Physics-based modelling of fires transitioning from the forest floor to the canopy

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Can a physics-based model predict a transition from a surface fire to a crown fire?

HIGHLIGHTS

- Simulations of a fire in a hypothetical forest of Douglas Fir trees sitting on a grassland, which can be thought of as a model of a plantation, is simulated using Wildland Fire Dynamics Simulator (WFDS) [1].
- Transition from a surface fire to a crown fire depends on a number of parameters such as atmospheric condition, fuel moisture content, physical dimensions, density, proximity of the crown leaves to the surface fire etc.
- This is the first step to testing whether the physics-based model can predict a transition from a surface fire to a crown fire.

MODEL SETUP

The simulation domain is 124 m long, 8 m wide as shown in Fig 1. A forest of 2.25m Douglas Fir trees sitting on a grassland is modelled. The simulation is conducted with a narrow domain. The validity of such simulation approach was demonstrated by [1]. The inlet is prescribed as power law (1/7) model of the atmospheric boundary layer (ABL) with a wind speed of 3 m/s at 2 m. The two lateral edges are modelled as mirror, Therefore the simulation can be thought of as an infinite side-by-side mirroring of similar domains. The outlet and top of the domain are modelled as lines of constant pressure. The burnable grass plot (37 m long) starts 45 m (in the longitudinal direction) from the inlet. Four longitudinal columns of Douglas Fir trees are modelled. The crown was approximated as cones and the trunk as cylinders. 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.

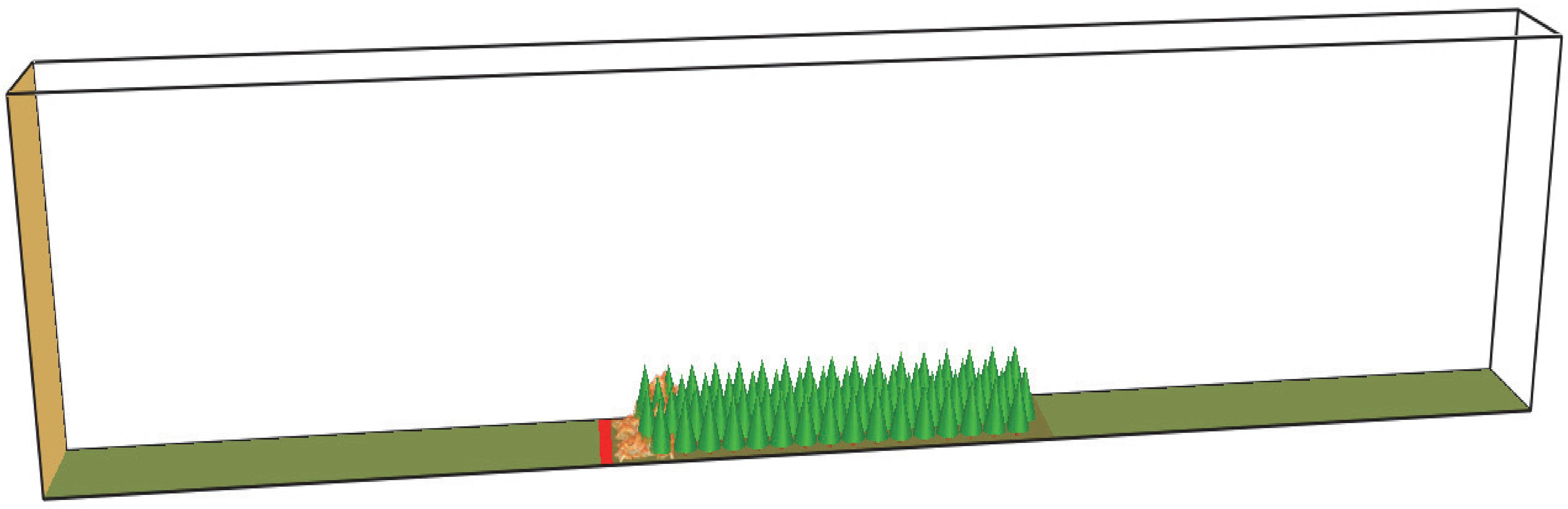


Figure 1. Graphical representation of surface fire-crown interaction simulation

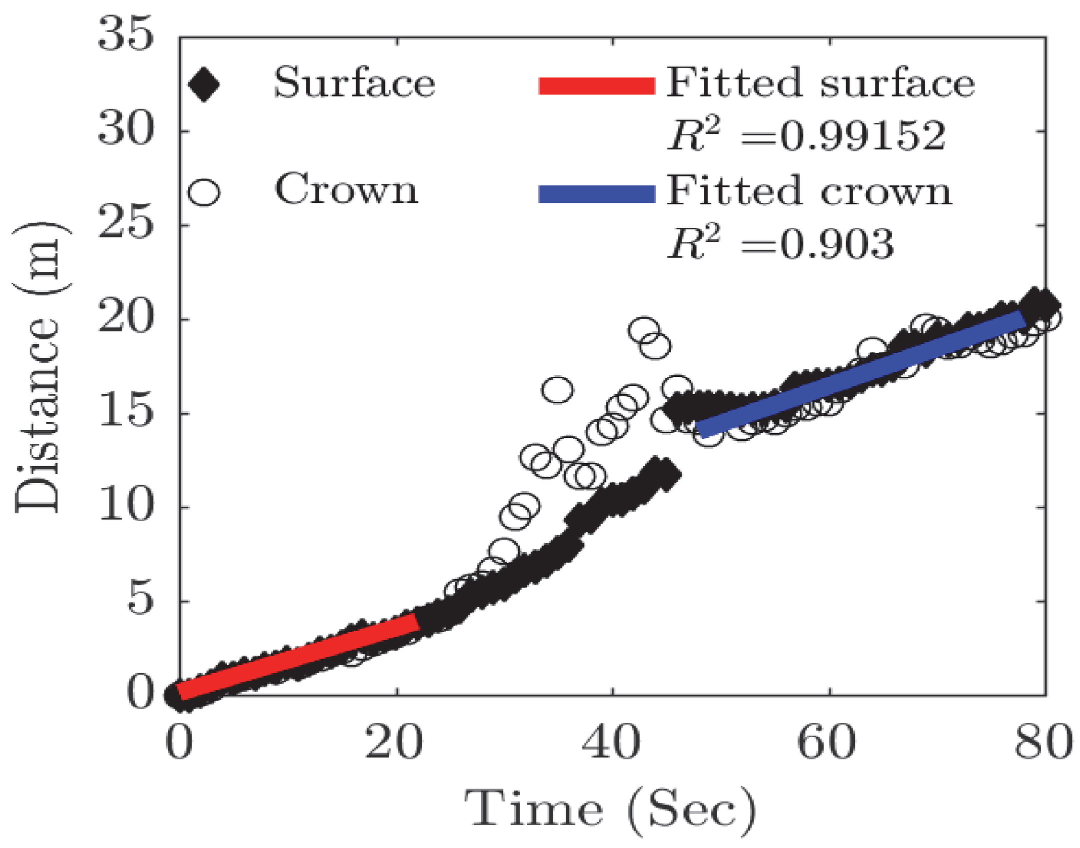
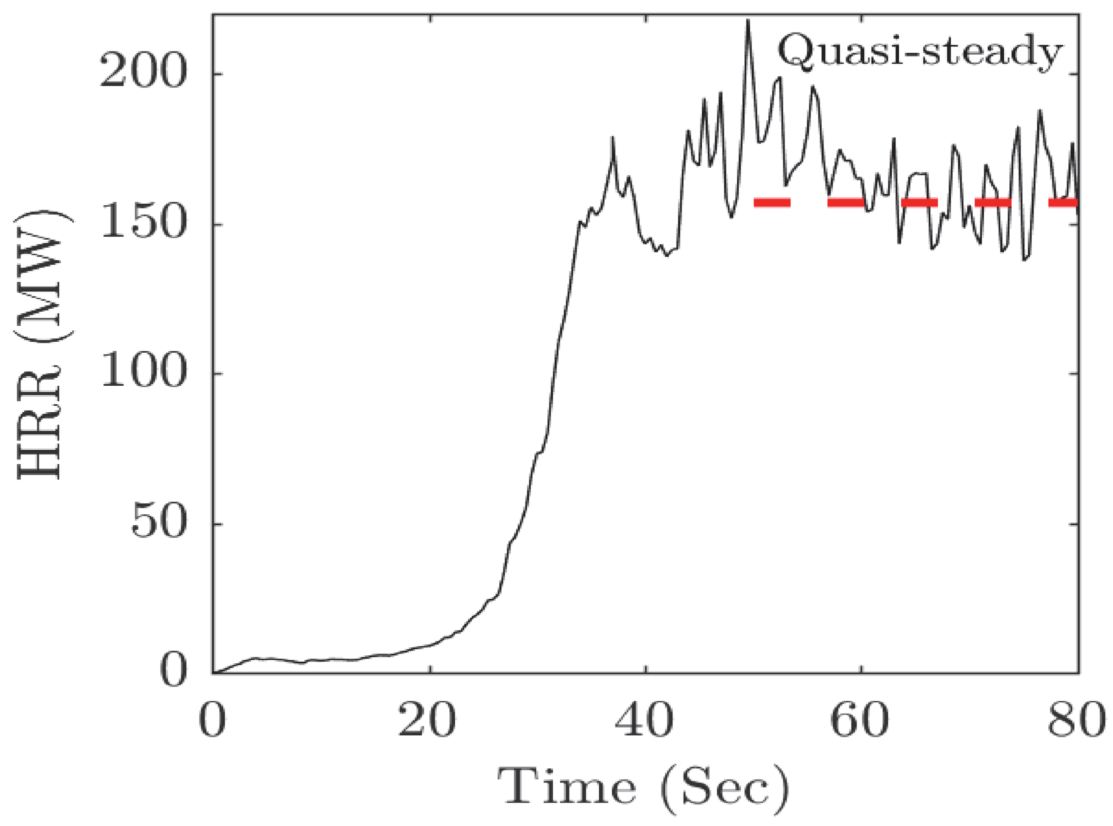


Figure 2: (a) Fire front location



(b) Heat release rate

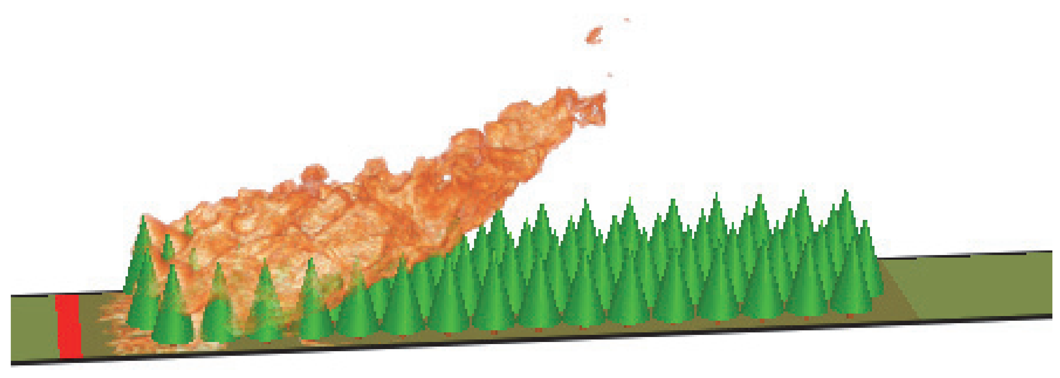
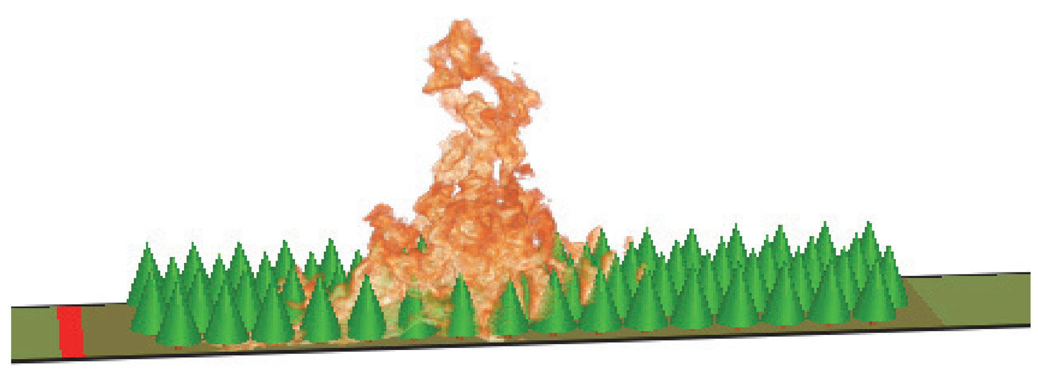


Figure 3: (a) Flame upon impacting the crown



(b) Quasi-steady flame propagation

RESULTS AND CONCLUSION

As observed in Fig 1, transition occurs from a surface fire to a crown fire. In Fig 2, fire front location and heat release rate (HRR) as a function of time are presented. A fire front is determined based on HRR data. In Figure 2(a) the red line is a least-squares regression fit to the surface fire behaviour and the blue line is a fit to the crown fire data. Surface fire and transition to crown propagation is clearly visible between 30 to 50 sec.

Visual representation of flames impacting on the crown and during quasi-steady period is shown in Fig 3. It appears as if the surface fire transitions up to the crown, then transitions back down again at some later time. The surface fire continues underneath the crown fire, this is a supported crown fire. That is, the surface fire puts energy into the crowns to sustain the burning of the crown material [3]. Overall many features are qualitatively in agreement with other crown fire studies (eg the experiments of [4]). We can therefore be confident that crown fire simulations are possible with the physics-based model.

REFERENCES

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