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Exploring the length-scale dependence of pool fire behavior through computational analysis

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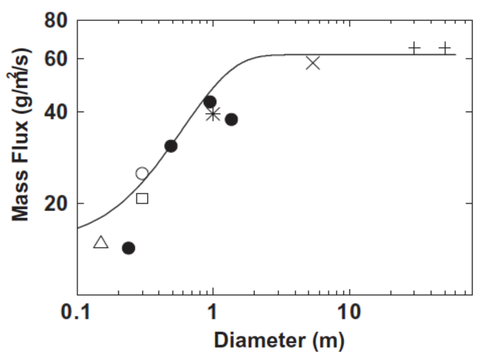
Background

Radiative heat fluxes rise for medium pool fires and level out for large optically thick pool fires.

Pool fire time scales are proportional to $D_{pool}^{1/2}$.

This work explores soot-radiation-mixing behavior for simulated pool fires from 0.3 m to 5 m scale. It describes the transition from optically intermediate to optically thick fires.

Mass flux vs. diameter for JP-8 pool fires [1]



Methods

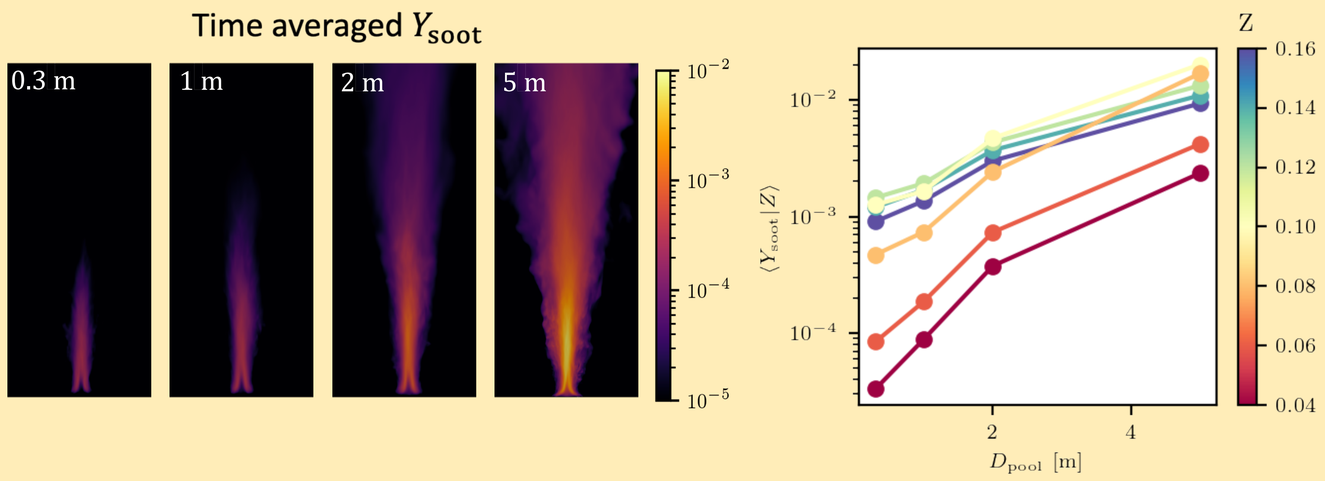
Simulations conducted with Sierra/Fuego as a large-eddy simulation using k_{sgs} turbulence models and non-adiabatic flamelet approach following [2].

Soot modeled with 2-eq. Aksit-Moss and also new 2-eq PAH-based model (Hansen), which produces more soot.

Radiation modeled with discrete ordinates.

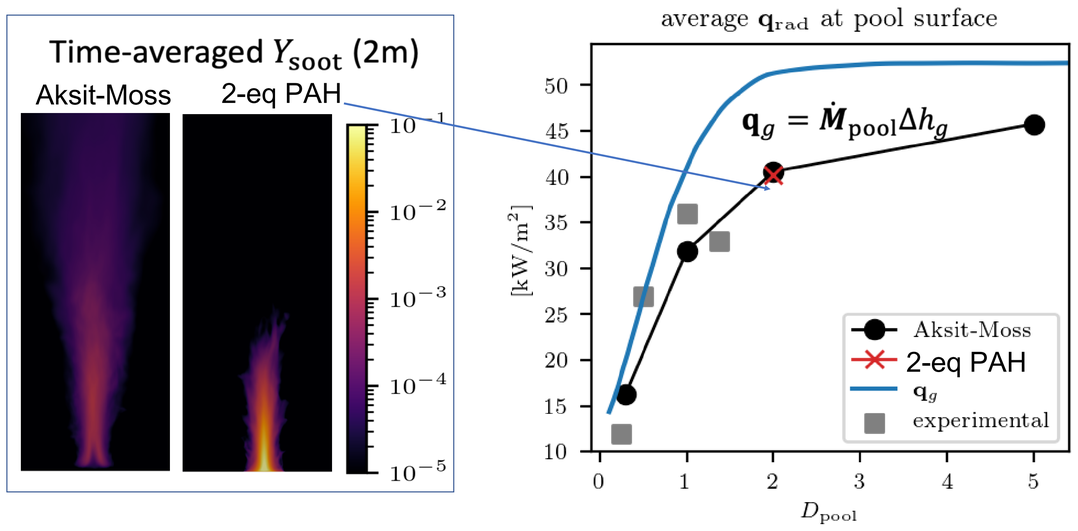
[1] Ditch *et al.* (2013). "Pool fires – An empirical correlation." Combust. Flame, **160**(12): 2964-2974.
[2] Domino, *et al.* (2021). "Predicting large-scale pool fire dynamics using an unsteady flamelet- and large-eddy simulation-based model suite." Phys. Fluids **33**(8): 085109.

With increasing pool residence time at larger $D_{\mathbf{pool}}$ soot mass fractions increase substantially. Soot increase is stronger for lean compositions.

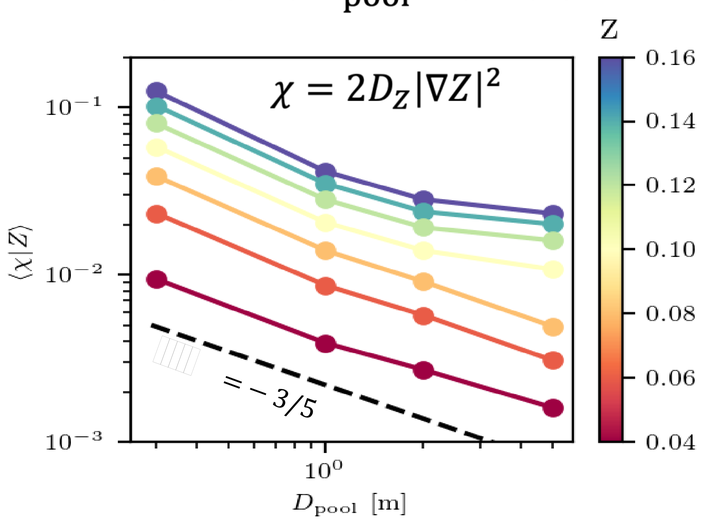


Soot predictions with Aksit-Moss underpredicted for 2m pool

Radiative flux to pool follows vaporization-rate correlation and measurement dependence on $D_{\mathbf{pool}}$.
It is only weakly dependent on the soot model for large pools.

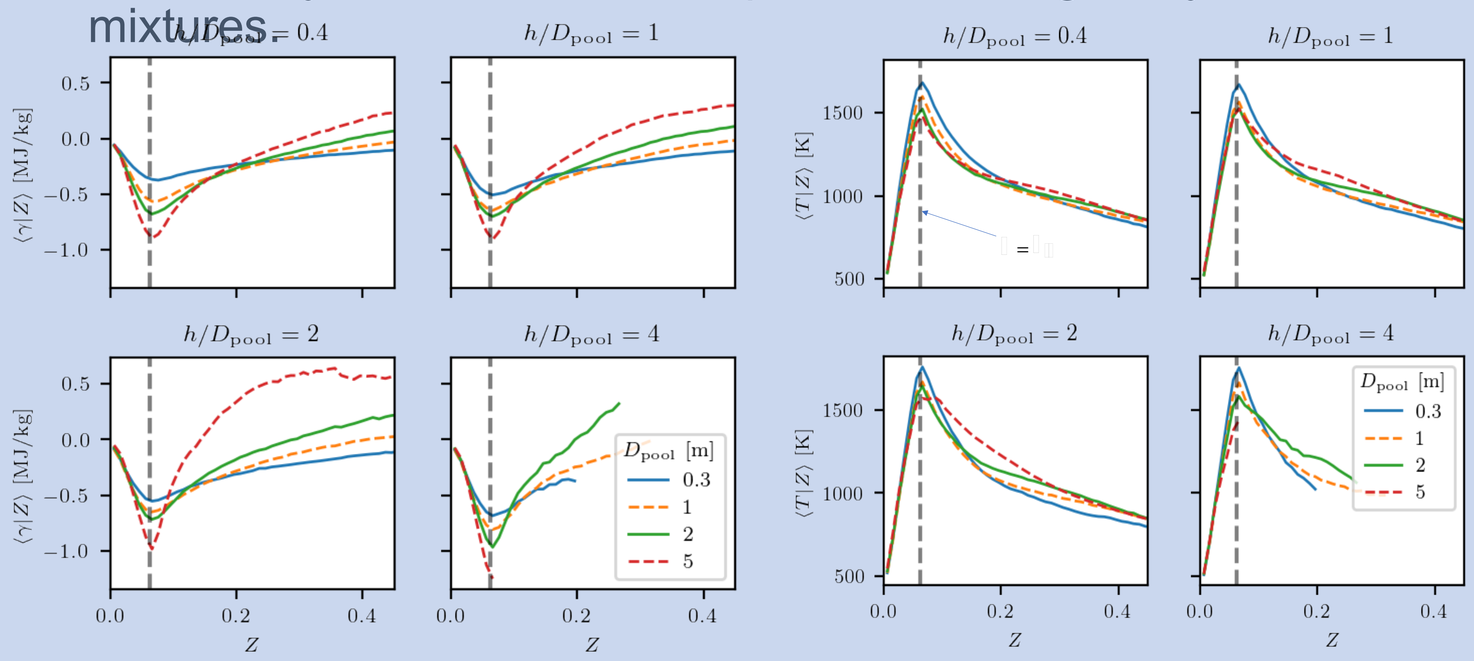


Average small-scale mixing rates decrease as $D_{\mathbf{pool}}$ increases



Soot and mixing-time predictions increase with larger $D_{\mathbf{pool}}$ following power-law mixing rate behavior

A tendency toward internal temperature homogeneity heats rich mixtures



In fire interior, radiation increasingly redistributes heat from higher temperature near-stoichiometric mixtures to nearby rich-soot mixtures for larger pools/slower mixing.

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