Abstract Submitted
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Embedded training of neural-network sub-grid-scale turbulence models[1] JUSTIN SIRIGNANO, University of Oxford and University of Illinois at Urbana-Champaign, JONATHAN MACART, University of Notre Dame, JONATHAN FREUND, University of Illinois at Urbana-Champaign — The weights of a deep neural network model are optimized in conjunction with the governing flow equations to provide a model for sub-grid-scale stresses in a temporally developing plane turbulent jet at Reynolds number 6000. The objective function for training is first based on the instantaneous filtered velocity fields from a corresponding direct numerical simulation, and the training uses the adjoint NavierStokes equations to provide the end-to-end sensitivities of the model weights to the velocity fields. In-sample and out-of-sample testing on multiple dual-jet configurations show that its required mesh density in each coordinate direction for prediction of mean flow, Reynolds stresses, and spectra is half that needed by the dynamic Smagorinsky model for comparable accuracy. The same neural-network model trained directly to match filtered sub-grid-scale stresses fails to provide a qualitatively correct prediction. The formulation is generalized to train based only on mean-flow and Reynolds stresses, which provides a robust model though a somewhat less accurate prediction. The anticipated advantage of the formulation is that the inclusion of resolved physics in the training increases its capacity to extrapolate, which is assessed for the case of passive scalar transport.

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