

Abstract Submitted  
for the DFD17 Meeting of  
The American Physical Society

**Data-free and data-driven spectral perturbations for RANS UQ<sup>1</sup>**

WOUTER EDELING, AASHWIN MISHRA, GIANLUCA IACCARINO, Stanford University — Despite recent developments in high-fidelity turbulent flow simulations, RANS modeling is still vastly used by industry, due to its inherent low cost. Since accuracy is a concern in RANS modeling, model-form UQ is an essential tool for assessing the impacts of this uncertainty on quantities of interest. Applying the spectral decomposition to the modeled Reynolds-Stress Tensor (RST) allows for the introduction of decoupled perturbations into the baseline intensity (kinetic energy), shape (eigenvalues), and orientation (eigenvectors). This constitutes a natural methodology to evaluate the model form uncertainty associated to different aspects of RST modeling. In a predictive setting, one frequently encounters an absence of any relevant reference data. To make data-free predictions with quantified uncertainty we employ physical bounds to a-priori define maximum spectral perturbations. When propagated, these perturbations yield intervals of engineering utility. High-fidelity data opens up the possibility of inferring a distribution of uncertainty, by means of various data-driven machine-learning techniques. We will demonstrate our framework on a number of flow problems where RANS models are prone to failure.

<sup>1</sup>This research was partially supported by the Defense Advanced Research Projects Agency under the Enabling Quantification of Uncertainty in Physical Systems (*EQUPPS*) project (technical monitor: Dr Fariba Fahroo), and the DOE PSAAP-II program.

Wouter Edeling  
Stanford University

Date submitted: 21 Sep 2017

Electronic form version 1.4