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Toward Improved Regional Prediction of Arctic Climate Change at seasonal to interannual scales

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Wieslaw Maslowski
Naval Postgraduate School

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Towards Advanced Understanding and Predictive Capability of Climate Change in the Arctic using a High-Resolution Regional Arctic Climate System Model (RAMC)

Participants:

Wieslaw Maslowski - Naval Postgraduate School
John Cassano - University of Colorado
William Gutowski - Iowa State University
Dennis Lettenmeier - University of Washington

Other collaborators:

David Bromwich - OSU
Greg Newby, Andrew Roberts, Juaxion He -UAF/IARC/ARSC

Primary science objective: to synthesize understanding of past and present states and thus improve decadal to centennial prediction of future Arctic climate and its influence on global climate.

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Specific Goals

- develop a state-of-the-art Regional Arctic Climate system Model (RACM) including high-resolution state-of-the-art atmosphere, ocean, sea ice, and land hydrology components
- perform multi-decadal numerical experiments using high performance computers to minimize uncertainties and fundamentally improve current predictions of climate change in the northern polar regions

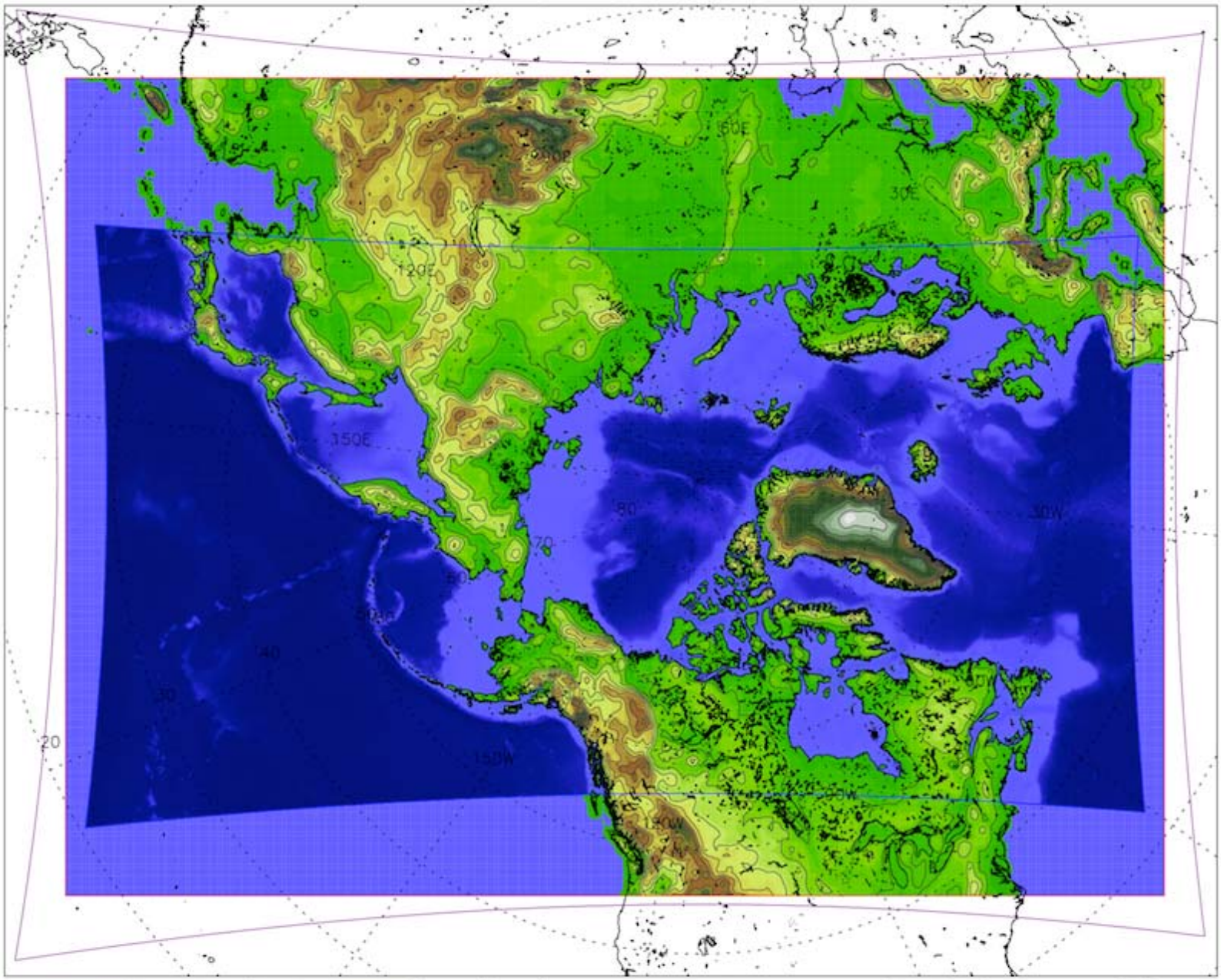
RACM components and resolution

- **Atmosphere - Polar WRF** (gridcell ≤50km)
- **Land Hydrology – VIC** (same as WRF)
- **Ocean - LANL/POP** (gridcell ≤10km)
- **Sea Ice - LANL/CICE** (same as POP)
- **Flux Coupler – NCAR CPL7**

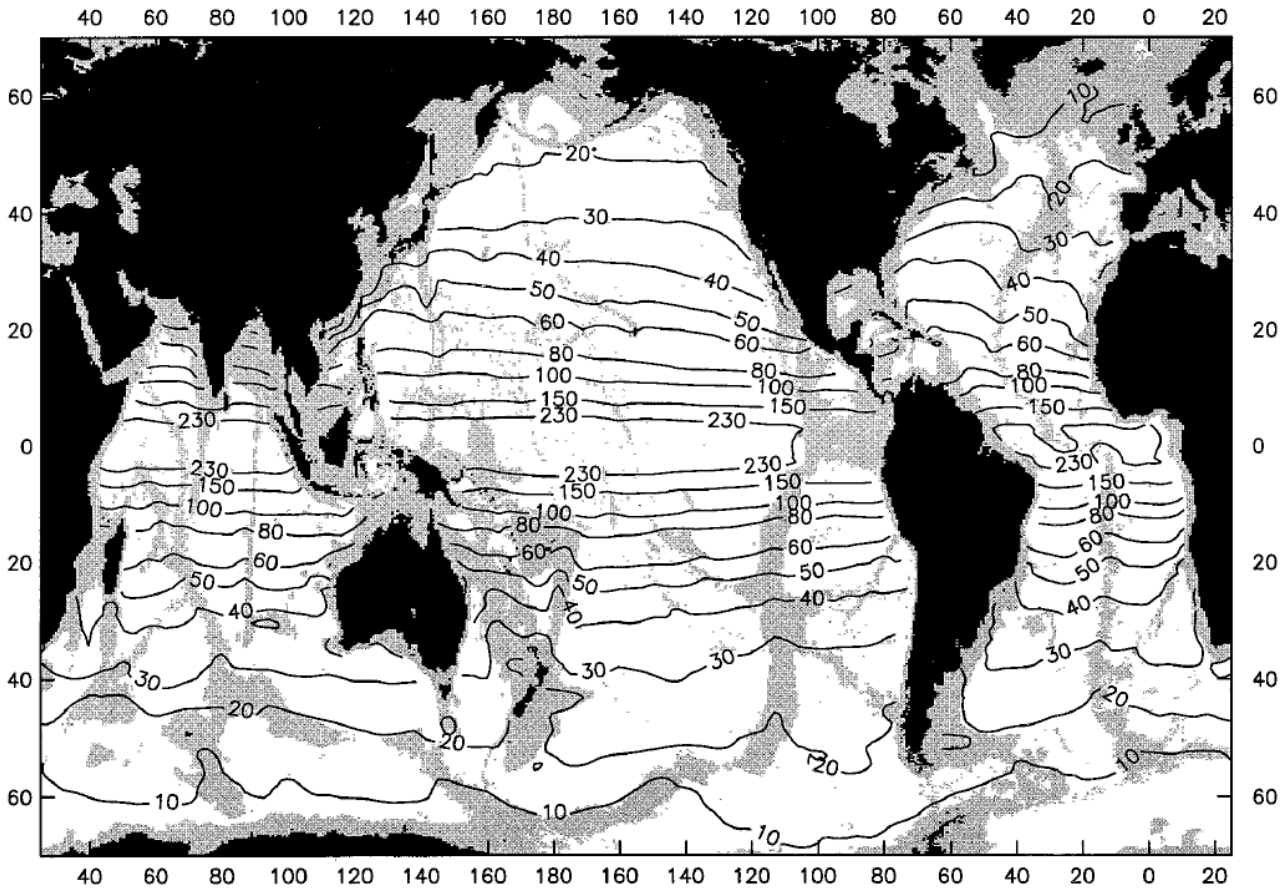
Use NCAR CCSM4 framework for developing RACM

Higher component resolutions to be evaluated subject to availability of computer resources

Pan-Arctic region includes:
- all sea ice covered ocean in the northern hemisphere
- Arctic river drainage
- critical inter-ocean exchange and transport
- large-scale atmospheric weather patterns (AO, NAO, PDO)

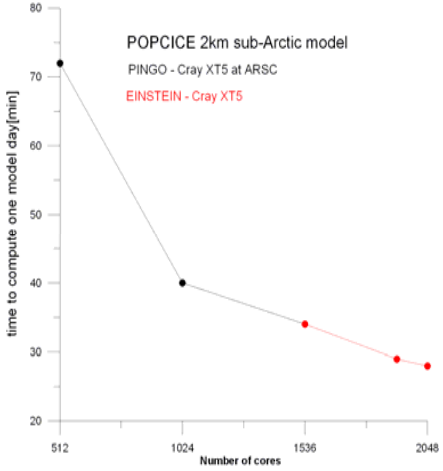

RACM Pan-Arctic Domains
150E
120E
90E
60E
30E
30W
150W
120W
90W
60W
80
70
60
50
40
30
20
Atmosphere/Land
Ocean/Sea-ice
Extended Ocean
Elevation Contours = 250 m
-7000
-6000
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

First bariclinic Rossby radius of deformation in the Ocean Word



$$R_1 = \frac{NH}{|f|}$$

where: N – Brunt-Väisälä frequency,
H – water depth,
f – Coriolis parameter



Scalability of coupled sea ice ocean model (POPCICE) at Cray XT5 supercomputers.

Chelton, D. B., R. A. deSzoeke, M. G. Schlax, K. E. I. Naggar, N. Siwertz, 1998. *Geographical variability of the firstbaroclinic Rossby radius of deformation.* J. Phys. Oceanogr., 28, 433–460

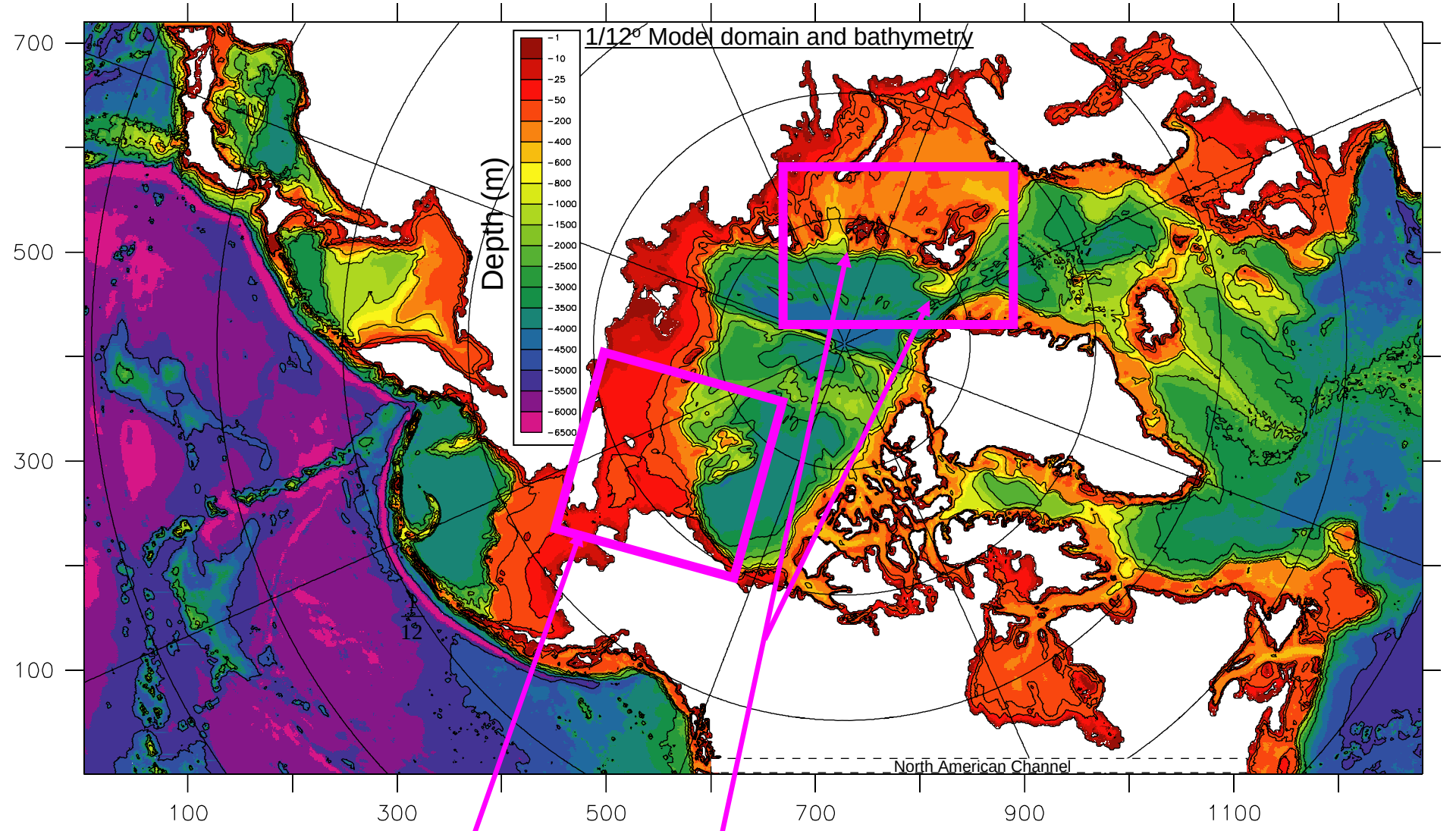
A Comprehensive Modeling Approach Towards Understanding and Prediction of the Alaskan Coastal System Response to Changes in an Ice-diminished Arctic

A NOPP Project – 2007-2010

Participants:

Wieslaw Maslowski	- Naval Postgraduate School
John Cassano	- University of Colorado
John J. Walsh	- University of South Florida

Revolutionary Research . . . Relevant Results



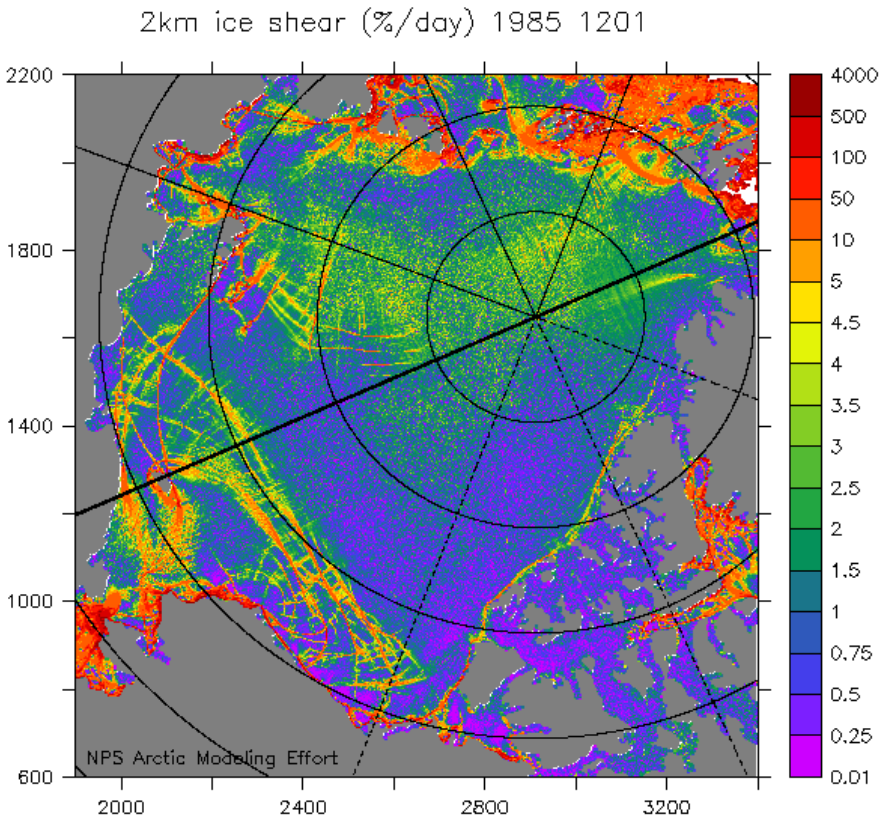
Gateways/Margins of Pacific Water and Atlantic Water Inflow into the Arctic Ocean

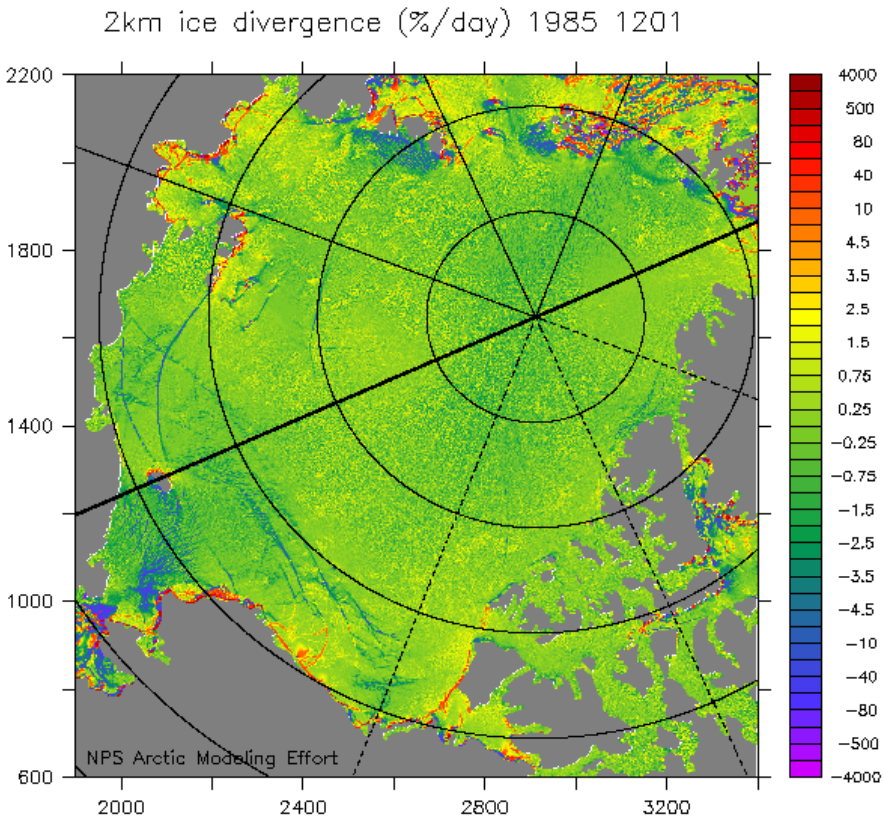
Main uncertainties of importance to global climate

1. Northward heat transport from the N. Atlantic/Pacific to Arctic Ocean *
2. Arctic sea ice thickness and volume *
3. Freshwater export from the Arctic to North Atlantic

Simulated sea ice deformations in the NPS eddy-resolving pan-Arctic model

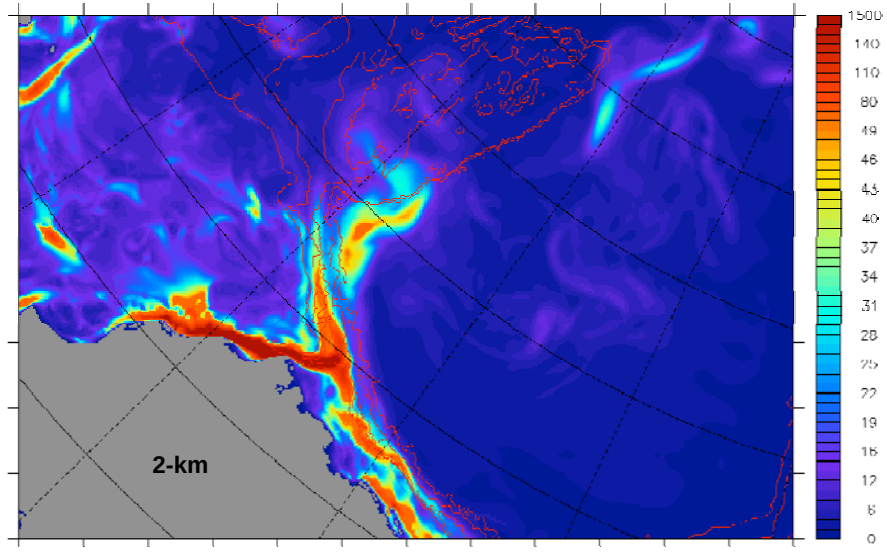
- Climate change is amplified in the Arctic - the recent sea ice decline is a clear evidence of it
- Realistic representation of sea ice deformations and air-sea energy exchange is critical for advanced prediction at seasonal to interdecadal scales

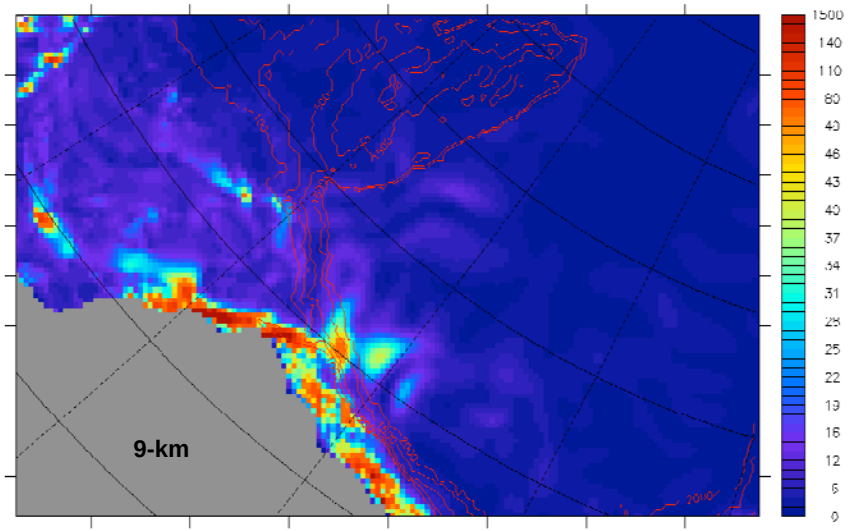


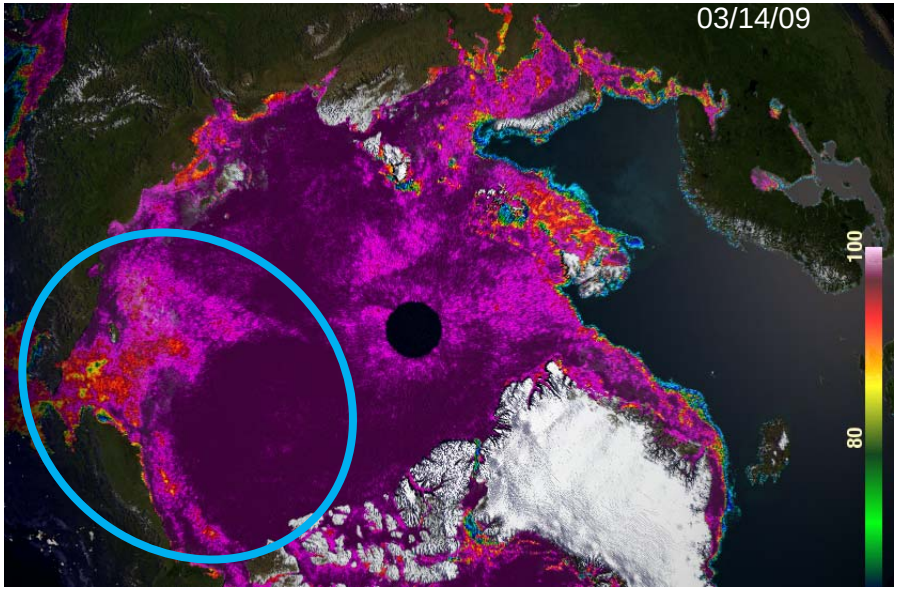


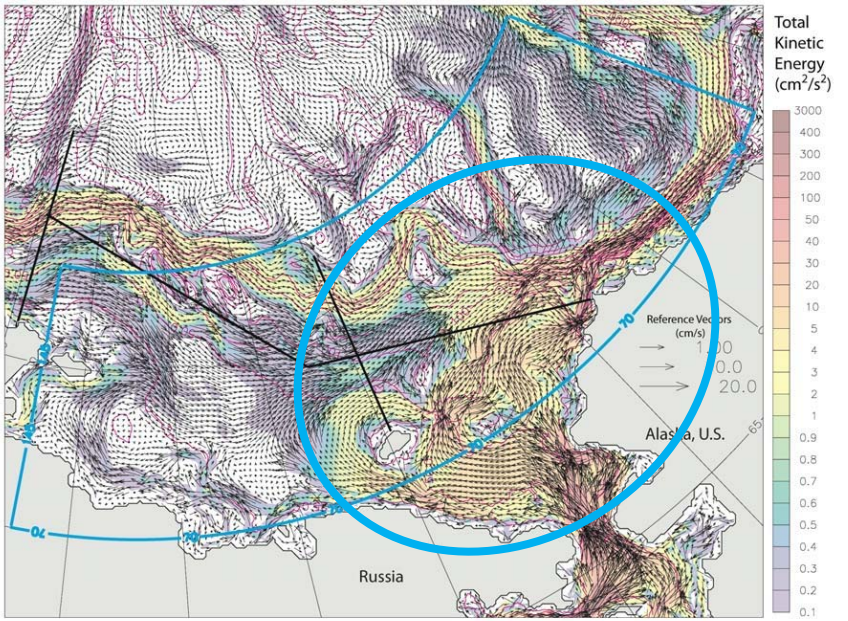
Dedicated computer and personnel resources are needed for model development, simulations and analyses

Eddy activities over the Northwind Ridge : Summer (JAS) mean EKE in the upper 110m from 1/48^{o} (left) and 1/12^{o} (right) model









Oceanic impact on sea ice in the western Arctic …… continues!

Model Requirements of Improved Prediction of Arctic Climate Change

(Sea Ice Centric)

- Operational/synoptic versus seasonal-decadal prediction needs
- Improved parameterizations
  - sea ice-ocean coupling (sea ice embedded in mixed layer)
  - fast ice
  - ice sheet – ocean coupling
- Fresh water fluxes from land
  (runoff, ice sheet / glacial melt, permafrost)
- Tides
- High spatial resolution to resolve
  - mesoscale eddies
  - boundary / coastal currents
  - coastline / bathymetry features
- High-resolution realistic atmospheric forcing data
- Dedicated high performance computer (HPC) resources