Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Uncertainty quantification of the scale determination in steady RANS modeling for turbulence with large-scale structures[1] ZENGRONG HAO, CATHERINE GORLE, Stanford University, WIND ENGINEERING LAB TEAM — The scale determining variable (e.g. energy dissipation rate ε, frequency scale ω, or length scale l) is notoriously difficult to model and thus a major source of uncertainties in RANS simulations for turbulence. Particularly in the turbulence with large-scale structures that usually yield highly non-equilibrium energy spectra, a steady RANS simulation using a single modeled scale can result in considerable errors, especially for energy levels. In this report, we present a dual-scale, three-equation steady RANS approach to quantify the uncertainties originating in the scale determination in a model for the turbulence with large-scale structures (LS). The uncertainty quantification (UQ) approach is developed in three steps. First, we obtain the equations for the energies of LS and quasi-equilibrium small-scale turbulence (ST) from a triple decomposition, and employ a traditional model for the dissipation rate of ST energy. Second, under the limit condition where LS and ST have identical scales, we derive the form of the energy transfer rate (ETR) from LS to ST via a conceptual analogy with the 'return-to-isotropy' evolution of Reynolds stress. Last, a marker with a single uncertain parameter is designed to identify the regions potentially bearing LS (particularly for those in large separation regions), and is used to suppress the ETR. Applications of this UQ approach in several cases show its capability of encompassing the real energy levels in the separation regions.

[1]IWT-140068

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Date submitted: 31 Jul 2019 Electronic form version 1.4