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Performance Bounds of Data-Driven Reynolds Stress Models via Optimal Tensor Basis Expansions[1] ANDREW J. BANKO, CHRISTOPHER J. ELKINS, JOHN K. EATON, Stanford University — Reynolds-Averaged Navier-Stokes simulations continue to be primary tools for engineering design, but standard models are inaccurate when applied to 3D turbulent flows with large-scale separation. As a result, data-driven approaches were developed to derive non-linear algebraic stress models from high fidelity simulations. Most use a tensor basis expansion and learn the coefficients as functions of the basis tensor invariants. However, it is often unclear how to adjust the model form or algorithm hyperparameters to further improve a priori and a posteriori accuracy. In this work, we propose optimal tensor basis expansions as a methodology to determine the performance bounds of data-driven Reynolds stress models. The optimal expansion is independent of the machine learning algorithm, and therefore isolates errors associated with an assumed tensor basis. We apply the optimal bases in forward simulations using large-eddy simulation data to analyze the relative importance of errors in the anisotropy and auxiliary turbulence equations. Results are demonstrated for the flow over a 3D bump with large-scale separation. We find that few tensor basis terms are needed to model the Reynolds stress anisotropy, and that the greatest errors reside in the auxiliary equations.

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Andrew Banko
Stanford University

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