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Stable and Generalizable Subgrid Modeling of Forced Burgers Turbulence Using Neural Networks and Transfer Learning ADAM SUBEL, ASHESH CHATTOPADHYAY, YIFEI GUAN, PEDRAM HASSANZADEH, Rice University — In order to model turbulence on computationally affordable coarse grids, methods like LES and RANS are used to model the feedback of the subgrid scales not explicitly resolved. Recently, there has been an increasing interest in using machine learning to improve the accuracy of these subgrid-scale models by either directly predicting the subgrid closure terms, or by estimating coefficients for LES or RANS. These data-driven methods lose accuracy when the parameters (e.g. the Reynolds number) of the system change from those of the training set. This is an obstacle for practical applications as long, high-quality simulations of high-Re turbulent flows, and thus enough data for training, may not be available. Here, using the forced Burgers equation as a test bed, we look at the generalization of a data-driven parameterization method, which uses a regularized artificial neural network (ANN) to stably predict the subgrid closure terms a posteriori. We find that a fivefold increase in the Reynolds number degrades the performance of the ANN. Transfer learning provides a practical solution to this problem: By taking an ANN trained on a lower Reynolds number and using a small dataset to re-train the final layers of the ANN, we show that we can recapture the statistics of the subgrid terms.

Adam Subel
Rice University

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