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Fractional LES Subgrid-Scale Modeling for Scalar Turbulence[1]

ALI AKHAVAN-SAFAEI, MEHDI SAMIEE, MOHSEN ZAYERNOURI, Michigan State University — Filtering the passive scalar transport equation in the large-eddy simulation (LES) of turbulent transport gives rise to closure term corresponding to the unresolved scalar flux. Respecting the statistical features of subgrid-scale (SGS) flux is a vital point in robustness and predictability of LES. We investigate the intrinsic nonlocal behavior of the SGS flux through its two-point statistics obtained from filtered direct numerical simulation (DNS) data in homogeneous isotropic turbulence. Presence of long-range correlations in true SGS flux urges to go beyond the conventional local closure modeling approaches that fail to predict the statistical features of turbulent transport. We propose an appropriate statistical model for microscopic SGS motions in the filtered Boltzmann transport equation (FBTE) for passive scalar by approximating the filtered equilibrium distribution with an α-stable Levy distribution. This incorporates a power-law behavior to resemble the observed nonlocal statistics of SGS flux. Ensemble-averaging of such FBTE lets us formulate a continuum level model for the SGS scalar flux appearing in terms of fractional operators that are inherently nonlocal. In an $a-priori$ testing, our model yields a great two-point statistical behavior for SGS scalar flux.

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