WIND-DRIVEN CIRCULATION IN A SMALL SHALLOW LAKE: EFFECTS OF WEAK STRATIFICATION AND LITTORAL-ZONE VEGETATION

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Wind-driven circulation is one of primary hydrodynamic processes in lakes. It is responsible for spatial heterogeneity of water quality, and plays an important role in nutrient transport for aquatic lives. In small shallow lakes, the circulation can be largely affected by some distinctive physical and biological characteristics of the lake.

The objective of this study is to examine wind-driven circulations during a weakly stratified period (with vertical temperature differential of order 1 ^oC over 3 m depth), in a small sheltered lake with a large portion of littoral-zone vegetation (about 30 percent to the surface area). A three-dimensional non-hydrostatic model [1], in combination with a generic length scale approach [2] for turbulence closure and a drag force model [3] for vegetation simulation is developed. Extensive field experiments were conducted to measure three-dimensional velocity and temperature fields, and spatial wind patterns. Three model scenarios are chosen to in turn examine the role of weak stratification and littoral-zone vegetation in three-dimensional circulations.

Comparison of model results and field data shows that the barotropic conidition (Scenario 1) leads to an unsatisfied agreement in velocity profiles, while the inclusion of weak stratficiation (Scenario 2) significantly impoves the agreement especially in the open water region. If littoral-zone vegetation is included (Scenario 3), the model predicts that flows are retarded inside the littoral zone, depending on the density of vegetation. This predicted local effect is consistent with findings from laboratory experiments [3]. At regions outside but close to the littoral zone, the model result also shows an evident effect from vegetation. This space-limited effect, determined by density and spatial distribution of vegetation, is responsible for further improving the model result at regions near the littoral zone. Overall, this study shows that both weak stratification and littoral-zone vegetation can be of fundamental importance to wind-driven circulations in small shallow lakes, and their effects can by no means be ignored.

References

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