REGIONAL ARCTIC SYSTEM MODEL (RASM)

Rapid changes in the polar regions are impacting world populations, industry, and national economies. Research can provide a better understanding of Arctic earth system dynamics—atmosphere, land, ocean and sea ice, vegetation, ice caps, and smaller glaciers.

Over the past decades, there have been a significant depletion of ice pack, especially in the western Arctic Ocean, leading to a rise in subsurface temperatures as more of the ocean surface is exposed to the sun. Some of this solar energy becomes trapped below the surface layer after it freezes and can reduce the growth of sea ice in winter, resulting in earlier melting and ice retreat in spring and summer. This cycle is one of the causes of the continuing overall decline of the Arctic sea ice cover.

The U.S. Department of Energy's (DOE) Regional Arctic System Model (RASM) has advanced modeling to provide scientists a more realistic and detailed picture of environmental patterns emerging in the region and guiding future development of earth system models.

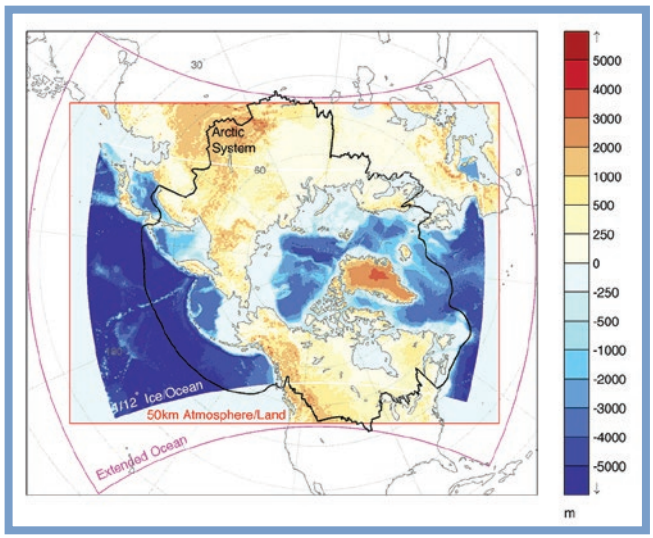
GUIDANCE FOR EARTH SYSTEM MODELS

A major goal of RASM is to provide guidance for earth system models on what processes and feedbacks are critical to improving representation of the Arctic region. For example, in the Barents Sea on the eastern side of the Arctic Ocean, research indicates mixing and cooling of Atlantic water and air-sea fluxes may help explain some model inaccuracies related to regional atmospheric circulation and sea-ice melting.

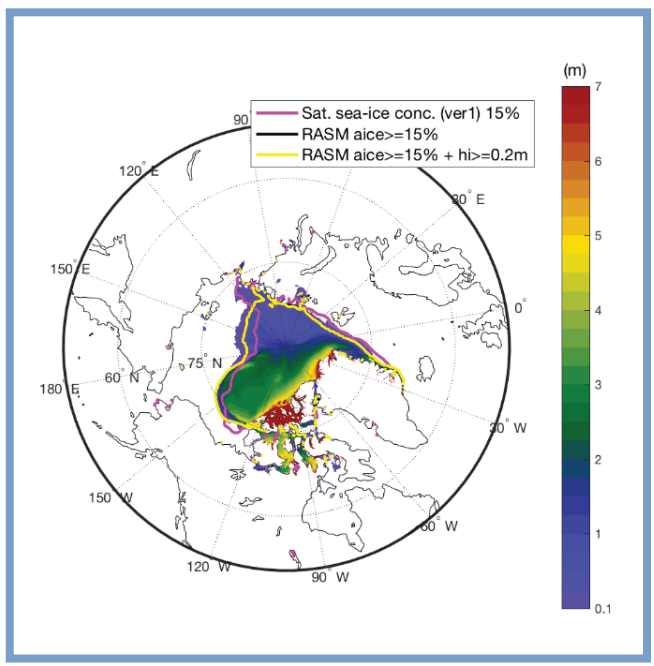
RASM results help explain the large, positive sea level pressure bias centered over the Barents Sea, as shown in many earth system models of the World Climate Research Programme's (WCRP) third and fifth Coupled Model Intercomparison Projects (CMIP3/CMIP5). A more accurate model simulation of water vertical mixing and cooling in the Barents Sea requires improved representation of oceanic currents, eddies, tides, marginal ice zones, and of overall comprehensive ocean measurements.

Further, a depletion of sea ice may affect weather and climate forecasting because larger areas of direct ocean-atmosphere interaction increase oceanic regulation of the atmosphere. For instance, areas in Alaska have shown an increase in warm- and a decrease in cold-extremes. The warmer weather is likely due to a change in atmospheric circulation influenced by a decrease in sea ice.

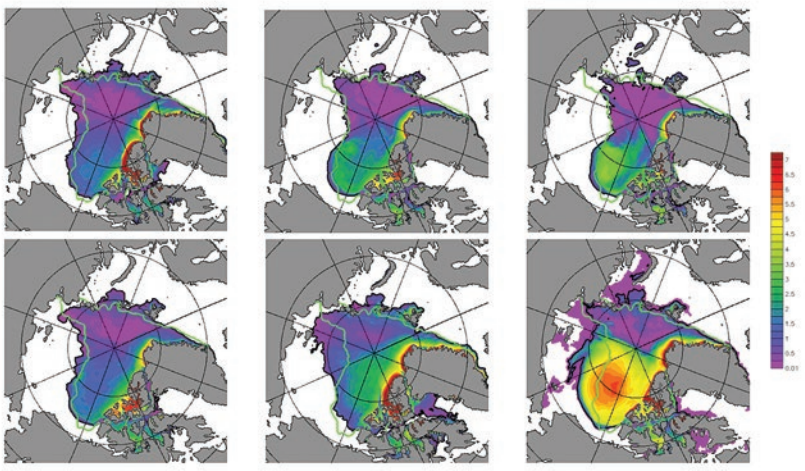
RASM has also indicated an increase in precipitation in Alaska and Canada, suggesting future uses for the model in exploring precipitation extremes.



Pan-Arctic domains are shown here from the Regional Arctic System Model (RASM). Shading indicates model topobathymetry (underwater depth topography). The black line outlines the Arctic system domain.



RASM monthly average of sea ice thickness [m] and extent from 1/48° ice/ocean configuration for September 2007 is shown. The purple and yellow contour lines are the respective satellite and RASM estimates for sea ice.



Sea ice thickness and extent are shown from the RASM runs for H-compset sensitivity forced with CORE2 for September 2007. The green contour line represents 15% ice concentration from satellite data (NSIDC) with the respective black line from the model. Varying, yet realistic changes in parameter space yield significant variability in sea ice thickness/extent and help determine the optimal setup for RASM.

RASM research is in agreement with satellite observations of sea-ice variability. More importantly, RASM realistically represents extreme sea-ice events, such as the September 2007 and 2012 minima, when forced with realistic atmospheric data from the Common Ocean Reference Experiment version 2 (CORE-2). Results like these increase scientific confidence in the model.

ADVANTAGES

Although similar to earth system models, RASM provides three critical advantages:

1. Regional focus permits significantly higher spatial resolution to explicitly represent and evaluate the role of important fine-scale arctic processes and feedbacks, such as sea-ice deformation, ocean eddies, and associated ice-ocean boundary layer mixing, multiphase clouds, as well as land-atmosphere-ice-ocean interactions.
2. Provides direct comparison of its results with data for any given time, which enables optimization of parameter space and more accurate, internally consistent initial conditions for predictability studies.
3. Reduces computational cost and allows for a large-number ensemble of probabilistic high-resolution simulations, which might offer useful and more detailed information to stakeholders in addition to earth system model projections alone.

FUTURE DIRECTION

RASM will advance knowledge, reduce uncertainty, and improve prediction of Arctic climate. Working with the larger science community, RASM will expand its modeling of ice-sheet/ocean interaction in fjords, terrestrial and marine biogeochemistry and ecology, and the associated carbon cycle. Given the Arctic is warming faster than the rest of the globe, understanding this region of the earth system is critical.

ACKNOWLEDGEMENTS

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