

Turbulence Subgrid Closure for the Lattice Boltzmann Method via Artificial Neural Networks

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Abstract:

This work focuses on the development of a Data-driven turbulence Subgrid Closure model in the context of the Lattice Boltzmann Method (LBM). The model is defined as a correction on the classical BGK collisional operator operated by an Artificial Neural Network (ANN) taking as input the pre-collisional populations, and trained on DNS data. The training and testing of the model is done in the context of 3D Homogeneous Isotropic Turbulence (HIT). We consider for training fixed Reynolds number and various coarse-graining factors. The proposed closure is observed to be less dissipative than the classical Smagorinsky closure model, while accurately capturing anomalous scaling exponents. The successful development of this closure required the imposition of physical constraints on the neural network and the utilization of an online training approach. Additionally, we discuss the generalization capabilities of the model in terms of different forcing schemes and different Reynolds numbers. The findings suggest the potential of this approach in enhancing turbulence modeling and its applications in various engineering and environmental contexts.