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On Fokker–Planck Equations for Turbulent Reacting Flows. Part 1. Probability Density Function for Reynolds-Averaged Navier–Stokes Equations

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Abstract
The accurate treatment of finite-rate chemistry is possible by the application of stochastic turbulence models which generalize Reynolds-averaged Navier–Stokes equations. Usually, one considers linear stochastic equations. In this way, fluctuations are generated by uncorrelated forces and relax with a frequency that is independent of the actual fluctuation. It has been proved that such linear equations are well appropriate to simulate near-equilibrium flows. However, the inapplicability or unfeasibility of other methods also results in a need for stochastic methods for more complex flow simulations. Their construction requires an extension of the simple mechanism of linear stochastic equations. Two ways to perform this are investigated here. The first way is the construction of a stochastic model for velocities where the relaxation frequency depends on the actual fluctuation. This is a requirement to involve relevant mixing variations due to large-scale flow structures. The stochastic model developed is applied to the simulation of convective boundary layer turbulence. Comparisons with the results of measurements provide evidence for its good performance and the advantages compared to existing methods. The second way presented here is the construction of scalar equations which involve memory effects regarding to both the stochastic forcing and relaxation of fluctuations. This allows to overcome shortcomings of existing stochastic methods. The model predictions are shown to be in excellent agreement with the results of the direct numerical simulation of scalar mixing in stationary, homogeneous and isotropic turbulence. The consideration of memory effects is found to be essential to simulate correctly the evolution of scalar fields within the first stage of mixing.

Keywords
, consistent turbulence models, convective boundary layer turbulence, micromixing model, probability density function, Reynolds-averaged Navier–Stokes equations

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