AN EXPLICIT ALGEBRAIC MODEL FOR SCALAR TRANSPORT IN TURBULENT SHEAR FLOWS

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An explicit algebraic model for the turbulent scalar flux is developed, based on the use of tensor representation theorems in expressing the flux as an isotropic vector-valued functions of two symmetric tensors, the mean rate of deformation tensor and the Reynolds stress tensor, and a vector defined by the gradient of the scalar quantity being transported.

What sets apart this model form other similar ones is the exclusion of the dependence of the turbulent scalar flux on the mean vorticity tensor, as it is shown that the inclusion of such dependence would violate the requirement of invariance under Superposed Rigid Body Motion (SRBM). Unlike other publications which dealt with the subject matter in the past from the perspective of invariance under an observer's frame rotation, the SRBM invariance requirement, if correctly interpreted and implemented, excludes the dependence not only on the vorticity tensor in representations of this kind, but also on the so-called intrinsic vorticity tensor. This does not mean the complete elimination of the role of the vorticity tensor in the modeling process, the vorticity tensor naturally arises in the transport equations of evolution for the Reynolds stress.

The new and quite simple model is calibrated using data from Large-Eddy Simulations of homogeneous flows with constant shear rate and constant gradients of scalar. Subsequently its performance is on the one hand assessed by comparisons with data from two-dimensional flows, and on the other hand contrasted with that of alternative models.

Keywords: turbulent scalar flux