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Modeling the turbulent scalar fluxes in heated compressible flows

GEORGES GEROLYMOS, Universite Pierre et Marie Curie, BASSAM YOUNIS, University of California-Davis, ISABELLE VALLET, Universite Pierre et Marie Curie, CELINE LO, University of California-Davis — We use results from Direct Numerical Simulations of compressible flow in a heated channel (M_{cl} = 0.34, 1.5) to advance an explicit, algebraic model for the turbulent scalar fluxes. The scalar fluxes of interest are the heat fluxes which enter into the equation for total energy and the mass fluxes which enter into the equations for turbulence kinetic energy and density variance. Both fluxes are usually modeled via gradient-transport hypothesis which does not account for the dependencies implied in the exact equations. Moreover, in fully-developed flows, the streamwise fluxes, which are greater than the fluxes in the direction of normal to the flow, are predicted as zero in models based on this hypothesis – an outcome which is at variance with all results from experiments and simulations. The starting point is model is derived from the representation of the turbulent heat fluxes as a function of the Reynolds stresses, the mean strain rate and the mean vorticity. The time scales for the fluctuations in the scalar fields are often assumed to be proportional to the mechanical time scale. We test this assumption using the DNS results. The focus is on the near-wall region which determines the rate of heat transfer to the wall, and proposals for incorporation of a direct dependence of the heat fluxes on the gradients of mean density are examined.

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