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Predicting particle paths: Lagrangian dynamics in turbulent flows

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ABSTRACT

Lagrangian dynamics are omnipresent in both natural and industrial flows, from pathogen and sediment transport to ash distribution in volcanic episodes. The multiscale nature of these flows makes them highly complex, posing significant challenges for both the prediction and interpretation of their dynamics. This is particularly relevant to flows involving particle deposition, agglomeration, dispersal, and similar phenomena. We therefore carried out a series of experiments to examine an inhomogeneous turbulent jet from the perspective of the particles. We investigate the role of temporal scales in the evolution of Lagrangian dynamics and highlight their significance in understanding how turbulence evolves. Based on these insights, we develop a simple model to "mold" inhomogeneous turbulent fields using a stationary, homogeneous signal input—such as data from Direct Numerical Simulations or stochastically modeled trajectories. In the end, this study presents a straightforward technique to accurately predict not only the large-scale dynamics but also to capture the intermittent effects known to be prevalent, and sometimes detrimental, in many turbulent applications. Finally, we propose extensions to this model that are currently being investigated.