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Transect measurements by micro-probes in hydrodynamic turbulence: a numerical study

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The temporal statistics of incompressible fluid velocity and passive scalar fields in three-dimensional homogeneous and isotropic turbulent conditions is investigated by means of direct numerical simulations along the trajectories of self-propelled point-like probes drifting in a flow. Such probes are characterised by a propulsion velocity which is fixed in intensity and direction however, they are continuously deviated by their intended course as the result of the local sweeping of the fluid flow. The recorded time-series by these moving probes represent the simplest realisation of transect measurements in a fluid flow environment. By means of time-series analysis we show how transect measurements display a non trivial combination of Lagrangian and Eulerian statistical properties and we quantify how the transition from these two behaviours occurs at increasing the propulsion velocity. Furthermore, our study of the intermittency of finite-time increments highlights in a striking way the opposite trends displayed by fluid velocity and passive scalar statistics, which are connected to their different spatio-temporal structures. The implications of this study on the interpretation of measurements of fluid flows and bio-geo-chemicals performed by micro-autonoumous underwater vehicles in the ocean will be discussed.