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Modeling the 1998–2003 summer circulation and thermal structure in Lake Michigan

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[1] A three-dimensional primitive equation numerical model was applied to Lake Michigan on a 2 km grid for 6 consecutive years to study interannual variability of summer circulation and thermal structure in 1998–2003. The model results were compared to long-term observations of currents and temperature at seven moorings and two NOAA buoys. The accuracy of modeled currents improved considerably relative to previous summer circulation modeling done on a 5 km grid, while the accuracy of temperature simulations remained the same. Particle trajectory model results were also compared with satellite-tracked surface drifter observations. Large-scale circulation patterns tend to be more cyclonic (counterclockwise) toward the end of summer as the thermocline deepens and density effects become more important. Circulation in southern Lake Michigan appears to be more variable than circulation in northern Lake Michigan. An important new feature not previously seen in observations was found in southern Lake Michigan: an anticyclonic gyre extending northward from the southern shore of Lake Michigan, sometimes occupying the entire southern basin.

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1. Introduction

[2] The current knowledge of circulation patterns and thermal structure in the Great Lakes is still somewhat fragmentary despite significant progress in numerical modeling of lake hydrodynamics [*Beletsky and Schwab*, 2001]. Lake circulation climatology and interannual variability are still distant goals which will require many more simulations and observations than are currently available. Growing computer power allows us to move closer to these goals and also helps to describe medium and small scale processes better due to increased model resolution. This is especially true for the horizontal resolution improvement which is crucial for accurate modeling of lake hydrodynamics in summer when the Rossby radius of deformation is on the

(LMMBS), thermal structure and circulation in the lake were modeled on a 5 km grid in 1982–1983 and 1994–1995 [*Beletsky and Schwab*, 2001]. Next, the same model was applied to Lake Michigan on a 2 km grid as part of the Episodic Events – Great Lakes Experiment (EEGLE) to study cross-margin transport of biogeochemically important materials during storm events in 1998–2000 [*Beletsky et al.*, 2003]. Finally, the 2001–2003 circulation and thermal structure were modeled in the course of a larval fish transport study [*Beletsky et al.*, 2004] with a particular focus on summer months (June–August).

[4] While model results for unstratified conditions were successfully tested against field observations in 1998, results for summer circulation and thermal structure have not yet been reported. The 2 km model results showed an