Abstract

The objective of this investigation is to develop a single point model for the global effects of pressure in turbulence, while striking a judicious balance between mathematical rigor and empiricism. In this vein, we perform a linear stability analysis of planar quadratic flows to isolate and identify the action of pressure herein. This leads to the identification of the Statistically Most Likely behavior engendered by modal ensembles. Thence, we develop a framework to augment the classical realizability constraints. Herein, we ensure that not only is the statistical state physically permissible, but the stochastic process is realizable as well. These process realizability conditions are applied a posteriori, to evaluate the dynamics predicted by established models and a priori, to develop illustrative models that maximize realizability adherence. This serves to identify the range of possible dynamics of the system. Thence, a set of studied compromises are introduced in the scope and framework of the classical modeling procedure to develop a modeling framework that ensures a high degree of fidelity along with adherence to process realizability. An illustrative model using this paradigm is constructed and its predictions are compared against numerical and experimental data, while being contrasted against established closures. The robustness of the linear analysis is tested via stochastic modeling using a Langevin equation based model. Finally, to extend this paradigm to all homogeneous flows, we carry out a linear stability analysis of general three-dimensional homogeneous flows.