The nonhomogneous vertical distribution of small neutrally buoyant particles in a convective ocean-mixed-layer model.

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Approximately 20 million tons of plastic enter the ocean each year [1]. The study of the fate and transport of microplastics is complex since it involves several physical processes at different scales. It is unclear where and under what processes plastics entering the ocean are transported and redistributed. In this work we investigate the transport and vertical concentration profiles of neutrally buoyant microplastics through direct numerical simulations of small particles in an inhomogeneous turbulent flow. Using an idealized two-dimensional convective mixed-layer model [2], we reproduce some relevant features of the upper ocean flow : at the surface, a well-mixed region where temperature and density gradients almost disappear, and a lower region where a strong stratification in temperature and density develops.

The dynamics of these inertial particles in both the well mixed and stratified regions are analyzed using a simplified model derived from the Maxey-Riley-Gatignol equation [3,4]. This model assumes particle density (ρ_p) equal to a reference flow density (ρ_0) at a given depth, with density variations considered only when they influence buoyancy (i.e., the Boussinesq approximation) [5]. Our results show that particle accumulation is influenced by temperature differences along Lagrangian paths, which determine whether particles settle at specific depths or remain near the surface (See Fig 1). A theoretical prediction for the vertical concentration profiles, derived from the particle mass conservation equation, further reveals that while gravity has a pivotal role on particle transport and accumulation, the fluid's eddy diffusivity can also have non-negligible effects on the spreading of particles, depending on the physical properties of the latter.

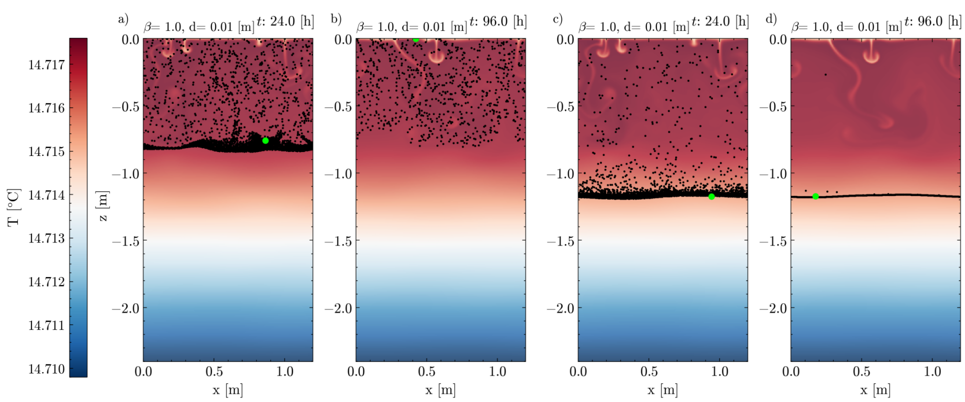

Figure 1. Evolution of temperature field and particle distribution after 24 and 96 h.The particle density equals the average density in the mixed layer in a), b), and the average surface temperature in c), d).

References

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