Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Scalar Transport in Restricted Nonlinear Turbulence[1] BENJAMIN MINNICK, XIAOWEI ZHU, DENNICE GAYME, Johns Hopkins University — Streamwise coherent structures have been shown to play an important role in momentum and energy transport in wall bounded shear flows. Studies regarding the transport of scalars, such as heat or chemical species, have revealed scalar fluctuations are highly correlated with streamwise velocity fluctuations, suggesting coherent structures also play a key role in scalar dynamics. We test this hypothesis by modeling scalar transport in the restricted nonlinear (RNL) framework. RNL models of wall-turbulence represent the flow as a large scale streamwise constant field that nonlinearly interacts with simplified streamwise varying perturbations. Our results show that a similar restriction of both the velocity and scalar fields to streamwise constant mean dynamics interacting with streamwise varying perturbation fields supported by a single non-zero wavenumber leads to a coupled model that accurately predicts low-order statistics. Furthermore, the quasi two-dimensional nature of the RNL system implies cross-plane features are largely responsible for mixing the scalars in wall-bounded turbulent flow. We further extend this model to demonstrate the utility of the RNL paradigm in investigating high Prandtl number and buoyancy effects in stably-stratified turbulence.

[1]This work is supported by the NSF CAREER award (CBET 1652244).

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Date submitted: 30 Jul 2020 Electronic form version 1.4