SENSITIVITY OF ARCTIC SEA ICE THICKNESS DISTRIBUTION TO SEA ICE INTERNAL DYNAMICS IN A CHANGING CLIMATE

EXECUTIVE SUMMARY

Changes in sea ice are a critical indicator of the climate system state. However, uncertainties exist in understanding, simulating, and predicting sea ice thickness distributions in the Arctic Ocean. In particular, the drastically thinned sea ice and more frequently occurring intense storms might have dramatically changed sea ice dynamic properties and air–ice momentum flux, raising further challenges to reducing the uncertainties. By conducting sensitivity experiments using the coupled sea ice–ocean component of the Community Earth System Model, the research team examined the interactive processes between sea ice internal dynamics and thickness distribution. The results suggest that sea ice thickness distribution is highly sensitive to the treatment of its internal force in collaboration with air–ice momentum flux. A decrease in ice strength causes more energy conversion to potential energy, leading to an increase in the ridging process and thickness but a decrease in export via the Fram Strait. A decrease in air–ice momentum flux, however, demonstrates the opposite effect.

RESULTS & IMPACT

Through examination and comparison of the results from the sensitivity experiments, the PI found that sea ice thickness distribution and sea ice motion are highly sensitive to perturbed sea ice strength prescribed in the model in collaboration with different air–ice momentum fluxes. Using a default sea ice strength defined as the ratio between loss of total sea ice energy and change in sea ice potential energy (a nondimensional parameter) is defined as 17, which is a default value commonly used in ocean–sea ice climate modeling studies. (b) and (c) are the same as (a), but the sea ice strength is reduced to 10% and 80% of its default value, respectively. The sea ice strength represents the conversion ratio between kinetic energy and potential energy of sea ice due to its dynamic deformation, which is a measure of sea ice internal force (Peng and Zhang, 2019).

WHY BLUE WATERS

Blue Waters provided a unique opportunity to conduct modeling experiments at an ultrahigh resolution. Dynamic processes associated with sea ice thickness occur at small spatial and temporal scales. The only way to solve these problems with higher accuracy is through model simulation at superhigh resolutions. Furthermore, high resolution simulations also improve the understanding of upscaling impacts on basin scale sea ice thickness distribution. In addition, synoptic-scale intense storms and the resulting large fluctuation of forcings occur at small spatial and temporal scales. The state-of-the-art climate modeling studies generally do not take this into account. The Blue Waters system and staff paved the way for successful implementation of these model experiments.

METHODS & CODES

The coupled sea ice–ocean component model of the National Center for Atmospheric Research's Community Earth System Model was employed to conduct 25 sensitivity experiments with prescribed different sea ice strengths. The model experiments were initialized using the Polar Science Center hydrographic climatology data [2] and forced by the monthly mean climatological forcing data constructed from the ERA-Interim reanalysis data set [1]. Each experiment covered a period of 100 years, allowing the sea ice and upper ocean to reach a quasi-equilibrium state.

PUBLICATIONS & DATA SETS