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

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A KEY PROBLEM IN WILDFIRE MODELLING IS HOW TO CAPTURE DYNAMIC FIRE BEHAVIOUR IN MODELS SUITABLE FOR OPERATIONAL USE. THE INCLUSION OF FIRE-LINE GEOMETRY MAY LEAD TO WAYS OF INCORPORATING ASPECTS OF THIS BEHAVIOUR INTO OPERATIONAL TOOLS

INTRODUCTION

Dynamic (or intrinsic) fire behaviour involves significant and rapid changes in behaviour that are not in response to changes in ambient conditions. Current operational models do not predict this behaviour well. Coupled atmosphere-fire models capture aspects of it, but are currently too computationally expensive for operational use. Fire-line geometry affects fire behaviour and including it in simple models may lead to ways of incorporating some aspects of dynamic fire behaviour into operationally feasible tools. Curvature has been proposed as one candidate for this. In this study we use WRF-Fire to model the dynamic behaviour of junction fires. We compare the results with previous experimental work of Viegas et al., and look for relationships between rate of spread and curvature in the model output.

EXPERIMENTAL SET UP

Computational domain: 6.4 x 6.4 x 3 km; horizontal resolution 20m (atmos.), 2m (fire); vertical resolution ~4m to ~140m. *Atmospheric conditions*: no wind; 1 km deep neutral layer topped by stable layer; dry atmosphere. *Ignition scenarios*: V-shaped junction fires with initial angles of 10°, 20°, 30° and 45°; Five member ensembles for each angle with random orientations; fuel = long grass.

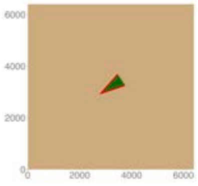

Figure 1: Example of model ignition scenario.

RESULTS

Agreement with experimental work

The model results show a rapid initial acceleration of the fire front and a subsequent slowing, dynamic behaviour that is in line with the experimental results of Viegas et al. Figure 2 shows the advance of the front for one member of the ensemble of 30° configurations; the centre of the front advances more than 500m in the first 10 minutes after ignition, but only ~250m in the next 10 minutes.

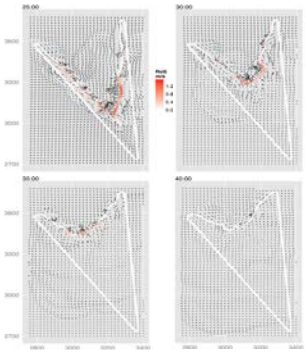

Figure 2: Evolution of fire line for one ensemble member with 30° configuration.

Figure 3 shows the good qualitative agreement that exists between the model and the experimental results relating junction angle and rate of spread (ROS). The differences in scale (2 to 3 orders of magnitude) preclude a direct quantitative comparison.

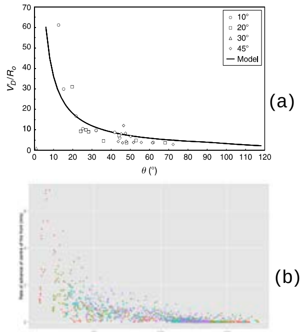

Figure 3: ROS vs junction angle for (a) experiment results (Viegas et al.), (b) model results.

Curvature and rate of spread

It has been proposed (eg Sharples et al.) that the curvature of the fire line may influence ROS, with large negative curvature being associated with higher ROS. Figure 4 shows the relationship between instantaneous ROS and local fire-line curvature for model results; there does not appear to be a strong relationship between these two quantities in the results. A more refined analysis is currently being undertaken.

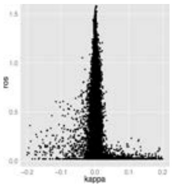

Figure 4: Local ROS vs local curvature for the model output of junction fires.

DISCUSSION

The dynamic behaviour observed in experimental junction fires is captured well by the WRF-Fire model. With no explicit radiation component, the model behaviour can only be a result of pyro-convection. It is conjectured that the geometry of the fire line affects both the bulk properties of the surface-level winds and their vortical structure, producing the dynamic behaviour. For example, counter-rotating vortex pairs lie ahead of the curved fire line in Figure 5(a), whereas they lie largely behind the fire line of Figure 5(b). These vortex pairs induce strong local winds in their vicinity.

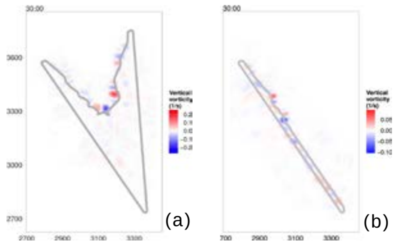

Figure 5: Counter-rotating vortex pairs in the modelled surface flow of curved (a) and straight (b) fire line.

However, no local relationship between ROS and curvature was found in the model output, and a non-local analysis is currently being conducted.

END USER COMMENT

Understanding the behaviour of extreme fires is critical to predicting fire spread, managing suppression operations, and improving fire fighter safety. These events are not adequately predicted by current quasi-steady state models and this project is developing valuable insights into extreme fire behaviour through physical modelling.
Dr Simon Heemstra, NSW Rural Fire Service.

References

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