SIMULATION OF HEAT FLUXES ON A STRUCTURE FROM A FIRE IN AN IDEALISED SHRUBLAND

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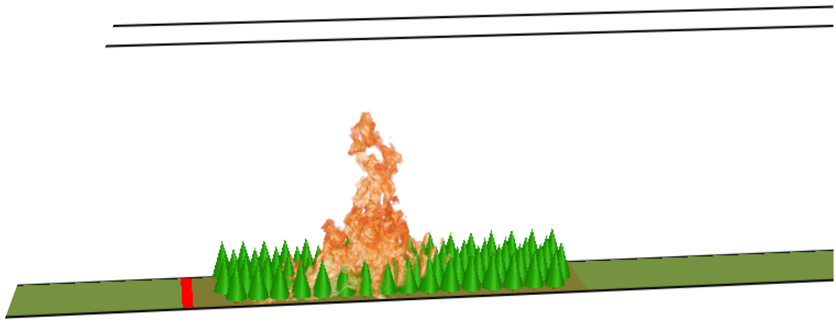

bushfire&natural **HAZARDS**CRC

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Introduction

- AS 3959 is based upon a view-factor model of radiant heat flux on the house
  - how much of the fire is 'seen' by the structure
  - a straight-line vertical fire of 100 m width
  - a constant flame temperature of 1090 K
- In reality,
  - flame temperatures can exceed 1200 K (Worden et al. 1997)
  - the flame angle is determined by the interaction of the buoyant fire plume and the driving background wind.
  - Due to vertical flame, a buoyancy dominated fire will have a larger view-factor
- AS 3959 shortcomings
  - do not account for the differences between buoyancy dominated and wind dominated fires
  - may not correctly predict what set of weather/ fuel conditions give worst-case scenario
  - lack of a model for ember attack

Introduction (2)

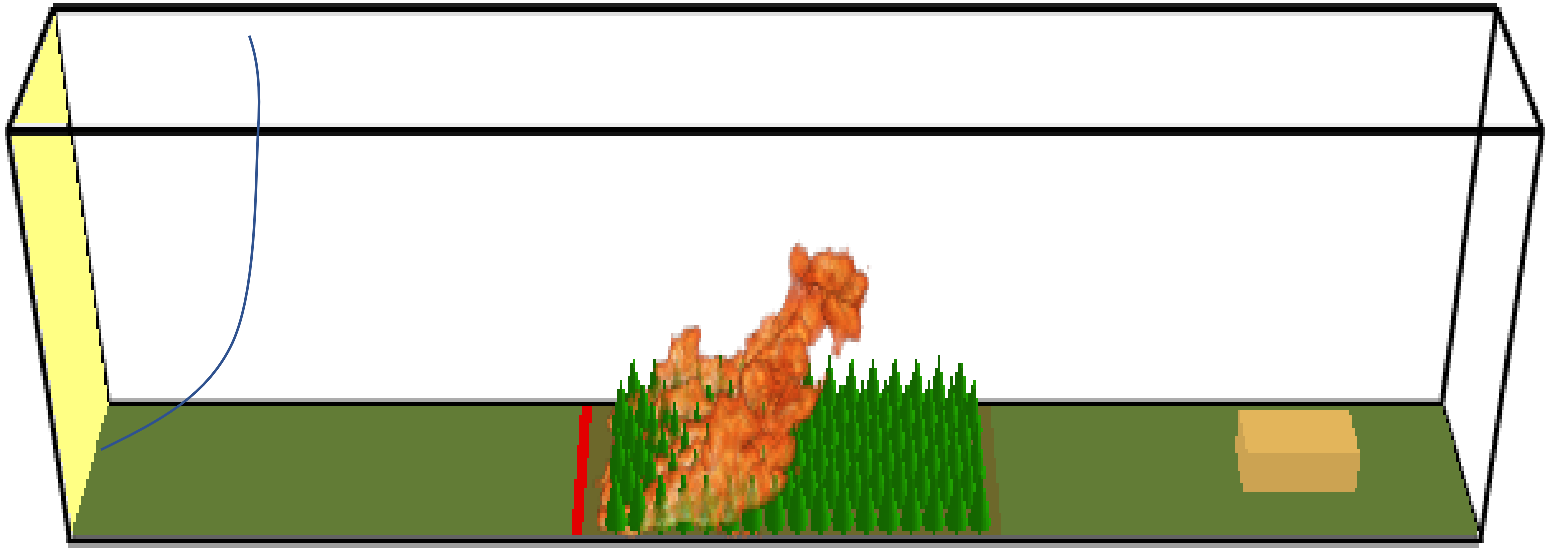
- Khan et al. (2019)
  - used a physics-based model to simulate closed tussock grass fires impacting on a structure
  - compared the simulated heat flux with the predictions of AS 3959-2009
  - AS 3959 was found to somewhat under predict the heat fluxes in the higher bushfire attack level (BAL) classifications.

- In this study we
  - simulate fires from an elevated fuel source like a shrubland
  - determine the radiative heat flux on a nearby house-like structure.

Physics-based simulation

- We use *Willdland-urban Interface Fire Dynamics Simulator (WFDS)* developed by US Forest Department-NIST
- Solid phase pyrolysis modelled using the linear model of Morvan and Dupuy (2004)
- Gas-phase combustion simulated using a mixing-controlled combustion model
- Flame & smoke propagation modelled by Navier-Stokes equations with large eddy simulation (LES) turbulence approach

Model set up

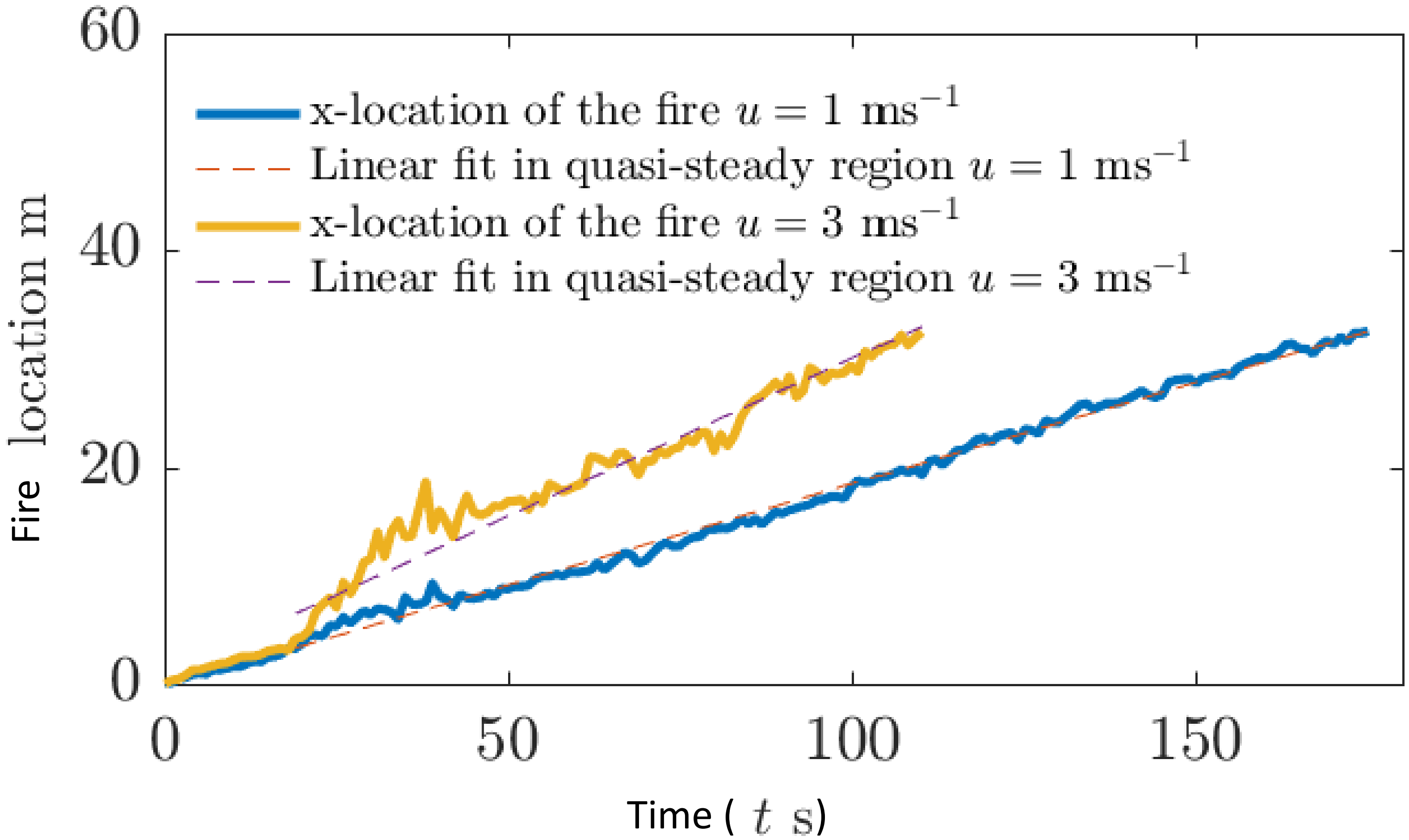


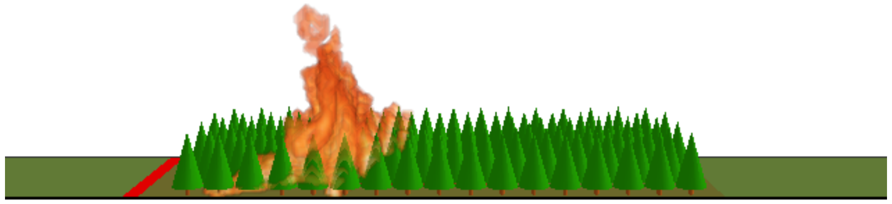
Graphical representation of the scenario

- Domain is 124 m long, 16 m wide 25 m high
- The forested area is 37 m long and starts 45 m from the domain inlet.
- Power law (1/7) with wind speed 1 & 3 m/s at 2 m height
- Surface fuel is modelled as grass

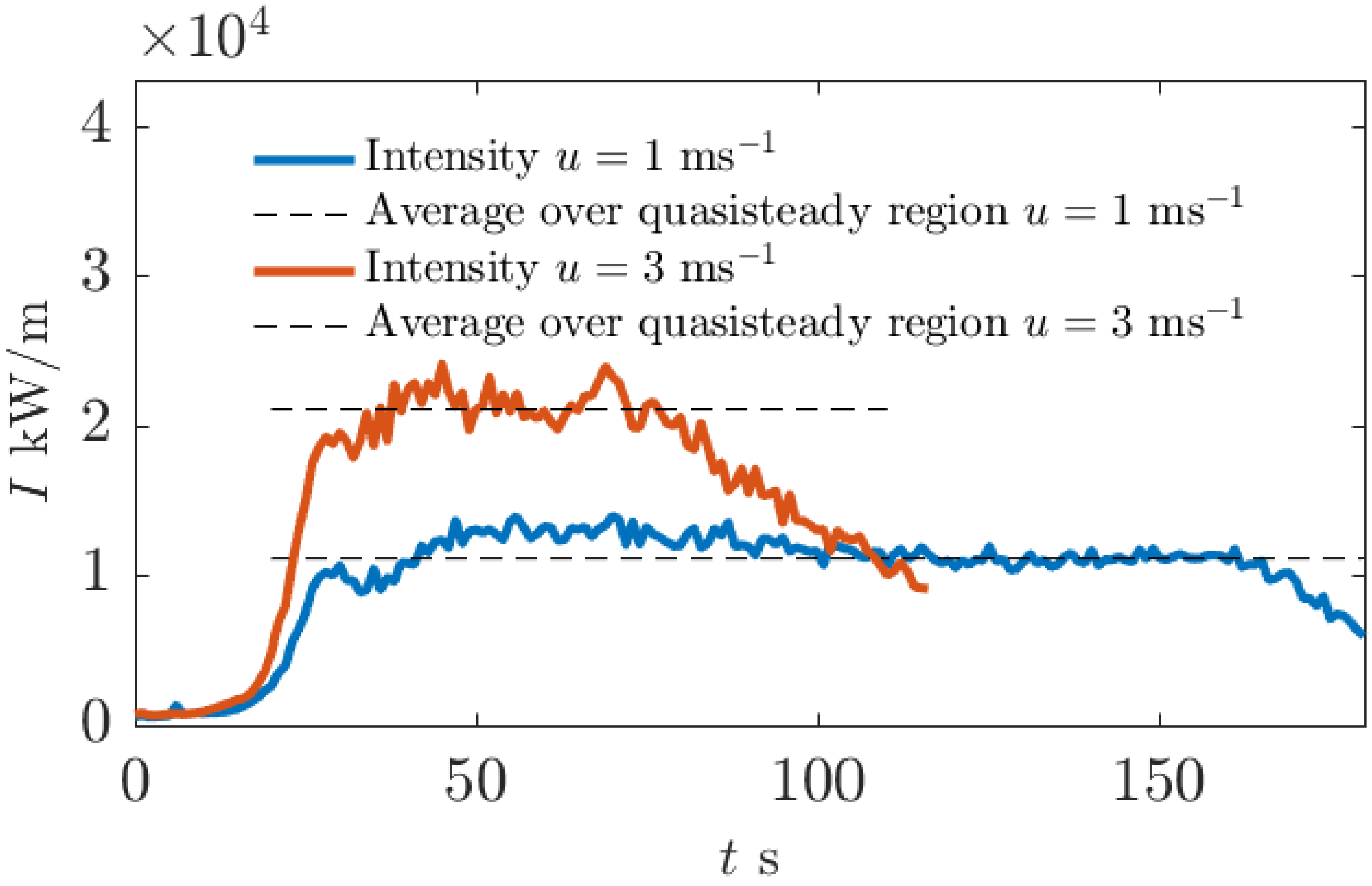
- 8 columns of Pine trees on a surface of grass are modelled.
- Validated fuel property measurements exist (Mell et al 2009)
- Alternate columns had 16 and 17 trees in a staggered fashion.
- The columns are 2m apart and within the column, the trees are also 2m apart.

FIREFRONT LOCATION AND RATE OF SPREAD (ROS)





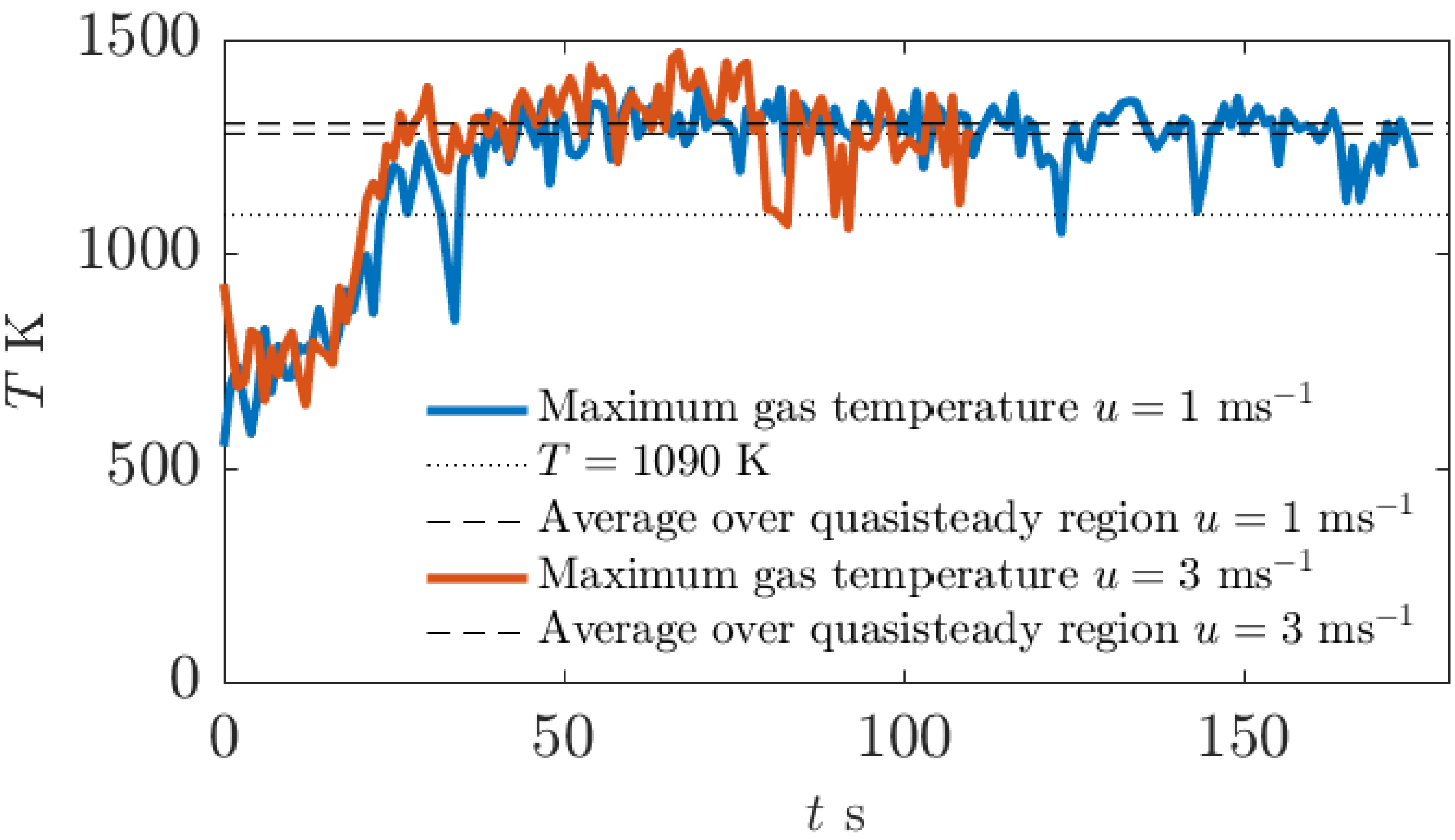
LINE INTENSITY

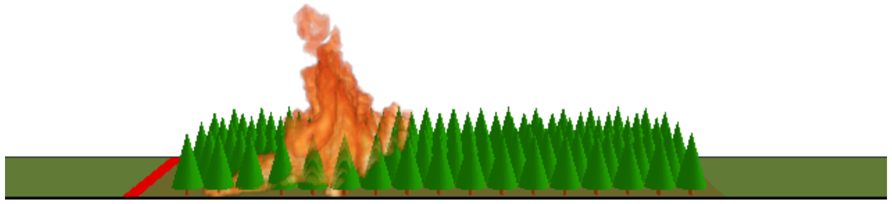


Byram's fire intensity model for shrubland

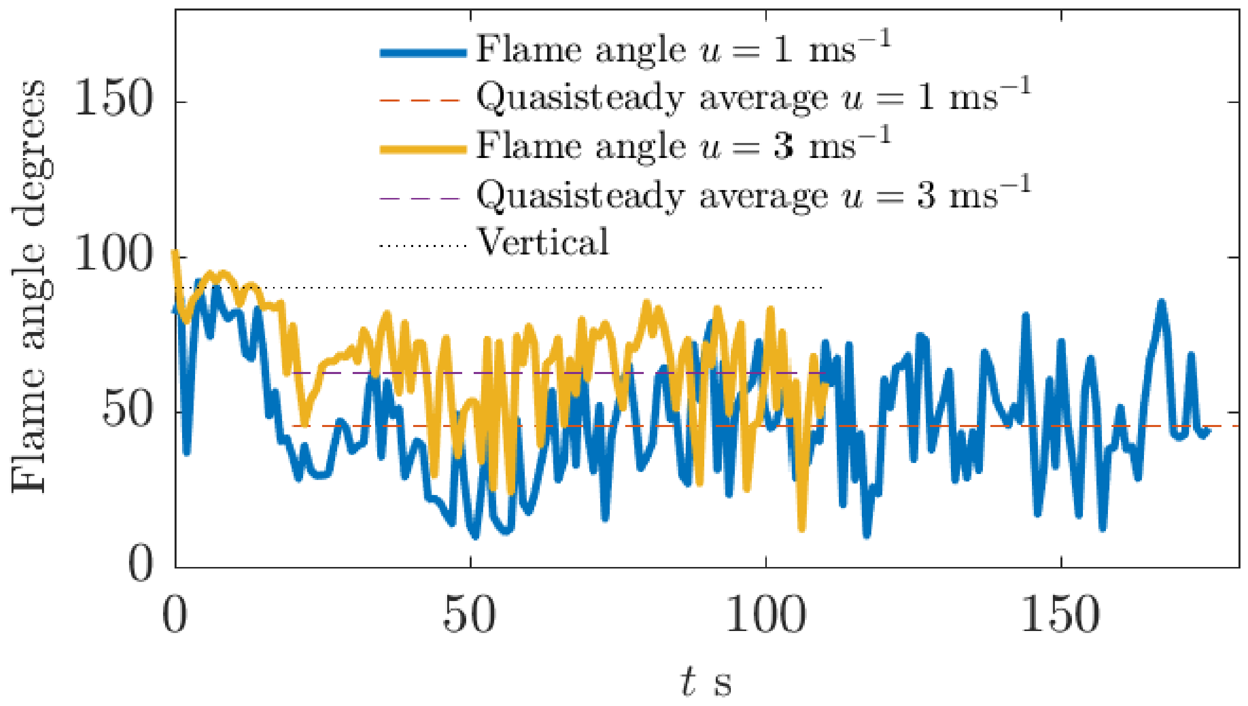
$$I = \frac{H\,w\,RoS}{36}$$

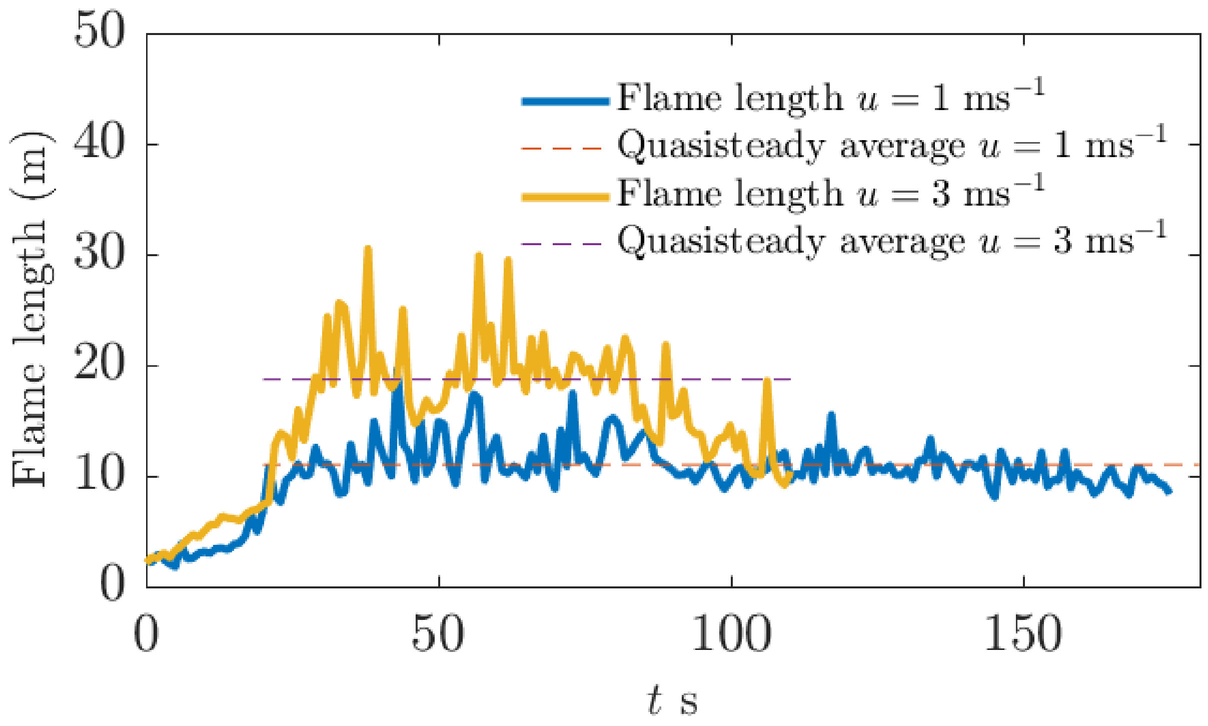
Flame temperature





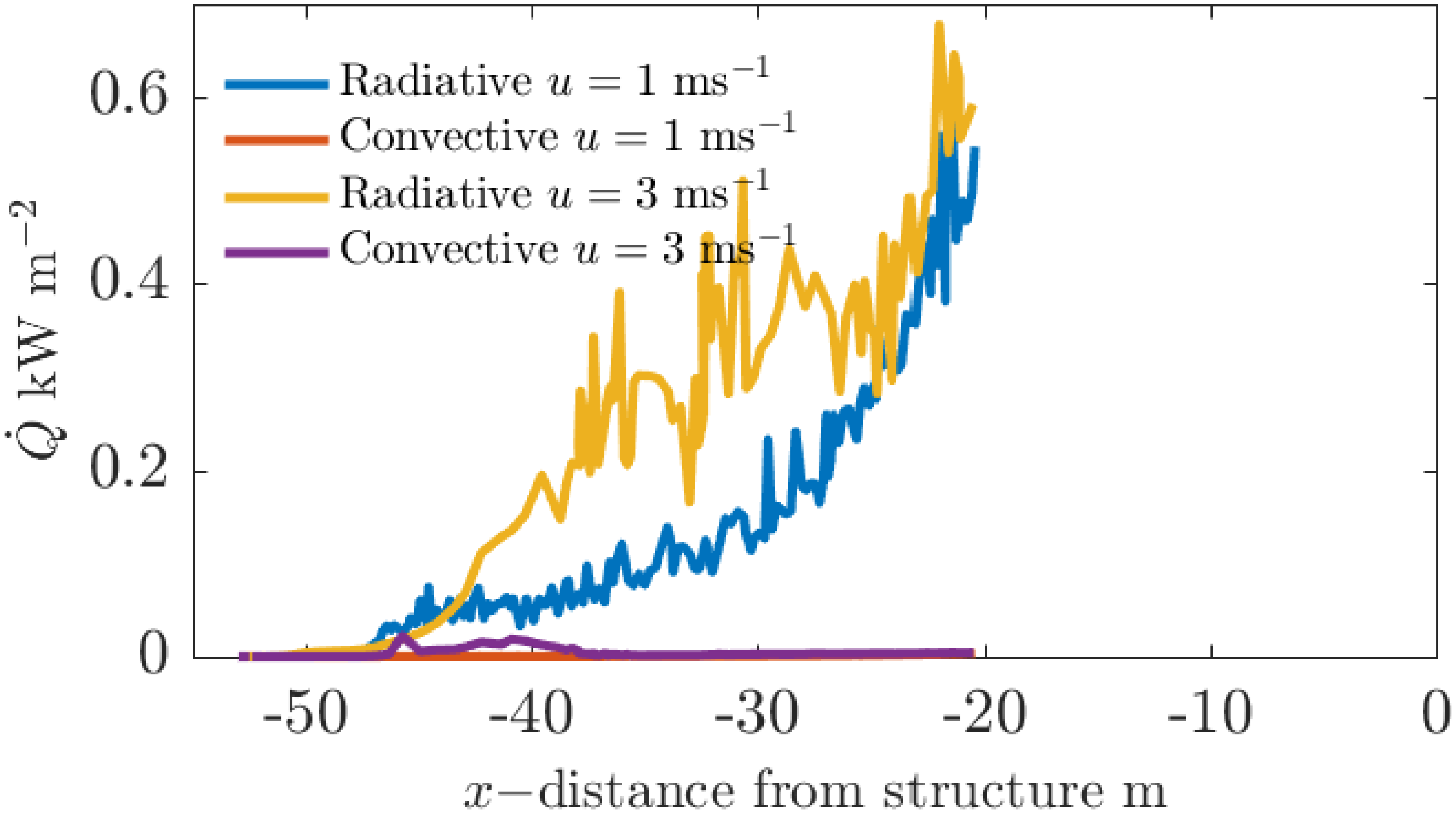
Flame angle and length





Higher intensity → more buoyancy → more vertical and elongated flame

Heat Flux



Radiative $u = 1$ ms^{-1}
Convective $u = 1$ ms^{-1}
Radiative $u = 3$ ms^{-1}
Convective $u = 3$ ms^{-1}
$\dot{Q}$ kW m^{-2}
0.6
0.4
0.2
0
-50
-40
-30
-20
-10
0
$x-$distance from structure m

Discussion

- Demonstrated that it is possible to simulated the impact of a design fire upon an idealized structure
- Performance-based design of structures is a possibility
  - resilience of the structure can be optimized to meet certain prescribed criteria
  - work on a case-by-case basis and if a structure satisfies the performance criteria, then the design is deemed suitable for construction
- Two key points must be addressed before adopting performance-based design
  - Determine design criteria such as the intensity, ember flux and duration of fire that a compliant building is expected withstand
  - More validation of physics-based modelling of impact upon structures, especially the impact of embers, ember showers.
- In future, physics-based simulations of realistic fires impacting on proposed structures will become a routine part of the design process.

Conclusions

- Simulated heat flux to a structure from pine shrubland using a physics-based model
- Maximum flame temperature ~1400 K, greater than the 1090 K used by the model in AS 3959
- Flame angle ~48 and 60 degrees, less than the vertical flame assumed under AS 3959 for flat ground
- Incident heat flux quite low; due to distance
- Appraise physics-based simulation for performance-based design for construction in a bushfire prone area
- More research is needed including modelling firebrand impact