Development of a Regional Arctic Climate System Model (RACM)

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1. Introduction

Observations and global climate system model projections indicate significant changes in the state of the Arctic climate (IPCC, 2007). These changes are impacting many aspects of the climate system (atmosphere, ocean, sea ice, land) and changes in one component of the climate system are intimately linked to changes in other components of the climate system. In order to understand the forcing for observed change in the Arctic and to increase confidence in future projections of Arctic climate change it is necessary to consider coupled changes in the Arctic climate system.

Global climate system models include many, but not all, components of the Arctic climate system, yet errors remain in their simulation of the current and past state of the Arctic. These errors arise from many sources including errors propagating into the Arctic from lower latitudes, inadequate representation of polar climate processes, and coarse model resolution. One way to address these shortcomings is through the use of an Arctic regional climate system model. An Arctic regional climate system model allows increased horizontal and vertical resolution and improved model physics that are optimized for polar regions, as well as the use of "perfect" lateral boundary conditions for retrospective simulations.

This extend abstract, and associated presentation, discusses plans for and the status of a collaborative project to develop a state-of-the-art Regional Arctic Climate system Model (RACM) including high-resolution atmosphere, land, ocean, sea ice and land hydrology components. The ultimate goal of this project is to perform multi-decadal numerical experiments with RACM using high performance computers to minimize uncertainties and fundamentally improve current predictions of climate change in the northern polar regions.

The project involves PIs from four institutions: Naval Postgraduate School (lead institution, PD/PI - Wieslaw Maslowski), University of Colorado in Boulder (co-PI - John J. Cassano), Iowa State University (co-PI - William J. Gutowski) and the University of Washington (co-PI - Dennis P. Lettenmaier) funded by the United States Department of Energy. In addition, collaborators from the University of Alaska – Fairbanks Arctic Regions Supercomputing Center and International Arctic Research Center (Andrew Roberts, Juanxiong He, and Greg Newby) are actively involved in this effort, while several other international experts in Arctic climate modeling are contributing to this project.

2. Regional Arctic Climate System Model

The regional Arctic climate system model (RACM) that is currently under development couples atmosphere, ocean, sea ice, and land component models. The atmospheric model used in RACM is a version of the National Center for Atmospheric Research (NCAR) Weather Research and Forecasting (WRF) model that has been optimized for the polar regions. The ocean and sea ice models are basically the same as those used in the NCAR Community Climate System Model (CCSM3), although used on a regional domain: the Los Alamos National Laboratory POP ocean model and CICE sea ice model. Land surface processes and hydrology will be represented by the Variable Infiltration Capacity (VIC) model. These four climate system component models are being coupled using the NCAR CCSM coupler CPL7.

The simulation domain of RACM covers the entire pan-Arctic region and includes all sea ice covered regions in the Northern Hemisphere as well as all terrestrial drainage basins that drain to the Arctic Ocean. The simulation domain is shown in Figure 1, with the red line indicating the extent of the atmosphere and land model domains and the blue line indicating the extent of the ocean and sea ice model domains. The ocean and sea ice model will use a horizontal grid spacing of less than 10 km, while the atmosphere and land component models will use a horizontal grid spacing of 50 km or less.

3. Benefits and Outcomes

A major product of this effort, and a principal community benefit, will be the development of a high-resolution pan-Arctic climate system model that combines all major climate elements in an internally consistent framework for focused studies. The coupling framework will allow straightforward implementation of additional climate-system components, thereby extending its capacity to cover a range of natural and human impacts.

A primary focus of the project is to improve our understanding of processes leading to reductions in Arctic sea ice cover. One outcome from this effort will be improved prediction of ice-free Arctic Ocean for use in policy planning.

This project will facilitate synthesis and integration of historical and new observations with model results. It will involve undergraduate, graduate, and postdoctoral students, who will receive practical training in coupled climate system modeling and/or analysis of model output.

References

IPCC, Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp, 2007

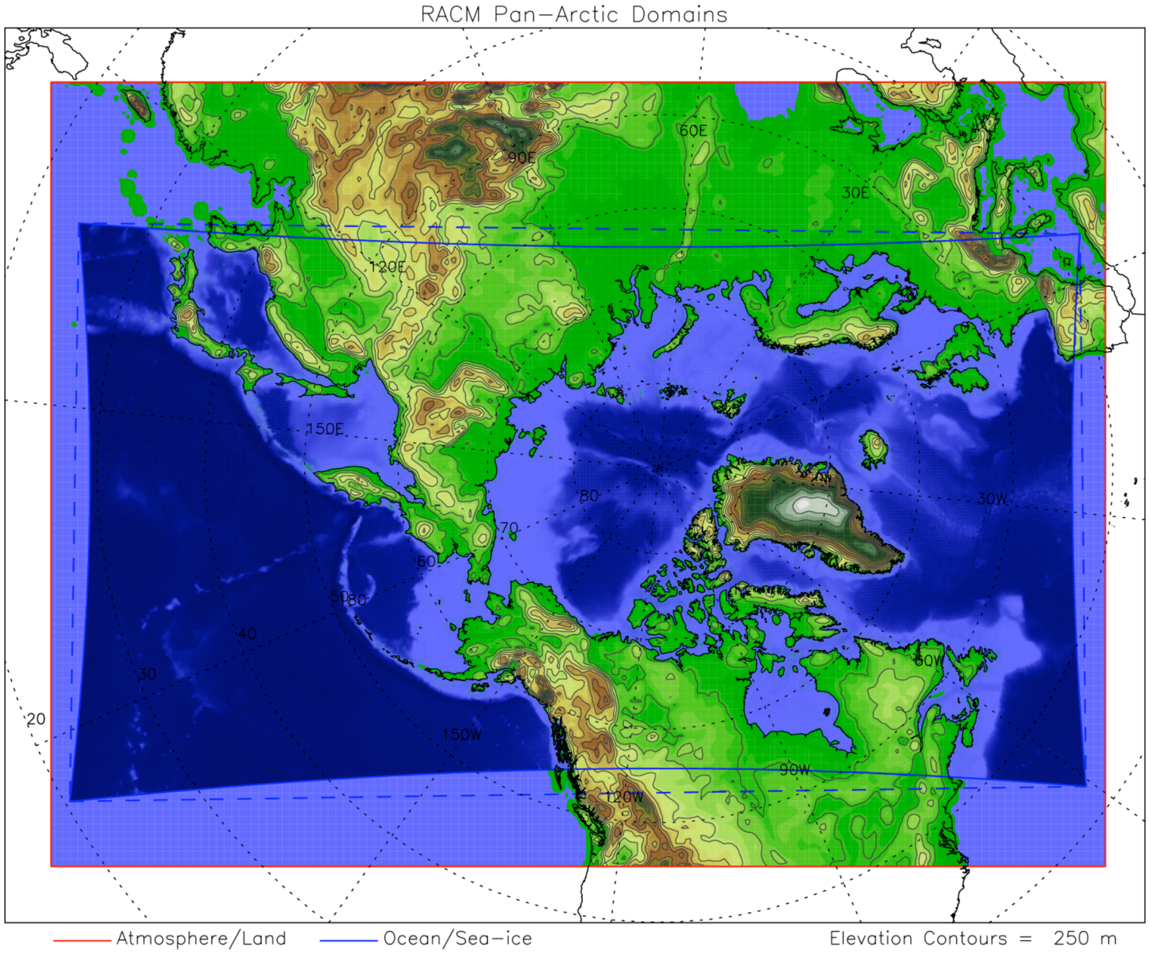

Figure 1. Model domain for the regional Arctic climate system model. The extent of the atmosphere and land model domains is shown by the red line and the extent of the ocean and sea ice model domains is shown by the solid blue line. Land topography and ocean bathymetry are given by color shading.