Development of a Model for Water and Heat Exchange between the Atmosphere and a Water Body

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A model for studying the heat and mass exchange between the atmosphere and a water body is developed, in which the phase change process of liquid water-ice-snow system freezing in winter and melting in summer and the function of the convective mixing process are taken into consideration. The model uses enthalpy rather than temperature as the predictive variable. It helps to set up governing equations more concisely, to deal with the phase change process more easily, and make the numerical scheme simpler. The model is verified by observed data from Lake Kinneret for a non-frozen lake in summer time, and Lake Lower Two Medicine for a frozen lake in winter time. Reasonably good agreements between the model simulations and observed data indicate that the model can serve as a component for a water body in a land surface model. In order to more efficiently apply the scheme in a climate system model, a sensitivity study of various division schemes with less layers in the vertical direction in the water body is conducted. The results of the study show that the division with around 10 vertical layers could produce a prediction accuracy that is comparable to the fine division with around 40 layers.