The role of turbulent mixing for the success of the cyanobacterium Microcystis aeruginosa in a hypertrophic freshwater lake

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Abstract

There is an increasing awareness among aquatic ecologists that in most planktonic ecosystems, the magnitude of turbulent mixing is one of the key determinants for the success of a particular species or phytoplankton group. Here, we combine a recently improved Lagrangian particle tracking model with a species-specific photosynthesis model to examine the effect of turbulent mixing on the cyanobacterium *Microcystis aeruginosa*. The biological-physical model was set-up with and compared to *in situ* observations from a lake experiment, in which the turbulence structure of the entire lake was manipulated using artificial mixing. Vertical eddy diffusivities were calculated based on the measured temperature microstructure in the lake. At low turbulent diffusivities the buoyant and potentially toxic cyanobacterium *Microcystis aeruginosa* dominated the lake, whereas sinking diatoms and green algae prevailed at high turbulent diffusivities. The model clearly reproduces the decline of *Microcystis* with increasing turbulence and elucidates the underlying causes. We show that turbulence is not detrimental to *Microcystis per se* but the turbulent intensity needs to be above a certain threshold in order to have a negative effect on the growth of *Microcystis*. In fact, *Microcystis* shows a positive response to increases in the turbulent diffusivity until about 10^{-3} $m^2 s^{-1}$. Further increases beyond this threshold have a negative effect, however, leading to a rapid decline in light availability and thus photosynthetic performance. These findings underline the importance of turbulence in natural waters as a key discriminator in phytoplankton species competition and an important driver for the phytoplankton community structure.

Keywords: individual based modelling · *Microcystis* · turbulence · temperature microstructure · Péclet number · harmful algae · Lagrangian modelling · vertical migration

Introduction

Turbulent mixing affects planktonic organisms in various ways, ranging from the supply of nutrients to the individual cell (Munk and Riley, 1952; Osborn, 1978; Csanady, 1986), the