High-Order Semi-Lagrangian Numerical Method for the Large-Eddy Simulation of Reactive Flows

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A high-order Semi-Lagrangian numerical method is developed for the simulation of a subsonic methane/air flame. The fluid is described by the Navier-Stokes equations for a mixture of ideal gases. Turbulence is modeled using Large-Eddy simulation (LES) together with a transport equation for the subgrid kinetic energy. For the chemical reactions we use an unsteady flamelet model based on transport equations for the mixture fraction and a reaction progress variable. This allows for extinctions and re-ignitions by not assuming fast chemistry nor steady flamelets.

To solve the resulting system of coupled transport equations a Semi-Lagrangian (FSL) method, known from climate modeling, is used. For the interpolations from the Lagrangian mesh points to a fix mesh an interpolation based on piece wise polynomials of degree 2m which are m-tmes differentiable are used. This interpolation is easy to implement, computations are fast. It is conservative, conservative and creates low or zero numerical diffusion and dispersion.

Finally the FSL method is used to simulate Sandia flame D. For the 3-d simulations a mesh in cylindrical coordinates is used where singular derivatives and high frequencies at the polar axis are controlled.