Developing Great Lakes Ice Model (GLIM) using CIOM (Coupled Ice-Ocean Model) in Lake Erie

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Overview

We will modify CIOM coding and model configuration in Lake Erie. The GLIM will be run for a seasonal cycle to conduct quality control assessment of the code. Additional activities to be performed include: participation in field data collection, research on new parameterization development of the ice-ocean models, assistance with development of project reports and scientific presentations, and computer system and software support. The National Weather Service has expressed interest in working with us to develop GLIM toward a nowcast/forecast system to be merged with the current GL nowcast/forecast system developed by Schwab. A working group has formed to support such implementation.

Proposed Work

We will first start the implementation of the CIOM in Lake Erie, assemble satellite observations of ice cover, and conduct model-data comparisons. A daily or hourly atmospheric forcing during winter 2004 will be used to drive the GLIM. We will compare the results with and without lake ice.

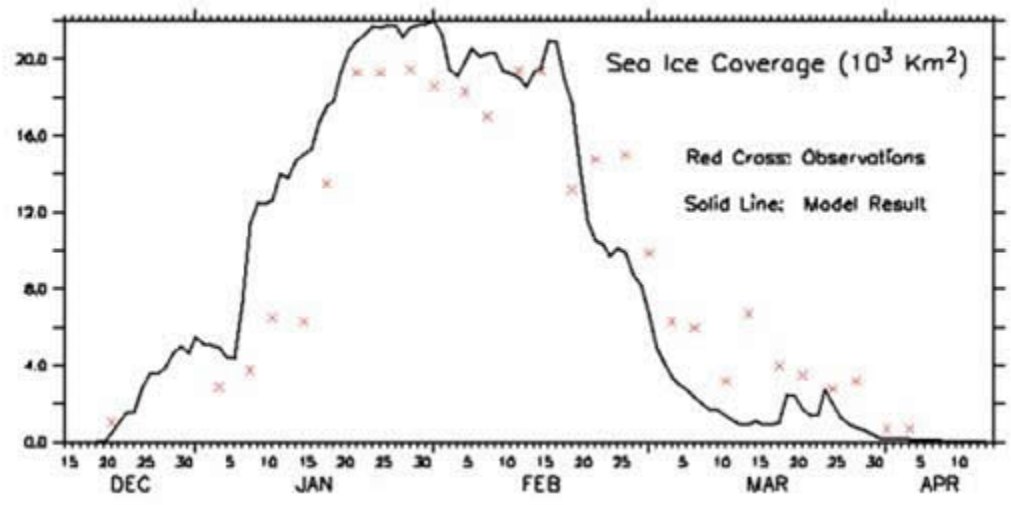

Figure 1: *Comparison of observed sea ice coverage with model results for winter 2004.*

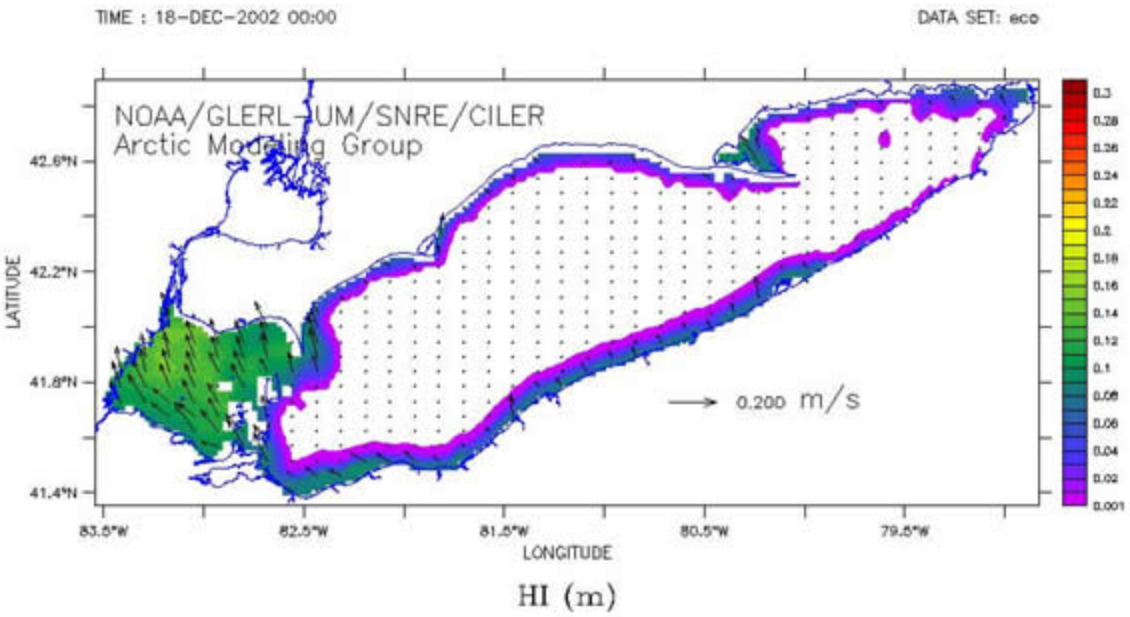

Figure 2: *Seasonal cycle of ice thickness in 2003 - December*

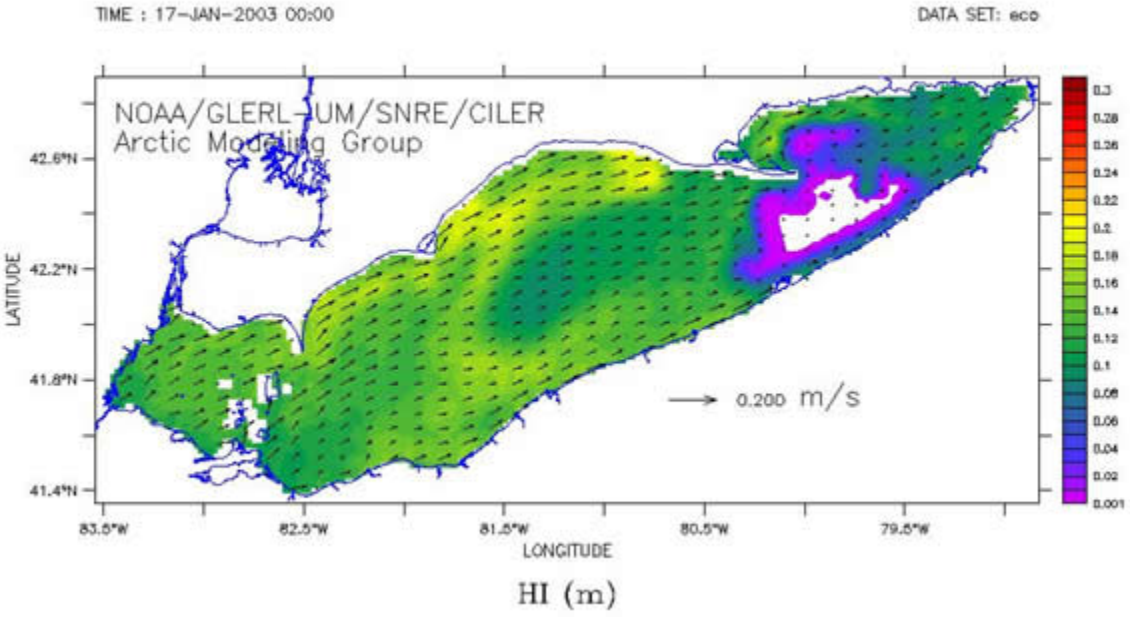

Figure 3*: Seasonal cycle of ice thickness in 2003 - January*

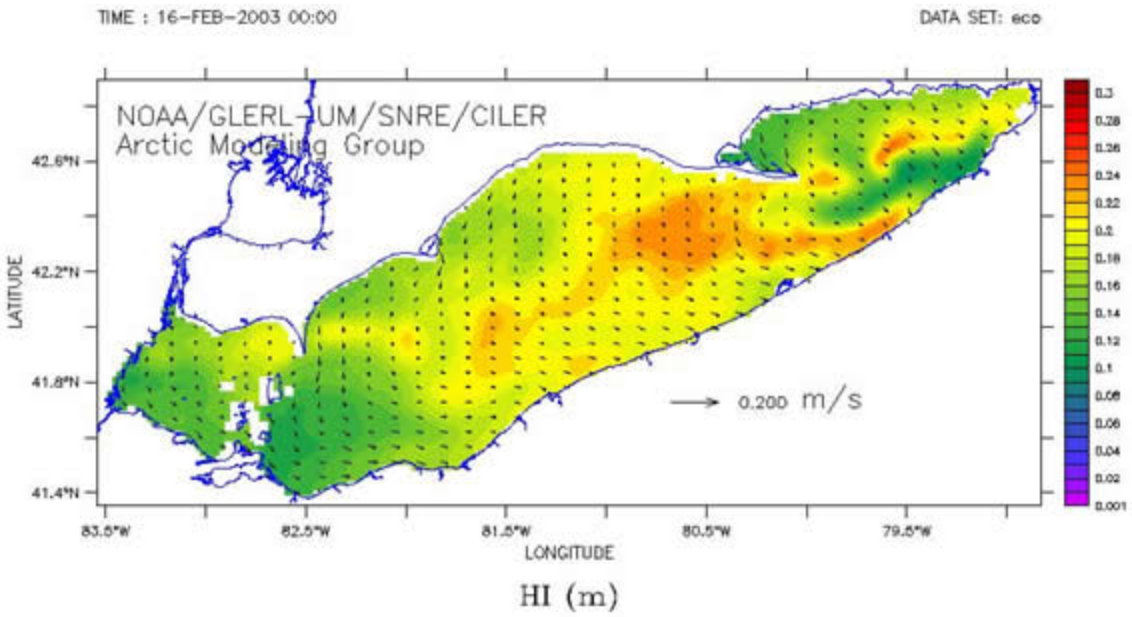

***Figure 4**: Seasonal cycle of ice thickness in 2003 - February*

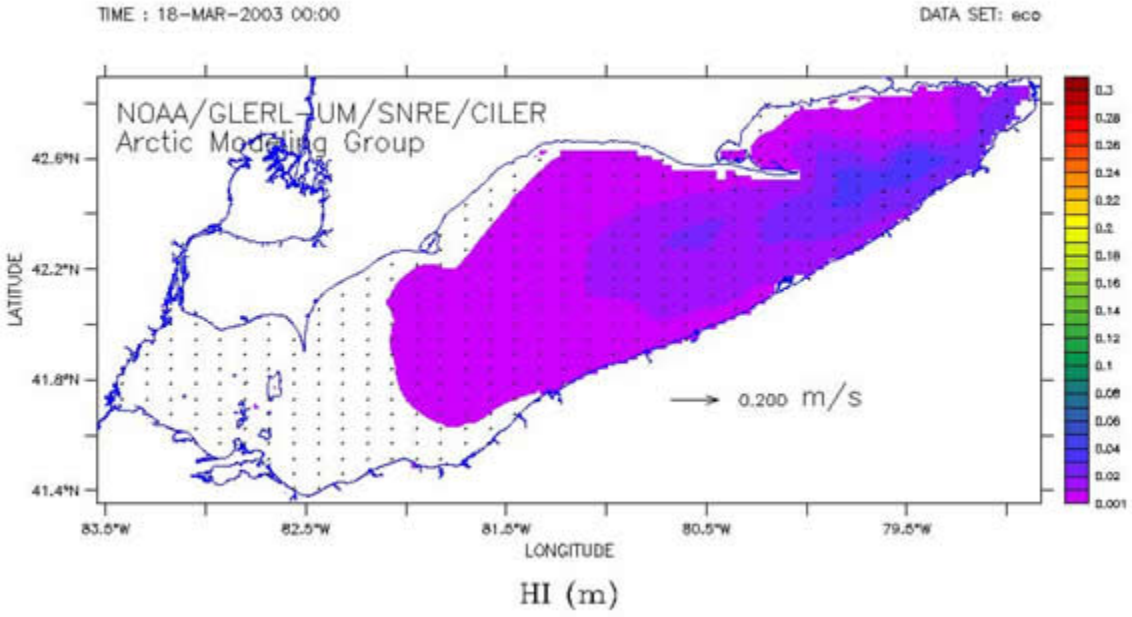

***Figure 5**: Seasonal cycle of ice thickness in 2003 - March*

Scientific Rationale

Lake ice cover is an important predictor of regional climate. Lake ice extent also modifies the circulation patterns and thermal structure because: 1) wind stress drag is different in magnitude over water surface than over ice surface; 2) the albedo over ice vs. water differs; and, 3) heat and moisture exchange between the atmosphere and the lake water can differ significantly (as much as an order of magnitude) in magnitude with and without lake ice, thus leading to striking differences in evaporation in winter due to wind mixing. Thus, prediction of the lake ice extent (i.e., cover) is crucial for predicting the mixed layer, circulation, temperature, and lake water level, and for predicting primary and secondary productivity. In addition, the timing of ice melting, determined by climate variability, will determine the timing of phytoplankton and zooplankton blooms. As a result, lake ice conditions in Lake Erie will be simulated with atmospheric forcing on synoptic and seasonal time scales (winter of 2004-2005). It is inadequate to use a hydrodynamic-only model to examine the lake hydrodynamics, thermodynamics, and ecosystem dynamics in the Great Lakes. This is in part because sea ice dynamics and thermodynamics control the water temperature, heat flux, and water column stratification, which are very important factors controlling the phytoplankton blooms.

Governmental/Societal Relevance

Knowledge of the lake ice dynamics and thermodynamics in the Great Lakes is important not only to winter navigation, recreation safety, and rescue efforts, but also to prediction of lake circulation, water level variability, and environmental preconditioning for phytoplankton and zooplankton blooms.

Relevance to Ecosystem Forecasting

Incorporation of a lake ice model into the circulation models of the lakes is one of the next goals of the physical modeling effort at GLERL. The results from this project will aid this effort by providing knowledge of the important processes in lake ice affecting lake circulation and ecosystems in the lakes.

Products

Presentations

Wang, J. 2008. *Projections of the Great Lakes climate in the 21st century and coupled lake - ice modeling*, Workshop of Impact of Climate Change on the Great Lakes Ecosystems, July 19-22, Ann Arbor, MI (invited)

Wang, J. and H. Hu, *Development of the Great Lakes ice model (GLIM)*. IAGLR's 51st Annual Conference on Great Lakes Research, May 19-23, 2008, Peterborough, Ontario

Publications

Wang, J., H. Hu, D. Schwab, D. Beletsky, A. Clites, and G. Leshkevich, Development of the Great Lakes ice-circulation model (GLIM): application to Lake Erie in 2004 (submitted to *Journal of Great Lakes Research*)

References

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Wang, J., C. Deal, Z. Wan, M. Jin, N. Tanaka and M. Ikeda, 2003. User's Guide for a Physical-Ecosystem Model (PhEcoM) in the Subpolar and Polar Oceans, *International Arctic Research Center-Frontier Research System for Global Change*, Tech. Rep. 02-02, 69 pp.

Wang, J., R. Kwok, F.J. Saucier, J. Hutchings, M. Ikeda, W. Hibler III, J. Haapala, M.D. Coon, H.E.M. Meier, H. Eicken, N. Tanaka, R. Prentki, and W. Johnson, 2003. Working towards improved small-scale sea ice and ocean modeling in the Arctic seas. *EOS*, AGU, Vol . 84 (34), 325, 329-330.

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