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Quantifying Structural Uncertainties for Turbulent Passive Scalar Transport[1] ZENGRONG HAO, CATHERINE GORL, Stanford University, WIND ENGINEERING TEAM — Modeling turbulent passive scalar transfer is relevant to a variety of engineering problems, such as the optimization of heat exchangers, or the prediction of pollutant dispersion in cities. Classic gradient-diffusion models for turbulent scalar flux are known to fail in complex flows, and a method to quantify model form uncertainties would provide a useful engineering tool. We therefore propose a framework for estimating the upper and lower bounds of the intensity of turbulent scalar transfer. It is based on two approximations: 1) a selected baseline turbulent scalar-flux closure is trusted in predicting the level of flux magnitude; and 2) the bounds of the scalar transfer intensity are explored by identifying local flux direction for which the local growth rate of flux magnitude reaches its maximum and minimum Accordingly, first a generalized baseline form for both transport and algebraic models of scalar-flux is suggested. Second, the growth rate of flux magnitude is represented as function of local flux direction, and the bounds are identified using an optimization for an inhomogeneous quadratic function with constraints. An algorithm for the optimization is implemented together with a damping function to avoid possible discontinuities in the flux direction field. The framework is applied to a pin-fin heat exchanger, showing promising capabilities to bound the overall heat transfer rate and some local key features.

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