RESEARCH AREA NO.: 3
THEME NO.: 10

TITLE: Development of an Arctic System Model

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COLLABORATORS AND ROLES:

C. Deal (IARC): Marine ecosystem model development
M. Jin (IARC): Marine ecosystem model implementation
P. McRoy (IARC): Marine ecosystem model assessment
A. Roberts (IARC): Sea ice/ocean component model implementation
E. Watanabe (JAMSTEC): High-resolution Arctic Ocean modeling
H. Park (JAMSTEC): Land surface modeling
BACKGROUND:

• IARC has been facilitating development of an Arctic System Modeling activity (three workshops during 2008-09); report published in summer 2010

• Various modeling activities are underway in JICC themes, providing potential contributions of component models for an Arctic System Model

• JICC themes also include observations and measurements that can be utilized in system model development and testing
OBJECTIVES:

(1) A specific goal of Theme 10 is to develop a land surface model, for use in evaluating changes in land surface processes caused by climate change and altered land surfaces in Arctic region.

(2) The JICC activity will also contribute to development of marine biochemistry and Arctic ocean/sea ice modules for an Arctic System Model.
METHODOLOGY:

(1) Target the implementation plan for Arctic System Modeling (ASM)

(2) Identify JAMSTEC and IARC modeling participants and build upon their capabilities with component models

(3) Modify existing components models to conform to ASM modularity

(4) Implement JAMSTEC/IARC component modules into ASM coupler when coupler is established
The three primary JAMSTEC/IARC modeling emphases:

- marine biochemistry/ecosystems
- Arctic Ocean/sea ice (high-resolution)
- Land surface/hydrology
Results from global POP-CICE-ecosystem model

Model estimate of annual primary production in sea ice and ocean (integrated upper 100m)

--- Significant northward movement of production in warm years, e.g. from the Bering Sea to the Chukchi Seas

Ongoing study: The timing between ice algal bloom and subsequent ocean pelagic bloom is essential for survival of zooplankton. Could zooplankton adjust to the temporal variations caused by climate changes?
Other recent activities (marine ecosystems): 

C. Deal and M. Jin participated in AOMIP ecosystem model intercomparison

Journal paper --

Eddy-induced transport of Pacific water seems to be dominant.
Beaufort Shelfbreak Eddies

Ocean velocity [cm s\(^{-1}\)] and relative vorticity [s\(^{-1}\)] (30 m depth)

Barrow Canyon Jet 70 km
Change in snow depth

Since 1990, snow cover extent of <35 cm increased, while > 35 cm decreased.

The decrease of snow cover extent is significant more in North America than in Siberia, especially higher snow depth (i.e. > 35 cm).

Snow depth began to decrease since 1981.

Interannual variation of snow cover extent

The decrease of snow cover extent is significant more in North America than in Siberia, especially higher snow depth (i.e. > 35 cm).
ACTIVITIES FOR REMAINDER OF 2011FY:

For ecosystem modeling, the specific objectives are:

(1) Initiate ecosystem experiment to evaluate role of Beaufort Shelfbreak eddies on lower trophic level production

(2) Improve the formulation of ecosystem processes for modeling different shelf types (e.g. Siberian shelf vs. Chukchi shelf) by utilizing new JAMSTEC/IARC observations

(3) Prepare for coupling marine ecosystem component to ASM sea ice component
ACTIVITIES FOR REMAINDER OF FY2011:

For the ocean/sea ice modeling, the specific objectives are:

(4) Evaluate the impact of improved resolution of forcing data on next-generation ocean-ice model simulation; high-resolution forcing will come from NCEP-CFSRR, JRA-55 or ERA-77 reanalyses

(5) Evaluate the role of eddies in shelf-basin exchanges involving Pacific water and its properties

For the land system model development, specific objectives are:

(6) Initiation of coupling of components of land surface model into ASM

(7) Quantify long-term variability of water and energy budget in tundra and forest in Alaska, utilizing observe snow processes and soil water and temperature in Kuparuk watershed
EXPECTED OUTCOMES FOR FY2011:

(1) Journal paper submission on CHANGE model simulations of Alaskan tundra and boreal forest regimes

(2) Journal paper on impact of enhanced resolution on Arctic ocean-ice model simulations

(3) Publication of book chapter on biological and biogeochemical model synthesis in the Pacific Arctic including collaborations with JAMSTEC/IARC and international colleagues

(4) Contribution to IARC Special Issue on the trajectory of the Arctic system

(5) Initiation of the coupling of these three modeling efforts in a way that will accelerate integration into comprehensive Arctic System Modeling framework
TIME SCHEDULE:

FY2011: Work with component models. Initiate coupling discussions among JAMSTEC/IARC components, and interface with complementary system modeling activities in broader Arctic research community

FY2012: Achieve coupling between JAMSTEC/IARC models and other coupled models in research community; extend JAMSTEC/IARC modeling to include carbon dioxide and methane

FY2013-2015: Perform experiments directed at processes relevant to assessment of trace gas and water budgets of Arctic, utilizing JAMSTEC observational results for validation
PRACTICAL PROBLEMS:

- It is not apparent that a “critical mass” of JAMSTEC/IARC participation will be achieved

- Phasing of Arctic System Modeling activity is lagging original plans, so coupled framework may not be available for ~2 years

- System Modeling will require involvements of collaborating scientists from other institutions, and their funding is uncertain

- Metrics of success need to be determined