# Surface Mixing and Biological Activity in The North African Upwelling

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**Abstract**

Near-shore water along The North African margin represent one of the world's major upwelling regions. It is characterized by a high productivity of plankton associated with large commercial fisheries. Being characterized by physical structures of oceanic front such as eddies and filaments that influence the biological productivity, the study of these physical oceanic structures in connection with the chlorophyll has a fundamental importance for understanding how the plankton distributions is controlled. The aim of this work is to study the horizontal stirring and mixing in the upwelling area using attracting/repelling Lagrangian coherent structures (LCS) obtained as subset of hyperstreamline of the Cauchy-Green strain tensor, whom the normal repulsion rate is larger than tangential stretch over backward/forward time interval, and their link to the chlorophyll fronts concentrations, based on 10 years satellite data. These LCS move with the flow as material line, thus the horizontal mixing is calculated from the intersection of theses LCS with the finite time lyapunov exponent (FTLE) map. The temporal variability of surface stirring is compared to the fronts chlorophyll concentration, showing similar seasonal variations, nearly coincident maxima and minima, leading to a global positive correlation. This contradicts a recent work on the same region, which found negative correlation. However this work was based on Finite Size Lyapunov Exponent, (FSLE) whose output is a plot of scalar distributions. FSLE can only provide LCS for sharp enough ridges of nearly constant height. In the other hand, the method we use here (variational theory of hyperbolic LCS) yields analytical solutions of LCS as material lines that extremize the normal repulsion/attraction overall nearby material lines.