

INCORPORATION OF SPOTTING AND FIRE DYNAMICS IN A COUPLED ATMOSPHERE - FIRE MODELLING FRAMEWORK



CM Thomas¹, JJ Sharples¹, JP Evans²

¹ School of Physical, Environmental and Mathematical Sciences, UNSW Australia, Canberra, ACT

² Climate Change Research Centre, UNSW Australia, Kensington, NSW



INTRODUCTION

This project focuses on looking for ways to improve operational fire-spread modelling by looking for computationally cheap techniques to model dynamic fire spread, and by the incorporation of spotting. One idea is that the geometry of the fireline might itself influence the rate of spread. The curvature of the fireline is one geometric property that has been proposed in this regard. The first part of this project has focused on looking for a relationship between rate of spread and curvature in the output of a coupled atmosphere-fire model. The second part of the project involves using the model to study the transport of embers. The goal is the incorporation of ember transport and spot fire ignition into the model.

NUMERICAL EXPERIMENTS: JUNCTION FIRES

Junction fires occur when two straight firelines merge at an oblique angle. They have been studied experimentally (Viegas et al. 2012) and found to involve very rapid initial rates of spread, even in the absence of ambient wind. In this project WRF-Fire was used to model junction fires with the same geometric configurations as in the experimental work.

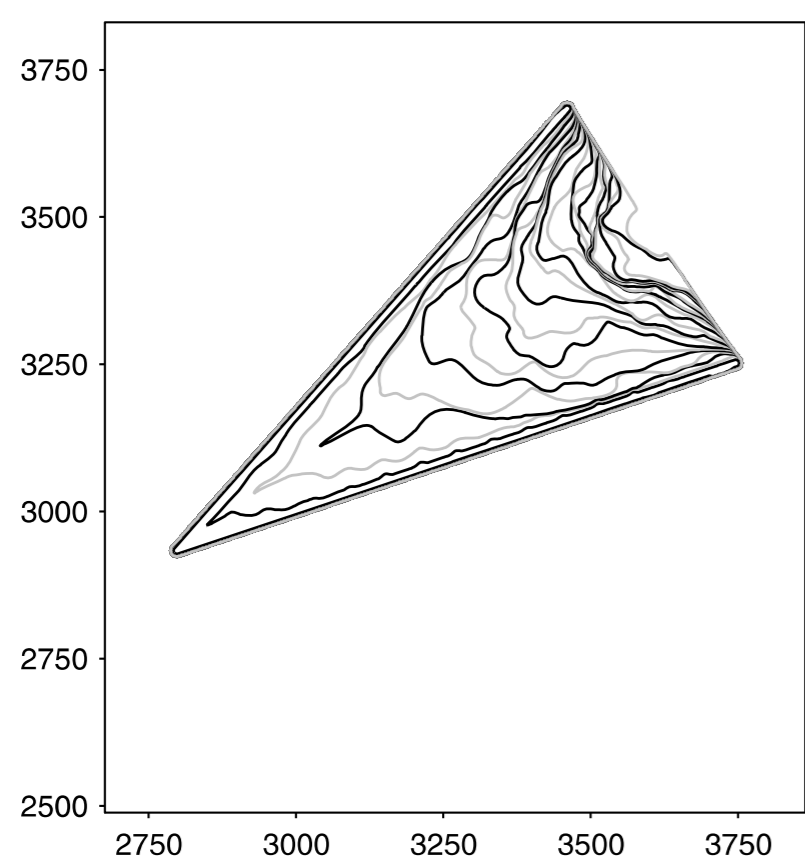


Fig. 1: Example of modelled junction-fire propagation.

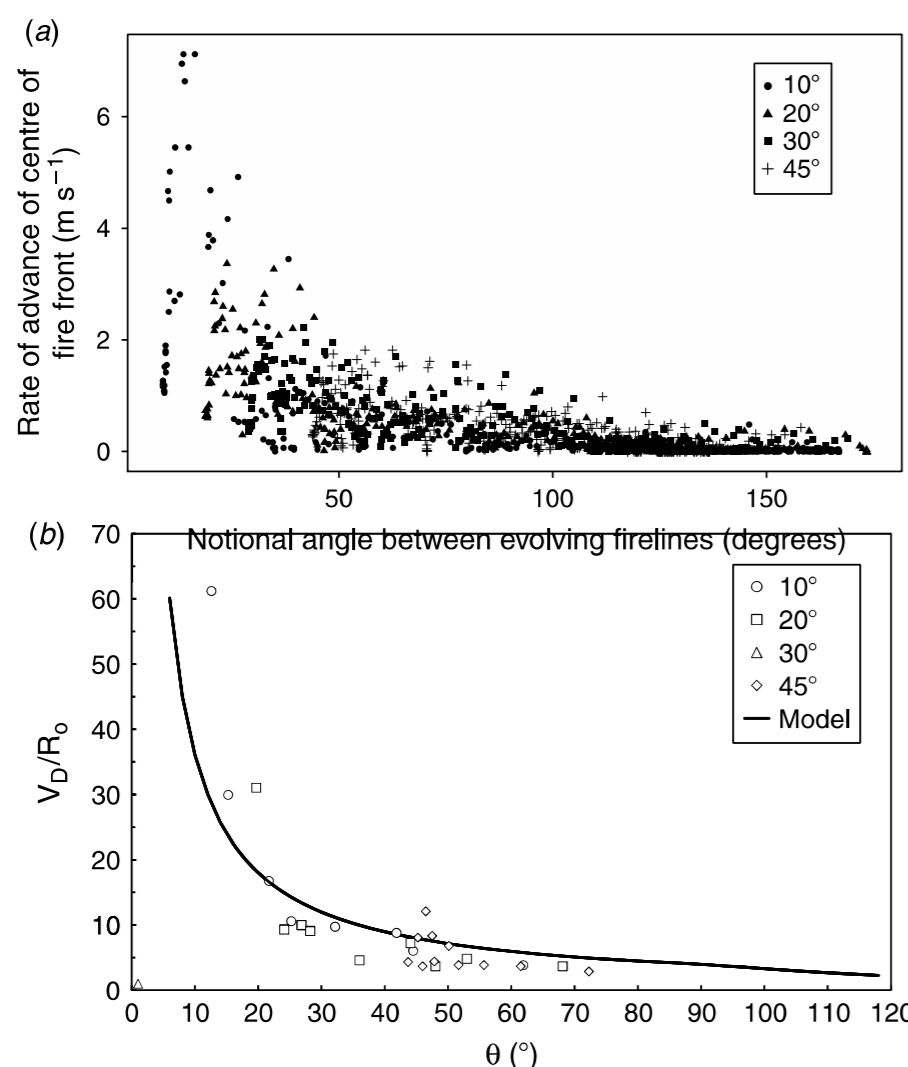


Fig. 2: ROS vs junction angle for (a) model results (b) experiment results (Viegas et al. 2012).

The simulations exhibit similar dynamic fire behaviour to that observed in the experimental work (Fig. 2). Fig. 3 shows the pattern of counter-rotating vortex pairs typically found in the simulations, and their relationship to enhanced rates of spread near the junction of the merging firelines. This vorticity is responsible, at least in part, for the modelled dynamic behaviour.

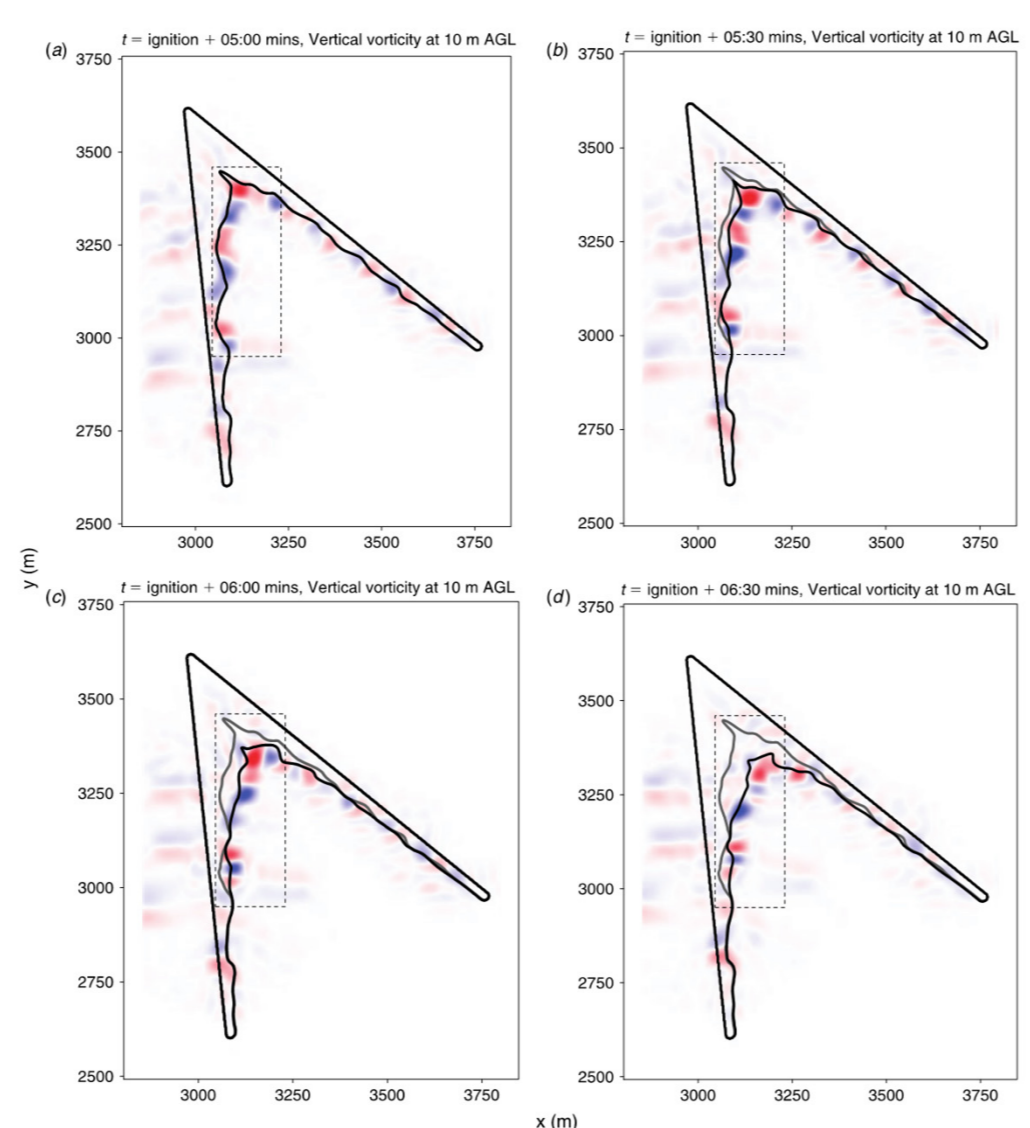


Fig. 3: Advection and merging of counter-rotating vortex pairs in a junction-fire simulation.

The vertical vorticity results from the tilting of horizontal vorticity produced by the buoyancy gradient (Fig. 4).

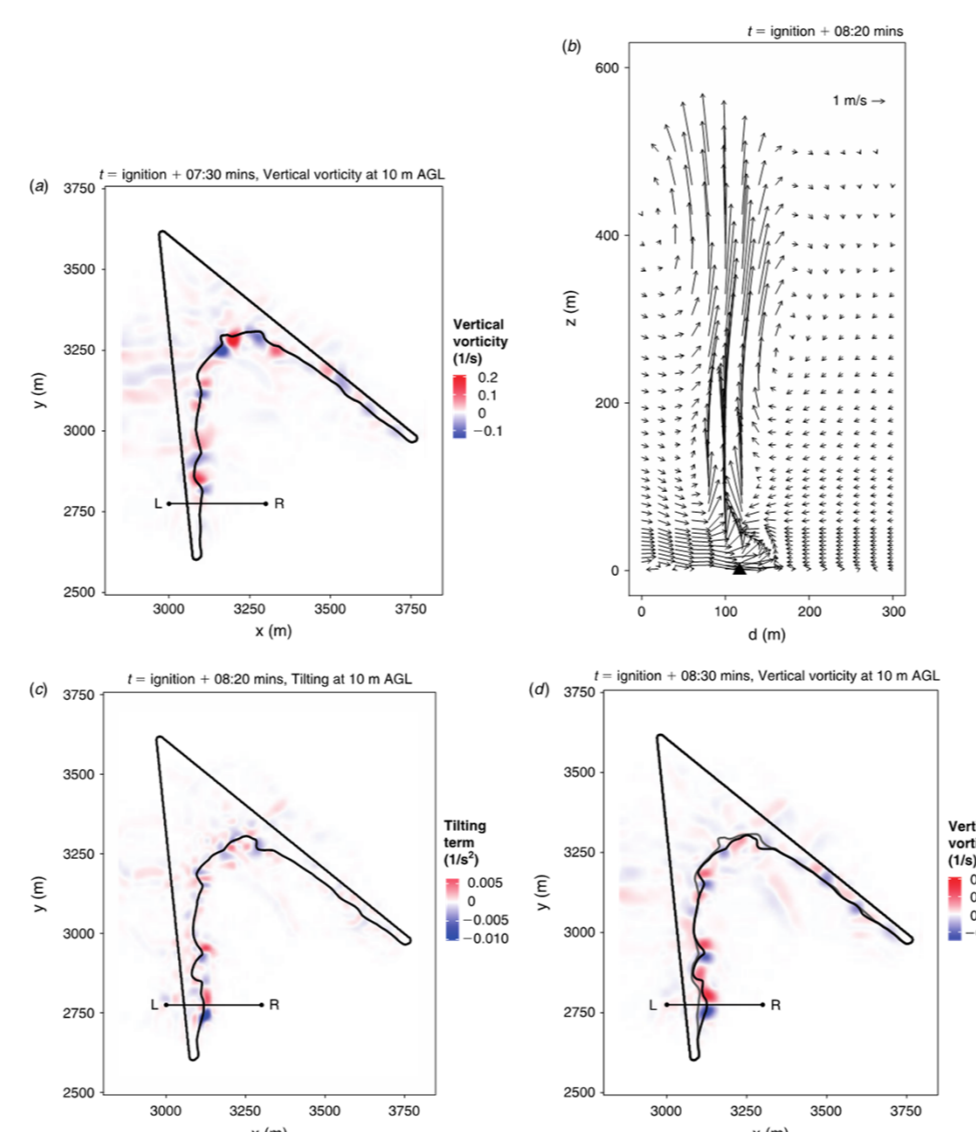


Fig. 4: Production of vertical vorticity

No relationship between fireline curvature and rate of spread was found in the junction-fire model output at the local scale, or at larger scales.

NUMERICAL EXPERIMENTS: ARC FIRES

To investigate further, we performed a series of simulations of fires lit around circular arcs of varying angular lengths. In this context the notions of curvature and mean curvature are more transparent. Fig. 5 shows examples of several of these simulations.

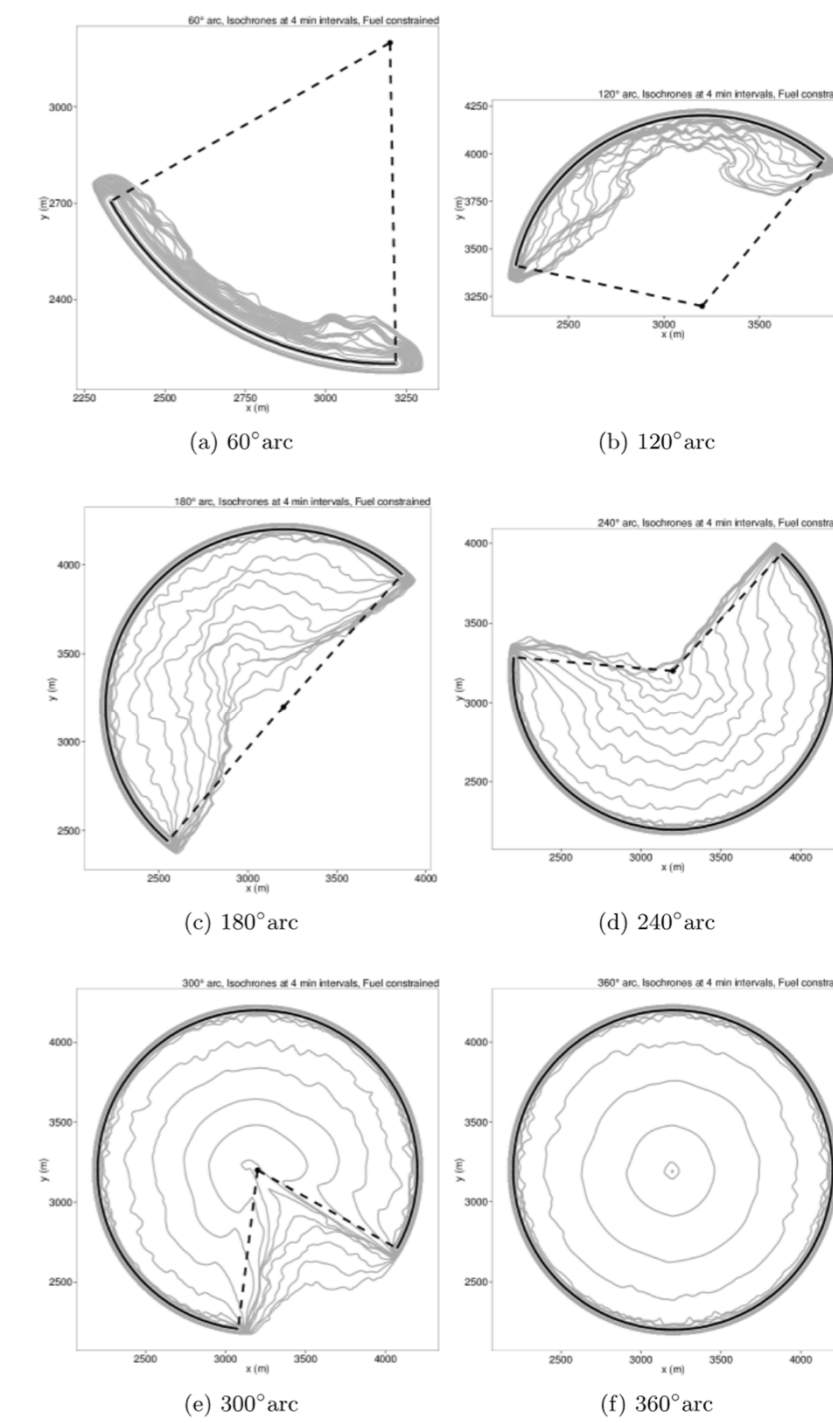


Fig. 5: Isochrones at 4 min. intervals of simulated arc fires.

Each of the initial firelines in Fig. 5 has the same radius of curvature, but they each have a different rate of spread (Fig. 6). Moreover, Fig. 6 indicates that rate of spread does not increase with increased curvature for these simulations.

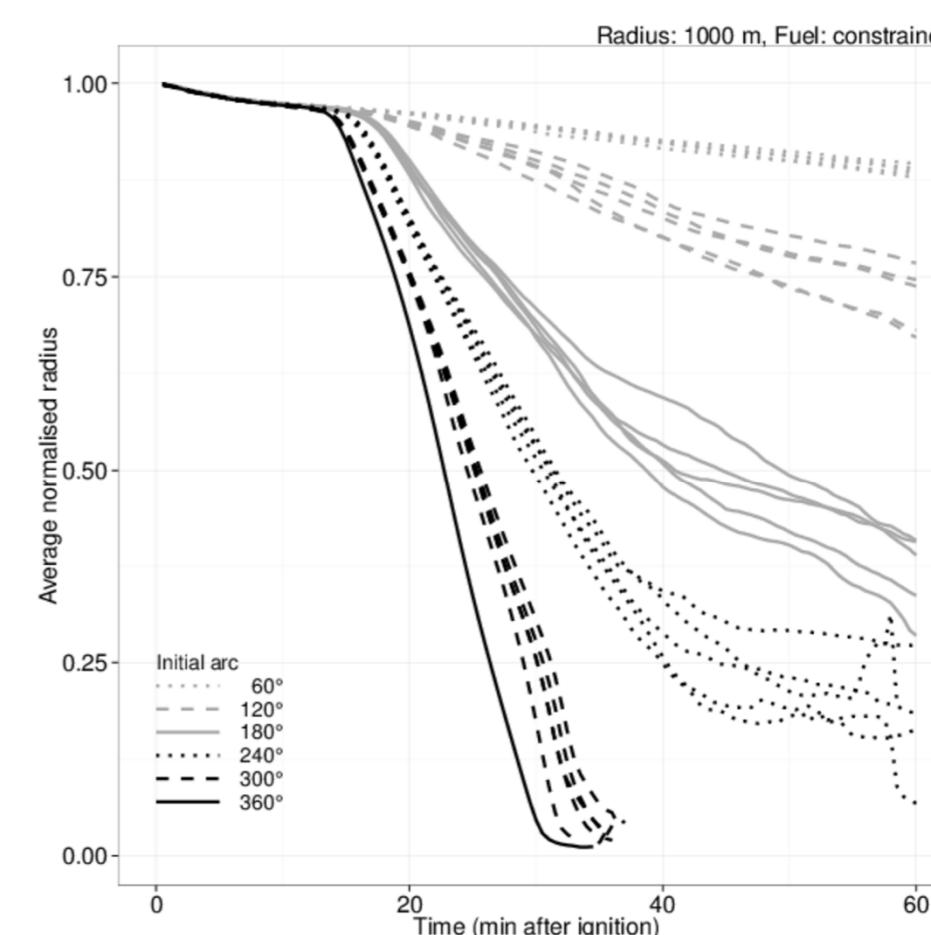


Fig. 6: Average radius of evolving arc fires as a function of time.

CONCLUSION

The qualitative agreement between the experiments and the modelling indicates that the dynamic behaviour is largely driven by pyroconvective processes. Recent unpublished analytical work by J. Hilton points to a connection between these processes and the geometry of the fireline, and bridges the gap between the curvature hypothesis and the results presented here.

END USER COMMENT

Coupled models can be highly computationally expensive. This research provides the necessary basis to suggest it may be possible to develop a significantly more accessible two-dimensional model which reasonably addresses some of the output features of far more computationally expensive models. Dr Simon Heemstra, Manager Community Planning, NSW Rural Fire Service

References

- Thomas, CM, Sharples, JJ, Evans, JP. 2017. "Modelling the Dynamic Behaviour of Junction Fires with a Coupled Atmosphere-fire Model." International Journal of Wildland Fire 26 (4): 331-44.
- Viegas, D.X. et al. 2012. "Study of the Jump Fire Produced by the Interaction of Two Oblique Fire Fronts. Part 1. Analytical Model and Validation with No-Slope Laboratory Experiments." International Journal of Wildland Fire 21: 843-56.

