Structures of scalar transport in a turbulent channel

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Abstract

Direct numerical simulation (DNS) of a turbulent channel with temperature treated as a passive scalar at a moderate Reynolds number (Re_τ = 395) was performed to investigate the large scale motions responsible for scalar transport. Structures are elicited by using three dimensional two-point correlations. Complete three dimensional structure of cross correlations between velocity and scalar fluctuations are evaluated for the first time. The results show that the organized motions which are responsible for transporting streamwise component of the turbulence kinetic energy, scalar variance, and streamwise heat flux are very similar only in the viscous sublayer. However, the large scale motions (LSMs) which transport streamwise component of the turbulent kinetic energy, scalar variance, and streamwise heat flux are clearly distinct to each other beyond the buffer region. In addition, comprehensive three dimensional two-point correlation data imply that LSMs which are responsible for carrying most of the Reynolds stresses are not exactly the same as those that transport most of the scalar fluxes in both inner and outer regions of the turbulent boundary layer. Analysis of the length scales of correlations revealed that the growth of LSMs which influence both momentum and thermal transport is linear. Comparison of physical extents of LSMs which are responsible for transporting Reynolds stresses and wall-normal heat fluxes reveals that Reynolds analogy holds for scalar transport by the LSMs in the boundary layer.

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