Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Fractional Reynolds-averaged Navier Stokesequations (f-RANS) for modeling of transitionaland turbulent boundary layers PAVAN PRANJIVAN MEHTA, Center for Fluid Mechanics, Brown University, USA, TAMER ZAKI, CHARLES MENEVEAU, Department of Mechanical Engineering, John Hopkins University,USA, GEORGE KARNIADAKIS, Center for Fluid Mechanics, Brown University, USA — Reynolds averaged Navier-Stokes (RANS) equations often invoke a local model for the Reynolds stresses, while in reality the correlations between these stresses and the strain rate are nonlocal. In this work, we propose to model the Reynolds stress in terms of the mean velocity using fractional gradients, which are nonlocal operators. We demonstrate mathematically that a single model structure is valid for all regimes of the flow. Also, when non-dimensionalized in wall units, there are no additional coefficient to model. Results are presented for modeling statistics from direct numerical simulations of bypass transition from JHTDB, and for analytical expressions of the total shear stress from the literature. The model can match the mean velocity profile in the transitional and fully turbulent regimes. The results demonstrate the mathematical expressivity of the fractional gradient, where a non-local physics are properly captured.

Pavan Pranjivan Mehta
Brown University

Date submitted: 31 Jul 2020 Electronic form version 1.4