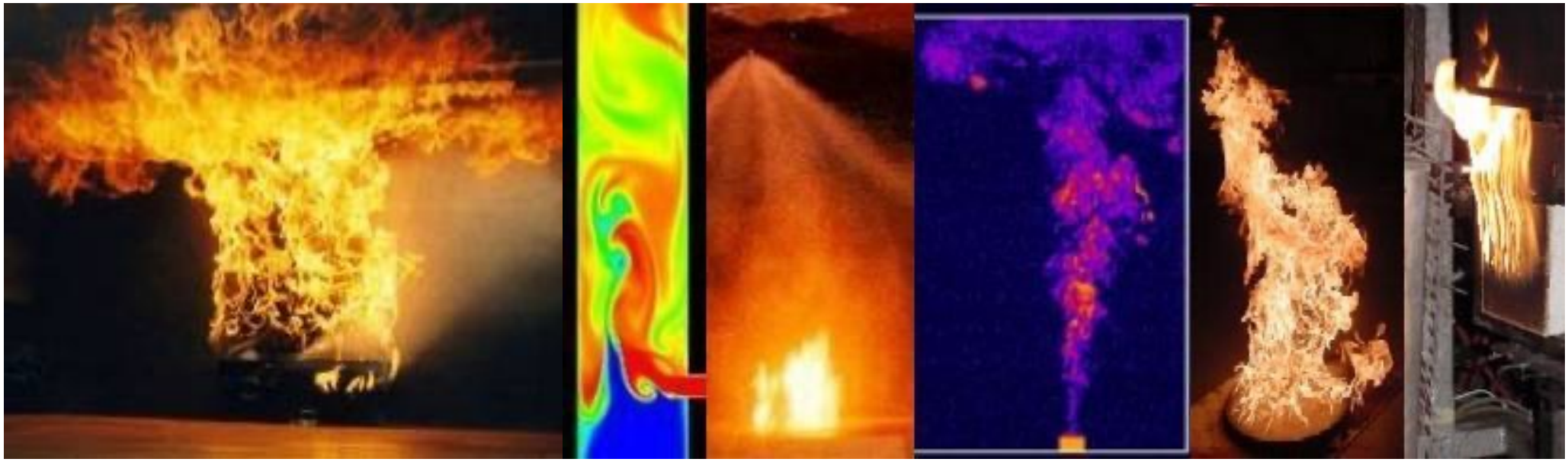


Research Overview

Department of Fire Protection Engineering
University of Maryland
College Park, MD 20742, USA

http://www.fpe.umd.edu

May 2025

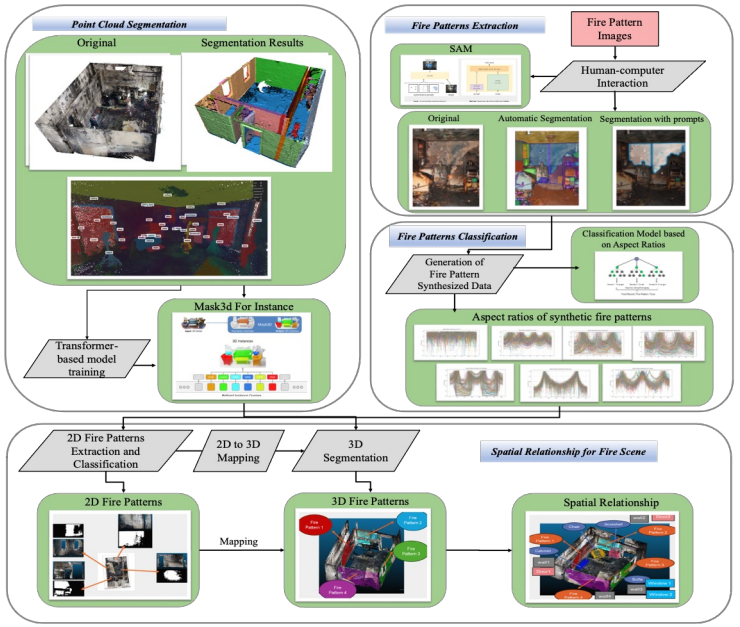
Full-Time Faculty

Faculty	Expertise/Research Areas
R. Hrybyk	life safety analysis, performance-based design
W.E. Koffel	suppression/detection systems, egress, codes & standards
S. Ni	structures, fire forensics, mass timber
F. Raffan-Montoya	toxicity, wildfire detection/monitoring/characterization
S.I. Stoliarov	pyrolysis, flammability, flame spread
P.B. Sunderland	firebrands, soot, microgravity, cool flames
A. Tohidi	CFD, fire/wildfire modeling, AI
A. Trouvé	CFD, fire/wildfire modeling

Fire Pattern Analysis

- *FPE Faculty*: S. Ni and S. Stoliarov
- *Student:* M.B. Mannan
- *Collaborators*: P. Tang
- *Title*: Investigating the Impact of Architectural Finishes on Fire Patterns in Support of Developing Data-driven Tools for Pattern Analysis
- *Sponsor*: National Institute of Justice
- *Objectives*: Study the effects of architectural finishes on fire patterns, and use the resulting test data in combination with other data to develop data-driven tools for automatic and quantitative fire-pattern analysis.

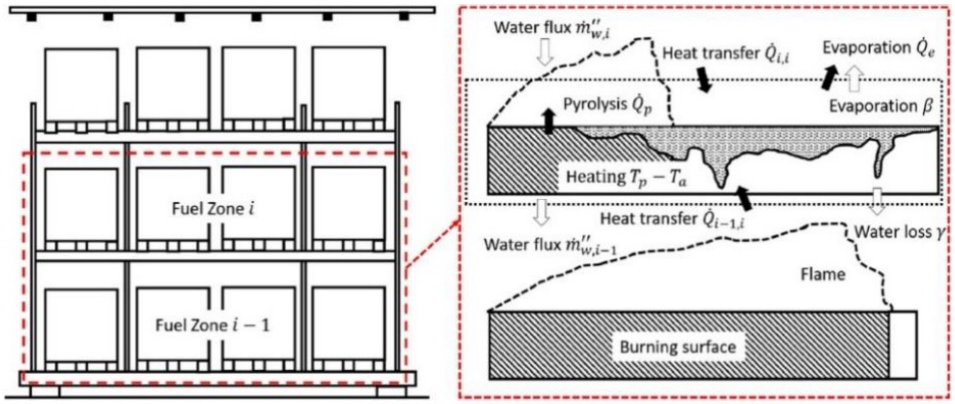
Burn cells used in this project to investigate the impact of architectural finishes on fire patterns



Framework for Automated and Quantitative Image-Based Fire-Pattern Analysis

Warehouse Fires

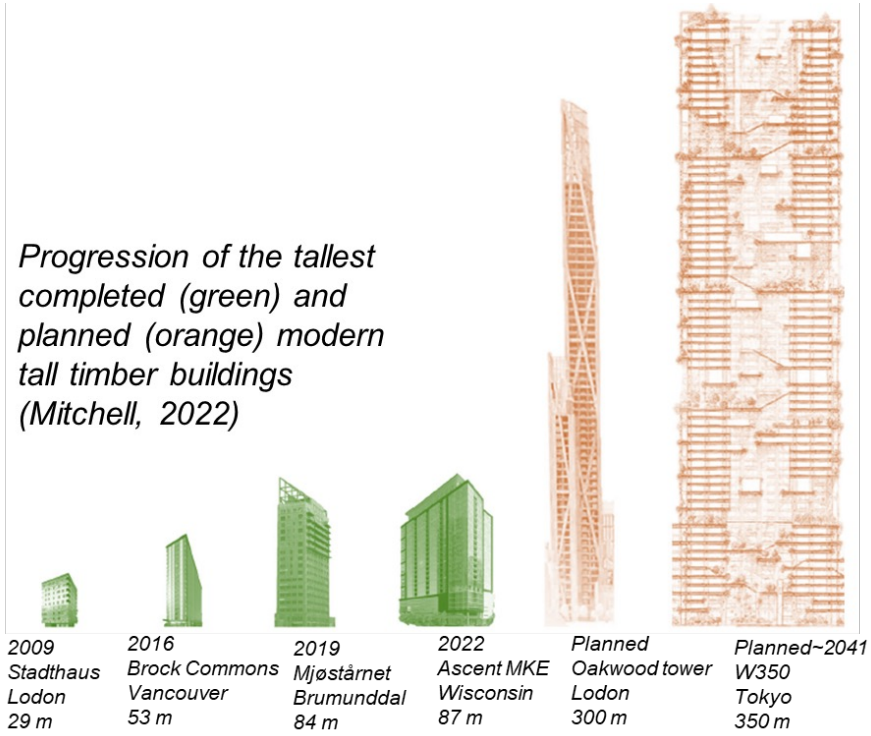
- *Faculty*: S. Ni and S. Stoliarov
- *Student:* V. Kumar (Postdoc)
- *Collaborators:*
- *Title*: "Improving Physics-based Engineering Framework for Commodity Classification"
- *Sponsor*: *FM*
- *Objective*: Improve a physics-based engineering model for accurately classifying commodities in warehouses for fire protection purposes.



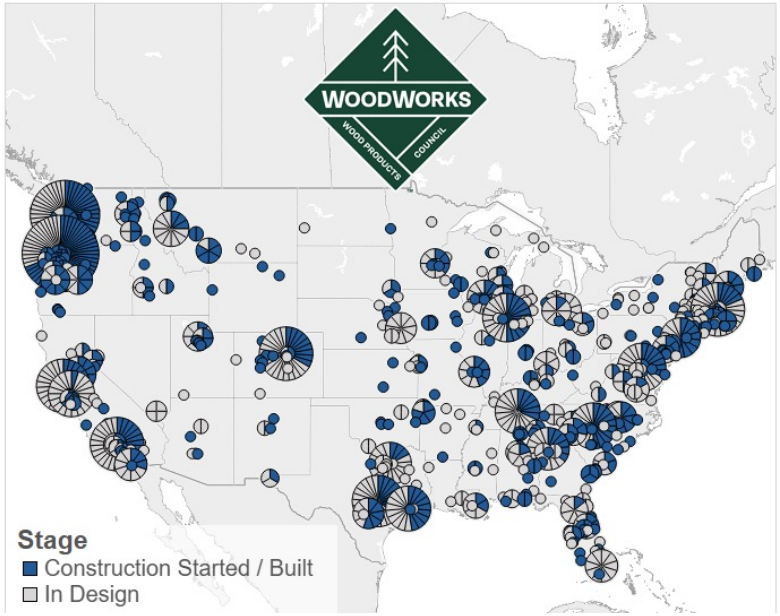
An illustration of the zone-based model for commodity classification (Han and Xin, 2020).

Fire Safety of Mass Timber Buildings

- *Faculty*: S. Ni and A. Trouvé
- *Student:* Z.H. Hussain
- *Collaborators:*
- *Title*: "Understanding the Impact of Wind on Fire Dynamics in Mass-Timber Compartment"
- *Sponsor*: Grand Challenge Grant at UMD
- *Objective*: Understanding the impact of wind on fire dynamics in mass-timber compartments.



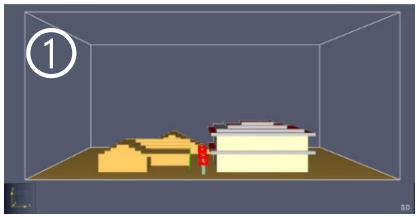
Progression of the tallest completed (green) and planned (orange) modern tall timber buildings (Mitchell, 2022)

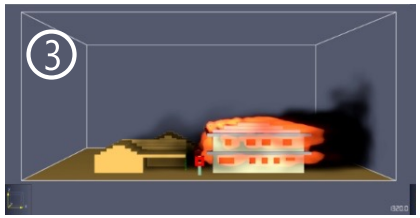


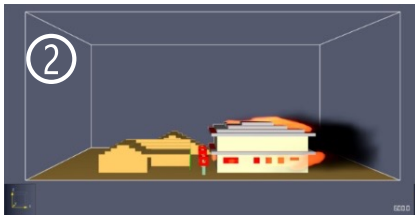
1,753 mass-timber projects either constructed or in design (Woodworks, 2023)

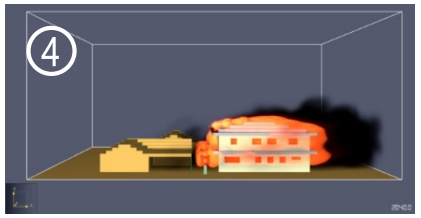
WUI Fire Resilience

- *FPE Faculty*: S. Ni, S. Stoliarov and A. Trouvé
- *Student:* E. Gironda
- *Collaborators*: IBHS and UL
- *Title*: Enhancing WUI Fire Assessment through Comprehensive Data and High-Fidelity Simulation
- *Sponsor*: National Science Foundation
- *Objectives*: Enhance wildfire risk assessment in WUI communities by compiling a detailed dataset from the Lahaina fire and testing the use of high-fidelity CFD models to simulate fire spread on individual structures.



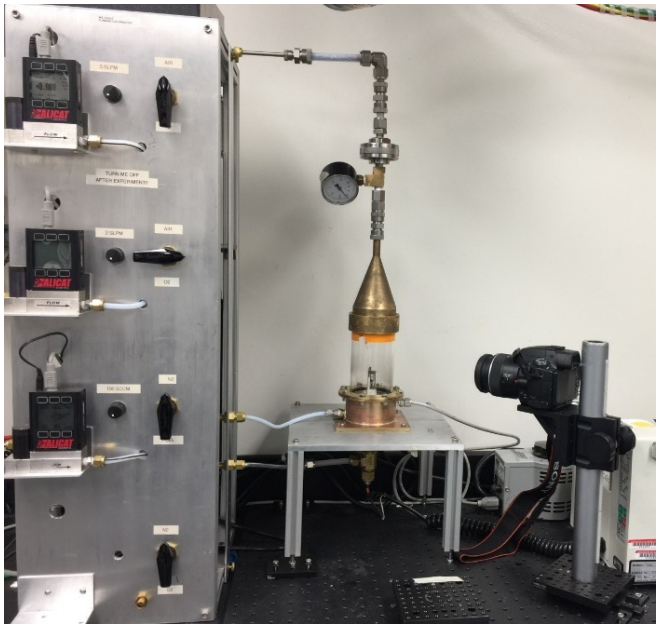






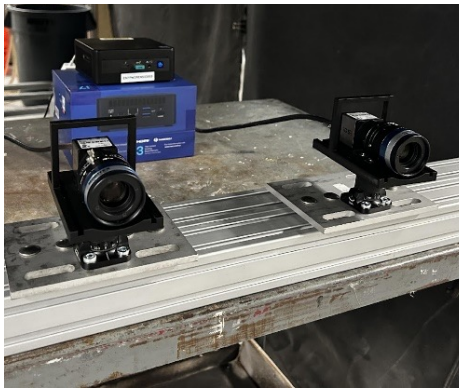
Milligram-scale Flame Calorimetry

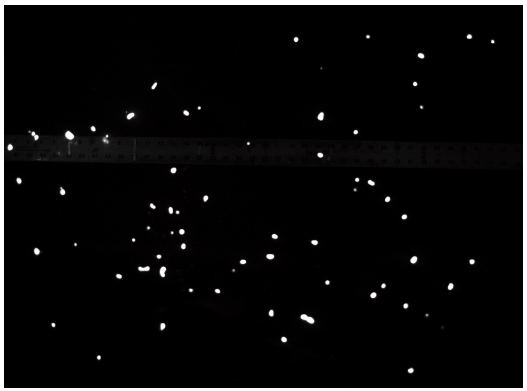
- *Faculty*: F. Raffan-Montoya and S. Stoliarov
- *Title*: Development of a methodology for the evaluation of fire retardancy of fabrics using the Milligram-scale Flame Calorimeter
- *Sponsor:* U.S. Army DEVCOM Soldier Center
- Collaborators: R. Nagarajan (Umass-Lowell), A.B. Morgan (University of Dayton Research Institute)
- *Objectives*: Characterize flammability parameters and thermal response of fabrics using milligram-sized samples and compare data to bench scale tests (vertical flame spread, mannequin test)

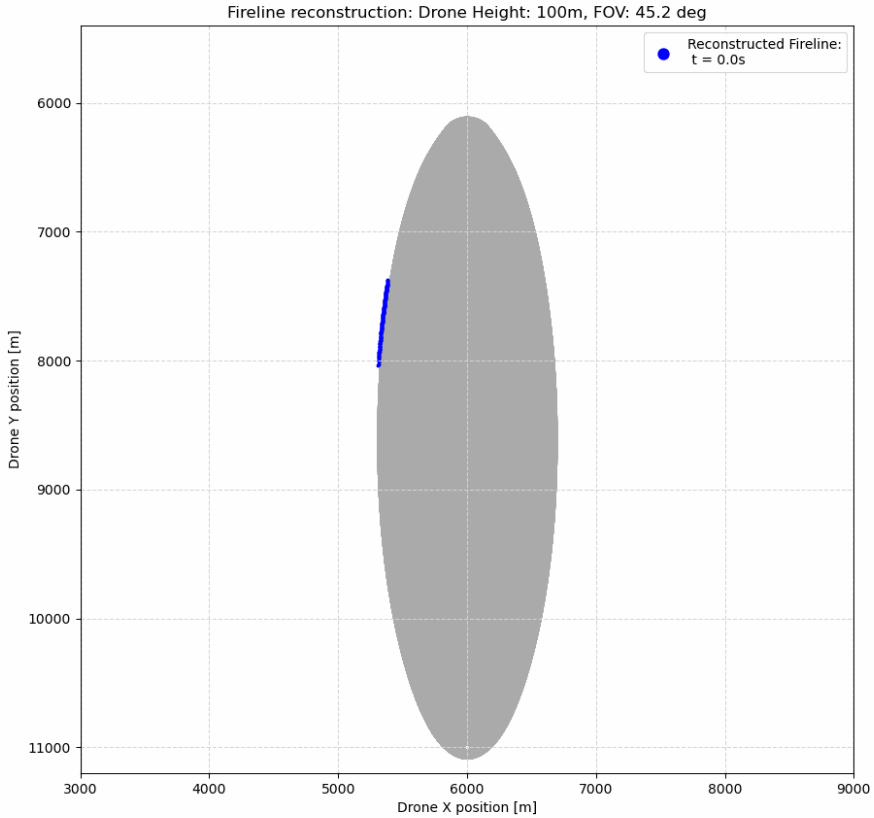


Wildfire Monitoring and Characterization

- *Faculty*: F. Raffan-Montoya, A. Trouvé
- *Title*: High-Resolution Observations of Wildfires and Wildland-Urban-Interface Fires Through State-of-the-Art UAVs and Fire Imaging Technologies
- *Sponsor:* UMD
- *Objectives*: Characterize ember fluxes with camera system onboard UAV. Autonomously monitor wildfire location, perimeter, size.



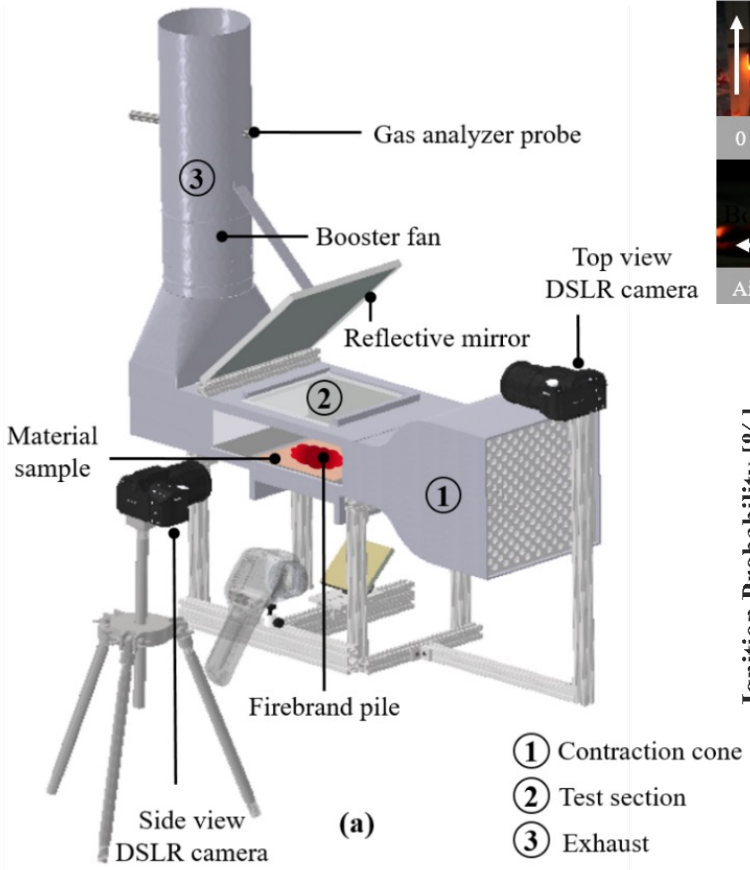


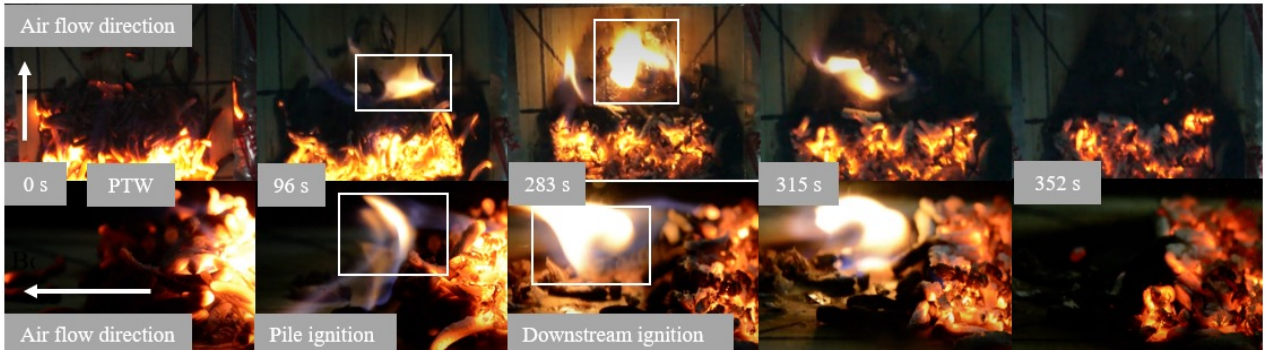


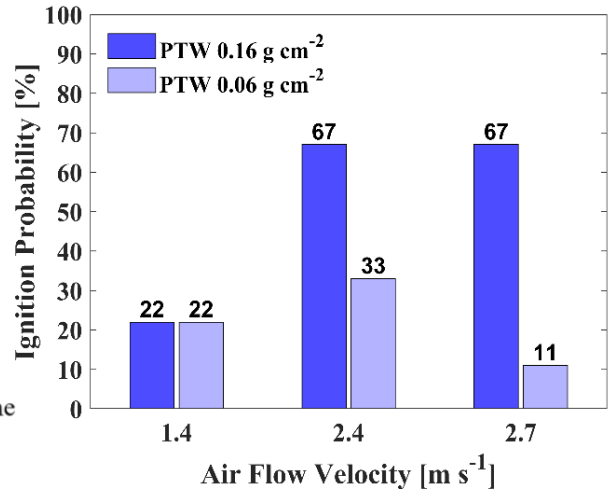
Wildland Fires

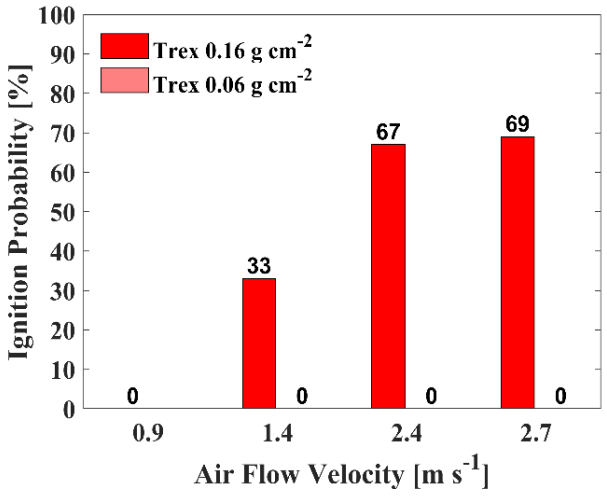
Ignition of Building Materials by Firebrands

- *Faculty:* S. Stoliarov and P. Sunderland in collaboration with A. Filkov, M. Gollner
- *Students:* S. Lee (Ph.D.)
- *Sponsor:* UL FSRI
- *Objective:* To determine the mechanism of ignition of representative building materials by firebrands and develop a model for this ignition process



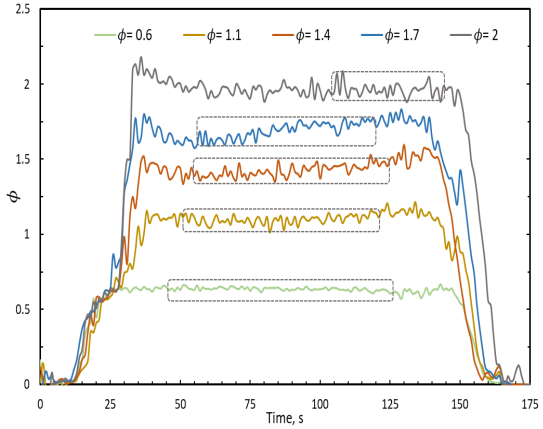


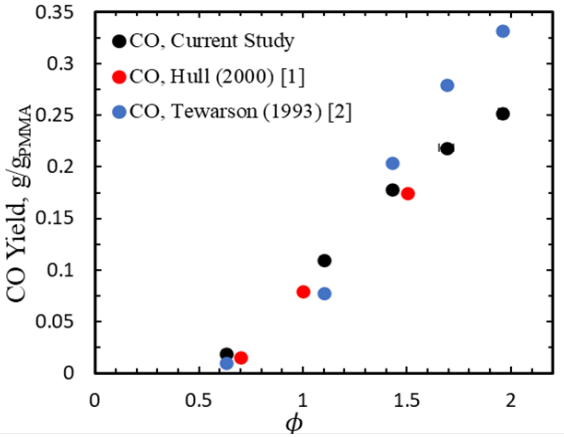


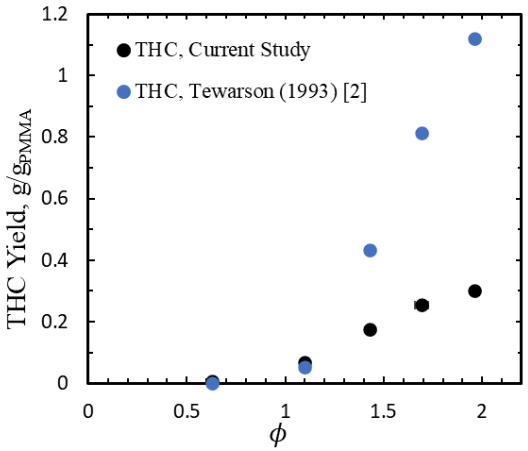


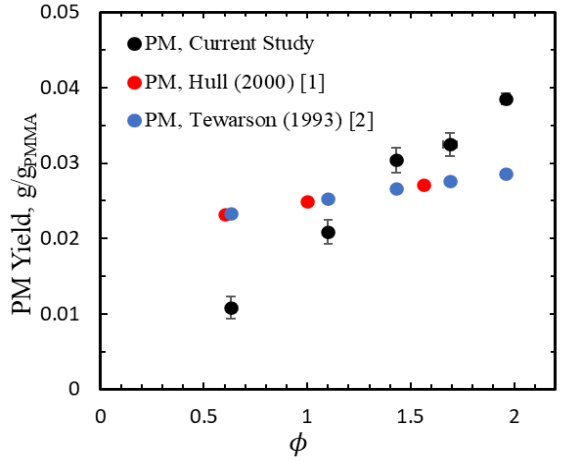
Characterization of Fire Effluent Composition

- *Faculty:* S. Stoliarov and F. Raffan-Montoya
- *Students:* F. Beygi (Ph.D.)
- *Sponsor:* FAA and FM Global
- *Objective:* To develop an advanced version of the Fire Propagation Apparatus that enables controlled equivalence ratio fire experiments including time resolved measurements of O_2, CO, CO_2, soot, HCN, HCl, HBr, and total hydrocarbons (THC)





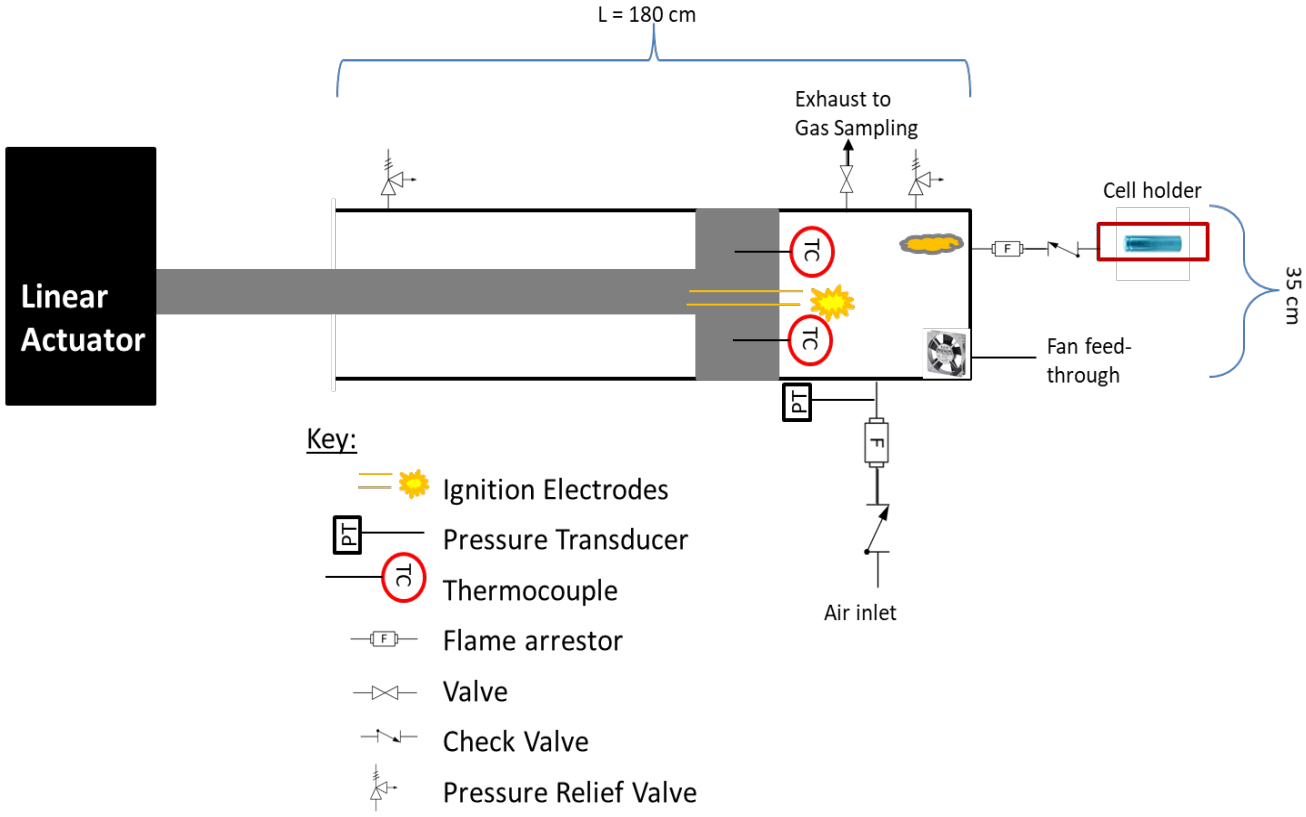




Lithium-ion Batteries

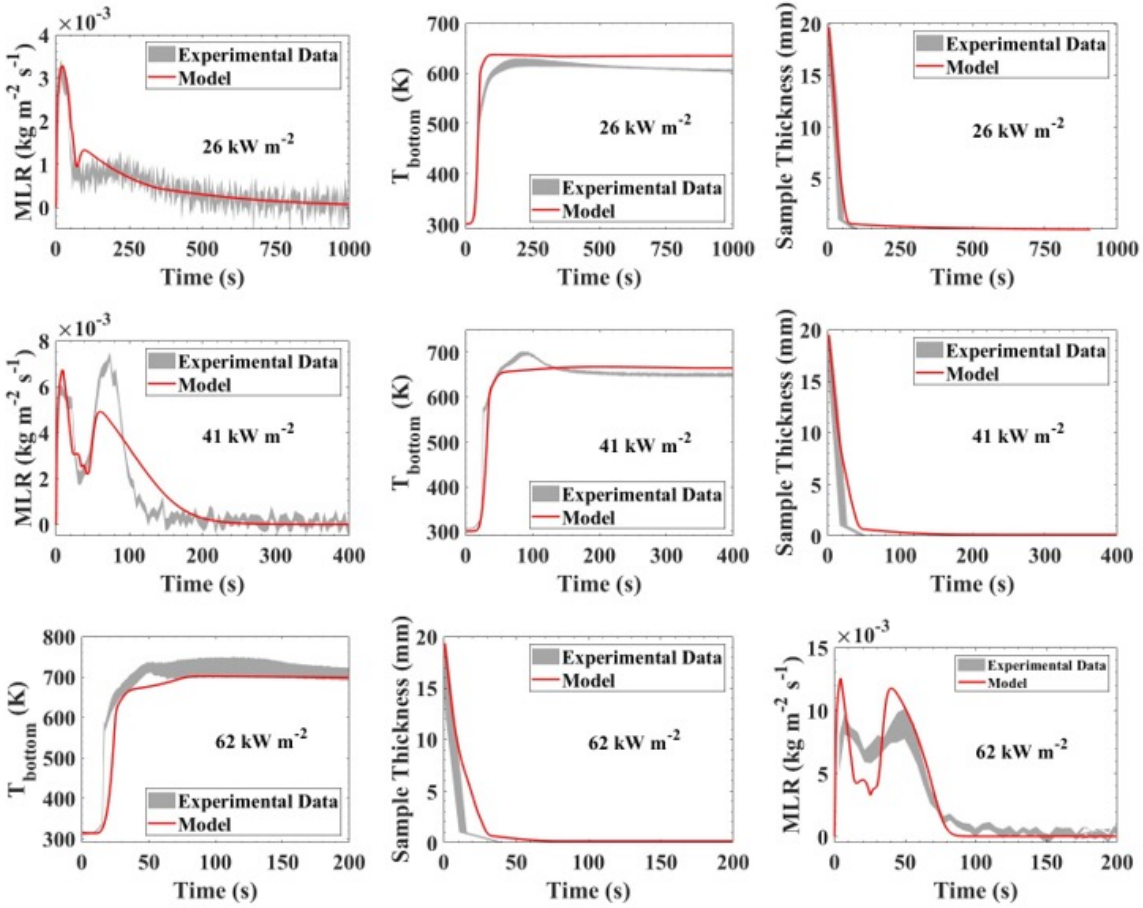
Flammability of Lithium-ion Battery Ejecta

- *Faculty:* S. Stoliarov
- *Students:* J. Schwartz (Ph.D.)
- *Sponsor:* ONR
- *Objective:* To develop a method for the measurement of the lower flammability limit for gases and aerosols ejected from a lithium-ion cell undergoing a thermal runaway

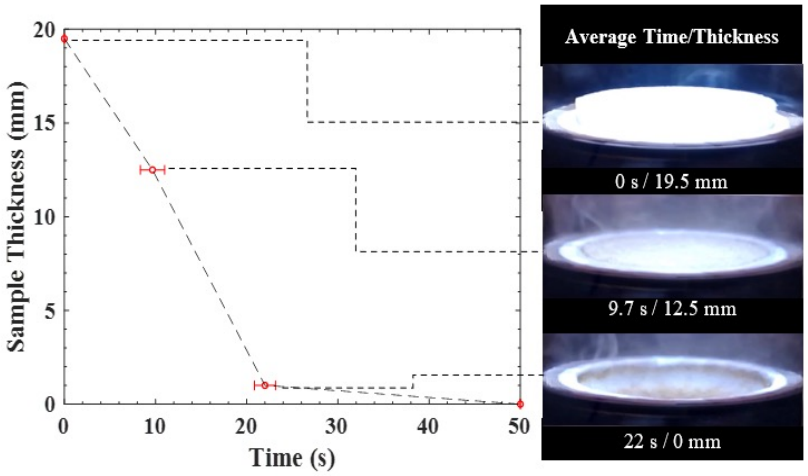


Development of Pyrolysis Model for Flexible PU Foam

- *Faculty:* S. Stoliarov
- *Students:* S. Kamma (M.S.)
- *Sponsor:* NIST
- *Objective:* To measure properties that govern gaseous fuel production by standard flexible polyurethane foam used in upholstered furniture and develop a complete pyrolysis model for this material

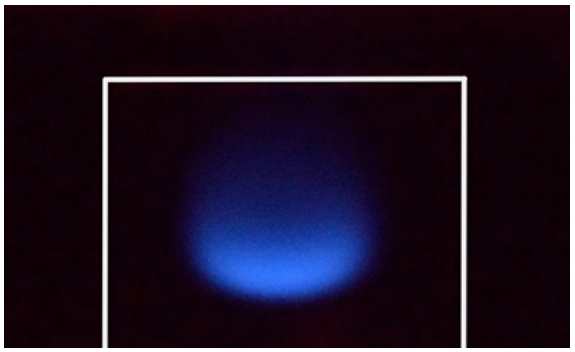


Controlled Atmosphere Pyrolysis Apparatus II test at 41 kW m^{-2}



Cool Pool Diffusion Flames

- *Faculty*: Peter Sunderland
- *Ph.D. Student:* Subhojit Roy
- *M.S. Students:* Shubham Pimple, Yufeng Zheng
- *B.S. Students:* Alexander Lyons, Nicholas Mertz
- *Sponsor*: National Science Foundation
- *Objectives*: Observe cool diffusion flames supported by pools of diverse liquid and solid fuels and perform detailed measurements and modeling.



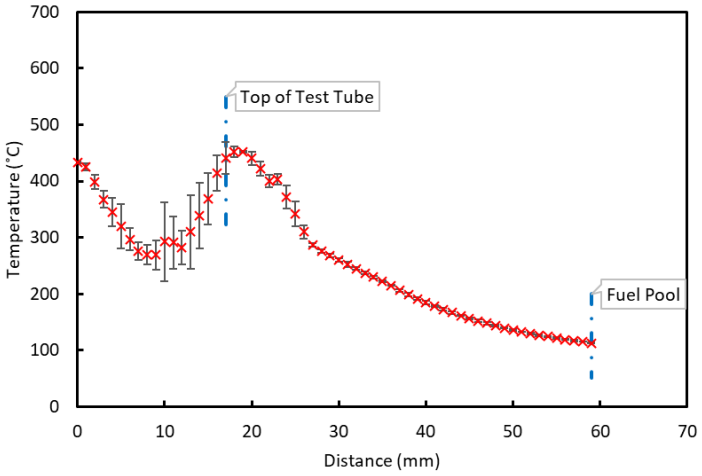
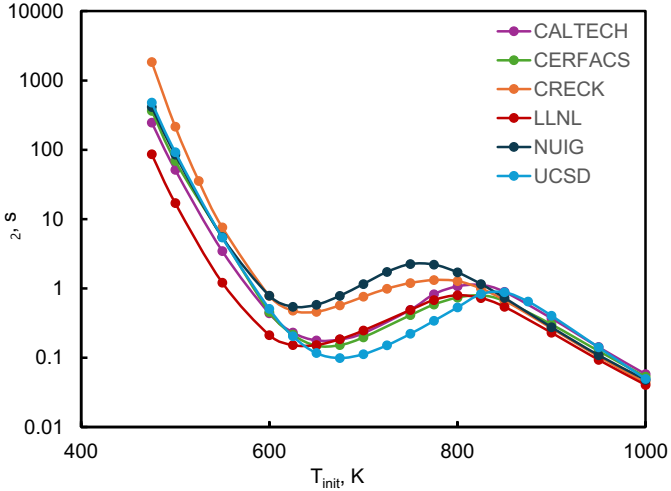


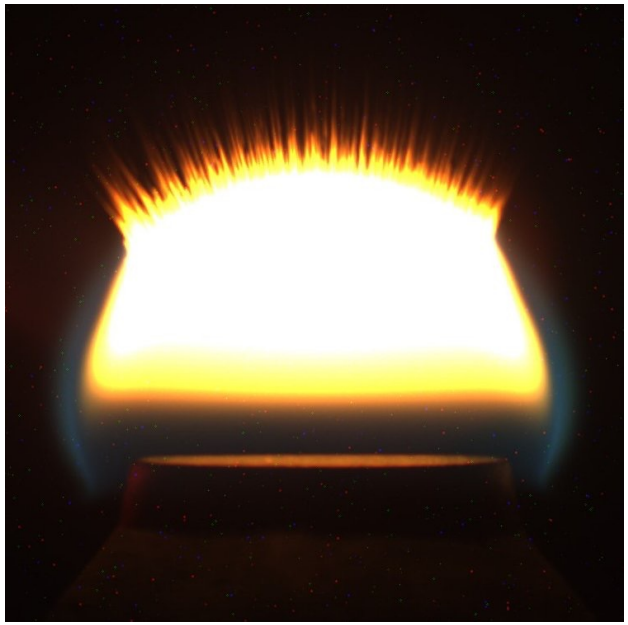
Image of n-heptane cool pool diffusion flame with the test tube shown in white (left), and measured temperatures (center).



Cantera simulations of n-heptane negative-temperature coefficient behavior.

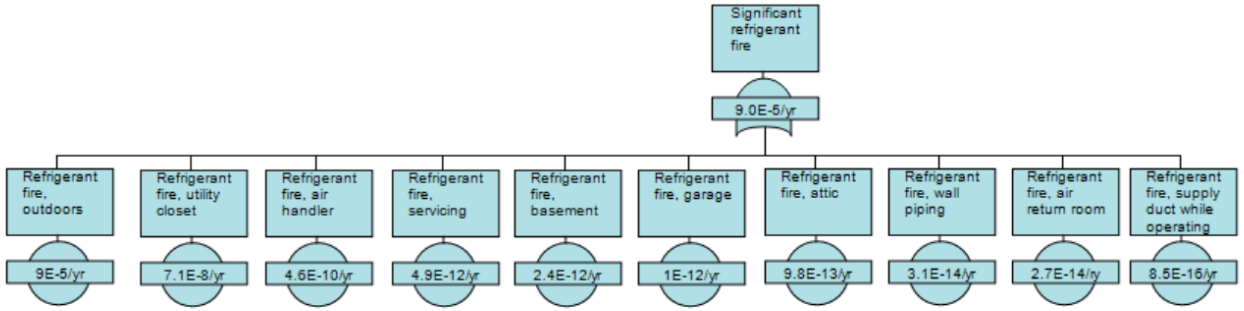
Burning Rate Emulator

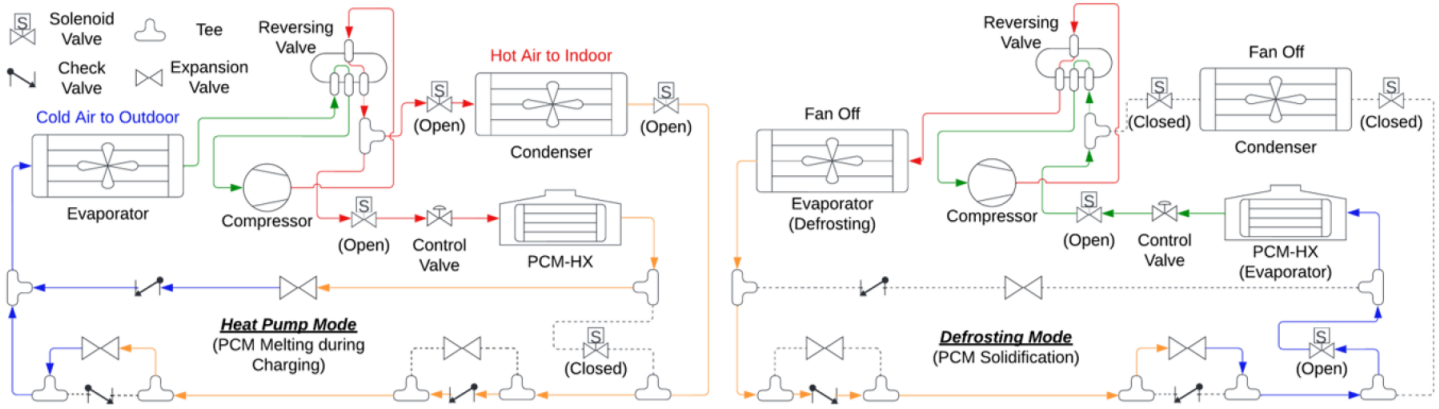
- *FPE Faculty:* J.G. Quintiere, P.B. Sunderland, H.R. Baum
- *Ph.D. Students*: P. Dehghani, A. Markan
- *M.S. Students*: E. Auth, M. Bustamante, H. Kim, R. Venzon, A. Wright
- *Collaborator*: J. deRis
- *Title*: Experimental Investigation of Emulated Burning Rate at Various Gravity Levels
- *Sponsor*: NASA Glenn
- *Objectives*: Use gases to emulate condensed fuel fires in microgravity aboard the International Space Station.



35 kW Heat Pump with Propane Refrigerant

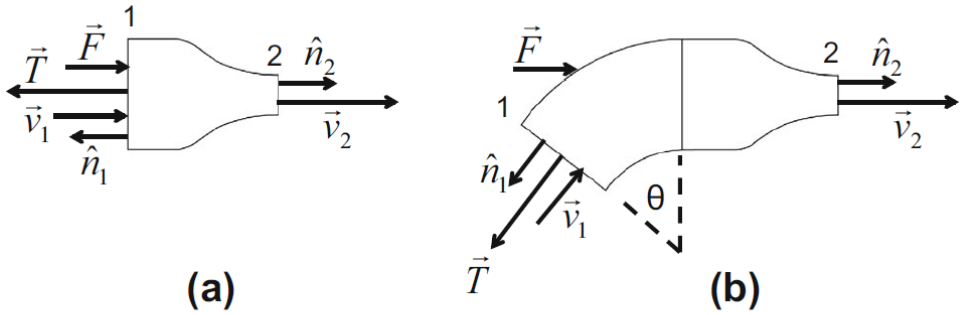
- *FPE Faculty:* Peter Sunderland
- *Ph.D. Students*: D. Kang, T. Seabourne, M. Siam, J. Yang
- *Collaborators*: R. Radermacher, Y. Hwang
- *Title*: Smart Cold Climate Rooftop Heat Pump with Low-GWP Refrigerant
- *Sponsor*: DOE - EERE
- *Objectives*: Design a 35 kW rooftop heat pump whose working fluid is R-290 (propane); perform fault-tree analyses; and propose code changes and safety systems that ensure safety.

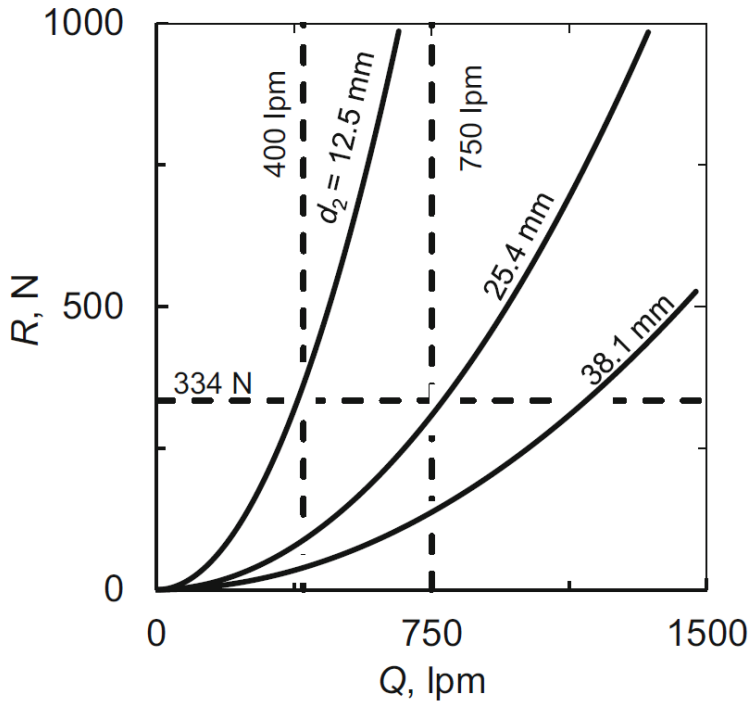




Low-Reaction Firefighting Nozzle

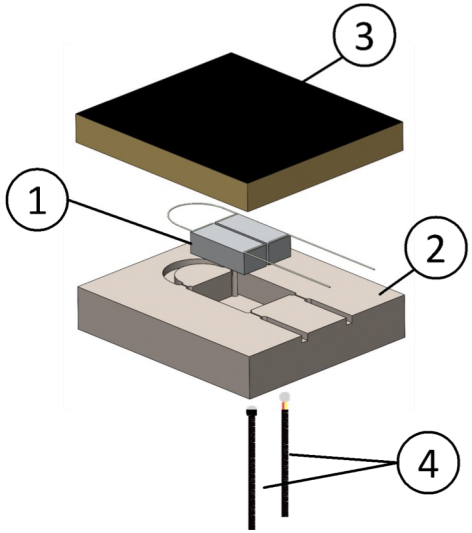
- *FPE Faculty:* Peter Sunderland
- *Undergraduate Students*: H. Coale, L. Duncan, E. Kim, A. Moulton, E. Mourlas, K. Paparrizos, R. Pusinsky, E. Safra, S. Schweitzer
- *Sponsor*: Gemstone Honors Program
- *Objectives*: Design a firefighting nozzle for handlines that minimizes reaction forces (without compromising hose pressure) by independently controlling the nozzle pressure and flowrate.

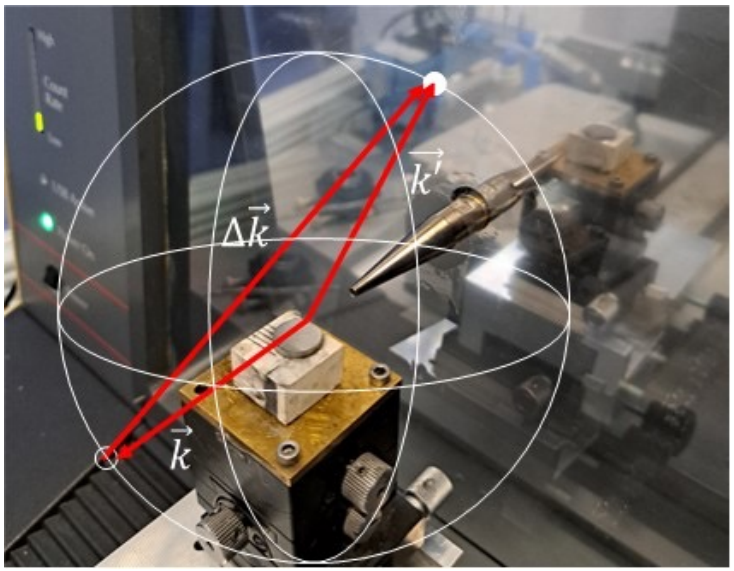


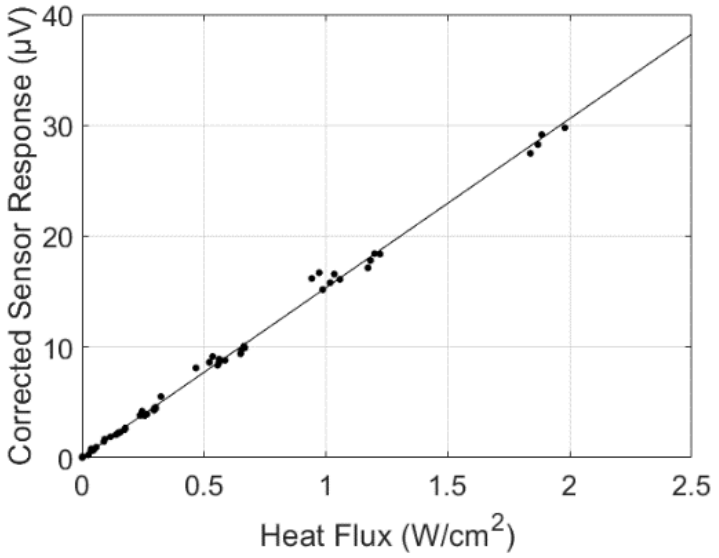


High Temperature Heat Flux Gages

- *FPE Faculty*: Peter Sunderland
- *MSE Faculty:* Oded Rabin
- *Ph.D. Student:* Kenneth McAfee
- *Title:* Robust Heat-Flux Sensors for Coal-Fired Boiler Extreme Environments
- *Sponsor*: DOE – NETL
- *Objectives*: Develop novel heat flux gages that exploit the transverse Seebeck effect in rhodium single-crystal pellets.

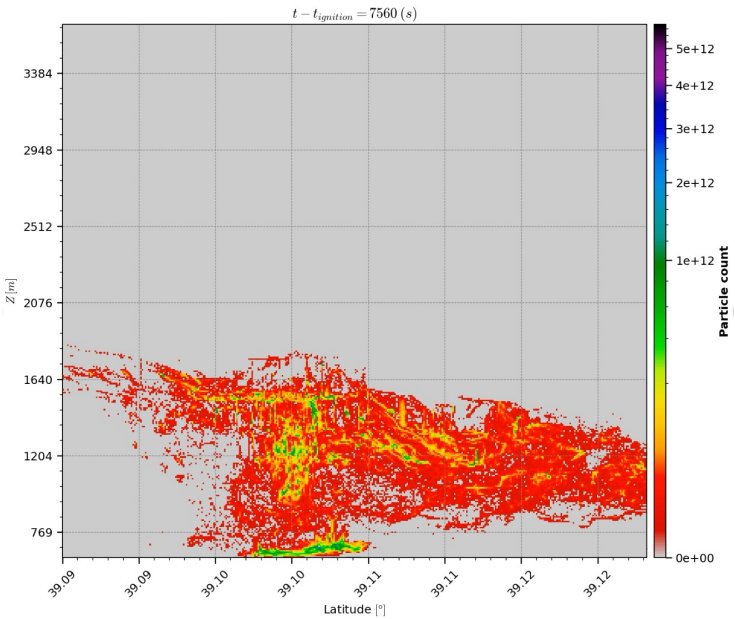




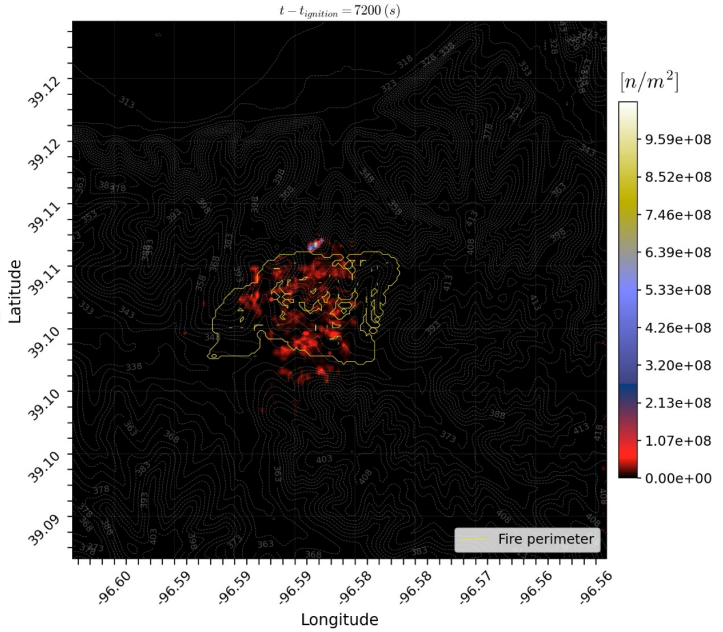


Polydisperse Particle Transport in Wildfire Plumes

- *Faculty*: A. Tohidi
- *Title:* "High-Resolution Pyroaerobiology Modeling of Prescribed Burn Experiments"
- *Sponsor*: National Science Foundation (NSF)
- *Collaborators*: Leda Kobziar (University of Idao), Adam Kochanski (San Jose State)
- *Objective*: Develop a highly-scalable emission transport model that simulates transport of aerosolized particulate matter and microbial emissions through wildfire smoke plumes at regional scales. The capability enables scientists in characterizing the large-scale impacst of smoke (in-house multi-GPU multi-threading I/O solver, coupled with WRF-SFIR).



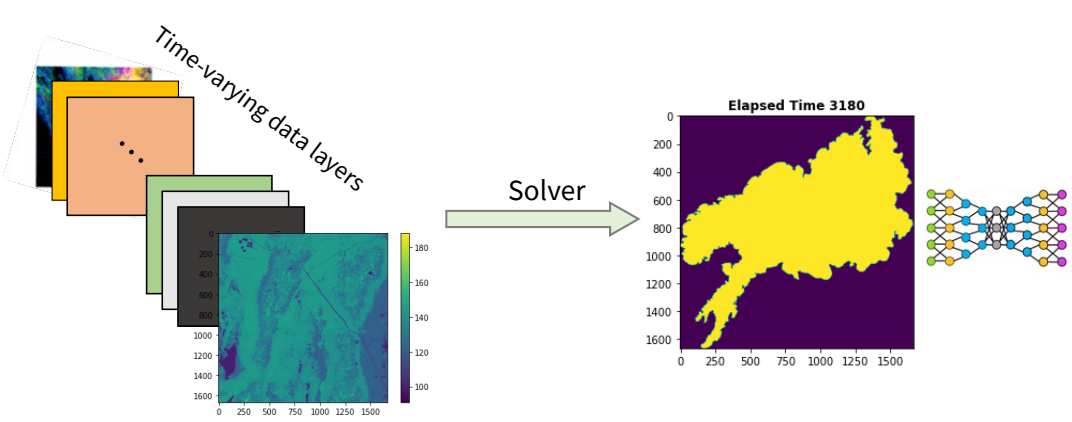
Simulated particle cloud at the Konza Burn experiment



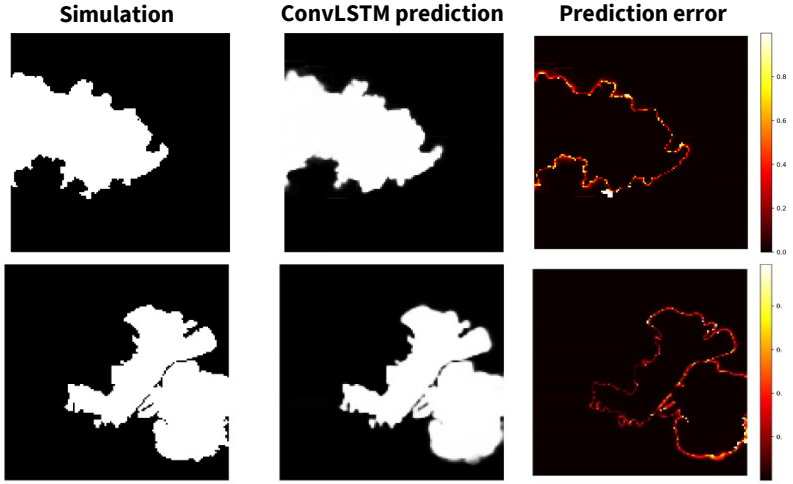
Estimated deposition patterns with respect to the burn perimeter resolved with WRF-SFIRE

Data-Driven Wildfire Modeling

- *Faculty*: A. Tohidi
- *Title:* "A Spatially Explicit ConvLSTM Model for Real-Time Ensemble Forecasting"
- *Sponsor*: IBM Public Impact Projects
- Collaborators: Jonathan Hodges (Jensen Hughes)
- *Objective*: Developing a foundation for robust, accurate, and fast ensemble wildfire forecast system for stakeholders to guide the risk estimation and mitigation efforts. This work takes a hybrid data-driven approach, leveraging data from 84,000+ synthetic wildfire simulations using Lagrangian front-tracking solvers. A data preprocessing solver takes the simulator inputs and data-layers and creates an analysis ready and spatially explicit dataset. The dataset is used to develop a ConvLSTM forward model.



New data layers of the synthetic simulations

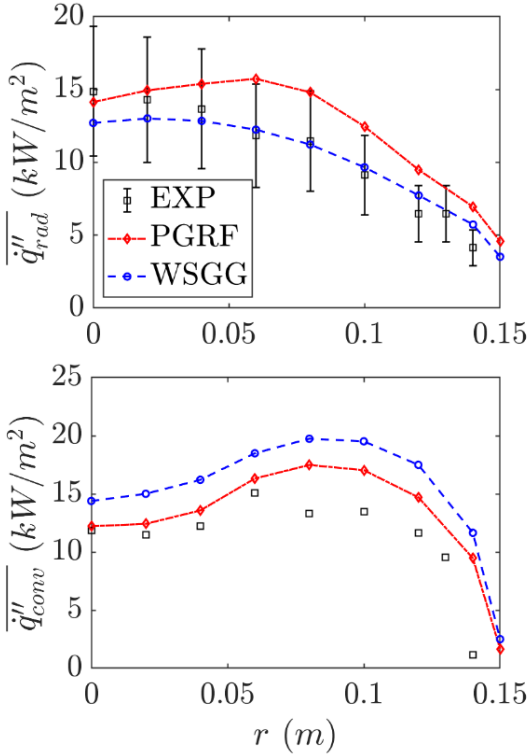


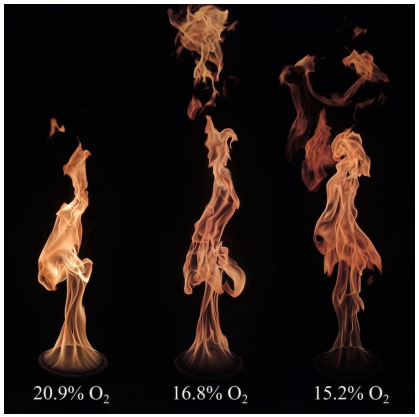
Original data of wildfire simulations received from Hodges [1,2] and later expanded in this work

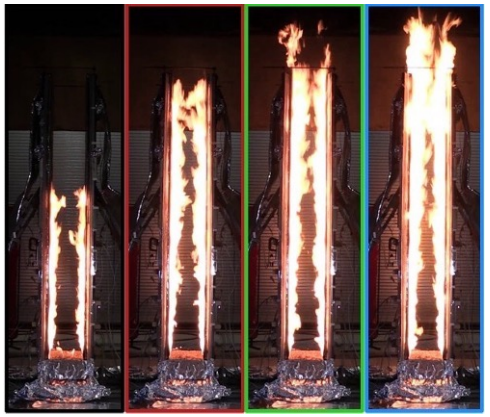
[1] J.L. Hodges, B.Y. Lattimer, Wildland Fire Spread Modeling Using Convolutional Neural Networks, Fire Technol 55 (2019) 2115–2142.
[2] J.L. Hodges, Predicting Large Domain Multi-Physics Fire Behavior Using Artificial Neural Networks, Virginia Tech, 2018.

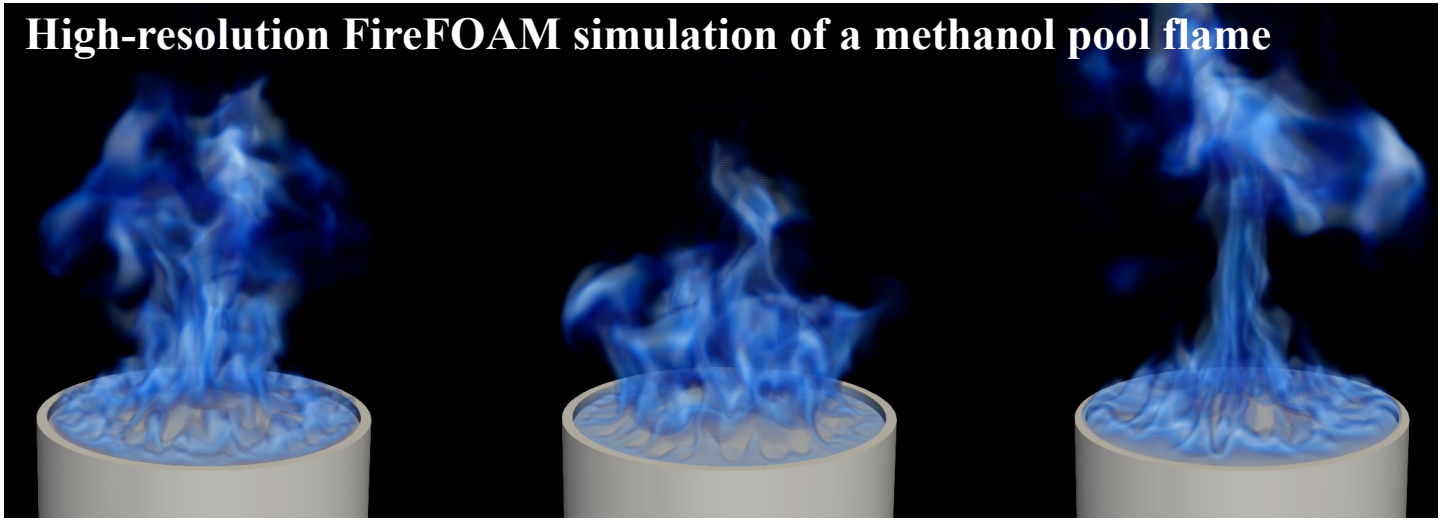
The MaCFP Working Group

- *Faculty*: A. Trouvé
- *Collaborators*: the IAFSS Working Group on Measurement and Computation of Fire Phenomena (the MaCFP Working Group, http://www.iafss.org/macfp)
- *Objective*: Build a collaborative framework (through a series of workshops) around the topic of the experimental validation of computer-based fire models.





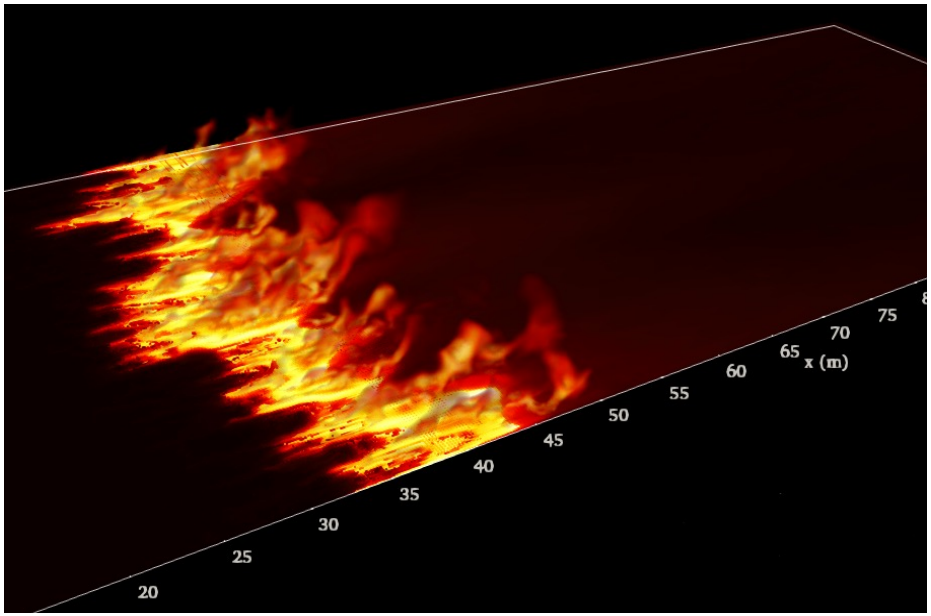




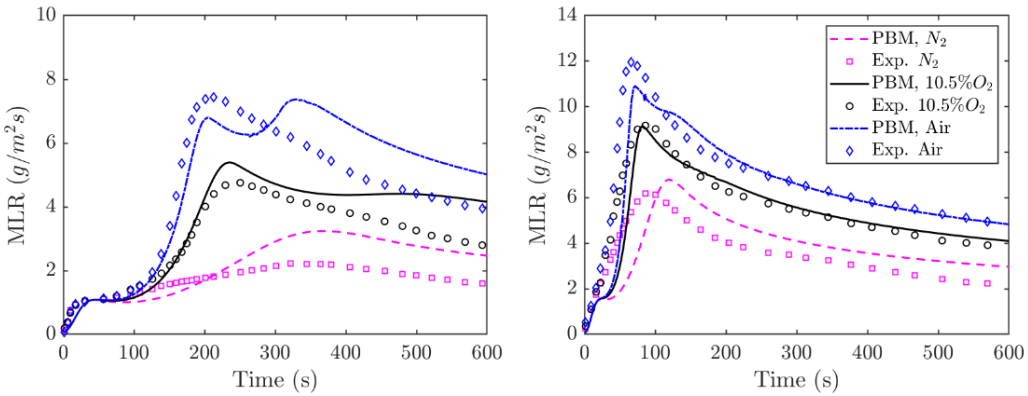
Flame-Scale Modeling of Wildland Fire Spread

- *Faculty*: A. Trouvé – *PhD student*: H. Al-Bulqini
- *Title:* "Modeling the burning of individual fuel particles and fuel beds in wildland fires"
- *Sponsor*: USDA Forest Service
- *Collaborators*: M. Finney, J. Forthofer (US Forest Service)
- *Objective*: Develop a state-of-the-art computational modeling capability that simulates wildland fire behavior at vegetation and flame scales. Perform detailed simulations of wildland fire behavior with a high-resolution description of flame spread, heat release and fuel consumption (including flaming and smoldering combustion). (Solver: OpenFOAM.)

OpenFOAM simulation of fire spread across a biomass vegetation bed treated as a population of discrete particles

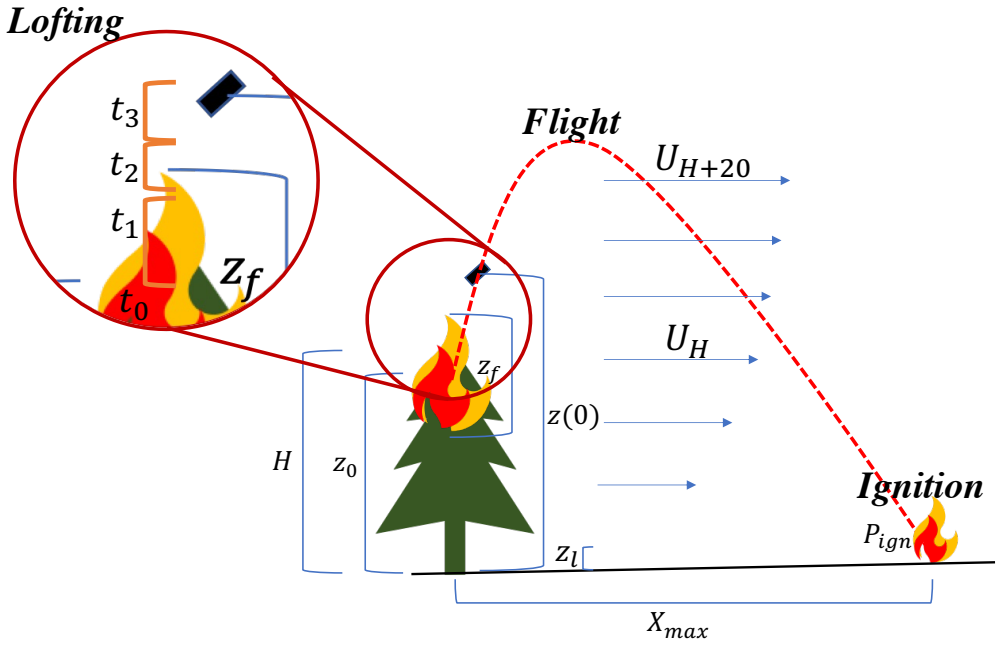


Simulations of drying, pyrolysis and char oxidation for a single particle representing biomass vegetation



Regional-Scale Modeling of Wildland/WUI Fire Spread

- *Faculty*: A. Trouvé – *PhD student*: Y. Qin
- *Title:* "Preventing the next Disaster at the Wildland-Urban Interface: Development of a validated end-to-end WUI modeling system to optimize mitigation"
- *Sponsor*: Gordon and Betty Moore Foundation
- *Collaborators*: M. Gollner (UCB), C. Lautenberger (CloudFire Inc.)
- *Objective*: Extend modeling capabilities of current landscape-scale wildland fire spread models to the case of wildland/WUI fire spread due to firebrands (Solver: ELMFIRE, developed by CloudFire Inc.)



ELMFIRE simulation of fire spread across the landscape