Experimental characterization of relative dispersion of buoyant materials at the ocean surface in a coastal environment



Ocean numerical models discretize the equations of fluid dynamics on a grid, which requires parameterizing the processes at scales smaller than the resolved grid size. In particular, the horizontal transport of tracers by sub-gridscale processes is commonly parameterized with a tracer flux proportional to the product of the large-scale (resolved) tracer gradient and a turbulent diffusivity coefficient.

Values for the latter must be determined experimentally, and have been shown to be proportional to the distance separating dispersing water parcels raised to a power close to 4/3 (Richardson, 1926). This has been verified recently in the Lower St. Lawrence estuary by releasing a fluorescent tracer (rhodamine-WT) at the surface and following its drift and dispersion using surface drifters and pictures taken from a drone.

The power of 4/3 is expected when the kinetic energy spectrum of turbulent motions follows a slope of -5/3 in wavenumber, which corresponds to the inertial range of three-dimensional (3D) isotropic and homogeneous turbulence or of 2D turbulence in the energy cascading range. However, the kinetic energy spectrum of 2D turbulent motions in the enstrophy cascading range follows a slope of -3 in wavenumber, and should lead to a different relationship between turbulent diffusivity and distance separating dispersing water parcels. This regime should be relevant for buoyant materials at the sea surface, such as oil and plastic debris, at horizontal scales smaller than the surface mixed-layer deformation radius at which kinetic energy is injected by mixed-layer instabilities.

Rhodamine-WT was observed to rapidly mix within the surface layer and did not remain at the surface. Therefore, new experiments using buoyant materials will be required to quantify the relationship between turbulent diffusivity and distance separating dispersing water parcels for this particular turbulence regime. In addition, the impacts of surface fronts and Langmuir turbulence on the horizontal dispersion of buoyant materials will be investigated.

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