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FINDINGS

- At different slope angles and driving wind velocities, different operational quasi-steady Rate of Spread *(RoS)* of fire roughly lies between dynamic maximum, minimum and averaged *RoS* values
- Within the slope angle considered in this study, a second order polynomial relationship exists between quasi-steady Rate of Spread *(RoS) of fire* and slope angle, pyrolysis width and slope angle and fire intensity and slope angle.
- As the upslope angle and wind velocity increases the plume inclines more towards the ground and when the fire runs uphill, the flame length is found to be higher

Physics based simulations of grassfire propagation on sloped terrains; upslopes and down slopes

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What effect does the slope have on fire Rate of Spread (RoS) and how does that compare with operational models?
What effect does the driving wind velocity has on the RoS, head fire, flame parameters, as the slope angle varies?

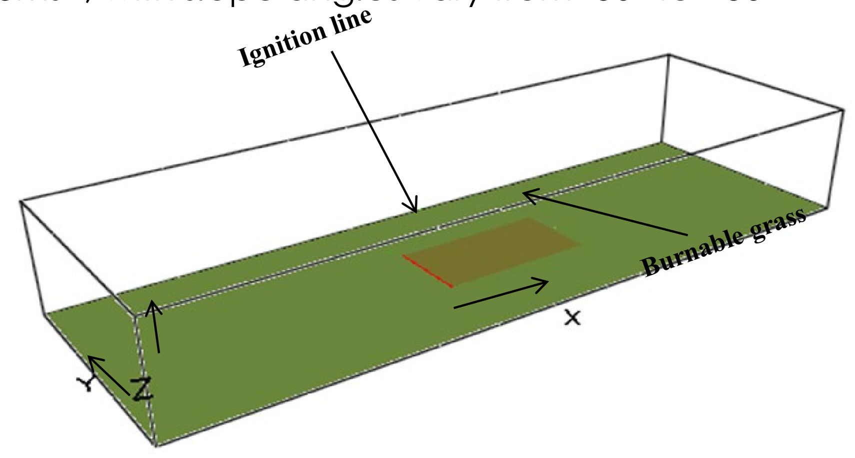
INTRODUCTION AND HIGHLIGHTS

- Rate of spread of fire *(RoS)* and fire behaviour depends on various topographical, weather and fuel factors. Topographical feature such as slope can increase or decrease *RoS* depending on whether the slope is upward or downward.
- A physics-based Fire Dynamics Simulation(FDS) model is used to conduct a set of field-scale simulations with varying wind velocities and slope angles.
- Rate of spread (*RoS*), head fire width, fire intensity, flame parameters are analyzed and compared with widely used empirical models.
- This study aims to provide insight into grassfire behavior which may then be used to improve operational models, improve prediction of real wild fires, and subsequently mitigate the risks of wildfire impact.

MODEL SETUP

The simulation domain size is 360m(L) x 120m(W) x60 m(H). The burnable plot is 80 m (L)x 40 m(W) x 60m(H). Slope is implemented in the simulations by changing the magnitude of components of gravitational force in the x and z directions. Grid size for burnable plot is chosen as 0.25x0.25x0.25m. Fuel and thermo- physical parameters are selected following Moinuddin et al [3].

Simulations are conducted for both upslopes and downslopes with varying wind velocities of 12.5,6 and 3ms^{-1}, with slope angles vary from -30° to +30°



RESULTS AND DISCUSSION

From the contour plots in Figure 1, it is observed that as the slope angle increases, the firefront becomes wider and reaches the end of the burnable grass plot much earlier. Pyrolysis width increases as the firefront progresses from the ignition line, then it plateaus (i.e. reaches a quasi-steady state) and finally decreases as shown in Figure 2 (a). Quasi-steady pyrolysis width values with lower wind velocities cases are found to be lower than that with higher wind velocities, for both upslope and downslope cases (Figure 2b).

The results show that within the slope angles considered in this study, a second order polynomial relationship exists between the quasi-steady *RoS* and the slope angle, pyrolysis width and slope angle and fire intensity and slope angle, for the upslope and downslope cases for U_{10}= 12.5,6 and 3ms^{-1}.

The dynamic averaged *RoS* values are found to be closer to quasi-steady *RoS* values, for all three velocity cases (Figure 3 for 6ms^{-1}cases). Comparing the numerical results, for a given slope angle, quasi-steady *RoS* values with lower wind velocity cases are found to be lower, however, the difference narrows between 3 and 6 ms^{-1} cases as the slope angle increases.

From the plots in Figure 4, with higher upslope angles the plume would be prone to flame attachment. When the fire runs uphill, the flame length is found to be higher when the flame is attached. It is also found that the flame height varies between 1.5 to 2.5m, which is less than value considered by fire behaviour analysts as 4m.

References:

[1] McArthur, A.G., *Weather and grassland fire behaviour*. 1966: Forestry and Timber Bureau, Department of national Development, Commonwealth
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[3] Moinuddin, K.A.M., D. Sutherland, and R. Mell, *Simulation study of grass fire using a physics-based model: striving towards numerical rigour and the effect of grass height on the rate-of-spread.* International Journal of Wildland Fire, 2018. 27(12): p. 800-814.

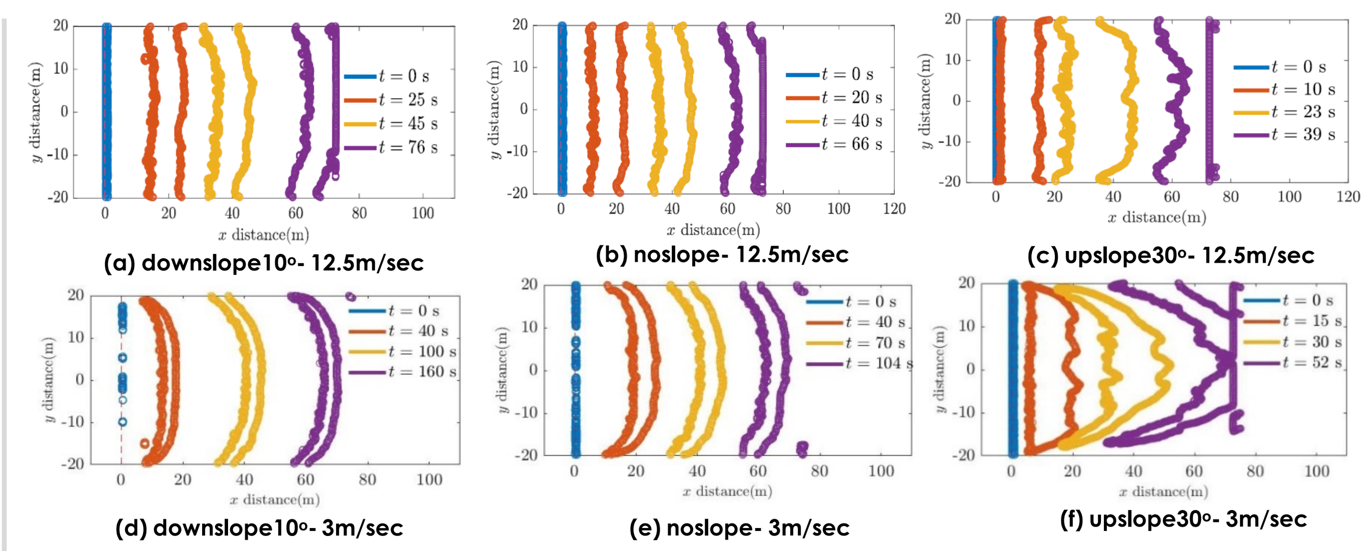

Figure1: Progression of isochrones- wind velocities 12.5 and 3 ms^{-1}

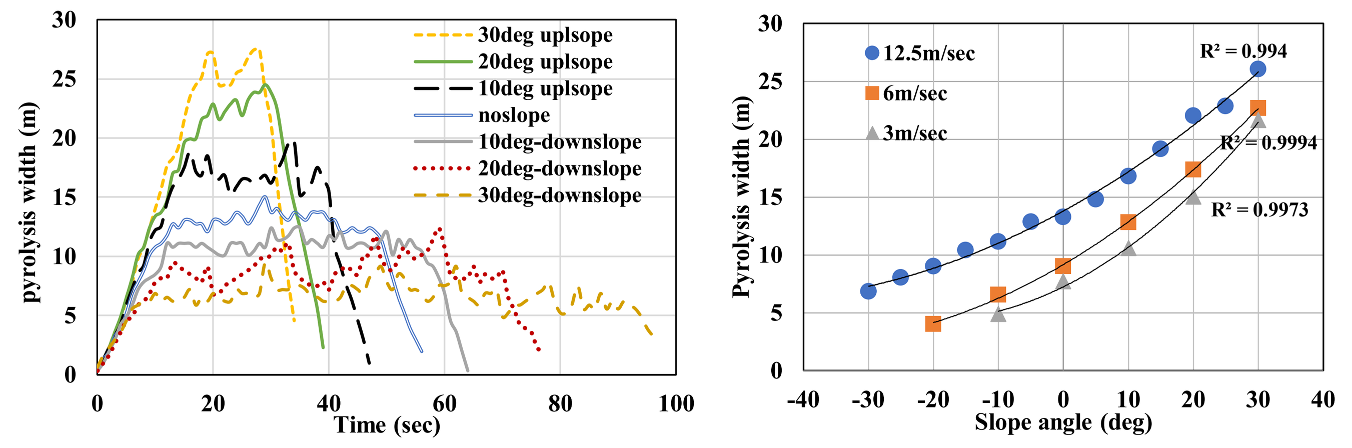

Figure2: (a) Pyrolysis width vs time at velocity 12.5 ms^{-1} (b) Quasi-steady Pyrolysis width vs slope angle

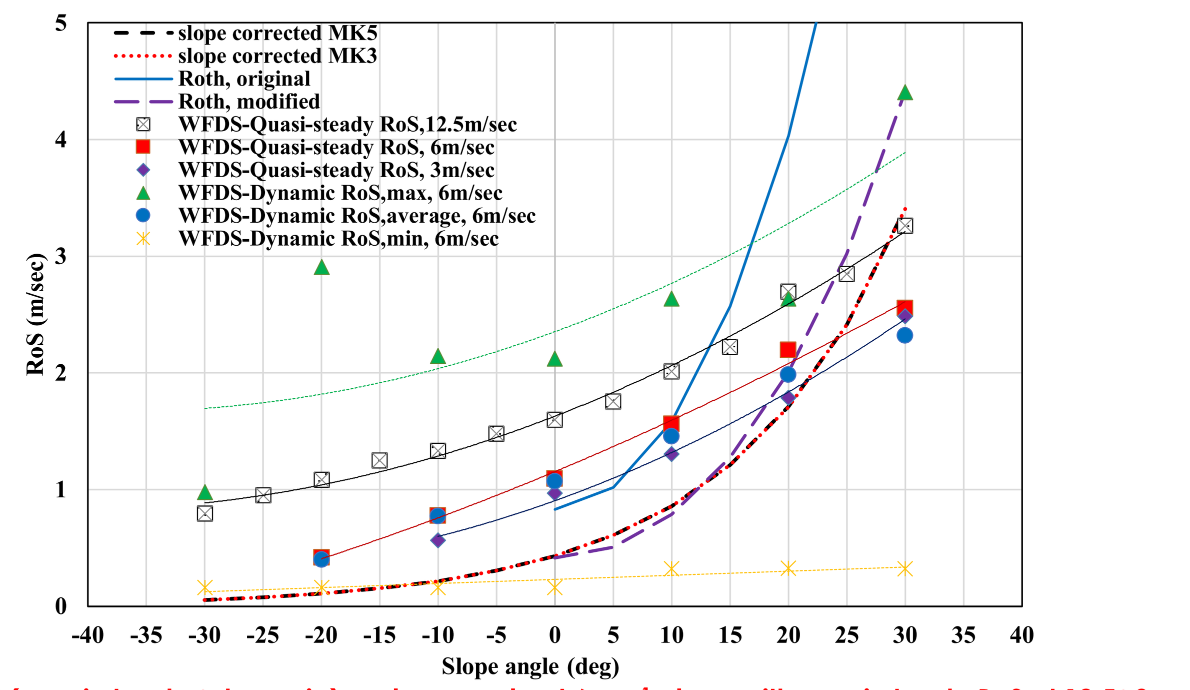

Figure 3: *RoS* (quasi-steady &dynamic) vs slope angle at 6 ms^{-1},along with quasi-steady *RoS* at 12.5&3 ms^{-1}

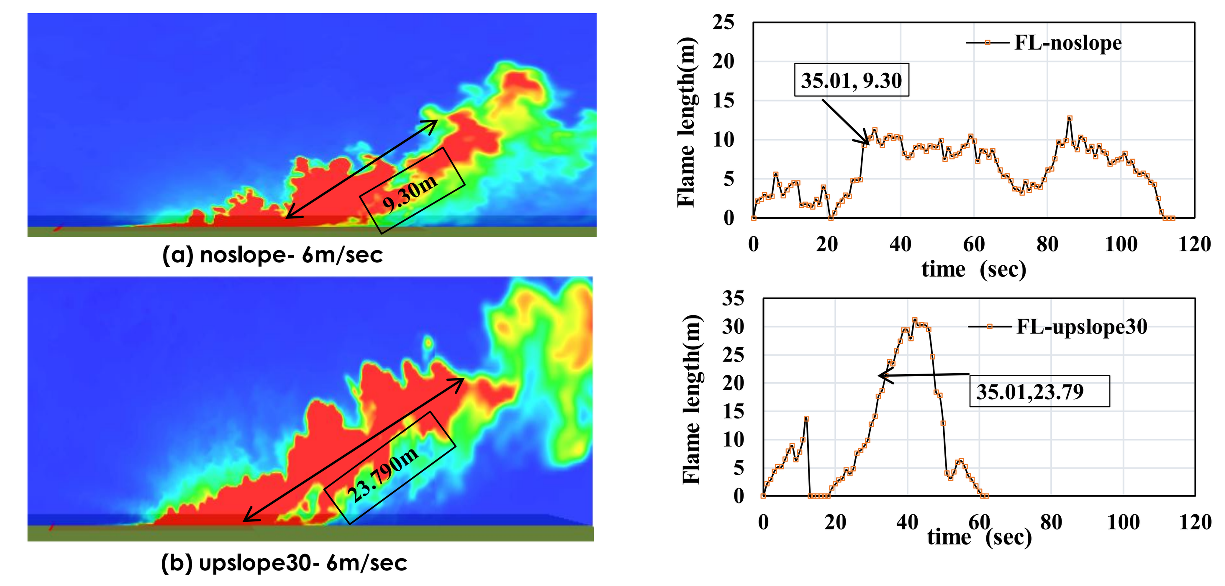

Figure 4: Graphic representation of plumes emanating from grass plot at 0°and +30° slope when the flame is attached and instantaneous flame length when flame is attached -wind velocity 6 ms^{-1}

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