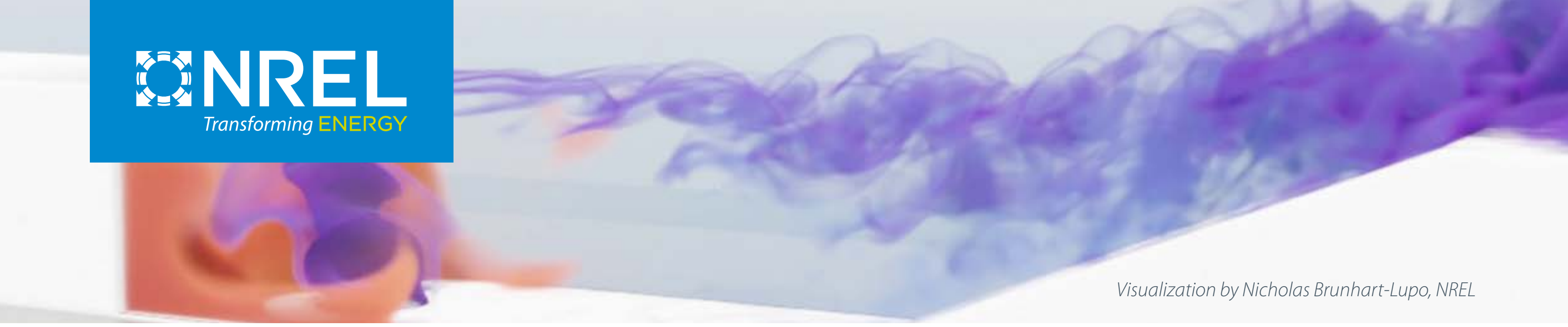
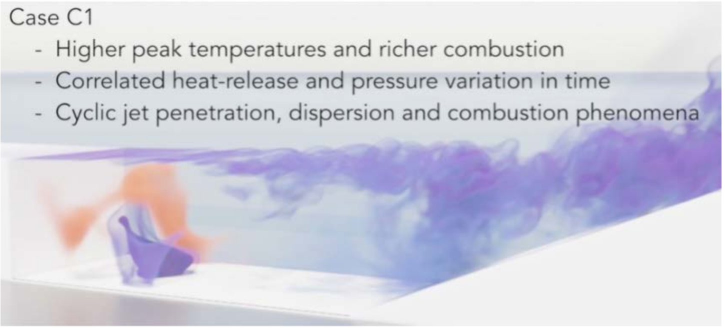


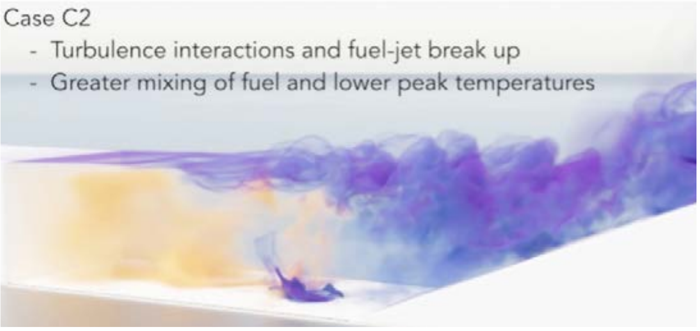
Visualization by Nicholas Brunhart-Lupo, NREL

Transforming **ENERGY** through Computational Excellence

Exascale Computing: Combustion

Simulating Effects of Direct Fuel Injection Location in Supersonic Jet Engines





Computationally tractable simulations using an adaptive-mesh-refinement solver for compressible reacting flows help researchers understand how variations in fuel injection location within the supersonic flow cavity impacts combustion efficiency. ***By identifying the important physical determinants of the combustion processes, this study shows a promising pathway to improving flame stability and combustion efficiency, as well as reducing emissions.***

Challenge

Cavities in supersonic flows can stabilize flames and improve combustion efficiency, particularly in applications such as scram-jets and air-breathing rocket engines. However, the uncertainties surrounding flame stability makes the design and scaling of cavity flame-holders an onerous research problem.

Objective

Our objective is to leverage an adaptive-mesh-refinement solver for high-fidelity simulations of compressible reacting flows to study how changes in the fuel injection location within the cavity impact flame structure and characteristics for a cavity-stabilized hydrogen combustor.

Approach

Specific focus was given to two injection locations within the cavity, one close to the backward facing step (Case C1) and the other further downstream (Case C2), close to the ramp. Central to our approach is a compressible multi-species reacting flow solver that uses adaptive mesh refinement, enabling the resolution of flame, shock-waves, boundary-layers, and small-scale structures in the computational domain.

Results

Our analysis indicates that shear-layer turbulence, which would not have been computationally tractable to resolve without adaptive mesh refinement, has a significant impact on fuel-air homogenization and subsequent combustion within the cavity flame-holder.

Results are represented visually in the Gallery of Fluid Motion presented by the APS Division of Fluid Dynamics:
https://gfm.aps.org/meetings/dfd-2020/5f5badc3199e4c091e67bc55

Sitaraman, Hariswaran, Shashank Yellapantula, Marc T. Henry de Frahan, Bruce Perry, Jon Rood, Ray Grout, and Marc Day. 2021. "Adaptive mesh based combustion simulations of direct fuel injection effects in a supersonic cavity flame-holder." Combustion and Flame, Vol 232, 111531, ISSN 0010-2180, https://doi.org/10.1016/j.combustflame.2021.111531

NREL *Transforming* ENERGY

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-2C00-80880 • October 2021