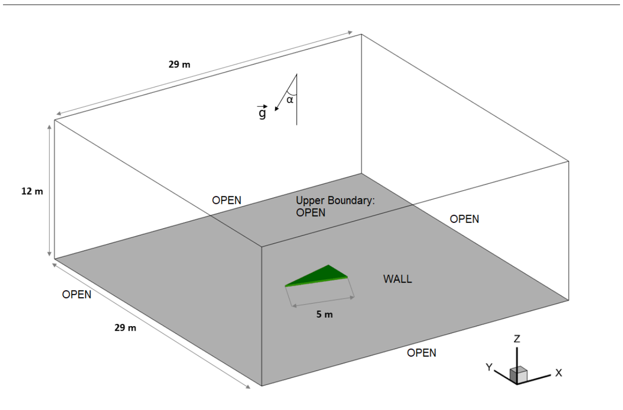
Physics-based modelling of junction fires: Effects of some topographical parameters in intersecting fires

A. Hassan [a], G. Accary [b], D. Sutherland [a,c] and K. Moinuddin [a]

[a] *Institute for Sustainable Industries and Liveable Cities, Victoria University, Australia*
[b] *Scientific Research Centre in Engineering, Lebanese University, Lebanon*
[c] *School of Science, University of New South Wales, Canberra, Australia*
Email: khalid.moinuddin@vu.edu.au

Abstract: A junction fire is the intersection of two fire fronts in a wildfire whose impact can be devastating. The rate of spread (ROS) of the junction point and the fire intensity can be intensified by slope and wind. The study of a junction fire using physics-based simulation tools aims to give an interpretation of the behaviour by examining the key factors that influence the fires, namely junction angle, slope and wind.

In this research, at first, the physics-based model FIRESTAR3D was validated against a set of laboratory-scale junction fire experiments conducted with a shrub fuel bed. A grid resolution and domain size sensitivity study was carried out. Then numerical simulations of laboratory-scale junction fires were conducted using FIRESTAR3D under various junction angles (15° to 90°), on different slopes (0° to 40°) and with and without unidirectional wind conditions. Simulations were carried out under low and intermediate driving wind speeds (maximum 4 m/s). Fig. 1 represents the computational domain and an example of fire perimeter evolution showing the deceleration in the junction point advancement for non-slope cases.



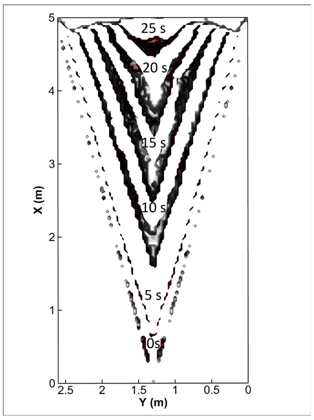


Figure 1. Perspective view showing the computational domain and the vegetation cover used in a V-shape (left) and evolution of fire perimeter for one of no-slope junction fire cases (right)

For no-wind cases, accelerative and decelerative behaviours were observed for junction angles lower than 45°, but above this, deceleration was absent. Fire propagation for the higher junction angles accelerated slightly and then appeared to be steady. The behaviour was firmly related to junction angle evolution which controlled the flame and the interactions between fire fronts. Some correlations between the dominant mode of heat transfer and the non-steady behaviour were found; as the acceleration could be related to the positive convective heat transfer. Fire intensity followed similar trends; maximum fire intensity increased with increasing junction angle. No significant effect on HRR due to slope was observed except for the deceleration phase.

For the cases of wind-driven fire, the advancement of junction fire was irregularly enhanced as an effect of wind. It was observed that the junction effect may either reduce or conceal the wind effect. For small junction angle, there was not a role for wind. While for 30° junction angle, the enhancement due to wind was conspicuous, but was reduced for higher angle. A similar uneven change in the fire intensity and mode of heat transfer was found. In high slope conditions the power densities (radiation and convection) followed almost identical trends for the different cases with or without.

This set of physics-based modelling provided a good insight into junction fire behaviour over a wide range of parameters. However, further investigations are required especially at the field scale.

Keywords: *Bushfire, fully physical model, merging fire, sloping terrain*