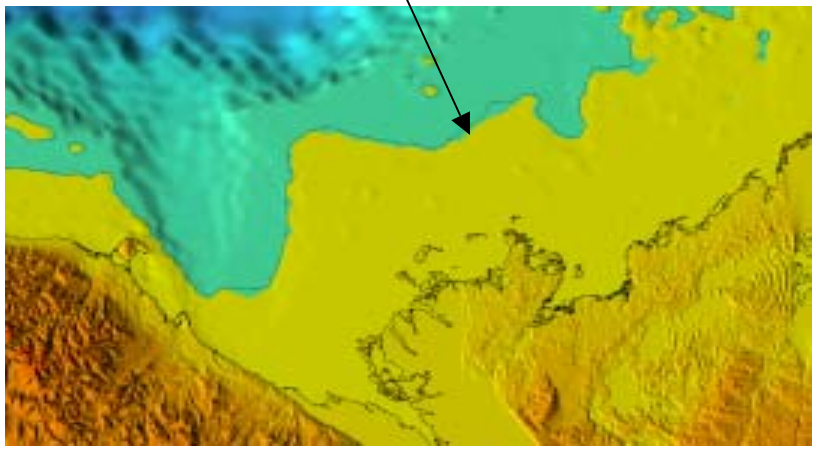

Peat Coring and Sampling Sites
Peat Coring Sites
2000
1999
Peat Core Depth
0-100 cm
100-200 cm
200-300 cm
300-400 cm
400-500 cm
500-600 cm
Additional Sampling Sites
2000
1999
Ob River
Yenisei River
North
300
0
300
600 Kilometers


Forcing
Meteorology
•wind (storms)
•timing
•frequency
•intensity
•direction
•Air temperature
•Precipitation
Oceanography
•Dynamics
•waves
•surges
•currents
•Properties
•salinity
•temperature
RSLR
Permafrost degradation
Sea Ice
•concentration and distribution
•type (landfast, pressure ridge, etc)
•timing and mode of formation, evolution and breakup
•role in sediment transport
Bathy interaction with wave and WL
Geology
•thermal properties
•stratigraphy
•material properties
•strength
•grain size
•permability
•ice content
•porewater properties
Sediment Transport
Morphology
2D - coastline position and orientation
3D - coastline form - topography and bathymetry
Natural Resources Canada
Ressources naturelles Canada

Relative Sea Level Rise - Higher sea levels mean increased rates of coastal retreat.

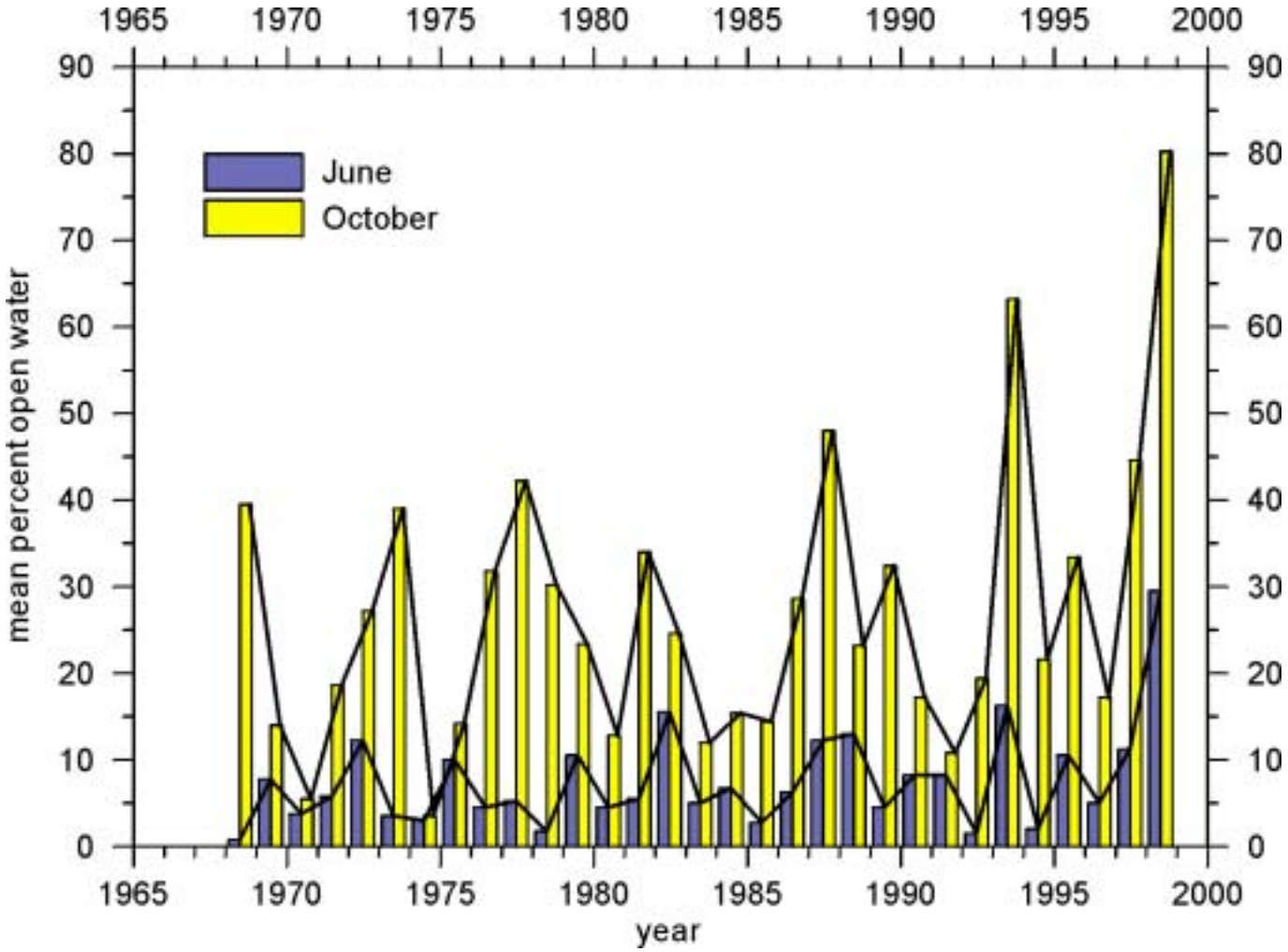


40 m contour
5000 year BP shoreline?



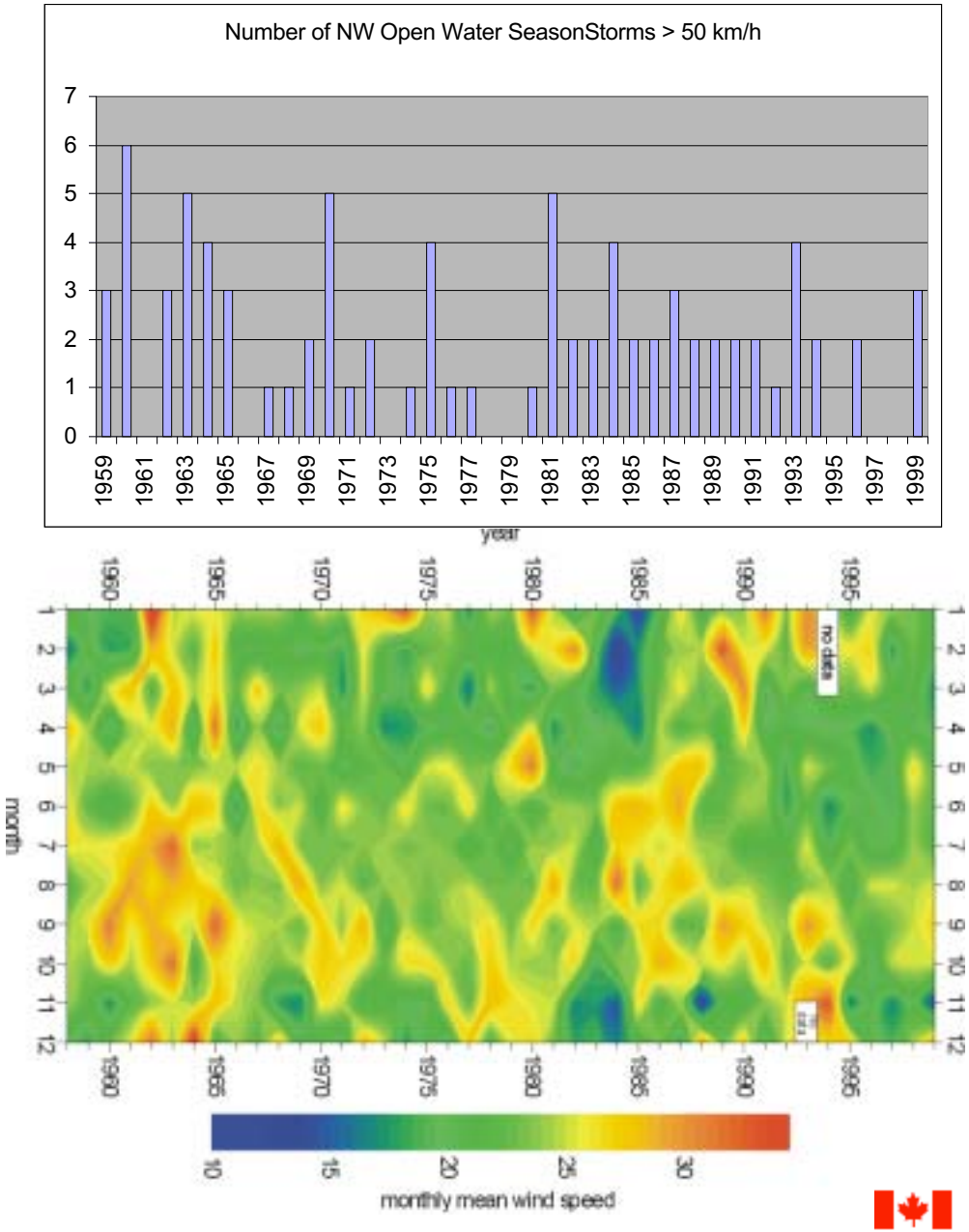
Sea level rise of 3.5 mm per year since 1950. Possible doubling over the next 100 y.

Historical sea ice trends



Natural Resources Canada | Ressources naturelles Canada

Meteorological Forcing - open water season storms



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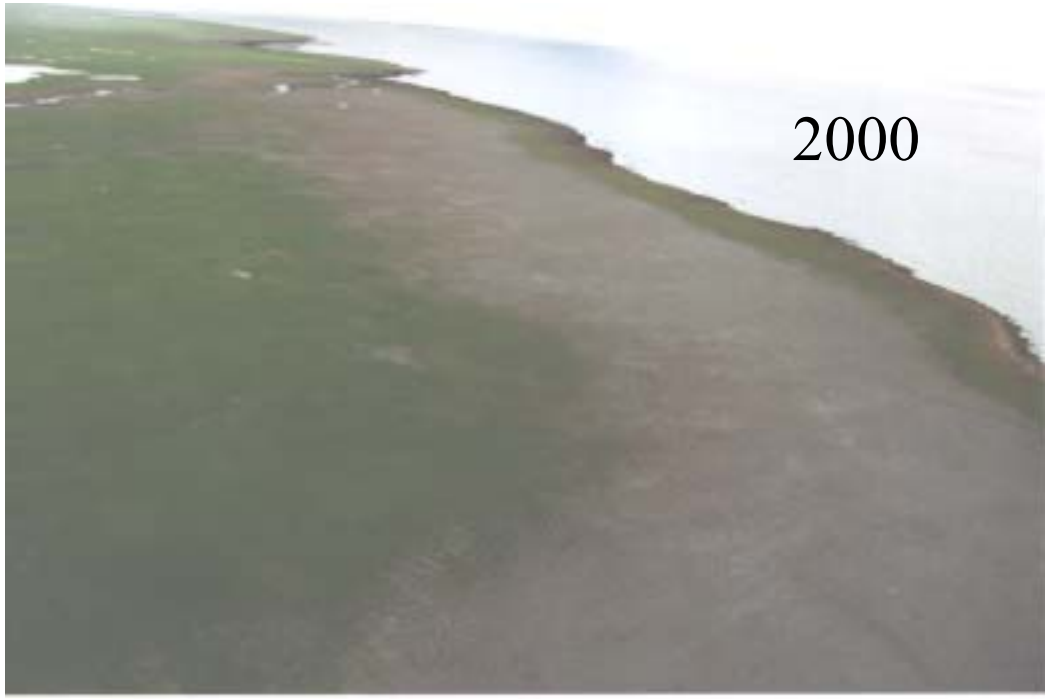
1999

Mackenzie Delta front - Sediment deposition after a storm.

2000



Natural Resources Canada Ressources naturelles Canada

Water and Constituent Fluxes Across the Eurasian Arctic: Evolving Land-Ocean Connections Over The Past 20,000 Years

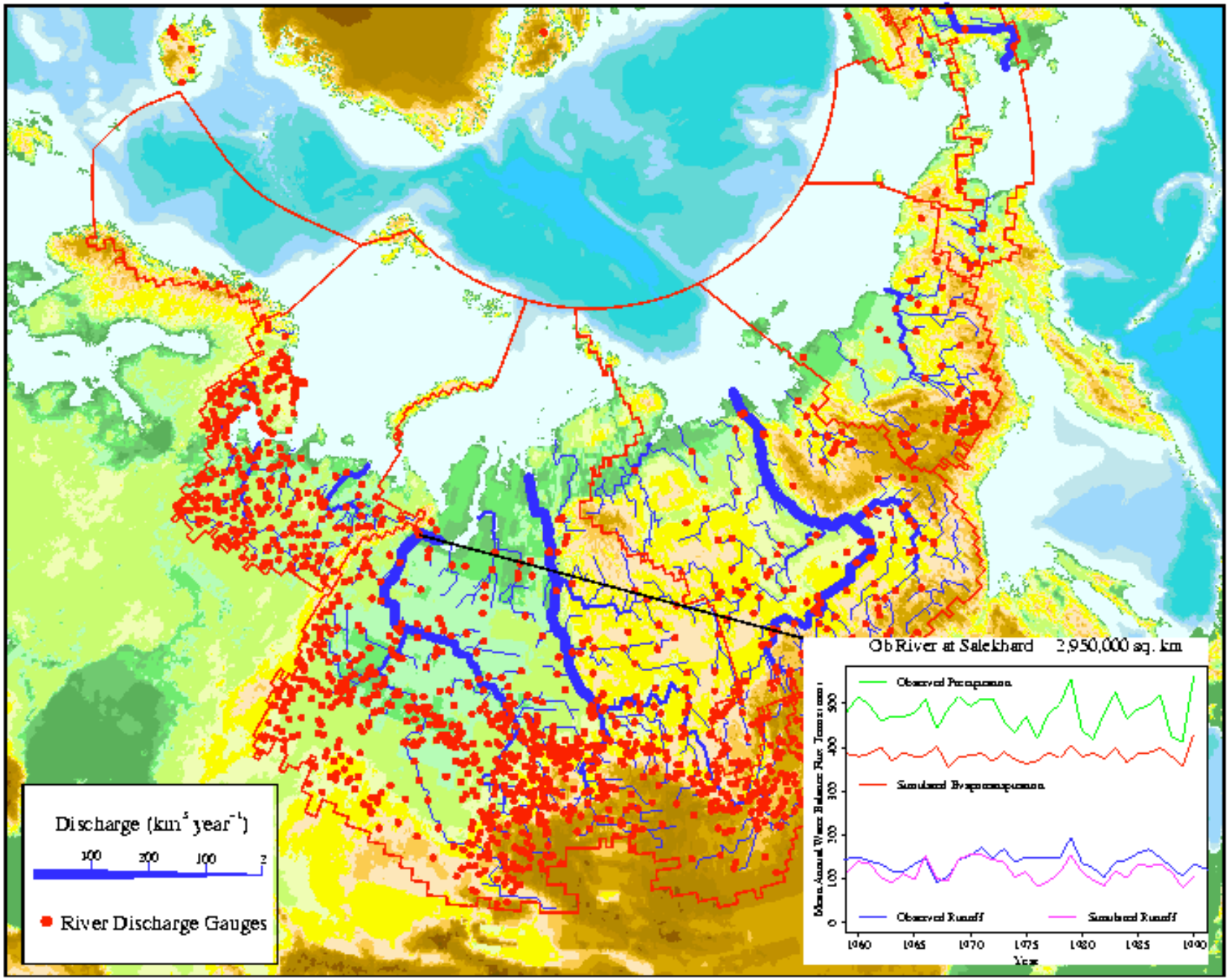
Bruce Peterson, Robert M. Holmes
Marine Biological Laboratory

Cort Willmott
University of Delaware

Mark Serreze
University of Colorado

Igor Shiklomanov,
State Hydrological Institute

Charles Vorosmarty, Richard Lammers, Alexander Shiklomanov, Balazs Fekete
University of New Hampshire


Discharge (km³ year⁻¹)
100
200
100
River Discharge Gauges
Ob River at Salekhard 2,950,000 sq. km
Observed Precipitation
Simulated Evapotranspiration
Observed Runoff
Simulated Runoff
Mean Annual Water Balance Flux Terms (mm)
0
100
200
300
400
500
1960
1965
1970
1975
1980
1985
1990
Year

R-ArcticNet - A Database of Pan-Arctic River Discharge

http://www.R-ArcticNET.sr.unh.edu/main.html

WATER RESOURCES RESEARCH, VOL. 36, NO. 8, PAGES 2309–2320, AUGUST 2000

Flux of nutrients from Russian rivers to the Arctic Ocean: Can we establish a baseline against which to judge future changes?

R. M. Holmes,[1] B. J. Peterson,[2] V. V. Gordeev,[3] A. V. Zhulidov,[3] M. Meybeck,[4] R. B. Lammers,[5] and C. J. Vörösmarty[6]

Abstract. Climate models predict significant warming in the Arctic in the 21st century, which will impact the functioning of terrestrial and aquatic ecosystems as well as alter land-ocean interactions in the Arctic. Because river discharge and nutrient flux integrate large-scale processes, they should be sensitive indicators of change, but detection of future changes requires knowledge of current conditions. Our objective in this paper is to evaluate the current state of affairs with respect to estimating nutrient flux to the Arctic Ocean from Russian rivers. To this end we provide estimates of contemporary (1970s–1990s) nitrate, ammonium, and phosphate fluxes to the Arctic Ocean for 15 large Russian rivers. We rely primarily on the extensive data archives of the former Soviet Union and current Russian Federation and compare these values to other estimates and to model predictions. Large discrepancies exist among the various estimates. These uncertainties must be resolved so that the scientific community will have reliable data with which to calibrate Arctic biogeochemical models and so that we will have a baseline against which to judge future changes (either natural or anthropogenic) in the Arctic watershed.

1. Introduction

Earth's temperature is predicted to rise 1°–3.5°C in the next century, with even greater increases in the Arctic [*Houghton et al.*, 1996]. This temperature increase is expected to impact numerous aspects of the Arctic system, including the extent of permafrost and ice-covered regions, the amount and distribution of precipitation, and the productivity and biogeochemistry of terrestrial and aquatic ecosystems [*Chapin et al.*, 1995; *Anisimov and Nelson*, 1996; *Hobbie et al.*, 1999; *Serreze et al.*, 2000]. All of these changes will affect river discharge and nutrient flux to the Arctic Ocean, which in turn may impact Arctic Ocean processes [*Aagaard and Carmack*, 1989; *Broecker*, 1997; *Anderson et al.*, 1998]. Because river discharge and nutrient flux integrate large-scale watershed processes, they should be early and accurate indicators of climate change in the Arctic.

Detection of future changes requires knowledge of current conditions. In this paper, we assess current (1970s–1990s) nutrient flux from Eurasia to the Arctic Ocean. We focus on Russian rivers because the majority of riverine input to the Arctic Ocean comes from Russia. Although several sources report nutrient concentrations and fluxes for Russian Arctic rivers [*Alekin and Brazhnikova*, 1964; *Zuravel et al.*, 1966; *Smirnov*, 1981; *Gordeev et al.*, 1996; *Gordeev and Pokhurov*, 1998; M. Meybeck and A. Ragu, Rivers Discharges to the Oceans: An Assessment of Suspended Solids, Major Ions and Nutrients, Interim draft, United Nations Environment Programme, 1995] (hereinafter referred to as Meybeck and Ragu, Interim draft, 1995) (see also Global Environmental Monitoring System (GEMS-Water), United Nations Environment Programme, www.cciw.ca/gems/), there has been little critical evaluation of the published values. We will derive nitrate, ammonium, and phosphate flux estimates for 15 Russian rivers that enter the Arctic Ocean using a previously unavailable data set and compare our estimate to model predictions [*Stendinger and Kroeze*, 1998] and to other data. We will conclude that in spite of the extensive data set, it is currently not possible to quantify riverine nutrient flux to the Arctic Ocean with sufficient confidence to establish a contemporary baseline. We will argue that the scientific community must soon resolve the remaining uncertainties so that we do not squander a potential opportunity to detect the impact of climate change on the Arctic system.

2. Description of Data Set

During the Soviet era the Russian water quality monitoring system was among the most extensive on Earth. However, prior to the 1990s, scientists (Russian and otherwise) were unable to access, analyze, or publish the official water quality data of the former Soviet Union (FSU), largely because of political and ideological reasons [*Zhulidov et al.*, 1998]. Such restrictions no longer exist, but many of the data remain inaccessible. For example, data are often stored in notebooks instead of digital form, and these notebooks are not necessarily centrally located but instead may reside in regional laboratories.

Owing to these complications, use of the Russian nutrient data has been limited, and their fate has been uncertain because recent economic and political instability in Russia has led to closure of laboratories and the potential loss of data. In order to help preserve the data set of the FSU and to estimate

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[2]P. P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow.
[3]Centre for Preparation and Implementation of International Projects on Technical Assistance, Rostov-on-Don, Russia.
[4]Laboratorie de Géologie Appliquée, CNRS, Paris.
[5]Complex Systems Research Center, University of New Hampshire, Durham.

Paper number 2000WR900096.
0043-1397/00/2000WR900096$09.00

Reconstructing the limits of the last glaciation and postglacial environments in the southeastern Barents and Kara seas

07.1999-06.2003

L.Polyak & V.Gataullin – Byrd Polar Res. Ctr., Ohio State Univ.

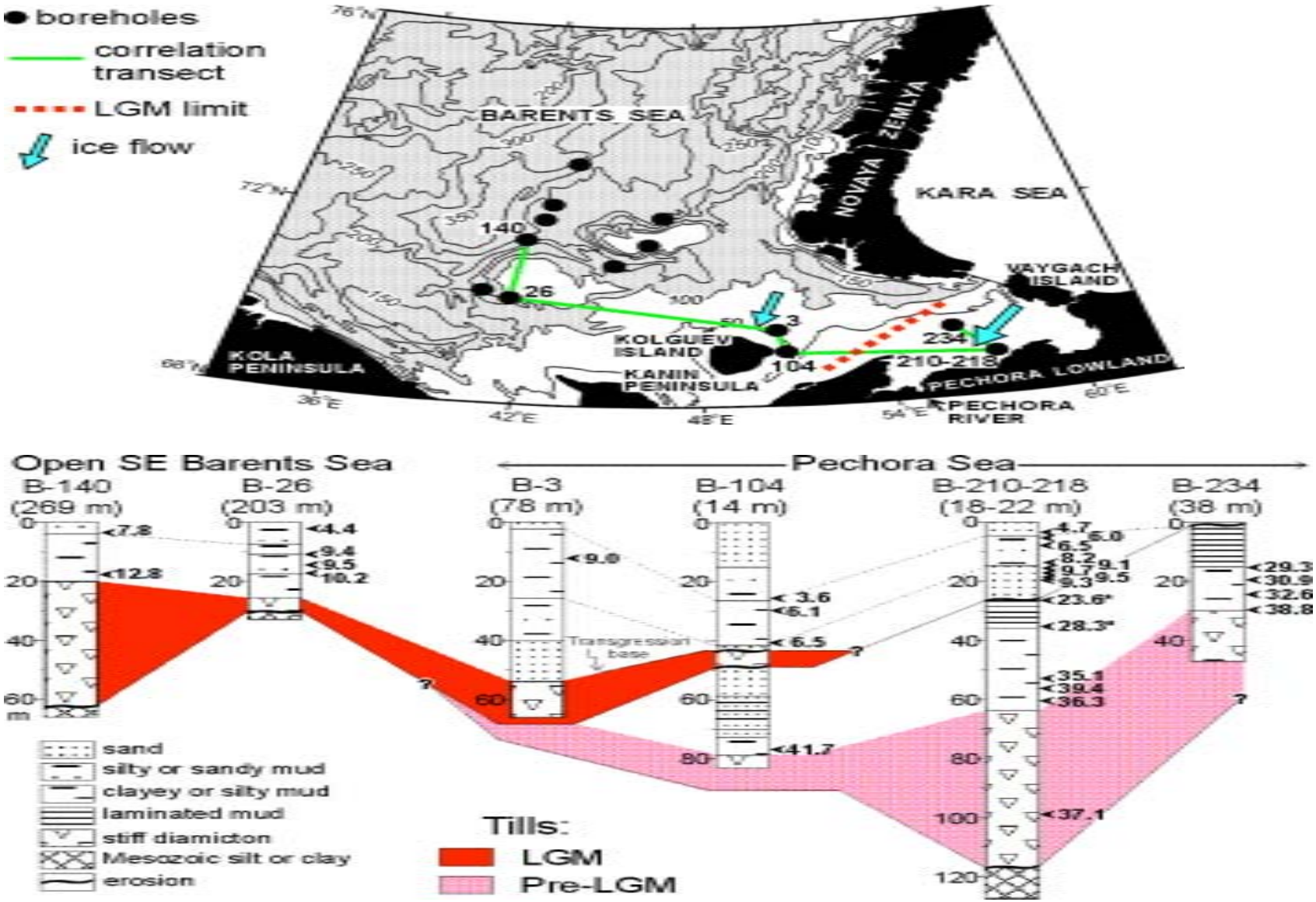
Collaborators in Russia: Okeangeologia, AARI, Moscow State Univ., Shirshov Inst. Oceanology

Activities:

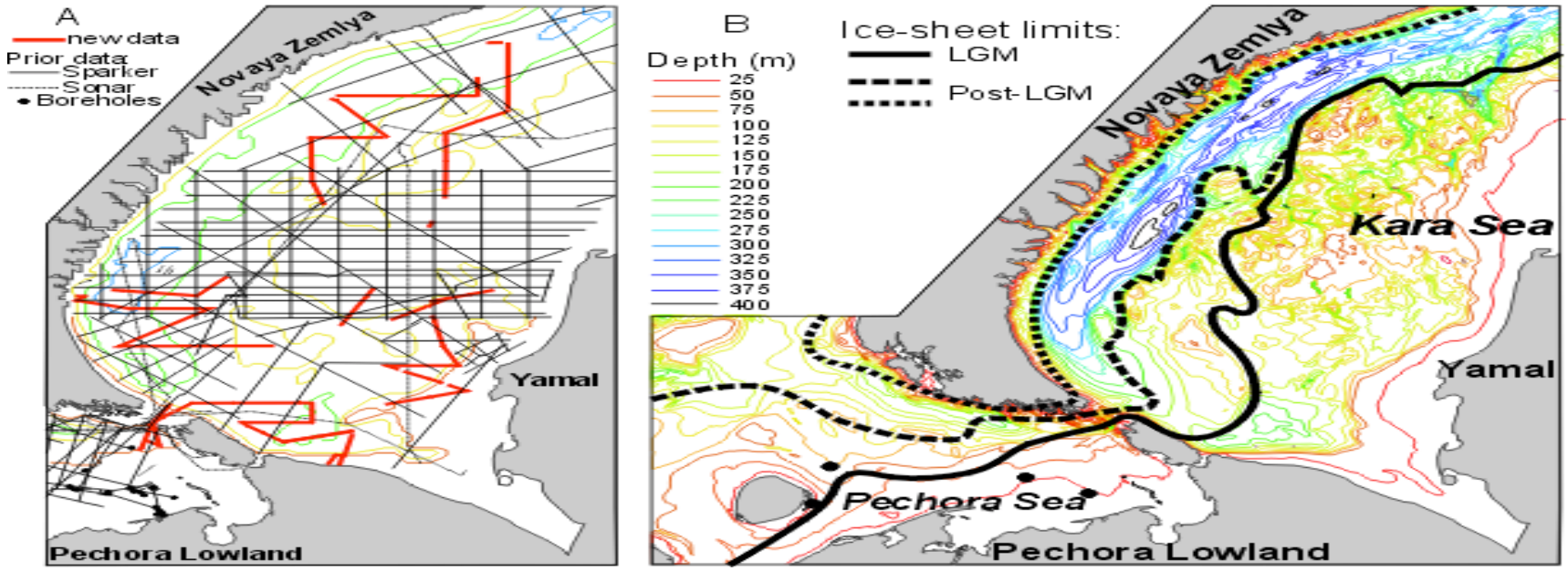
- Collection of new data on two research cruises
- Compilation of prior seismic-reflection and borehole data
- Processing and interpretation of new and complied data

Major results:

- Delineation of ice-sheet limits for the Last Glacial Maximum and major deglacial stages
- Construction of isopach maps for sedimentary units, as well as updated bathymetry
- Elucidation of marine and adjacent terrestrial environments for the study region for the time interval from the middle Weichselian (MIS 3) to Holocene

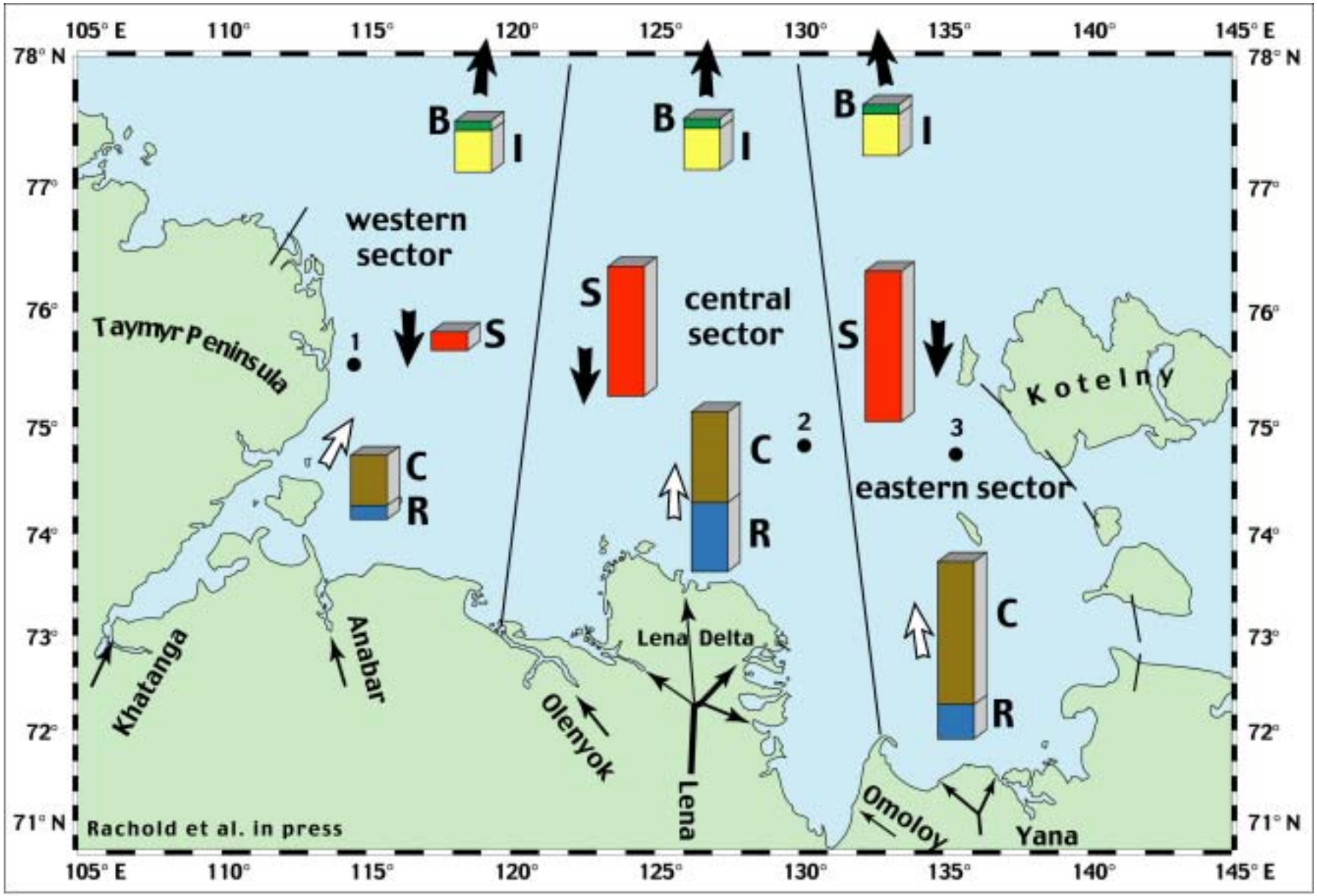


Stratigraphy of Quaternary sediments in the Pechora Sea. Chart shows the distribution of glacial deposits for the LGM and the penultimate glaciation.



A. Location of new and compiled data (see Gataullin et al., 2001, for more data in the Pechora Sea); bathymetry from GEBCO.

B. New, detailed bathymetry and reconstructed ice margins for LGM and deglacial stages.



R: river input (Gordeev et al. 1996)
C: coastal input (this study)
S: sedimentation (this study, based on Bauch et al. in press)
I: sea-ice export (Dethleff et al. submitted)
B: bottom export (Eicken et al. 1997)

1: PM 9499
2: PS 51/092-12
3: PM 9462

$= 10^{11}$ t • 5 ka^{-1}

input
output

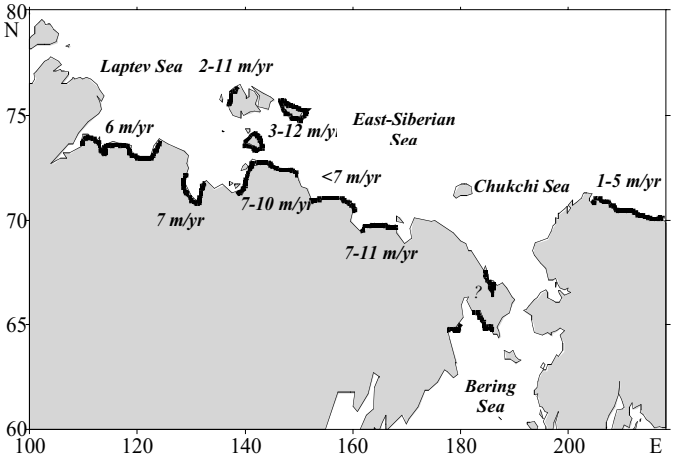


Figure 1. Coastal erosion in the study area in the Amerasian Arctic.

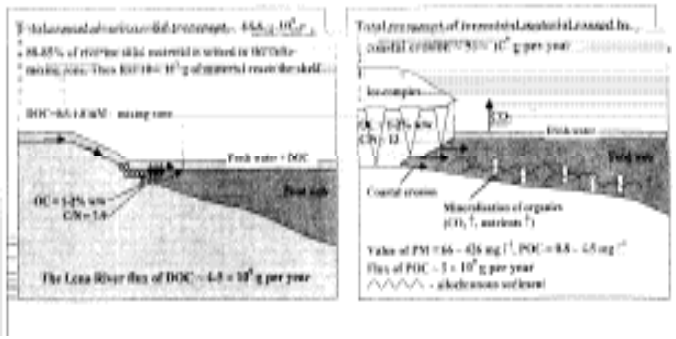


Figure 2. Major transport of terrestrial solid material into the Arctic Ocean: the Laptev and East-Siberian seas.

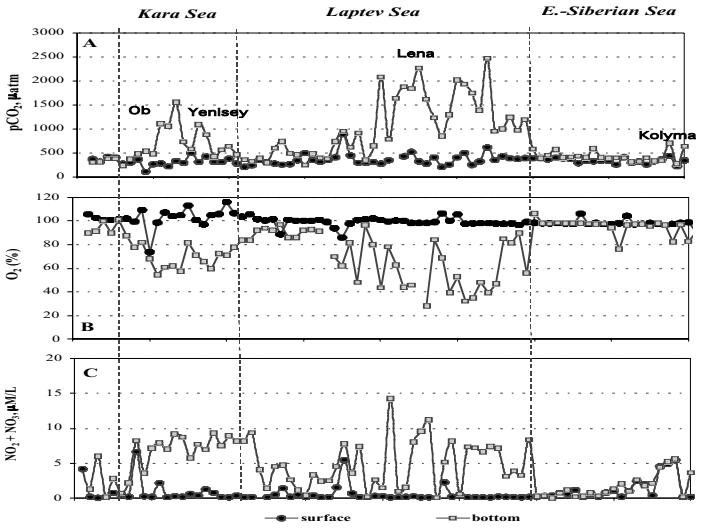


Figure 3. Distribution of A - CO_2 partial pressure (matm), B - oxygen saturation (%) and C - nitrate-nitrite sum (mM/l) in the arctic seas in 2000.

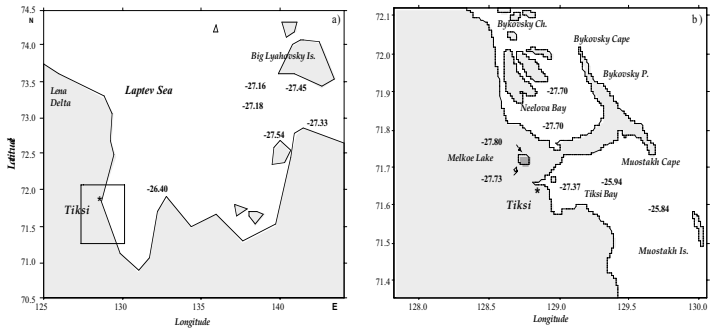
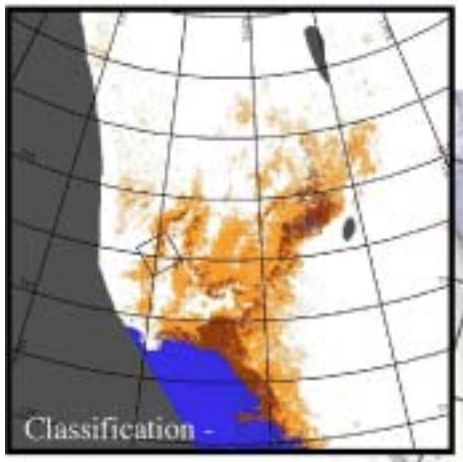
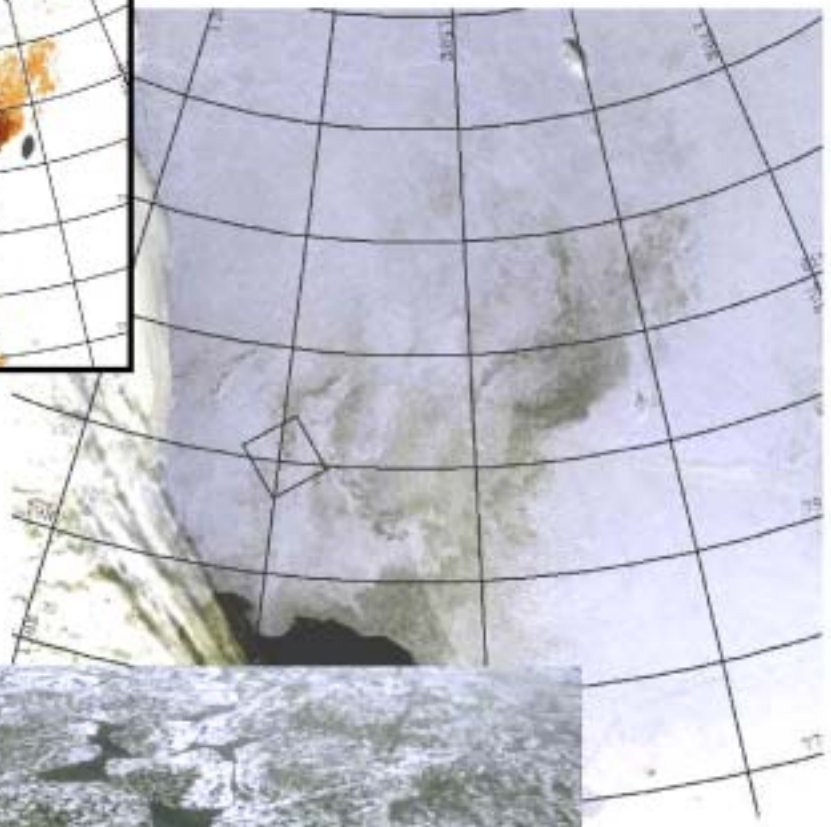


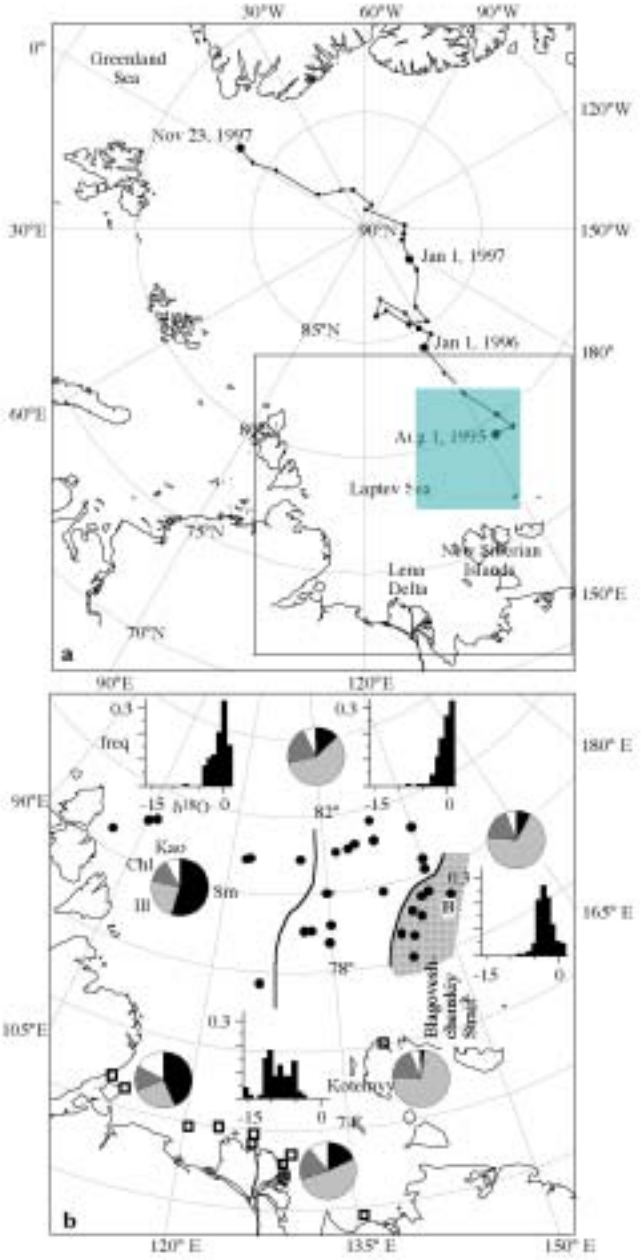
Figure 4. Distribution of $\delta^{13}C_{org}$ in the surface sediment in the Laptev Sea: a) -general map; b) the near-delta area.

Data courtesy of Igor Semiletov, Pacific Oceanological Institute

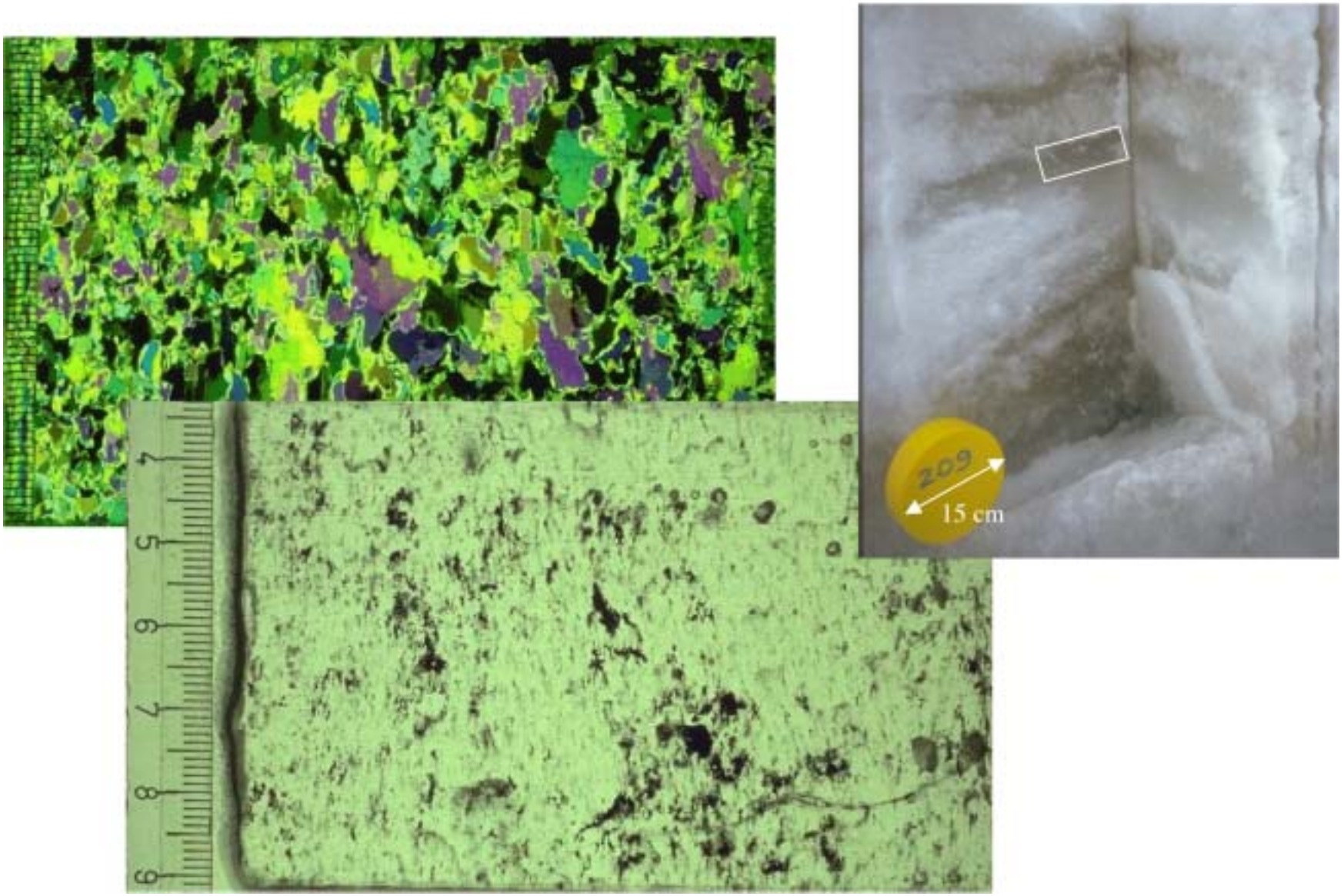
Images courtesy of Hajo Eicken,
University of Alaska Fairbanks

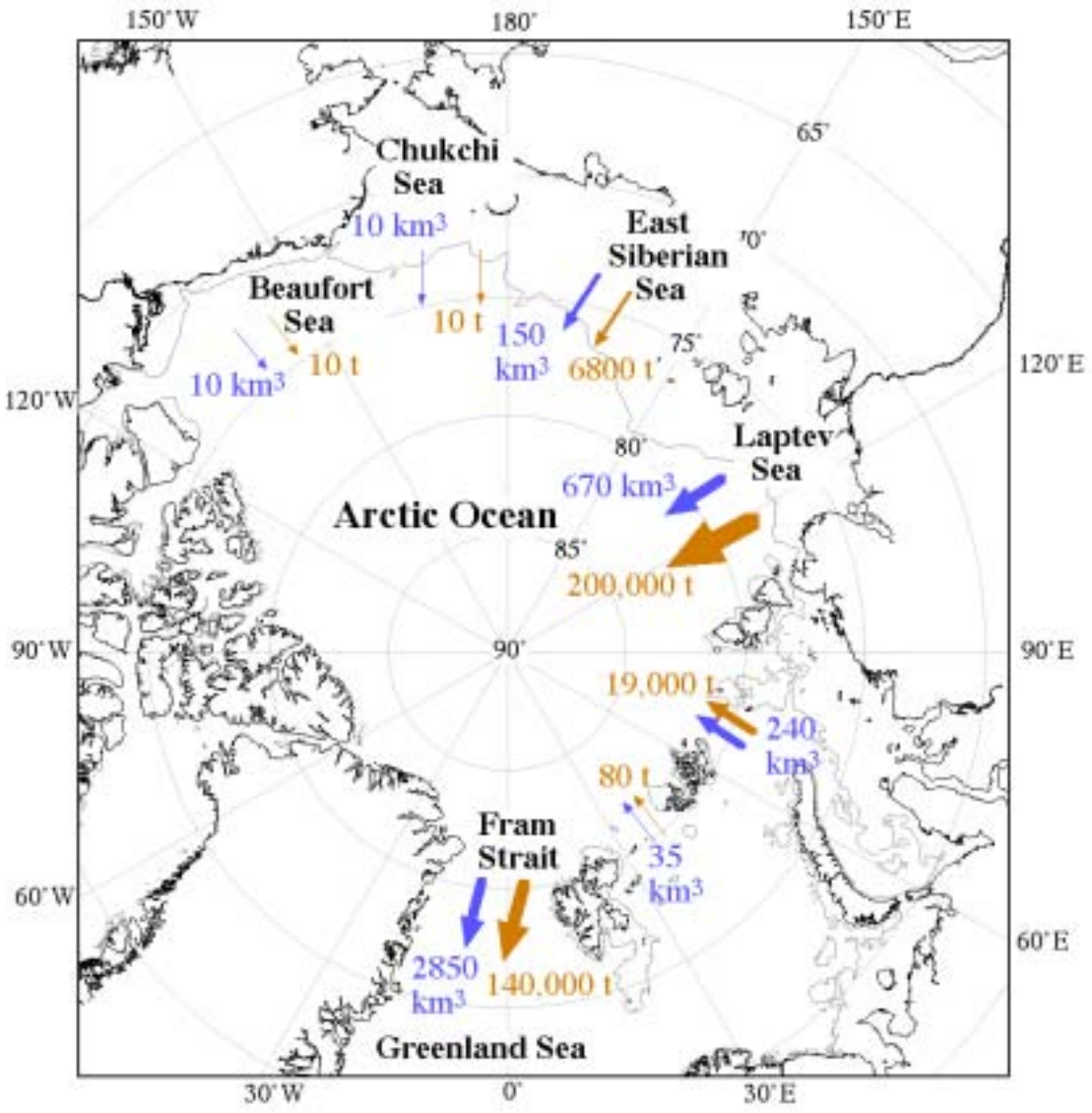






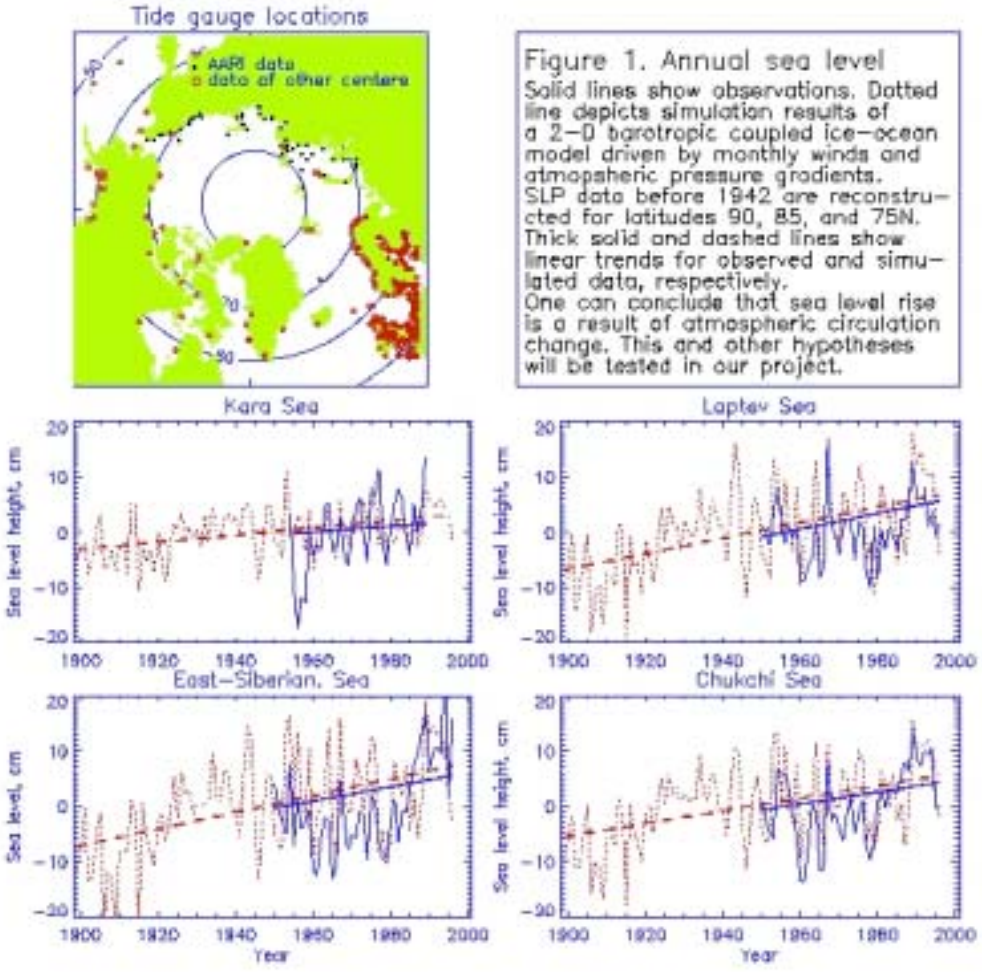
Sea ice core analyses





Annual export of first-year sea ice (blue arrows/numbers) and terrigenous particulate organic carbon transported by sea ice (brown arrows/numbers). Data based on Macdonald et al., 1998; Naidu et al., 2000; Romankevich et al., 2000; Stein et al., 1999; Lindemann, 1999; Stein, 1996; Hulth et al., 1996, for organic carbon concentrations and Timokhov, 1994, Alexandrov et al., 2000, Vinje, 1987, Thomas and Rothrock, 1993, Eicken et al., 2000, for sea ice export (details in Eicken, in prep.).

Ice-associated transport of terrestrial organic carbon

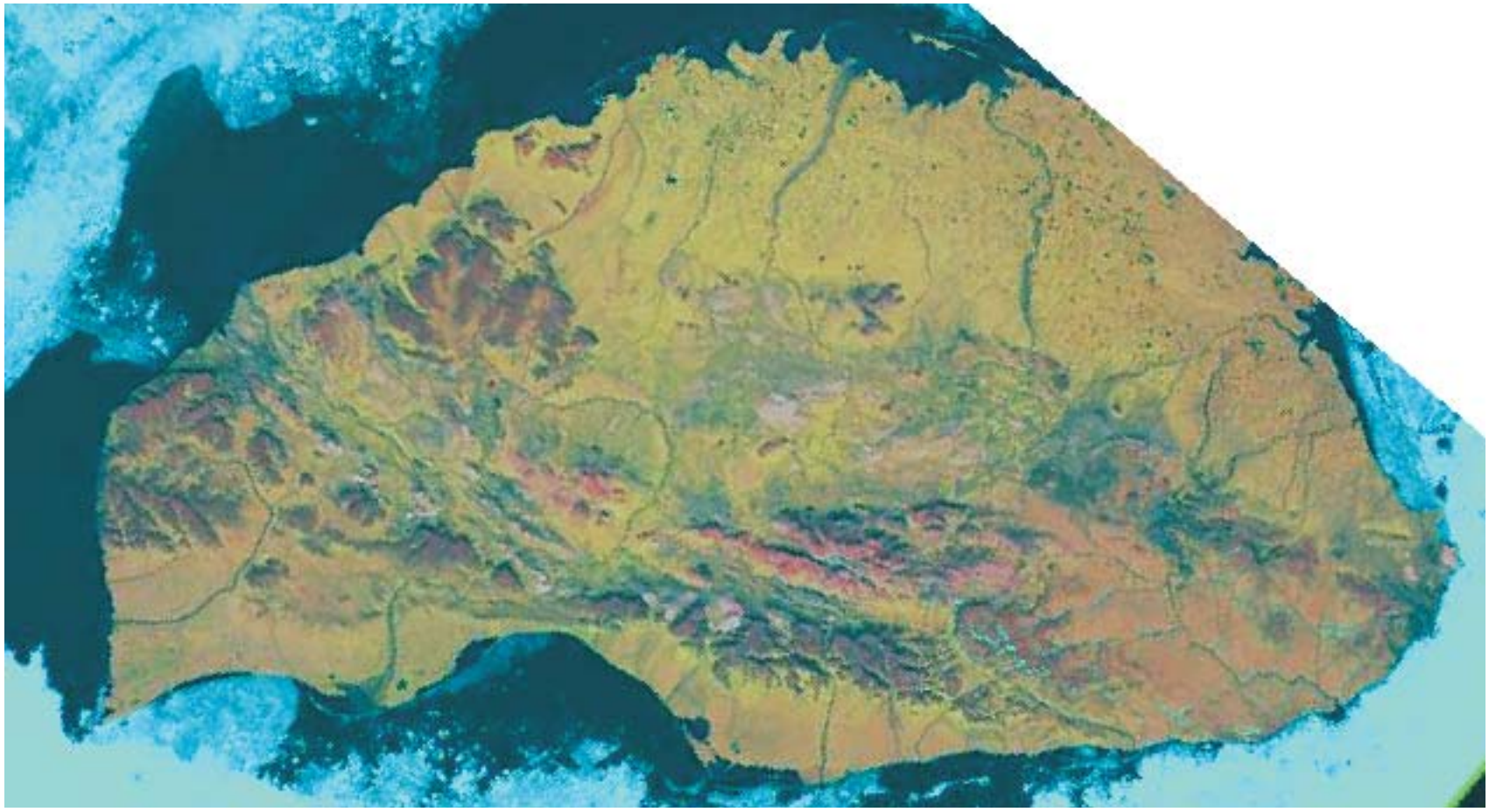


Sea level fluctuations

Data from Andrey Proshutinsky, Woods Hole Oceanographic Institution

THE GLACIAL AND SEA LEVEL HISTORY OF WRANGEL ISLAND, NE SIBERIA

Lyn Gualtieri, University of Washington
Sergey Vartanyan, Wrangel Island State Reserve
Julie Brigham-Grette, University of Massachusetts
Pat Anderson, University of Washington



A paleoenvironmental study using relative and numerical dating techniques to determine whether an ice sheet ever existed in the East Siberian Sea

^{10}Be and ^{26}Al cosmogenic isotope ages of >35 ka on tors like this one indicate that Wrangel Island has remained largely unglaciated during the LGM.

Amino acid analyses of fossil mollusks from raised marine sediment infer ages >500 ka. These shorelines are eustatic in origin and clearly preclude the existence of a marine based ice sheet in the East Siberian Sea or on the Chukchi Shelf during the LGM.

Images courtesy of Lyn Gualtieri, University of Washington

New RAISE project, Summer 2001

"Collaborative Research: A Measurement Program in Siberia to Assess Disturbance-Driven Changes in Arctic Carbon Fluxes" This RAISE project is conducting a field measurements program near Cherski (Kolyma River delta) to quantify the impacts of disturbance on the seasonal cycle of atmospheric carbon dioxide and the discharge of carbon and nitrogen into the Arctic Ocean in forest and shrubby tundra regions. Coastal plain tundra in the region has accumulated large stores of carbon in sediments during the Pleistocene that has been slowly released to the atmosphere and ocean through melting of previously frozen soils during the Holocene. Disturbance, particularly forest fires, of the vegetation exposes the soils to accelerated carbon loss through more direct exposure to erosion. The study will compare an undisturbed region to recently disturbed areas and determine the effects of changes in temperature and hydrology on the rate of carbon flux. The results will be utilized in models to examine possible future disturbance effects, particularly those that could be accelerated by warmer climate conditions.

Contact: Dr. James T. Randerson (California Institute of Technlogy), Dr. Sergey Zimov (Far Eastern Scientific Station, Cherski)

Objective: Better access to Arctic coastal zone for environmental change research


Nearshore Initiative
Current RAISE science planning efforts: Development of a science plan that will lead to a joint announcement of opportunity for research by the U.S. National Science Foundation and Russian Foundation for Basic Research on a ship platform in near-shore Arctic

Nearshore Initiative

Where things stand:

December 2000: RAISE PI and steering committee meeting formally kicks off effort

November 2001: Presentation at OAII and LAII PI meeting

January 2002: On-line discussion and posting of draft shell of a science plan

February 2002: Work during ARCSS All-Hands Meeting

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RAISE Steering Committee