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COMPARATIVE STUDY OF SUBFILTER SCALAR DISSIPATION RATE AND MIXTURE FRACTION VARIANCE MODELS

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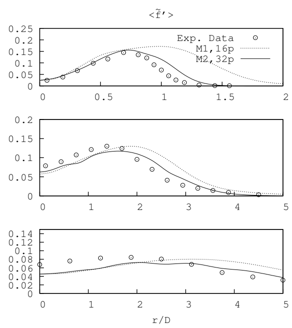
The evaluation of subgrid mixture fraction variance and subfilter scalar dissipation rate is a critical issue in flamelet/flamelet progress-variable (FPV) models as well as Conditional Moment Clousure (CMC) models. Both parameters model scalar mixing at the subgrid level, which in turn controls the combustion process. Usually, models used to evaluate both quantities have assumed a local equilibrium between production and dissipation of the variance at the small scales. Although being computationally efficient, they are not suitable in many cases of industrial interest.

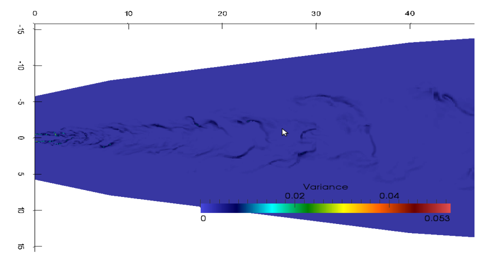
In the past several models have been proposed to account for deviations from local equilibrium, which model the subgrid mixture fraction variance and dissipation rate. An algebraic model [1], which assumed equilibrium between production and destruction at the small scales, has been found to produce erroneous estimations of the scalar mixing in technically relevant flow configurations [2]. Therefore, further models have been proposed to overcome this lack of generality. Non-equilibrium modelling can be achieved by constructing a variance transport equation (VTE). Alternatively, through the definition of a second moment of any statistical value, the variance can be computed $\widetilde{f_v} = \widetilde{f^2} - \widetilde{f}^2$, requiring a transport equation for $\widetilde{f^2}$ (STE). However, both equations require a closure for the subfilter dissipation rate. In the context of the VTE, an algebraic expression relating the subgrid variance with the subfilter dissipation through a turbulent time scale has been proposed [2, 3]. On the other hand, closure for the STE can also be performed through a transport equation for the scalar dissipation rate [4].

In the present study a large eddy simulation (LES) of a methane/hydrogen diffusion flame [5] using the flamelet/progress-variable model [6] will be performed to study the behaviour of different models for the subfilter mixture fraction variance and subfilter scalar dissipation rate. The comparative shall put forth the strengths and weaknesses of each model.

Time-averaged results are compared against experimental data. Figure 1a show the radial profiles of the mixture fraction intensities using the algebraic model [1]. The mixture fraction variance is seen to be underpredicted at positions higher than $y/D = 10$. Figure 1b shows an instantaneous snapshot of the mixture fraction variance.



(a) Radial distribution of the mixture fraction intensities. Top $y/D = 5$, middle $y/D = 20$, bottom $y/D = 40$.



(b) Snapshot of the subfilter mixture fraction variance f_v.

Figure 1: Mixture fraction variance and intensities using an algebraic model.

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