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A Random Matrix Approach for Quantifying Model-Form Uncertainties in Turbulence Modeling

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Abstract

With the ever-increasing use of Reynolds-Averaged Navier–Stokes (RANS) simulations in mission-critical applications, the quantification of model-form uncertainty in RANS models has attracted attention in the turbulence modeling community. Recently, a physics-based nonparametric approach for quantifying model-form uncertainty in RANS simulations has been proposed, where Reynolds stresses are projected to physically meaningful dimensions and perturbations are introduced only in the physically realizable limits (Xiao et al., 2016. Quantifying and reducing model-form uncertainties in Reynolds-averaged Navier–Stokes simulations: A data-driven, physics-informed Bayesian approach. Journal of Computational Physics. 324, pp. 115-136). However, a challenge associated with this approach is to assess the amount of information introduced in the prior distribution and to avoid imposing unwarranted constraints. In this work we propose a random matrix approach for quantifying model-form uncertainties in RANS simulations with the realizability of the Reynolds stress guaranteed, which is achieved by construction from the Cholesky factorization of the normalized Reynolds stress tensor. Furthermore, the maximum entropy principle is used to identify the probability distribution that satisfies the

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