

REGIONAL ARCTIC SYSTEM MODEL (RASM)

The core effort of this project involves the development and use of a Regional Arctic System Model (RASM), consisting of atmosphere, land, ocean and sea ice, as well as vegetation, Greenland Ice Sheet, ice caps and smaller glaciers. A major goal of the research is to produce a more realistic and detailed picture of the climate patterns, which are emerging in the region, as well as to provide a greater insight into what processes and feedbacks future Global Climate and Earth System Models should improve upon.

This project grew out of regional Arctic climate modeling work at the Naval Postgraduate School, the University of Colorado, Iowa State University, and the University of Washington. Currently, our team involves 30 researchers, including students, from 10 institutions. Members from each institution have worked with standalone model components, such as ocean, ice, atmosphere and land models, and saw the need for a fully coupled regional climate model that thoroughly explores the interactions between components.

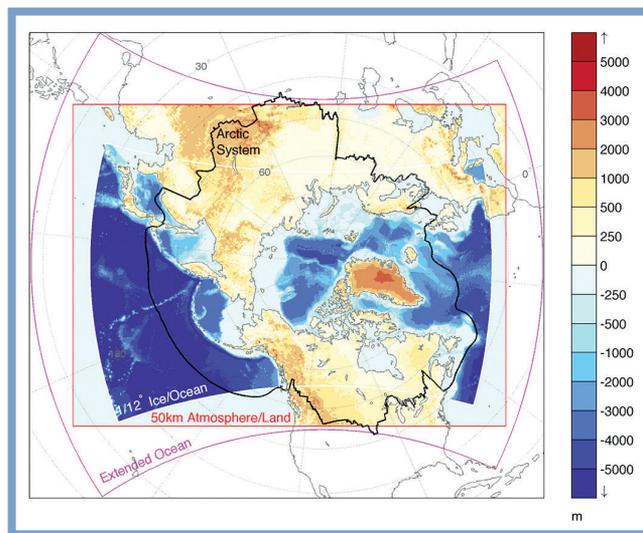
LONG-TERM GOALS

Our long-term goal is to advance knowledge, reduce uncertainty, and improve prediction of Arctic climate through continuous expansion of RASM involving a larger climate community and including ice-sheet/ocean interaction in fjords, terrestrial and marine biogeochemistry, and ecology, and the associated carbon cycle integral to human dimension components. As we continue developing our model and analyzing its results, we gain a greater insight into the basic workings of the climate system.

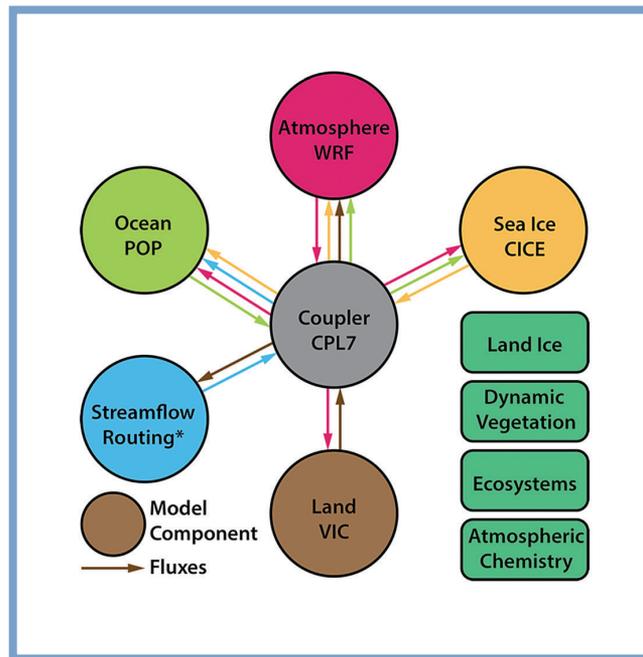
Given that the Arctic is warming faster than the rest of the globe, understanding the processes and feedbacks of this polar amplification is a top priority. In addition, Arctic glaciers and the Greenland Ice Sheet are expected to change significantly and contribute to sea level rise in the coming decades. The aforementioned high-spatial resolution allows for detailed study of the regional response of these land ice masses to long-term warming and interannual variability.

ADVANTAGES

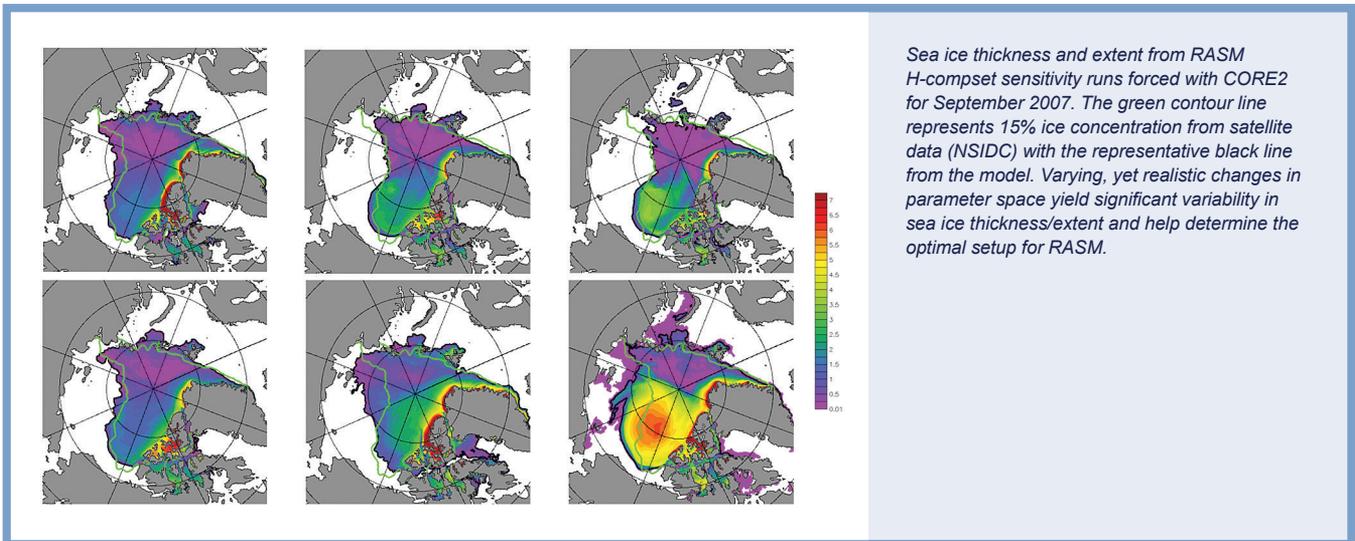
Although similar to Global Climate and Earth System Models, RASM provides two critical advantages. First, given its regional focus, it permits significantly higher spatial resolution to explicitly represent and evaluate the role of important fine-scale Arctic processes and feedbacks, such as sea ice deformation, ocean eddies, and associated ice-ocean boundary layer mixing, multiphase clouds as well as land-atmosphere-ice-ocean interactions. Second, it allows for simulation of a larger number of



Pan-Arctic domains from the Regional Arctic System Model (RASM). Shading indicates model topobathymetry. The black line outlines the Arctic system domain.



Wiring diagram of the Arctic system model.



ensemble members, using different initial conditions and space-dependent sub-grid parameterization, to generate probabilistic predictions that would be more useful to national and local decision makers than global model forecasts alone.

SCIENTIFIC PROGRESS

The first set of results indicates that ice-ocean interactions combined with diminishing sea ice cover plays an important role in the western Arctic Ocean. Over the last decade, there has been a significant depletion of ice pack leading to a rise in subsurface heat content as more of the ocean surface becomes exposed to the sun's rays. Some of this solar energy becomes trapped below the surface layer after freeze-up and can reduce the growth of sea ice in winter, leading to earlier melting/retreat in spring and a further reduction of the Arctic sea ice cover. Such a positive feedback would act in addition to ice-albedo feedback and further contribute to polar amplification.

On the Atlantic side of the Arctic, in the Barents Sea, oceanic heat transport and air-sea fluxes may help explain some of the Global Climate and Earth System Models biases related to the regional atmospheric circulation and excessive sea ice melting in the eastern Arctic. The former appears to be caused by insufficient mixing and cooling of Atlantic water over the Barents Sea. This could help explain the large, positive sea level pressure bias centered over the Barents Sea experienced in many of the Global Climate Models of the World Climate Research Programme's (WCRP) third Coupled Model Intercomparison Project (CMIP3). A more accurate model simulation of water vertical mixing and cooling in the Barents Sea will require improved representation of oceanic currents, eddies, tides, marginal ice zones, and of overall bottom bathymetry.

Further, a depletion of sea ice may have a positive feedback effect on summer weather forecasting because larger areas of direct ocean-atmosphere interaction increase oceanic regulation of the

atmosphere (areas, such as Alaska, have shown an increase in warm extremes and a decrease in cold extremes). The warmer weather is likely due to a change in atmospheric circulation influenced by an increase in open ocean area. RASM has also indicated an increase in precipitation in Alaska and Canada, suggesting in the future RASM can be used for exploring precipitation extremes, as well as its many other applications.

Overall, RASM is in good agreement with satellite observations for sea ice variability. More importantly, RASM can realistically represent extreme sea ice events, such as the September 2007 minimum, when forced with realistic atmospheric data from the Common Ocean Reference Experiment version 2 (CORE-2). Since the Arctic sea ice is highly sensitive to and dependent on combined forcing from the atmosphere and ocean, such results bring confidence in the model's ability to simulate processes and interactions affecting the region's surface climate.

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Project Website
<http://www.oc.nps.edu/NAME/RASM.htm>