Effect of background turbulence on the scalar entrainment into a jet: width of the scalar interface and evidence of detrainment

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The effect of zero-mean-flow external turbulence on the topology of the scalar turbulent/turbulent interface (TTI) has recently been studied in axisymmetric jets [1]. The present study aims to understand the process of turbulent entrainment into a jet, as affected by background turbulence, using scalar statistics. Planar-laser-induced fluorescence was employed to capture orthogonal cross sections of the jet at a fixed downstream station with varying background turbulence intensities. The ambient turbulence is generated using a random jet array. The conditional scalar profiles revealed that the thickness of the TTI is greater than that of the traditional turbulent/non-turbulent interface (TNTI), and that the interfacial thickness is an increasing function of the background turbulence intensity. External forcing tends to suppress the net rate of entrainment into the jet by increasing the relative contribution of the detached jet patches (i.e., 'islands') to the area of the main jet, despite a larger jet area, implying an increase in the local detrainment events. An increased occurrence of concentration 'holes' within the finite thickness of the interfacial layer in the presence of ambient turbulence suggests a more significant role of engulfment in the turbulent/turbulent entrainment process. Lastly, the lowered entrainment in the turbulent ambient as compared to the quiescent background is manifested as less negative values of scalar skewness deep within the jet, while positive skewness at far radial positions from the jet centerline indicates intense detrainment episodes, induced by external fluctuations.

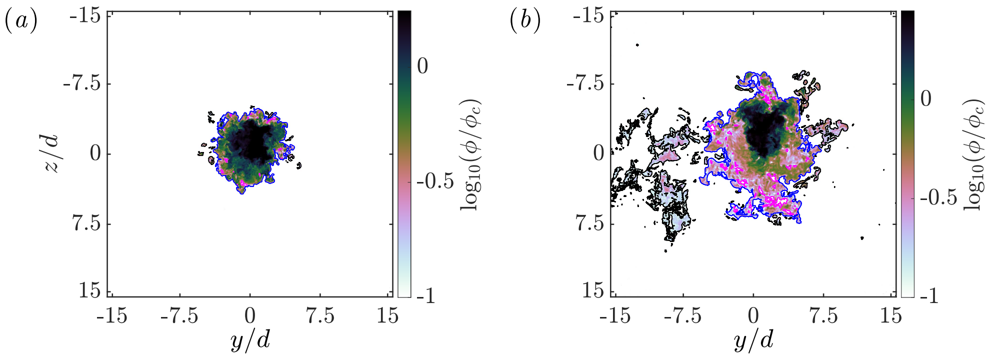

Figure 1: Normalized instantaneous scalar fields (ϕ/ϕ_c) of an axisymmetric jet at $x/d = 25$ in (a) quiescent ambient and in (b) turbulent ambient in logarithmic scaling. The TNTI and TTI outlines, ambient holes, and detached islands are shown with the blue, magenta, and black lines, respectively. Note the increased presence of islands and holes in the turbulent ambient. ϕ_c and d are the centerline concentration and the jet-exit diameter. The streamwise, lateral, and vertical coordinates are denoted by x, y, and z, respectively.

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