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Horizontal advection, diffusion and plankton spectra at the sea surface.

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Plankton patchiness is ubiquitous in the oceans, and various physical and biological processes have been proposed as its generating mechanisms. However, a coherent statement on the problem is missing, due to both a small number of suitable observations and to an incomplete understanding of the properties of reactive tracers in turbulent media. Abraham (1998) suggested that horizontal advection may be the dominant process behind the observed distributions of phytoplankton and zooplankton, acting to mix tracers with longer reaction times (Rt) down to smaller scales. Conversely, Mahadevan and Campbell (2002) attributed the relative distributions of sea surface temperature and phytoplankton to small scale upwelling, where tracers with longer Rt are able to homogenize more than those with shorter reaction times. Neither of the above mechanisms can explain simultaneously the (relative) spectral slopes of temperature, phytoplankton and zooplankton. Here, with a simple advection model and a large suite of numerical experiments, we concentrate on some of the physical processes influencing the relative distributions of tracers at the ocean surface, and we investigate:
1) the impact of the spatial scale of tracer supply;
2) the role played by coherent eddies on the distribution of tracers with different Rt;
3) the role of diffusion (so far neglected).
We show that diffusion determines the distribution of temperature, regardless of the nature of the forcing. We also find that coherent structures together with differential diffusion of tracers with different Rt impact the tracer distributions. This may help in understanding the highly variable nature of observed plankton spectra.