Simulations of climate effects on water temperature, dissolved oxygen, and ice and snow covers in lakes of the contiguous U.S. under past and future climate scenarios

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ABSTRACT: Daily water temperature, dissolved oxygen (DO) profiles, and ice and snow covers (where applicable) were simulated for 27 types of small lakes (up to 10 km² surface area) at 209 locations in the contiguous United States under past climate (observed from 1961 to 1979) and for projected doubled atmospheric carbon dioxide ($2^{\times}CO_2$) climate conditions. A verified, process-oriented, dynamic, and one-dimensional year-round lake water quality model (MINLAKE96) was applied to simulate water temperature and DO profiles continuously in daily time steps over a 19-yr simulation period. This regional lake model has no geographic constraints on the model's physical and chemical processes, but the climate forcing is a function of geographic location. Model calibration parameters and initial conditions are correlated to lake geometry, trophic state, and location. The $2^{\times}CO_2$ climate scenario is projected to increase lake surface temperatures by up to 5.2° C when the climate scenario projects an increase of mean annual air temperature up to 6.7° C. The $2^{\times}CO_2$ climate scenario is projected to increase the duration of seasonal summer stratification by up to 67 d, to shorten ice cover by up to 90 d, and to reduce the maximum ice thickness by up to 0.44 m. Under a $2^{\times}CO_2$ climate scenario, lake anoxia during the period of ice cover is projected to shorten so that fish winterkill can be avoided, but the periods of hypolimnetic summer anoxia are projected to lengthen. These projected changes will have many significant effects on ecological conditions and aquatic habitats in lakes in the contiguous United States.