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FUTURE STATES OF THE ARCTIC OCEAN USING A COUPLED ICE-OCEAN MODEL WITH PROBABILITY DISTRIBUTION FUNCTION

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As global warming proceeds, ice formation is decreasing especially over the shelf areas off Russia and in the Barents Sea. The Atlantic Water flows into the Arctic Ocean and is modified under ice formation, a decrease in which is thought to affect the density of the middle layer around 200 to 500-m depth in the Arctic Ocean. Then, the upper layer may be convected with the middle layer more easily. However, a careful modeling strategy is required for the prediction, because either nonconvected or convected state tends to appear in a model with low horizontal resolution. An extremely high resolution model may be required to represent a chimney, which grows under a salt input from sea ice and tends to mix the upper and middle layers vertically, but needs model development and computer resources.

A new modeling approach is proposed for representing the Arctic Ocean so that a low resolution model may predict the future state appropriately. A simple box model, built as a reference with the lowest horizontal resolution, has one active box for the upper layer, which interacts with the saltier box for the Greenland Sea and the lower box for the middle layer in the Arctic Ocean. The active box has sea ice and receives atmospheric forcing and freshwater flux, while the other boxes have their properties fixed. The active box possesses a salinity-driven state, at which the saltier water enters the active box, is freshened, and becomes lighter. The lower box provides another solution: a convected state.

The new component to the simple model is a probability distribution function (PDF) on the temperature–salinity (*T*–*S*) plane for the active box. The PDF represents heterogeneity in a horizontal plane. A *T*–*S* distribution retains only the probabilities of different water types, while their locations are discarded. The mechanisms to increase and reduce heterogeneity are modeled by divergence and convergence of the PDF on the *T*–*S* plane, respectively. The heterogeneity is generated by the intrusion of exterior water as well as variability in the atmospheric forcing and freshwater flux, while the heterogeneity is reduced by horizontal diffusion within the box. Convection with the lower box tends to concentrate the PDF to the lower box (*T, S*).

Under the exterior condition that could produce both nonconvected and convected states in the simple model, there is only one partly convected state in the probability model. This intermediate state becomes more probable, as the convected state appears more closely to the nonconvected state. It is suggested that the Arctic upper layer will be partly convected and have sea ice reduced significantly in the near future.

Reference

Ikeda, M., 1997: *J. Phys. Oceanogr.*, **27**, 2576-2589.