Interactions between plankton and turbulence

Eric CLIMENT
Institut de Mécanique des Fluides de Toulouse - UMR5502 CNRS/INPT/UPS
Contact : eric.climent@imft.fr

Phytoplankton are responsible for around 50% of the world's oxygen production and form the basis of the food chain in the marine environment. A detailed understanding of the physical mechanisms driving gyrotactic species to migrate vertically towards the surface allows better quantification of biogeochemical fluxes across the ocean.
Plankton microorganisms, cells of micron size, have the ability to move independently, swimming from a few tens to several hundred microns/second. Observations at sea suggest that chain swimming could confer an ecological advantage for certain species alternately in search of light on the surface and nutrients at depth.

Our simulation model combines two phenomena: the direct numerical resolution of the equations governing the movement of a turbulent flow and the tracking of trajectories (fig. 1) of several hundred thousand microorganisms (individual or in the form of a chain of cells). Statistical analysis of the data reveals that at moderate turbulence intensity - typically one to a few meters below the waves - it is more efficient to move in a chain rather than to remain isolated (the gain is a factor 2 for a chain of 8 to 16 individuals). Besides the intuitive mechanism of reducing chain drag as cumulative propulsion is increased, simulations revealed two other much less trivial mechanisms.

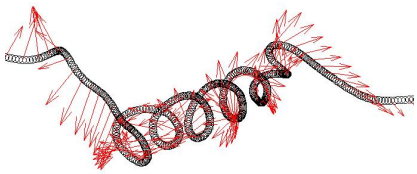

Figure 1 : Trajectory of a phytoplankton microorganism passing through a vortex tube in a turbulent flow. The arrows indicate the instantaneous direction of the swimming speed.

At the end of the talk, I will present some recent experimental results on the effect of microplastic pollution on the swimming dynamics of copepods in a fluid at rest and in a turbulent flow (collab. S. Souissi, FG Michalec - LOG Wimereux).

References

Chain formation can enhance the vertical migration of phytoplankton through turbulence. S. Lovecchio, E. Climent, R. Stocker and W. M. Durham. (2019) *Science Advances.* 5, eaaw7879.

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