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Statistical properties of plankton ecosystems in turbulent flows

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Plankton plays a crucial role in marine ecology in the oceans. Various factors influence its distribution, such as availability of light, the presence of nutrients, and the ocean circulation which advects, stirs and mixes the plankton ecosystem. In this work we examine a number of plankton ecosystem models coupled to a two-dimensional turbulent flow, which is characteristic of large scale flows in the ocean. We assess the relative importance of the biological and fluid dynamical parts of the flow which can be characterized by the ratio of the typical timescales associated with the ecosystem biological processes T_B (such as plankton growth rate), and the fluid advection T_F. Specifically we look at how statistical properties such as the mean and the variance of the plankton concentrations are affected by changes in the ratio T_B/T_F for a few different ecosystem models. We perform numerical simulations for a range of values of T_B/T_F. When T_B/T_F is small, the biological processes are much more rapid than the flow circulation and the overall behaviour is controlled by the biological processes. Conversely, when T_B/T_F is large the effects of the flow circulation are paramount. An analytical study is made for these two limiting cases and compared with the numerical results.