Investigation of Turbulent Jet Formation: A Neural Network Approach

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Recent advances in machine learning, particularly neural networks (NNs), have provided valuable insights into fluid dynamics and turbulence. In this work, we use NNs to study zonal jet formation in stratified turbulence. Zonal jets (localized regions of strong east/west flow), known as vertically sheared horizontal flows, often form spontaneously in simulations of stably stratified turbulence. Similar jets form near the equator in the atmosphere (the quasi-biennial oscillation of Earth's stratosphere) and in the ocean (the equatorial deep jets). Their existence is attributed to the interactions between the eddy momentum fluxes, transported by the field of waves and turbulence, and their own structure. We explore and develop several NN architectures to explore the relationship between the jet structure and the turbulence in the context of the stochastically excited stably stratified Boussinesq system. We compare our NN's predictions to those of a second- order turbulence closure theory, known as statistical state dynamics (SSD), which has successfully been used to understand jet formation in stratified turbulence.

Key words: Machine learning, Neural networks, Stochastic systems, Stratified turbulence, Zonal jets