Development of a firebrand landing model based on CFD simulation

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Abstract: Wildfires pose a significant risk to communities at the wildland-urban interface (WUI), threatening both lives and property. It has been observed that a significant proportion of destroyed properties at the WUI are destroyed through firebrand attack – either by firebrands alone, or by a combination of exposure to radiant heat and firebrands. These destroyed properties could be a considerable distance away from the fire front, such as in the 2003 Canberra or the 2018 Tathra fires in Australia. In addition to this, firebrands contribute to the spread of fires over long distances and over obstacles that may otherwise halt a wildfire by igniting spot fires. The ignition of spot fires downwind of the fire front greatly complicates firefighting efforts, as noted in reports on the behaviour of wildfires during the 2009 Black Saturday fires in Victoria, Australia. A model of firebrand landing distributions may help to develop risk models of house loss and for firefighting operations at the WUI. In this study, we present a practical model of firebrand landing distribution near a fire based on simulations of firebrand transport conducted using a validated computational fluid dynamics (CFD) model – a modified version of Fire Dynamics Simulator 6.6.0 (FDS) with a Haider & Levenspiel drag model.

The generation and transport of firebrands has been studied at a variety of scales by different researchers, from laboratory-scale experiments with model firebrands and burning vegetation, to field-scale measurements of firebrand landing patterns from controlled fires. The use of drag-modified FDS to model firebrand transport has been validated against a series of laboratory experiments by Wadhwani et al. (2017), modelling the distribution of a population of firebrands over an area. However, CFD techniques are too computationally expensive to be of practical use in an operational model, requiring hours or days of time to simulate a few minutes of firebrand transport. By analysing the distribution of firebrands obtained from a series of simulations under different initial conditions (such as wind speed, flame dimensions, heat release rate, and forest type) we have developed a model for this distribution based on a two-dimensional statistical fitting to the simulation data. Initial results from the simplified statistical model shown in Figure 1, illustrating the good match in shape and density to the simulations.

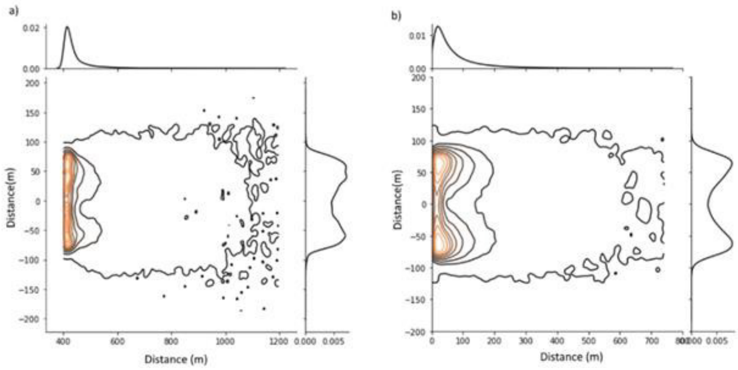

Figure 1. Comparison of Kernel Density Estimation plots of firebrand distribution: (a) directly obtained from simulation and (b) reconstructed using a developed statistical model

REFERENCES

Wadhwani, R., Sutherland, D., Ooi, A., Moinuddin, K., Thorpe, G., 2017, Verification of a Lagrangian particle model for short-range firebrand transport, Fire Safety Journal 91, 776-783

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