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FLake – A Lake Model for Environmental Applications

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Abstract

A lake model for environmental applications is developed. The model, termed FLake (http://nwpi.krc.karelia.ru/flake/index.htm), is capable of predicting the vertical temperature structure and mixing conditions in lakes of various depth on time scales from a few hours to a year. It is based on a two-layer parametric representation of the evolving temperature profile and on the integral budgets of heat and kinetic energy for the layers in question. The structure of the stratified layer between the upper mixed layer and the basin bottom, the lake thermocline, is described using the concept of self-similarity (assumed shape) of the temperature-depth curve. The same concept is used to describe the temperature structure of the thermally active upper layer of bottom sediments and of the ice and snow cover. The result is a computationally efficient bulk model that incorporates much of the essential physics. Empirical constants and parameters of FLake are estimated, using independent empirical and numerical data. They should not be re-evaluated when the model is applied to a particular lake (there are, of course, lake-specific external parameters, such as depth to the bottom and optical properties of water, but these are not part of the model physics). In this way, FLake does not require re-tuning, a procedure that may improve an agreement of model results with a limited amount of data but should generally be avoided as it greatly reduces the predictive capacity of a physical model. In order to compute fluxes of momentum and of sensible and latent heat at the lake surface, a parameterization scheme is developed that accounts for specific features of the surface air layer over lakes. The new lake model and the new surface-layer parameterization scheme are favourably tested against observational data through single-column numerical experiments.

Various applications of the new lake model are discussed. As a lake parameterization module, FLake is implemented (Mironov et al. 2005) into the limited-area numerical weather prediction system LM run operationally at the German Weather Service, Offenbach am Main, Germany. It is also implemented into the regional climate modelling systems CLM, run at GKSS Research Centre, Geesthacht, Germany, and RCA, run at Swedish Meteorological and Hydrological Institute, Norrkoping, Sweden. As a single-column lake model, FLake is used to assess the response of shallow lakes to climate variability (Kirillin 2003). It is also used as a physical module in models of lake ecosystems (Golosov et al. 2004, Maher et al. 2004) and as an educational tool (Braslavski 2004).