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TOWARDS PROCESS RESOLVING MODELING, INTEGRATED SYNTHESIS AND PREDICTION OF ARCTIC CLIMATE CHANGE

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The Arctic is a part of the Earth System influencing the global surface energy and moisture budgets, atmospheric and oceanic circulations, atmosphere-ice-ocean interactions and geosphere-biosphere feedbacks. Its sea ice cover is a key indicator of the state of global climate because of both its sensitivity to warming and its role in amplifying climate change. However, a system-level understanding of Arctic climate change and critical processes and feedbacks involved is still lacking. While the majority of existing regional Arctic models use higher resolution compared to global models, they do not account for important feedbacks among various system components. Global climate and Earth System models (GC/ESMs) have large uncertainties and limited skill in simulating and predicting the Arctic ice and snow covers, processes and feedbacks controlling them, and related high-latitude climate sensitivity. We hypothesize that such limitations are the primary reasons why GC/ESM predictions of decline of the Arctic sea ice cover under warming climate are too conservative.

To address these limitations we have developed a high resolution and limited-area analogue of the Community Earth System Model (CESM), the Regional Arctic System Model (RASM). RASM includes the Los Alamos Sea Ice Model (CICE) and Parallel Ocean Program (POP), Weather Research and Forecasting Model (WRF) and Variable Infiltration Capacity (VIC) land hydrology model coupled using the CESM flux coupler (CPL7). It is currently configured at an eddy-permitting resolution of 1/12-degree for the ice-ocean and 50 km for the atmosphere-land model components. This approach allows investigation of the importance of mesoscale processes, interactions among them, the sensitivity of modeled sea ice states to varying parameter space controlling sea ice dynamics, thermodynamics and its coupling with the atmosphere as well as direct comparison of model results with observations. In addition, the modular framework of RASM allows addition of new model components, such as marine biogeochemistry, ice-shelf/ocean interactions,

We demonstrate the capability of RASM in simulating observed seasonal to decadal variability and trends in the sea ice cover. RASM results, including realistic representation of sea ice and ocean dynamics at process scale and feedback processes between the upper ocean, sea ice and atmosphere, corroborated with observational data appear to support the importance of mesoscale processes and their feedbacks in the Arctic. In particular, a subset of RASM, where the atmospheric and land components are replaced with prescribed realistic atmospheric reanalysis data for 1948-2009, allows direct comparison of model results with observations and comparison of forced and prognostic model sensitivity to varying parameter space. Those results confirm that many parameterizations of sub-grid physical processes currently used in climate models are scale-dependent and we provide further details on fine-tuning required when changing model spatial resolution. We also show that the use of observed sea ice extent only to validate the skill of sea ice models is not a sufficient model constraint. Finally, we will discuss the ongoing work and future plans in expanding RASM modeling and predicting capability.