RESEARCH AREA NO.: 3
THEME NO.: 10

TITLE: Contributions to Arctic System Modeling

PI: J. Walsh, CO-PI: H. Park

COLLABORATORS AND ROLES:

C. Deal (IARC): Marine ecosystem model development
M. Jin (IARC): Marine ecosystem model implementation
P. McRoy (IARC): Marine ecosystem model assessment
G. Gibson (IARC): Marine ecosystem modeling
H. Park (JAMSTEC): Land surface modeling
[E. Watanabe (JAMSTEC): High-resolution Arctic Ocean modeling]
BACKGROUND:

• IARC facilitated development of an Arctic System Modeling activity (three workshops)

• 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
Framework for an Arctic System Modeling activity

(IARC report -- Roberts et al., 2011)
OBJECTIVES:

The goal of an Arctic System Modeling project is to produce a modeling system for the Arctic region, enabling investigations of Arctic climate variability and change as well as their potential impacts on humans, ecosystems and the global system.

Specific goals of the JICC Theme 10:

• Contribute to development of Arctic System Model, with emphasis on modules for
  -- marine biochemistry
  -- terrestrial surface/hydrology
  -- Arctic ocean/sea ice

• Enhance component models to meet requirements of a system model coupler

• Develop and test component modules with observational data
METHODOLOGY:

- Follow implementation plan of Arctic System Modeling based on IARC ASM Report (2011)
- Modify existing IARC and JAMSTEC model components to conform with ASM modularity
- Implement JAMSTEC/IARC modules into ASM coupler
The three primary JAMSTEC/IARC modeling emphases:

- marine biochemistry/ecosystems
- land surface/hydrology
- Arctic Ocean/sea ice (high-resolution)
ACTIVITIES FOR 2011FY:

For ecosystem modeling, the specific objectives are:

(1) Evaluate performance of IARC coupled ice-ocean-ecosystem model in the Pacific Arctic.

(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) Include of Arctic carbon, methane and sulfur processes.

Key scientists: C. Deal, M. Jin, P. McRoy
Simulated changes in annual primary production in sea ice (left) and upper ocean (right)

[M. Jin and C. Deal, 2012]
Schematic of coupled nutrient-reduced sulfur biogeochemistry attached to the CICE sea ice model

[Elliot et al., 2011]
ACTIVITIES FOR 2011FY:

For the land system model development, specific objectives are:

(1) To evaluate the performance of land surface model mainly dealing with biogeophysical and hydrological processes at the surface and sub-surface of land, including water and heat exchange with snow cover and/or atmosphere, water phase change, and carbon flux.

(2) Implement water phase changes of land surface model.

(3) Evaluate long-term variability of hydrologic processes in two different regions (tundra and forest) in Alaska: focus on snow

Key scientist: H. Park
Interannual variability of Snow Cover Extent (10^6 km^2) over the Arctic land in various snow-depth categories during 1948–2006

[Park et al., 2012]
Snow Cover Extent of 1961-1970 minus 2001-2006 at snow depth levels of (a) <6 cm, and (b) ≥36 cm. Blue and green indicate greater SCE during 1961-1970 and 2001-2006.

[Park et al., 2012]
ACTIVITIES FOR 2011FY:

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

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

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

(3) Begin imbedding of the state-of-the-art dynamical sea ice formulation
into a coupled atmosphere-ocean model. This coupled model will
provide the core of a regional system model for the Arctic.

Key scientist: E. Watanabe
Center: lateral volume transport (vectors), net Ekman convergence (shaded), sea level pressure (contours). In left and right figures, vertical salinity profiles along 145W section averaged from July to September are shown.
EXPECTED OUTCOMES FOR FY2011:

(1) Enhancement of IARC marine biochemistry/ecosystem model targeted for inclusion in ASM framework

(2) Quantify long-term variability of energy and water (snow) budgets of tundra and forest in Alaska

(3) Results on impact of improved resolution of forcing data on next-generation ocean-ice model simulations

(4) Contribution to synthesis paper in IARC special issue of *Ecological Applications*
CHALLENGES AND CONCERNS:

• 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

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

• Metrics of success need to be determined