Turbulent mixing and phytoplankton spring bloom development in a deep lake

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ABSTRACT: A one-dimensional (1-D) mechanistic phytoplankton model combined with a 1-D hydrodynamic model was applied to simulate phytoplankton growth during winter and spring in deep monomictic Upper Lake Constance. Modeled chlorophyll a concentrations agree well with data from the 8-y time period considered. In particular, the interannual variation in the timing of phytoplankton growth is adequately simulated by the model. The onset of phytoplankton blooms in Upper Lake Constance is not sensitive to variations in the photosynthetically active radiation, the sinking velocity of the algae, or the effect of water temperature on biological process rates, but is primarily determined by turbulent diffusion (i.e., by the transition from strong mixing in winter and early spring to weak mixing). The transition in mixing conditions and thus also the beginning of phytoplankton population growth correlates with the build up of the first slight temperature stratification. Simulations performed without consideration of phytoplankton loss due to grazing overestimate algal biomass soon after the onset of algal growth. Including grazing by zooplankton substantially improves the agreement between model and data and suggests that ciliate grazing in particular leads to a significant reduction of phytoplankton abundance in spring after the start of the algal bloom.

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