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Critical turbulence revisited: the impact of geophysical turbulence on three-dimensional plankton distribution patterns

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Spatial heterogeneity or ‘patchiness’ in phytoplankton distributions is ubiquitous in the marine biosphere. Although this phenomenon has been known for a very long time, there is still a vivid discussion about its causes. Until recently, the focus was on the role of horizontal stirring and mixing [1]. Vertical transports, however, play a crucial role by supplying nutrients (that are necessary for plankton growth) from the deep ocean. Large vertical transports particularly occur in regions with frontal dynamics. To investigate the relationship between such vertical transports and plankton distributions, we simulated a phytoplankton population in a submesoscale eddy. In this eddy, strong vertical transports are generated as a consequence of baroclinic instability which are responsible for a large increase in the total biomass [2]. In the plankton model, there are three state variables: living biomass, biomass detritus, and nutrient. The local biomass growth rate depends on the nutrient concentration and the light intensity according to Michaelis-Menten kinetics. Because no maintenance and reserves are included, the model belongs to the Monod-family of models. The simulated plankton distributions turn out to depend strongly on the light intensity and local vertical transport. From these three-dimensional simulations, we have identified a novel mechanism for the generation of phytoplankton patchiness. Details of this mechanism, which uses an extension of the critical turbulence concept [3], are presented using more idealised hydrodynamic models.

References:

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