Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur Lille Nord-de-France - 072

Title : Numerical simulation of phytoplankton transport in turbulent flows by means of kinematic and LES models

Fellowship: PhD scholarship from Université de Lille, starting in October 2018, 3 years

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Team : Mécanique des Fluides Complexes (MFC)

Description :

Context and objective:

Reaction transport systems emerge in many areas of research and applications as, e.g.: chemical reaction kinetics in fluids, plankton dynamics, infection spreading. While the dynamics of reacting species have been widely studied in homogeneous media, their understanding in heterogeneous environments, particularly relevant for ecological problems, is still limited. In this project we propose to elucidate, by means of numerical simulations of advection-reaction-diffusion systems, the complex interplay between environmental heterogeneity (due to resource limitations, such as light availability in the water column in the sea or in a lake) and transport by a fluid flow, which controls the appearance of *phytoplankton blooms in stirred aquatic environments*.

The focus is on the role of spatially structured flows and turbulent mixing on growth and persistence of algal populations, as well as on the resulting detailed vertical/horizontal population distribution. To investigate these issues, turbulent flows arising from Large-Eddy-Simulation (LES) models of Navier-Stokes equation or kinematic models will be considered. Such an approach is expected to allow access to the details at different scales of the interacting mechanisms that determine phytoplankton dynamics. Due to the wide range of spatial and temporal scales involved, this represents a highly challenging task and it constitutes the main original aspect of the project. For the purpose of enhancing biological and physical realism, model complexity will be gradually increased. By analysing the temporal behaviour of the adopted model systems it will eventually be possible to explore the mechanisms controlling the onset of environmental conditions acting as precursors of algal blooms.

This study is expected to provide insights on how to better account for the complexity of fluid motions, with respect to the population dynamics models typically used in fundamental and applied studies at scales larger than the spatial (turbulent) structures of the flow. In particular, we aim at characterizing the main effects due to turbulent fluctuations and, hence, at the possibility to account for a richer phenomenology. Results will then be useful to establish new constraints for improving food web models in marine ecology. Ameliorating the possibility to predict and, potentially, control phytoplankton blooms also has a major societal impact, e.g. for the management of the anthropogenically induced eutrophication (enhanced algal growth due to excess nutrients) of freshwater and coastal marine ecosystems.

Candidate: Candidate having good knowledge of fluid mechanics or dynamical systems and an interest for numerical methods; education: Master in Fluid Mechanics, Physics, Applied Mathematics. Good knowledge of oral and written English is required. Knowing Fortran, C or Python would be a plus.