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# Combustion Explicitly Filtered Large-Eddy Simulation: A novel approach to multi-species LES

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Large-Eddy Simulation is largely employed in combustion for its predictability and has proven accurate for simulating a wide range of cases. To dampen the smallest scales that cannot be resolved at the mesh size, an additional viscous term is added to the resolved equations. However this method entails a risk of over- or under-estimating the appropriate level of subgrid-scale viscosity. More specifically, when applied to a scalar field subjected to differential diffusion, the accurate representation of transport phenomena is jeopardized.

Significant progress has been achieved in the mathematical development of constrained and adaptive optimization frameworks for the automated calculation of explicit forward and direct-inverse discrete filter coefficients tailored to a given filter transfer function [4]. Along these lines, this paper introduces a novel approach to LES of reactive flows by leveraging these filters to capture flame dynamics on computational grids coarser than the flame thickness.

The proposed strategy involves removing the unresolved high frequency component of the scalar fields by a relaxation term $(\overline{\bar{\rho}\tilde{\phi}} - \bar{\rho}\tilde{\phi})/\tau_\Delta$. Here, $\overline{\bar{\rho}\tilde{\phi}}$ is the explicitly filtered density weighted scalar and $\tau_\Delta$ is a characteristic relaxation time that depends on the unresolved wrinkling of the flame front. This regularization makes the signal converge toward its filtered value to ensure that the scalar field remains resolved at the filter scale $\Delta$. A method for estimating the time scale parameter $\tau_\Delta$ is also proposed, based on Germano's dynamic procedure [1]. The chemical source terms are modeled using a deconvolution approach [2,3]. It is also discussed how usual sub-grid scale models are recovered from specific calibration of $\tau_\Delta$, as for instance eddy-diffusivity with $\tau_\Delta$ scaling as $M^2_\Delta/(k^{1/2}_{SGS}\Delta)$, with $M^2_\Delta$ being the second moment of the filter.

## References

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