Title: Predictability of the marine litter drift and turbulent dispersion in coastal environments

Fellowship : PhD scholarship from Région Hauts de France, starting in October 2020, 3 years

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Context and goal: The problem of ocean pollution by macro- and micro-plastic litter has become a global problem. The world produces 300 million tons of plastic annually. About 2% of this plastic (8 million tons) arrives to the ocean. A very small amount of this plastic waste (~ 1%) floats at the sea surface. Half of this amount is concentrated in large sub-tropical gyres, while the other half is completely dispersed. As a consequence, we have little knowledge about the fate of the remaining 99% plastic litter. Where is it going? Where is it concentrated? How is it dispersed?

This project aims to develop a new methodology for forecasting the transport and dispersion of macro- and micro-plastic litter drifting with currents in marine coastal environments in order to manage pollution risks and their mitigation. The characterization and short-term forecast (a few days) of the spatio-temporal distribution of the material transported by sea currents will be made on the basis of a synergy between two types of Lagrangian monitoring: the tracking of real drifting buoys and that of synthetic Lagrangian tracers advected by surface ocean flows from numerical regional models or experimental measurements. In particular, Lagrangian trajectory data will be obtained using a novel approach based on the tracking of virtual tracers transported by surface velocity fields measured by high-frequency (HF) radars. Presently, the HF radar is a unique technology capable of providing surface velocities in near real time over large areas extending up to 150 km offshore. Indeed, it can potentially provide a velocity field with spatial resolution of order 1 km and temporal resolution of about 1 h. As for the Lagrangian analysis, several indicators will be used: (a) one-particle statistics, apt to characterize the transport by the mean, most energetic, flow component; (b) multiple particle statistics that can provide access to processes governed by velocity gradients, like relative dispersion. It is also envisaged to extend such an approach to obtain dispersion rate maps, which can be used to identify Lagrangian coherent structures characterizing convergence or divergence zones of the flow. Different European sites (in the Mediterranean sea, in the North sea and in the Atlantic ocean) will be considered. A particular emphasis will be put on the analysis of seasonal variability and its possible impact on the dispersion process.

This study is expected to provide statistical information on the main space-time features (as, e.g., the location and evolution of fronts and eddies) of the currents in the selected areas. Furthermore, it will allow to determine the statistical properties of the turbulent dispersion process at different (temporal and spatial) scales and to identify different dynamical regimes (i.e. more/less energetic turbulence). These estimates can be used to characterize the marine litter spreading and its spatio-temporal variability (to identify areas of large litter dispersion or, on the contrary, of litter accumulation). They are an essential element in view of improving the forecasting capability of numerical models.

The planned research is inscribed in the efforts aimed at responding to the widespread concern about the pollution of the marine environment due to anthropic pressure, and its impact on marine ecology.

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