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# Super-grid Linear Eddy Model as chemical closure for turbulent combustion

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Linear Eddy Model (LEM) has been used successfully in previous years as sub-grid chemical closure for Large Eddy Simulation (LES) in turbulent combustion [1]. Here, every CFD cell contains a highly resolved one dimensional LEM line where diffusion and reaction equations are time advanced, the leading principle being that in a sufficiently turbulent flame region, the fluctuations of scalars such as temperature and mass fraction along a given line of sight are independent of orientation owing to isotropy of the small scales. LEM, by itself, is mode independent and accounts for the influence of turbulent mixing by locally applied mapping functions. Advection between the CFD cells is realized on the LEM level using a mass conservative splicing scheme in which resolved CFD fluxes determine the transport of LEM fragments between the CFD cells in a Lagrangian way.

The current implementation aims to reduce the computational expense of LES-LEM using CFD cell agglomeration to form a coarse level *super-grid*. Each cell cluster then contains a single LEM line, thereby reducing the total number of lines and splicing operations.The filtered chemical state variables for any CFD cell in a cluster are determined using joint integration of the conditioned averages (with respect to mixture fraction, $Z$, and/or progress variable, $c$) of state variables over the associated LEM line, weighted by the Probability Density Functions (PDFs) for $Z$ and/or $c$. PDF parameters are obtained by CFD-level time advancement of transport equations for mixture fraction mean, its variance and a mean progress variable. This flexible representative mapping strategy allows for either a premixed or non-premixed formulation.

LEM provides on-the-fly local flame statistics which should capture finite rate chemistry effects and the super-grid approach shows considerable speed-up compared to LES-LEM. A pressure based super-grid solver was implemented using the OpenFOAM library and tested with a premixed acetylene flame setup over backward facing step.

## References

[1] V. Sankaran, "Sub-grid combustion modelling for compressible two-phase reacting flows," PhD thesis, Georgia Institute of Technology, 2003.