Effects of large scale advection and small scale turbulence on vertical phytoplankton dynamics

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When studying the life cycle of phytoplankton frequently one is interested in the survival or death conditions of a population (bloom/no bloom). These dynamics have been studied extensively in the literature through a range of modelling scenarios but in summary the main factors affecting the vertical dynamics are : Water column mixing intensity, solar energy distribution, nutrients availability and predatory activity. The later two can be represented by different biological models whereas the vertical mixing is usually parameterized by a diffusive process. Even though turbulence has been recognized as a paramount factor in the survival dynamics of sinking phytoplankton species, dealing with the multi scale nature of turbulence is a formidable challenge from the modelling point of view. In addition, convective motions are being recognized to play a role in the survival of phytoplankton throughout winter stocking [2]. With this in mind, in this work we revisit a theoretically appealing model [1] for phytoplankton vertical dynamics with turbulent diffusivity and numerically study how large-scale fluid motions affect its survival and extinction conditions. To achieve this and to work with realistic parameter values, we adopt a kinematic flow field to account for the different spatial and temporal scales of turbulent motions. The dynamics of the population density are described by a reaction-advection-diffusion model with a growth term proportional to sun light availability. Light depletion is modelled accounting for water turbidity and plankton self-shading ; advection is represented by a sinking speed and a two-dimensional, multi scale, chaotic flow. Preliminary results show that under appropriate conditions for the flow, our model reproduces past results based on turbulent diffusivity. Furthermore, the presence of large scale vortices (such as those one might expect during winter convection) seems to hinder survival, an effect that is partially mitigated by turbulent diffusion.

Références

1. J. Huisman *et al.* , How do sinking phytoplankton species manage to persist ?, *The American Naturalist*, **3**, 245–254 (2002).
2. J. O. Backhaus *et al.* , Convection and primary production in winter, *Marine Ecology Progress Series*, **251**, 1–14 (2003).