Validation of FDS for simulating merging fires

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Abstract: Wildfires are a significant cause of ecosystem devastation, biodiversity loss, and vegetation loss, with climate change exacerbating the situation (Halofsky et al., 2020). When fires merge, they can lead to an increase in the overall rate of fire spread and cause extreme fire behaviour, making them challenging to control. The interaction between merging fires can be considered as three types based on their shape: coalescing, V-shaped junction, and parallel fires. Coalescing fires occur when multiple independent fire spots converge, while junction fires occur when two fire fronts converge at an oblique angle, forming a V-shaped fireline. Parallel fires are a special case of junction fire and occur when the two fire fronts converge at a zero-degree angle. Understanding the dynamics controlling the interaction between parallel fires provides a better insight into eruptive fire behaviour and the strip-burning practice carried out to manage grasslands. In this study, we present our initial research on simulating the merging of parallel fires and validating the results with experimental observation.

Recently, Ribeiro et al. (2022), carried out a set of controlled experiments to study the interaction between two parallel firelines with a working area of 8×6m^2. The fuel bed composed of straw (*Avena sativa*) of height 0.07m was spread over an area of 5×4m^2 (shown in Fig. 1). Two parallel firelines spaced apart by 2m were ignited and the rate of fire spread was measured in between them. The numerical simulation of the experimental setup was carried out with Fire Dynamics Simulator (FDS ver. 6.7.8) with the details provided in the experiment. Thermo-physical and chemical properties were obtained from the experiment or similar vegetative fuels found in the literature. The ground was set to have no-slip boundary conditions with vegetation described by the boundary fuel method of FDS while all other boundaries were prescribed with a constant pressure open boundary condition. The grid independence was assessed at three grid resolutions $\Delta x = \Delta y = \Delta z$ =0.0125, 0.025, and 0.05m. The result found that the variance in estimating the rate of fire spread between 0.0125m and 0.025m was less than 5% and the grid resolution of 0.025m was accepted. The simulation results show the growth of fire at different time steps, the merging of two firelines was buoyancy-driven (as shown in Fig. 1(a)-(d)). At t=39s (Fig. 1(a)), the flame of firelines was upright and starts to incline t= 45 s (Fig. 1(b)) as pressure dropped in the centre driving flame towards the centre. The incline continued to grow; Fig. 1(c) (t= 54s). The inward tilt of fires naturally enhances the radiant heat feedback because the view factor between the fires increases, increasing the rate of fire spread. The difference between the experimentally observed and simulated rate of spread measured along the three measuring lines was found to be in the range of 4-30%, which could be attributed to the resolution at which experimental measurements were carried out.

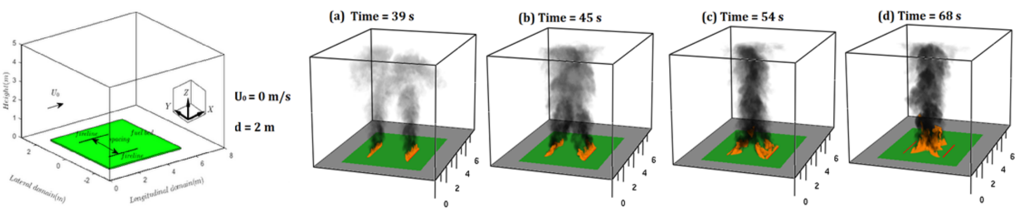

Figure 1. Computational domain simulated and interaction of parallel fire at different timesteps

REFERENCES

Halofsky, J.E., Peterson, D.L., Harvey, B.J., 2020. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology, 16: 1–26.

Ribeiro, C., Reis, L., Raposo, J., Rodrigues, A., Viegas, D.X., Sharples, J., 2022, Interaction between two parallel fire fronts under different wind conditions, International Journal of Wildland Fire, 31, 492–506.

Keywords: *Merging fire, fire dynamics simulator, parallel fires, simulation*