Next Generation Physics Models: Management Use

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SERDP • ESTCP
SYMPOSIUM
2018 | Enhancing DoD's Mission Effectiveness

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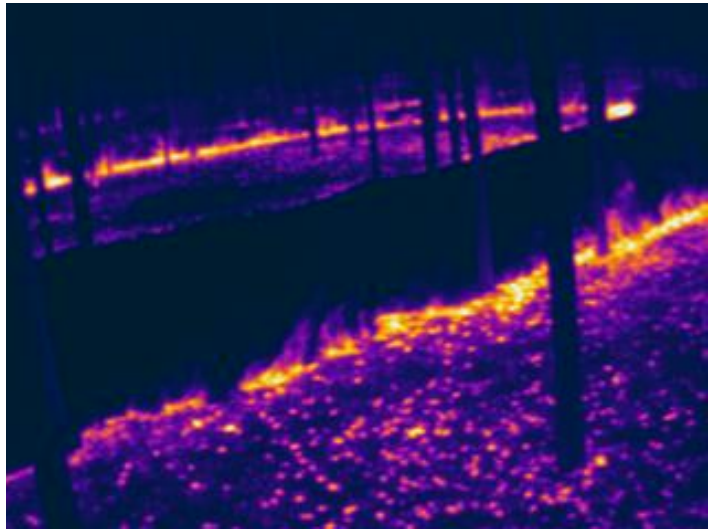
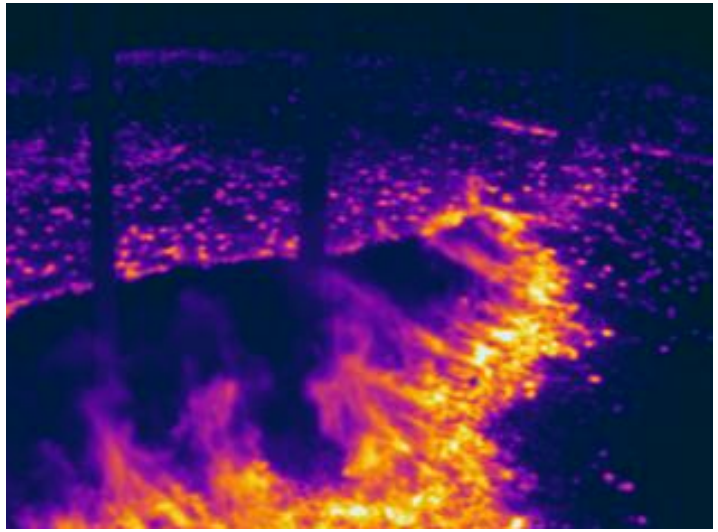
Why should we look to next-generation tools?

- Prescribed-fire and fire management tactics depend on interaction between fire and atmosphere
- Operational wildfire-behavior models
  - Intended for free-burning fires
  - Do not describe the interactions between multiple fires or fire's response to common prescribed fire tactics or backfire operations



Rx-Fire–
interactions
between fire lines



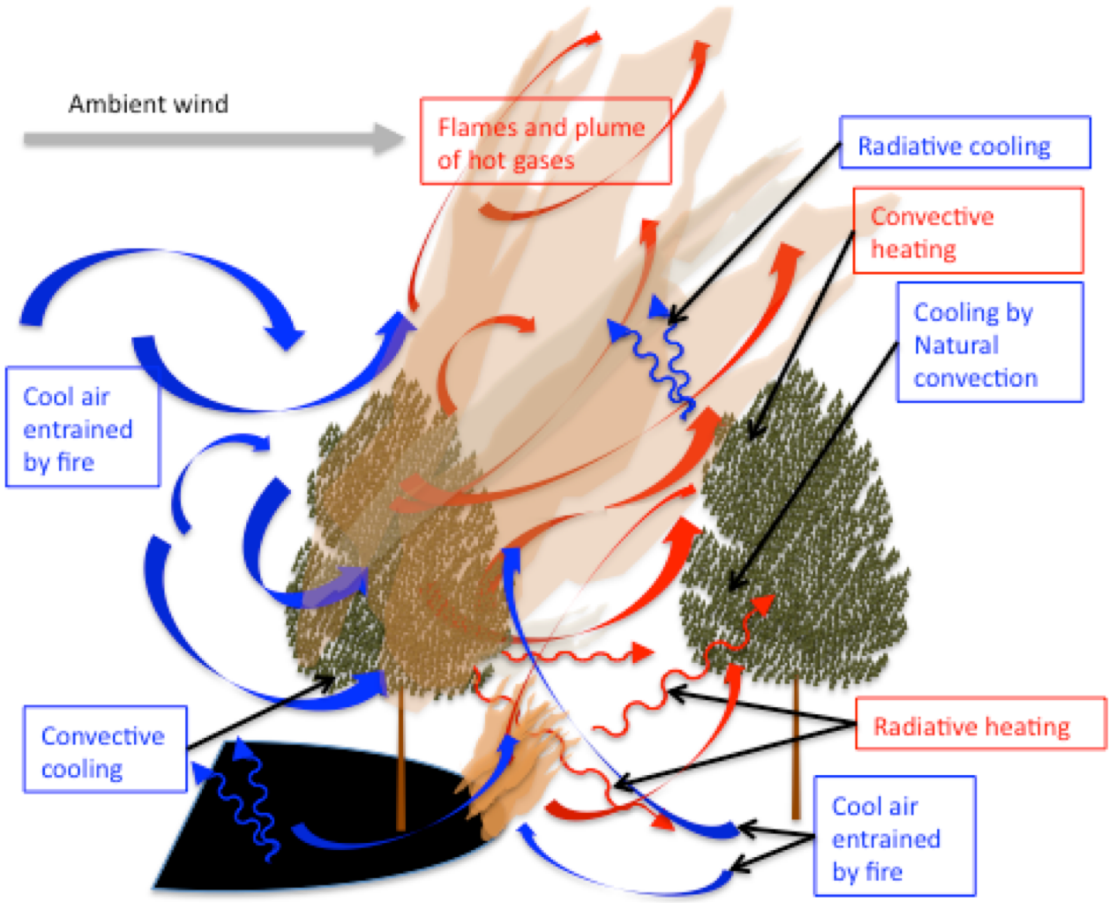
Opportunities for next generation modeling tools

- Training
- Exploration
  - Optimizing ignition tactics for ecologic objectives and environmental conditions.
  - Impacts of burn-block layout strategies
  - RxFire plume development/behavior
  - Influences of dynamic conditions
  - Options for counter fire measures
- Identify possible existence of fire behavior thresholds

One approach to meet this need:
Physics-based coupled fire/atmosphere modeling

Representing key interacting physical processes:

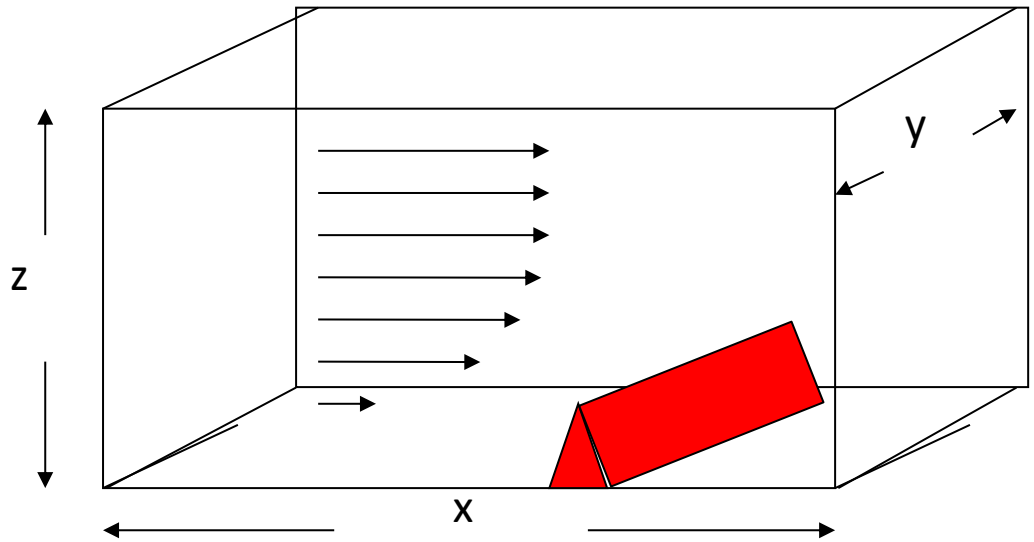
- Heterogenous and dynamic winds, influenced by:
  - Topography
  - Fire
  - Vegetation
- Heat transfer between fuels and gases
- Fuel moisture evaporation
- Combustion
  - Energy release
  - Fuel consumption



What can we do with these tools now?
Explore fundamental aspects of fire behavior

Many existing models use “Wall of flame” assumption

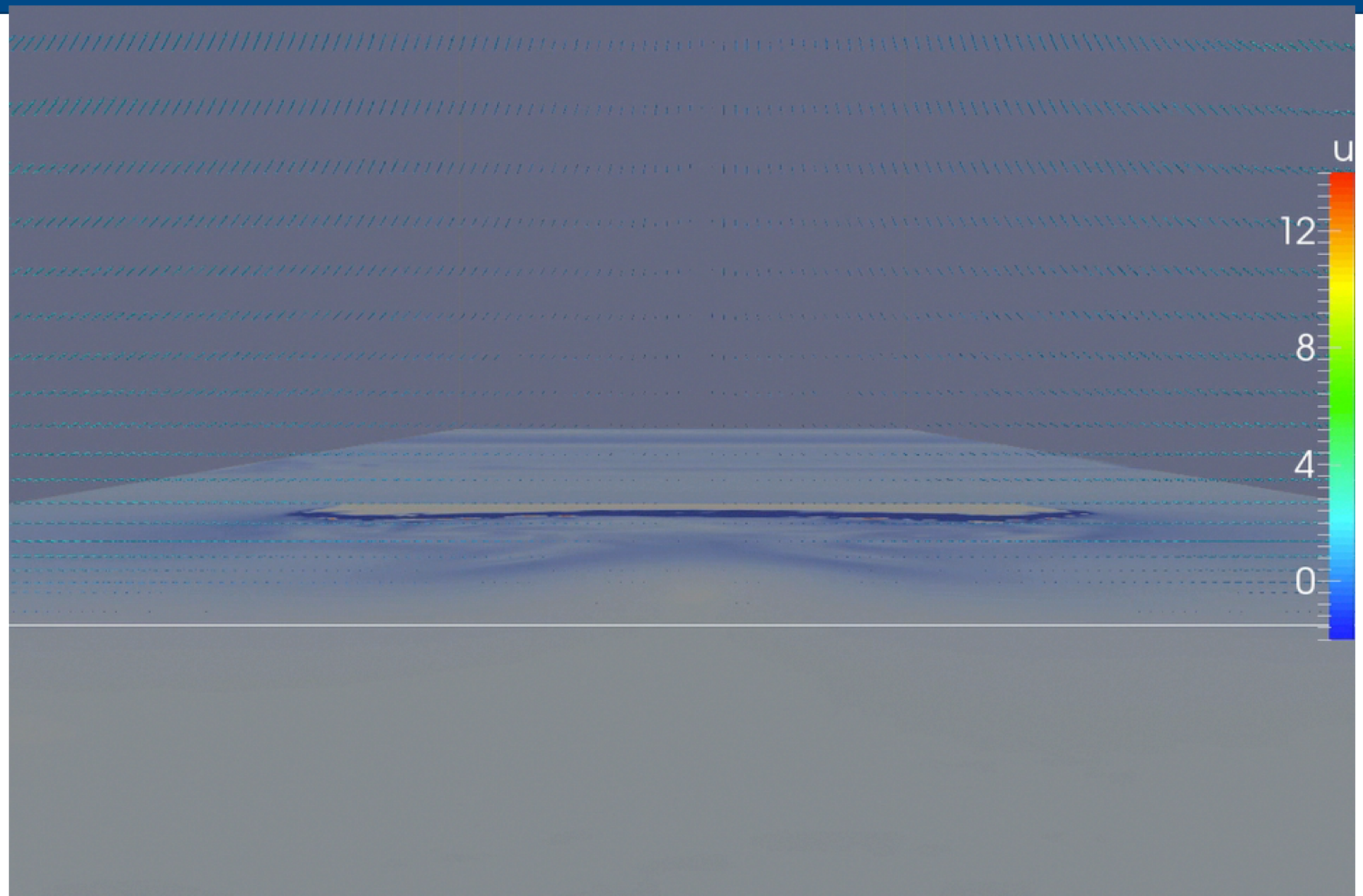
- Simplifies fast-running-model development by turning it into a 1-D or 2-D problem.
- Unfortunately, wildland fires often do not behave like a wall of flame.



What can we do with these tools now?

Explore fundamental aspects of fire behavior

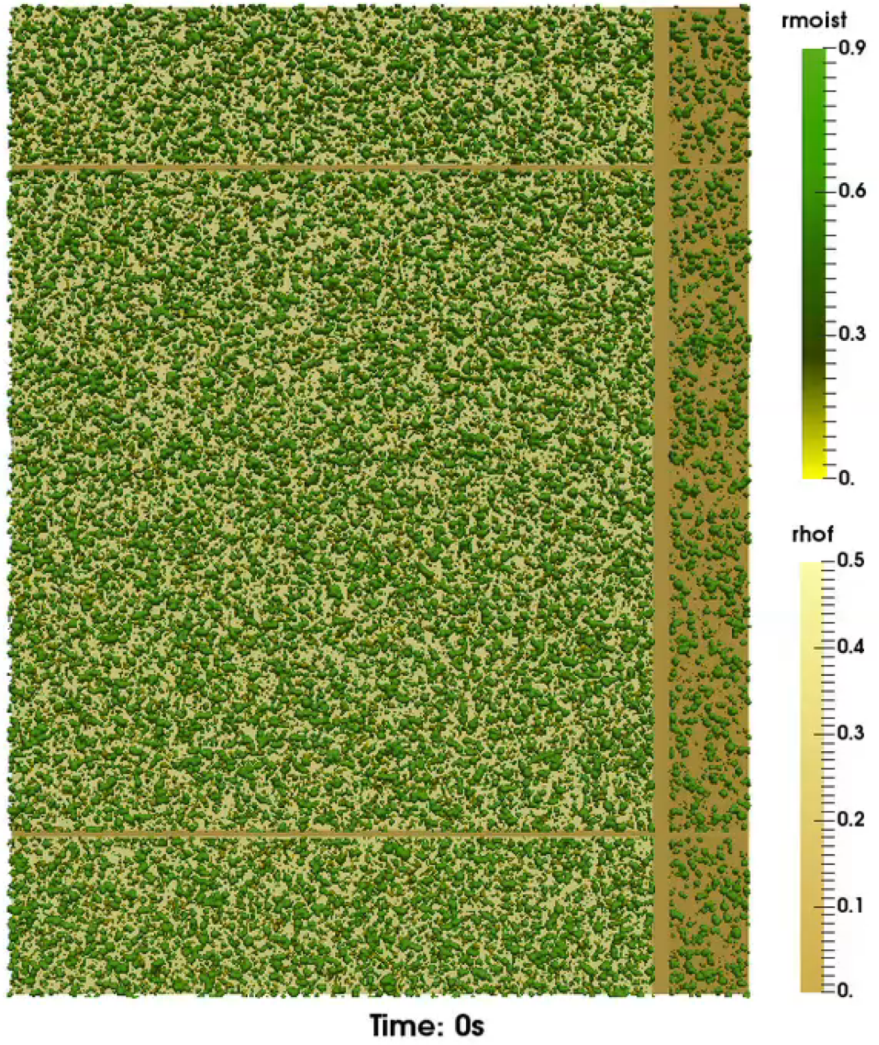
- Fire is moving at the viewer
- Vectors are in the plane indicated by the white line (colors indicate the component towards the viewer).
- Colors on the horizontal surface indicate convective cooling (blue) and convective heating (red).



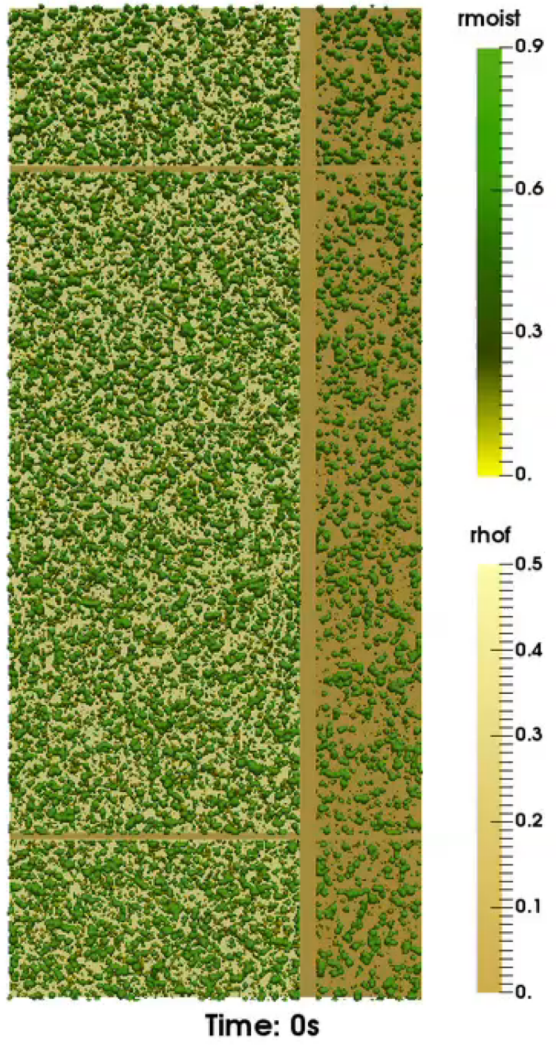
What can we do with these tools now?

Assist in engineering fire behavior through RxFire ignition tactics

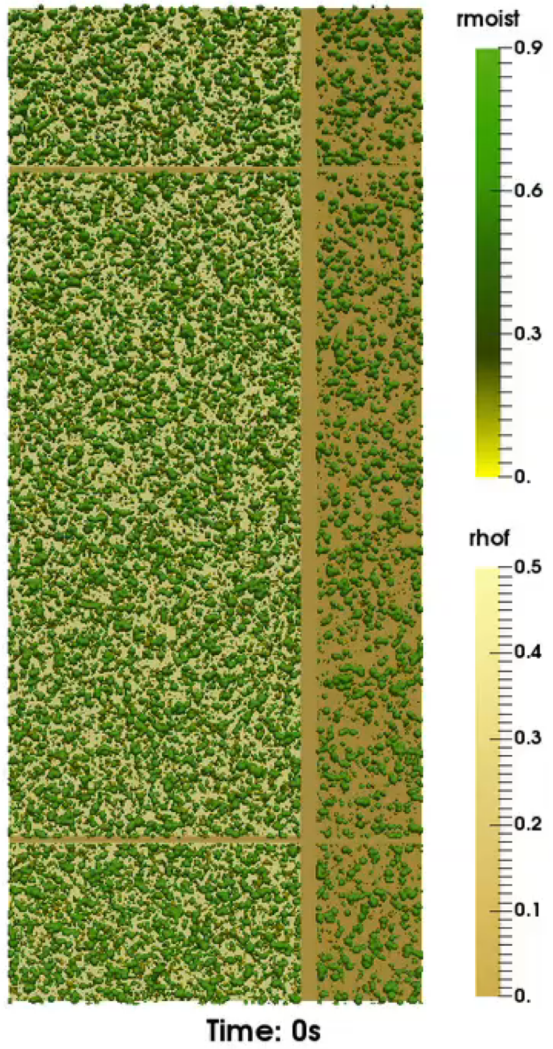
Aerial (helicopter) ignition



Dashed (ATV) ignition

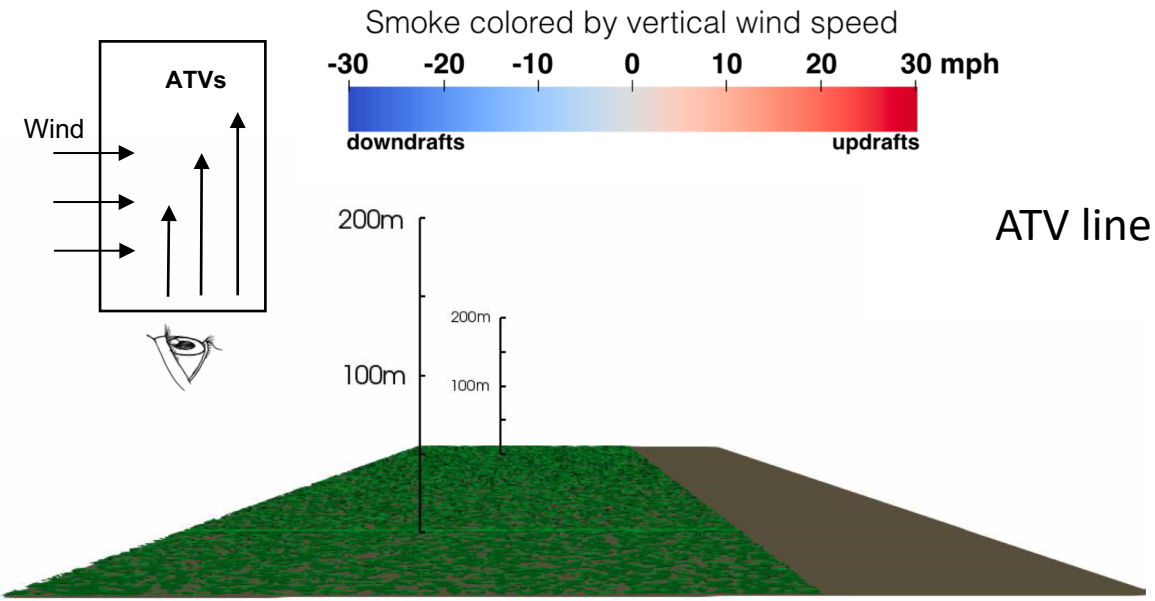


Line (ATV) ignition

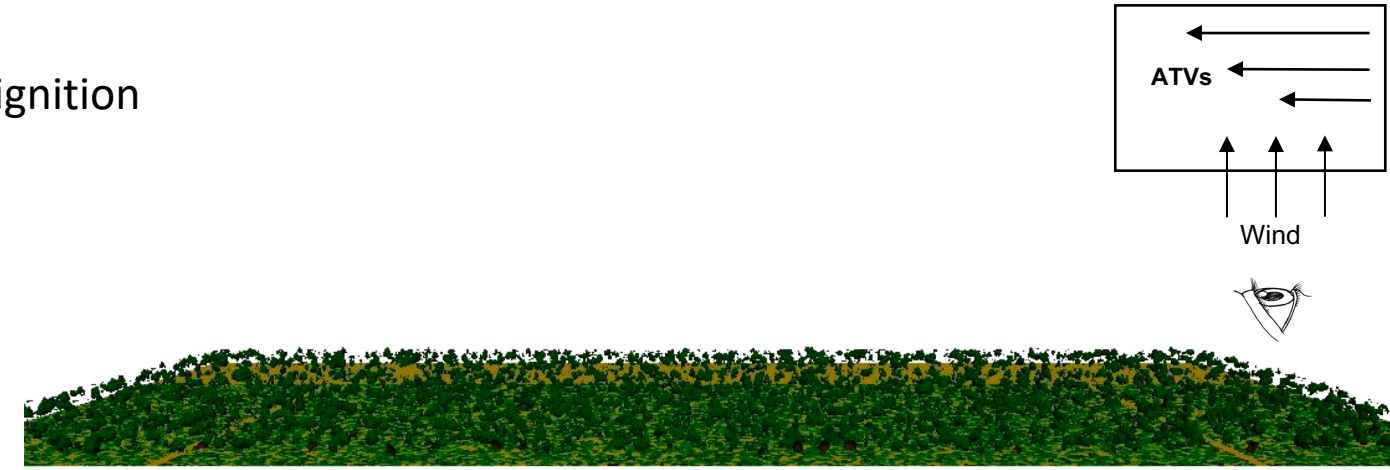


What can we do with these tools now?

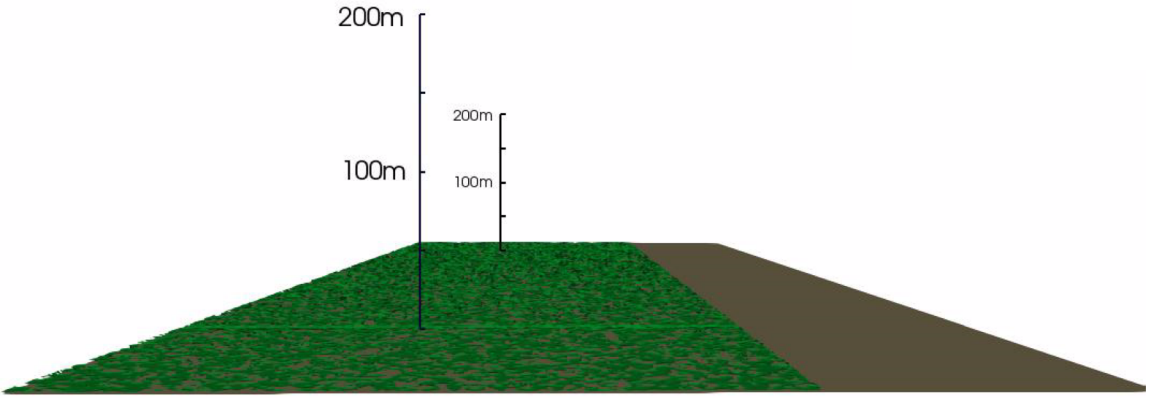
Improve understanding of connections between RxFire ignition techniques and plume dynamics



ATV line ignition



Aerial spot ignition

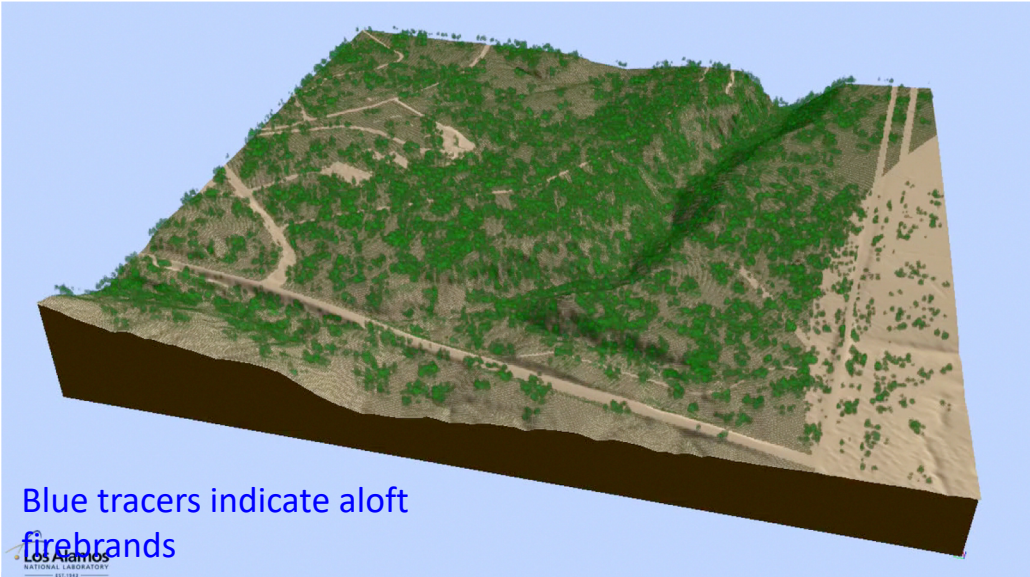


What can we do with these tools now?

Analyze impacts of strategic fuels management for protection of critical facilities

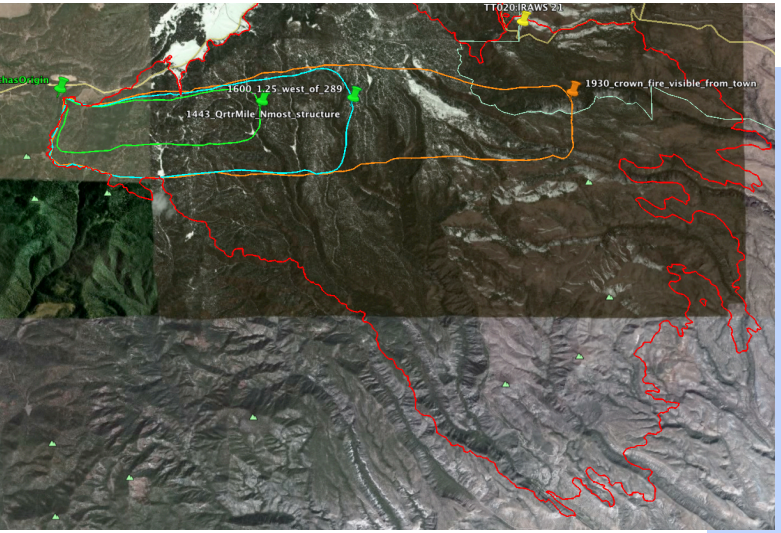
Simulations suggest potential impact of strategic fuels treatment (or gully-washing rain events) for managing fire risk at this facility from continuous fire spread.

However, these simulations also remind us of the importance of considering longer range spotting for facility protection.



What can we do with these tools now?

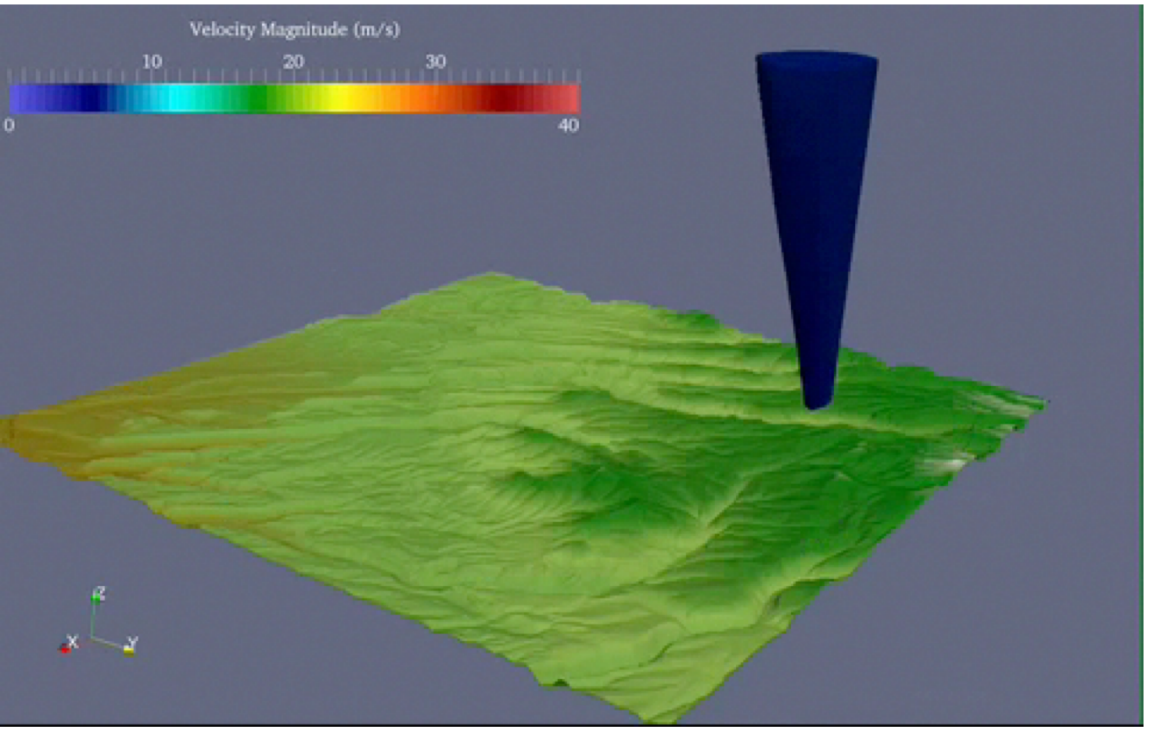
Evaluation of worst-case fire scenarios for critical facilities

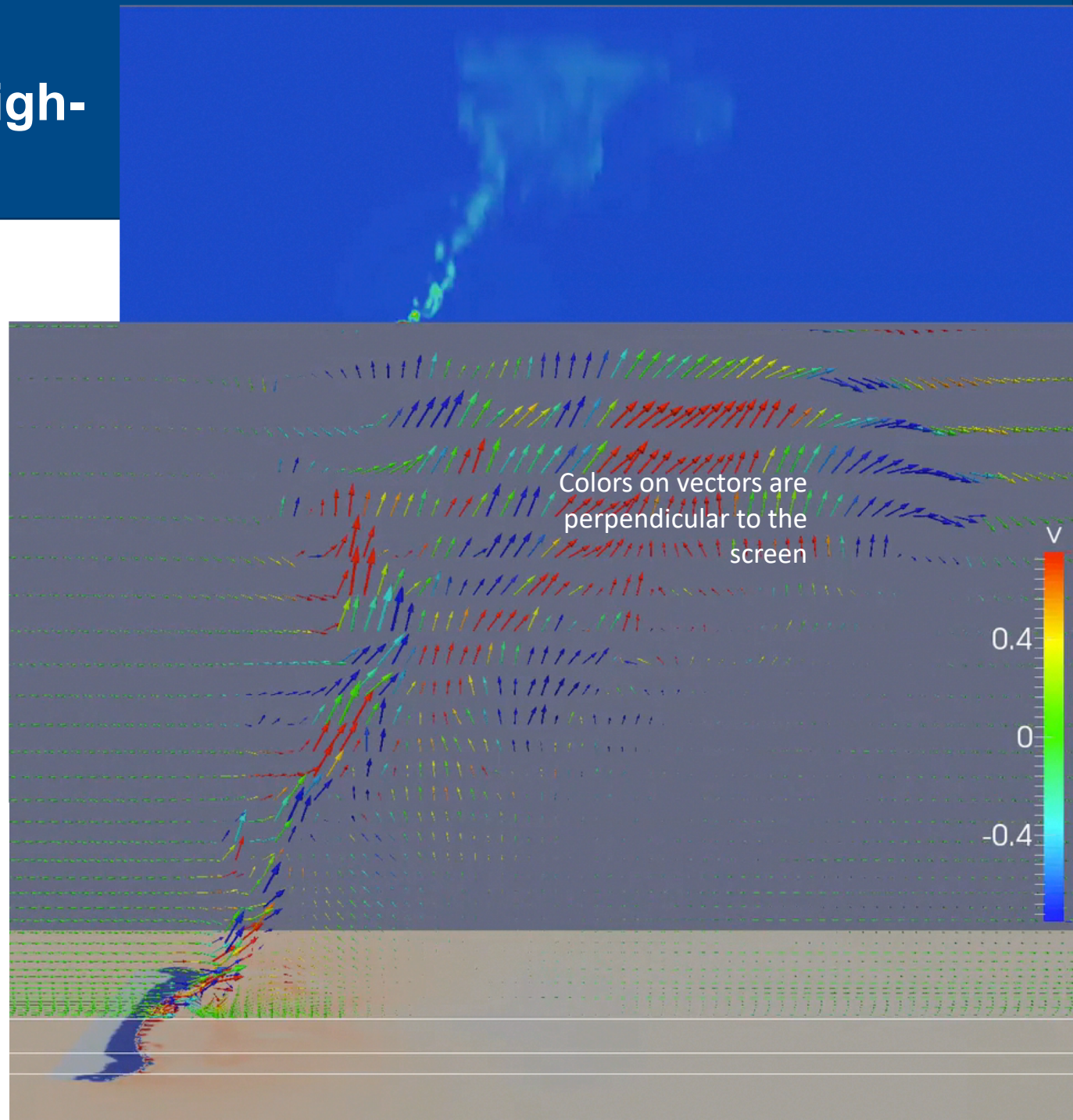


Based on fire behavior of the Las Conchas fire, concerns were raised about worst case fire-scenarios involving converging fire fronts at this critical facility

What can we do with these tools now?

Explore potential low-frequency/high-consequence events





Downwash events cause density current flow patterns

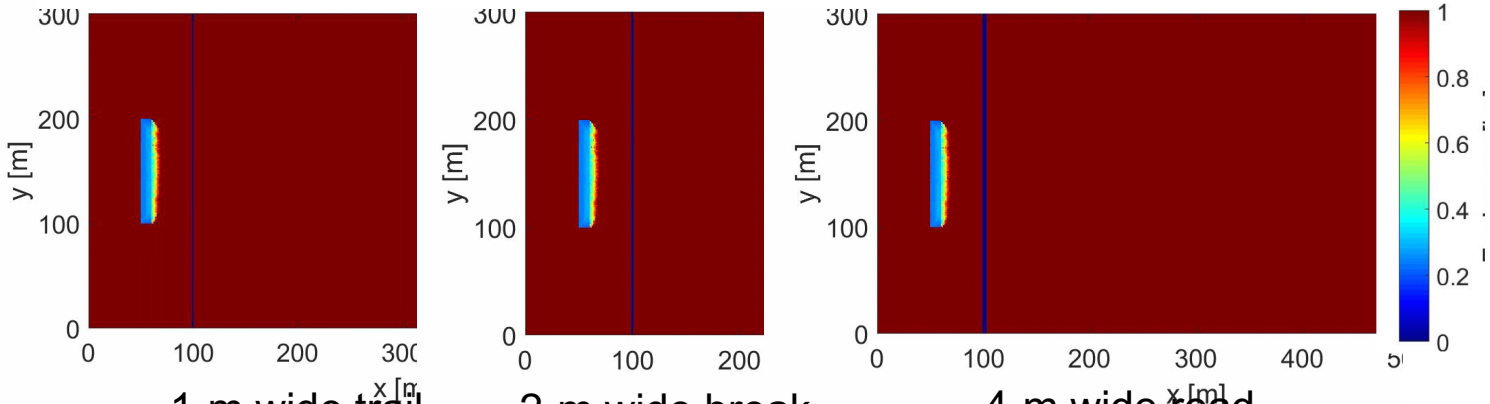
- Moving faster than ambient winds
- Containing “back-spin” vorticity
- Amplifies multiple aspects of fire

Using what we learn from these high-fidelity computationally expensive tools we can

Develop fast-running tools to assist planners and practitioners

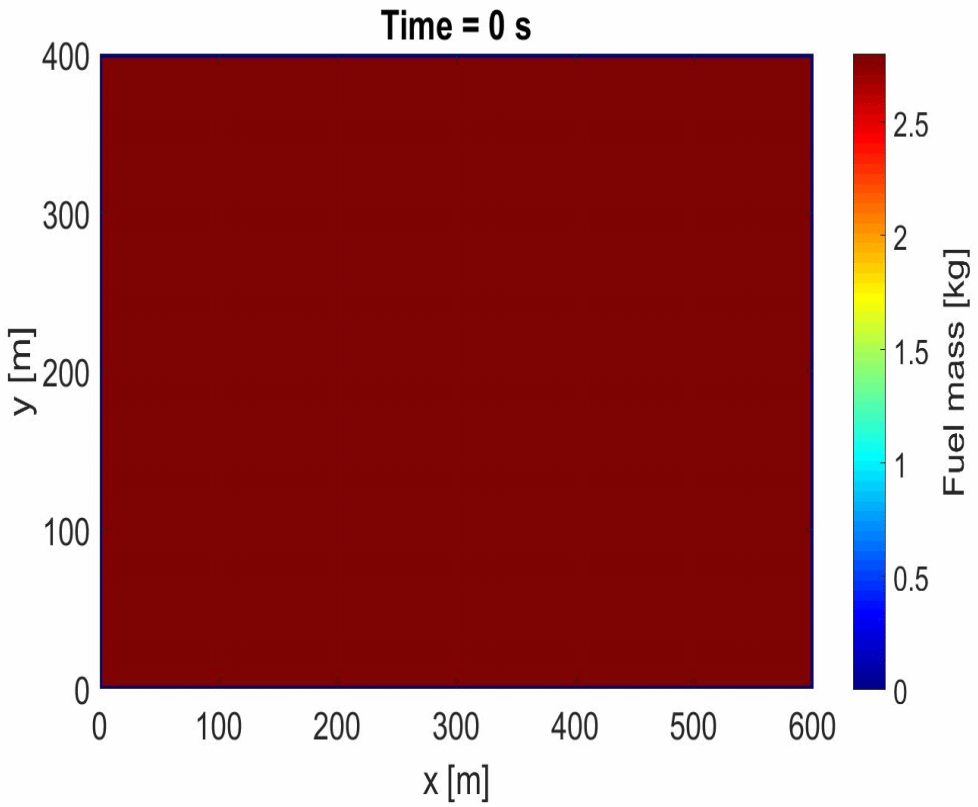
- Focus on most important building-block phenomenal
- Avoiding having to explicitly simulate the details
- Retaining critical sensitivities
- Capturing links between processes

Effect of fuel breaks (2 m/s wind)



1-m wide trail 2-m wide break 4-m wide road

Multiple fires show upwind fireline effects on downwind fire spread.

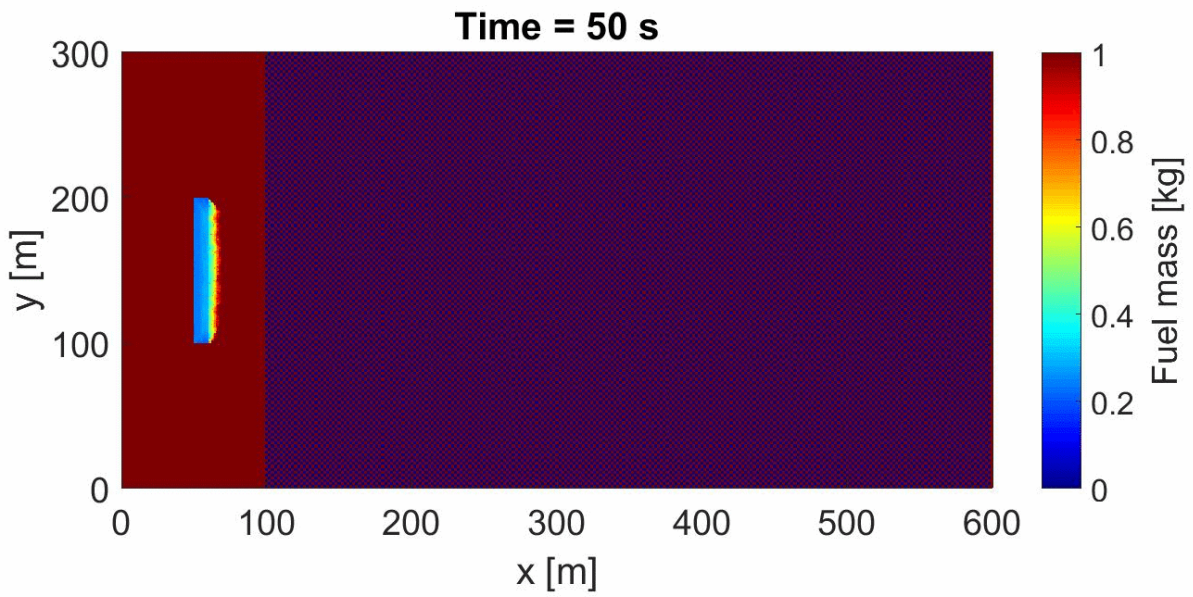


Density = 4.5 tons/ac
Windspeed = 6 m/s

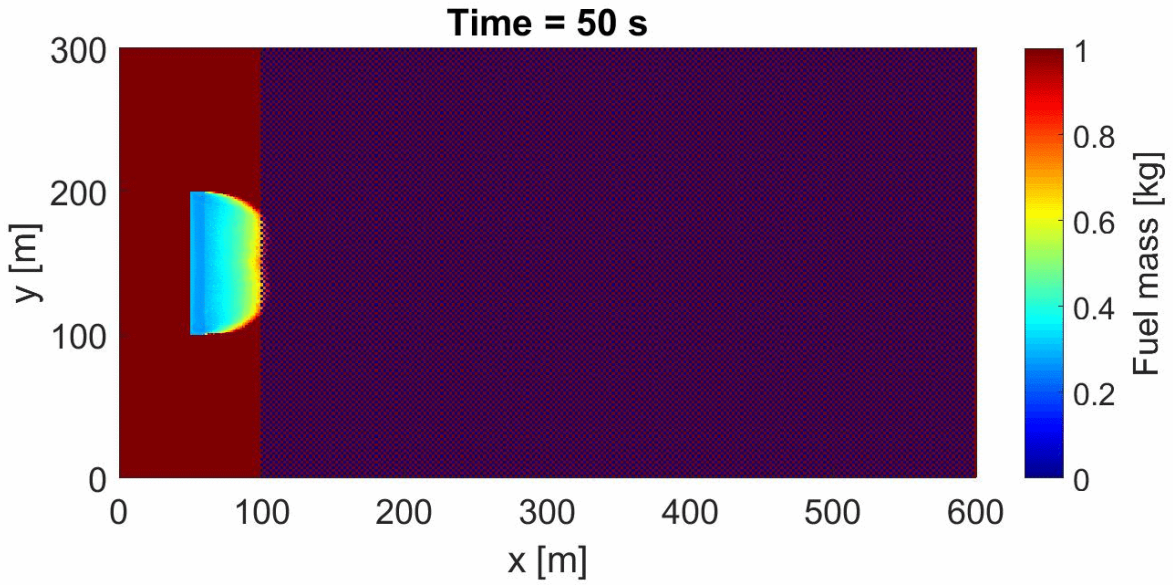
Example fast-running tool prototype:
Capturing influences fuel heterogeneities

Transition from homogeneous fuel to patchy fuels (e.g., bunch grasses, patches of dirt, rocks)

Purple indicates checker board fuel pattern (half as much fuel and patchy)

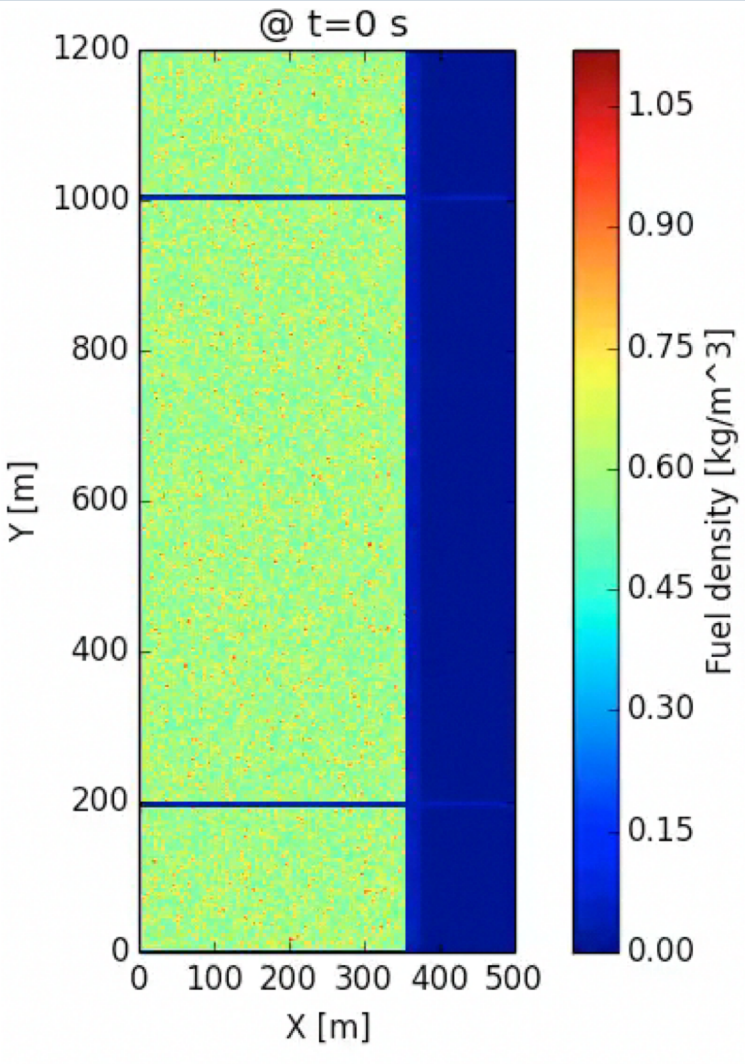


Wind speed = 2 m/s

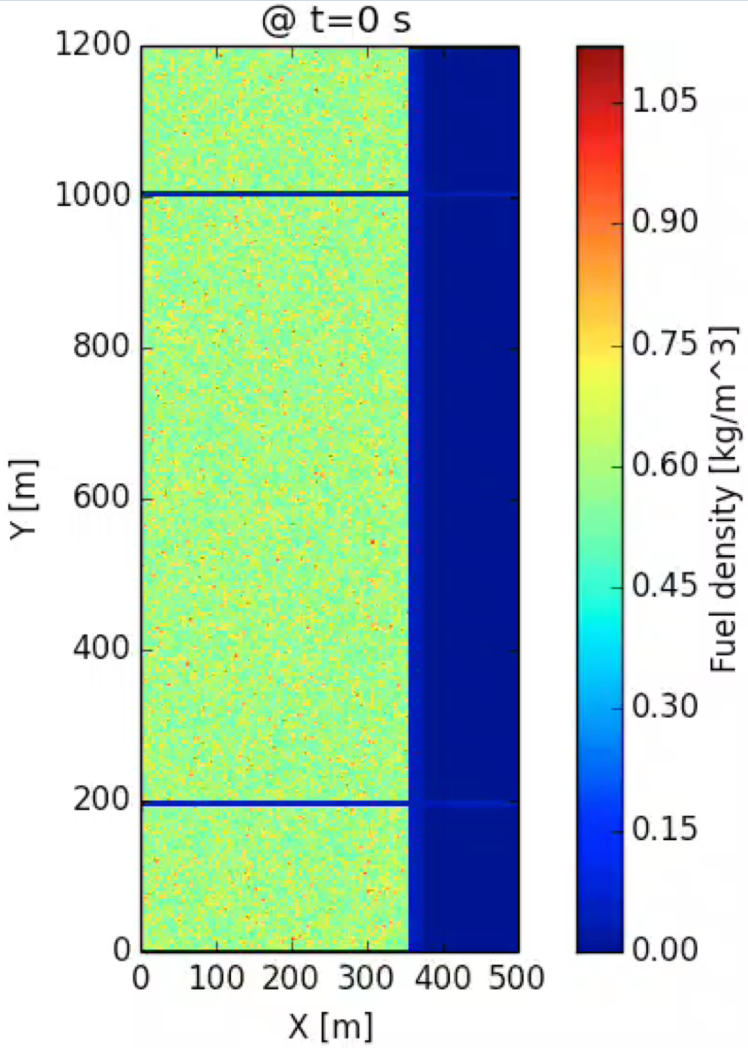


Wind speed = 6 m/s

Example fast-running tool prototype:
Applied to RxFire scenarios

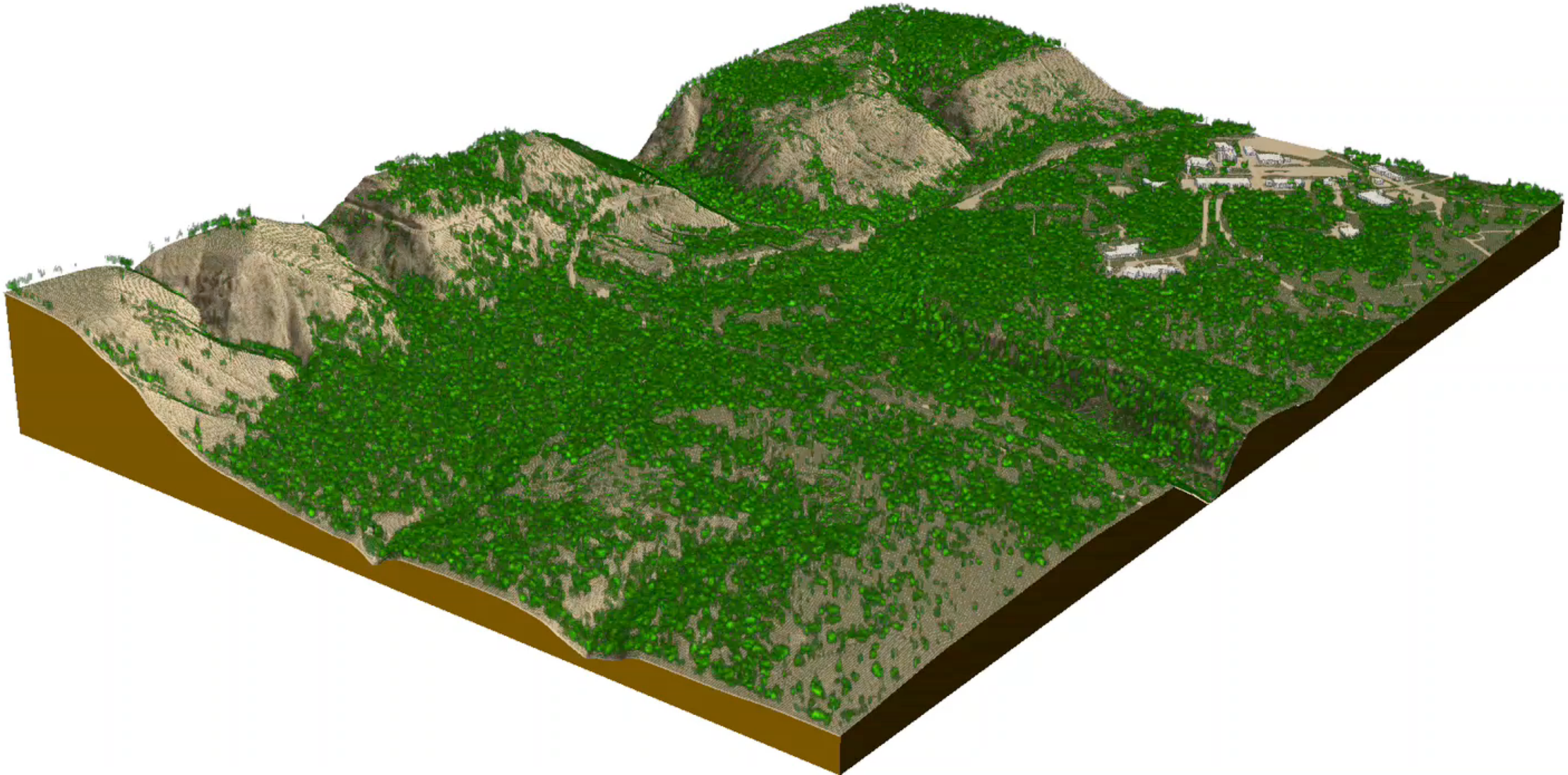


Ambient wind 2.4 m/s (5mph)



Ambient wind 5.6 m/s (12mph)

Thank you



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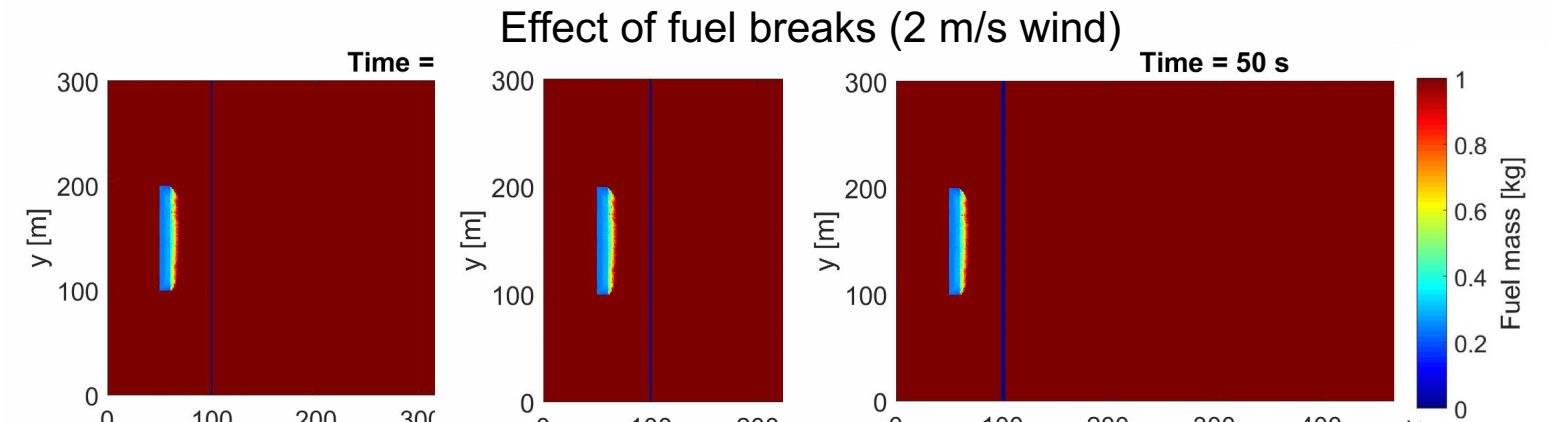
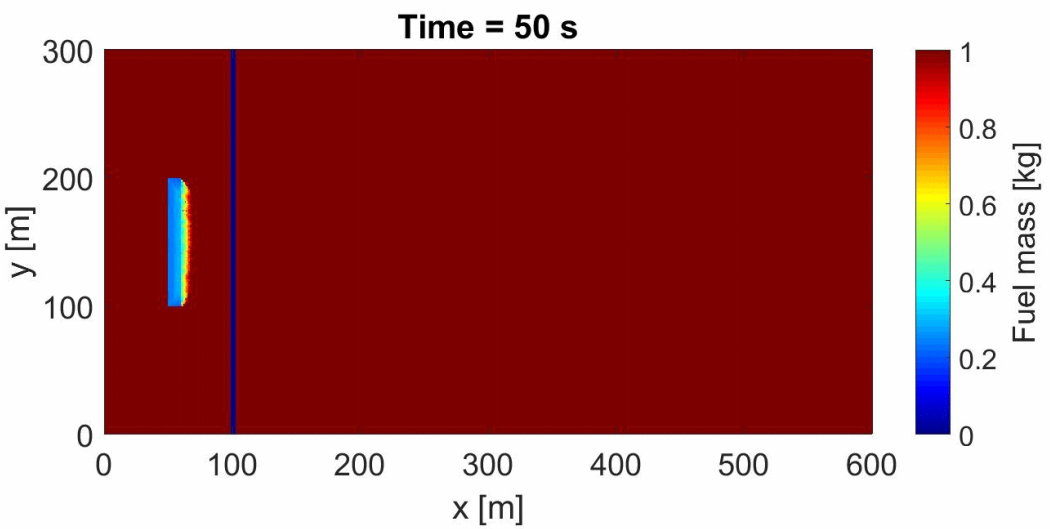
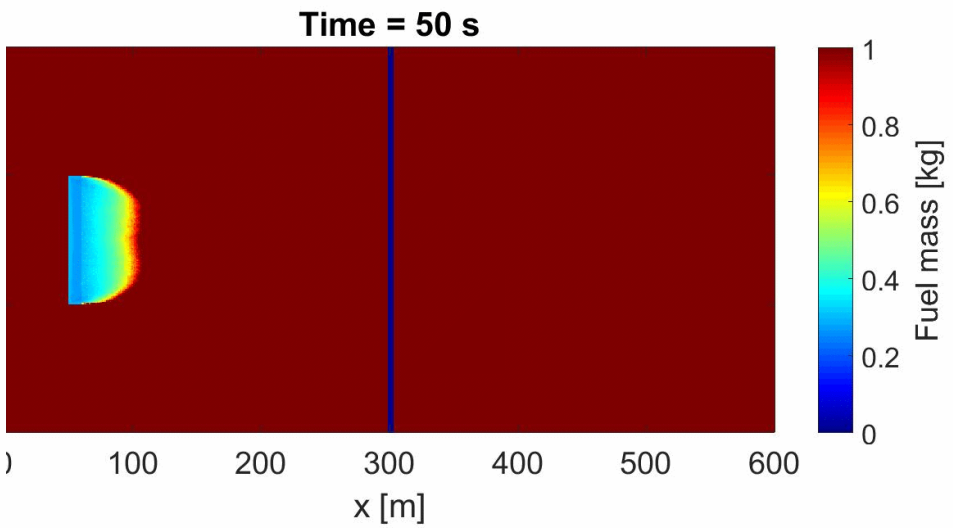


Example fast-running tool prototype:
Can a fast running tool capture influences of fuel discontinuities?

4-m wide roads



2 m/s wind

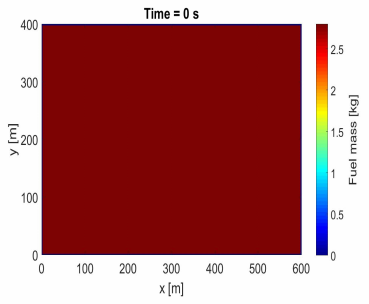


6 m/s wind

Example fast-running tool prototype:
Capturing correct phenomenological response from a fast-running self-determining coupled fire/atmosphere model

Capturing correct response to changes in fuel moisture

5%



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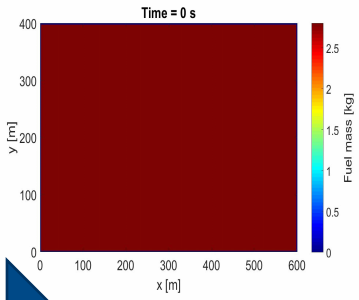

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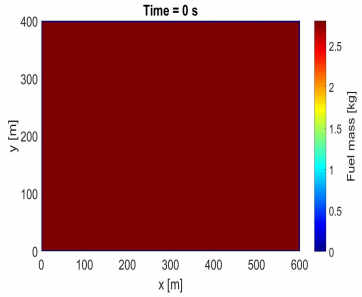

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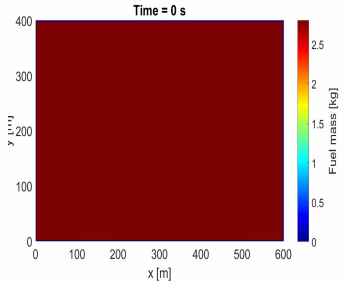

Wind 6 m/s

% Fuel moisture and affect on fire spread