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Evaluating the 10% wind speed rule of thumb for estimating a wildfire's forward spread rate

Accurate prediction of wildfire rate of spread and growth under high wind speeds and dry fuel moisture conditions is key to taking effective actions to proactively warn and protect communities. We evaluated the 10% wind speed rule of thumb that equates forward rate of fire spread to 10% of the average open wind speed against two independent wildfire datasets. We found it predicted the observed rates of fire spread with an accuracy comparable to that obtained by other fire spread models, with the percent error decreasing the faster a fire spreads.

The need for timely spread predictions

In the June 2019 PyroPage (#23), we described a new rule of thumb for quickly estimating a wildfire's forward spread rate when burning conditions are severe(i.e. high wind speeds and critically dry fuels) and the time available to prepare a more exacting prediction is limited (Cruz and Alexander 2019). The analysis of wildfire data collected across the world comprising 118 high-intensity fire runs showed the rate of spread to be roughly 10% of the prevailing 10-metre open wind speed. For example, with an open wind speed of 30 km/h, the estimated wildfire spread rate under severe burning conditions would be approximately 3.0 km/h.

Here we present a summary of an evaluation study that analysed the predictive accuracy of the 10% rule of thumb against two large, independent wildfire datasets.

The independent datasets

Documented observations of wildfire rate of spread were extracted from two databases totalling 350 high intensity fire runs. The analysis focused on the wildfires spreading during periods of strong wind speeds (>30 km/h) and low fine dead fuel moisture content values (<7% oven-dry weight). These criteria reduced the data used in the analysis to 88 fire runs. Thirty of these runs came from a database of fires burning in native eucalypt forests of southern Australia compiled by researchers from the Monash University in collaboration with the Victorian Country Fire Authority and Department of Sustainability and Environment (Harris *et al.* 2011; Kilinc *et al.* 2012). The rates of fire spread and corresponding wind speeds in this dataset ranged 0.8–8.0 km/h and 30–100 km/h, respectively.

The second reduced dataset consisted of 58 fire runs in shrublands, eucalypt forests and conifer forests garnered from the BONFIRE global fire behaviour database project led by the Universidade de Trás-os-Montes e Alto Douro in Vila Real, Portugal, starting in 2015 (Fernandes *et al.* 2020). The rates of fire spread and corresponding wind speeds in this dataset ranged from 0.55–12.5 km/h and 30–80 km/h, respectively.

Outcomes of the Analysis

The analysis of the performance of the 10% rule of thumb against wildfires spreading during severe burning conditions revealed:

- Its predictive accuracy is comparable to other evaluation studies of empirical fire spread models using wildfire data.
- No significant differences were observed in error trends between the three fuel types considered (i.e. shrublands, conifer or eucalypt forests).

- An over-prediction bias was detected for fires that spread at rates of less than 2 km/h. This was also observed in the original analysis related to the development of the rule of thumb.
- It works best for wildfires spreading at rates greater than 2 km/h with most fires predicted within ±35% error prediction band. Prediction error, expressed as a percent of the observed rate of fire spread, was found to decrease in absolute terms with increasing rates of fire spread (Fig. 1).

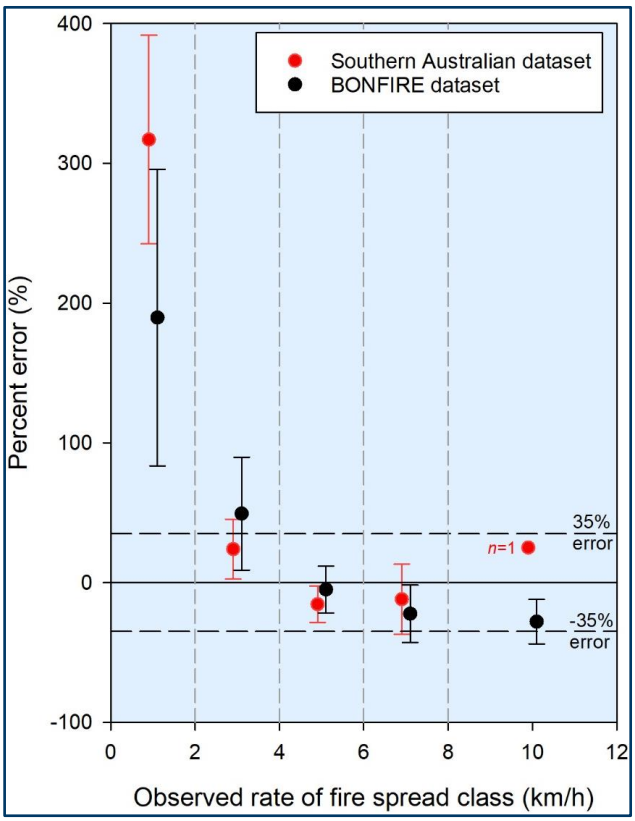

Figure 1. Variation in the percent error obtained with the 10% rule of thumb in relation to observed rate of fire spread. Solid dots denote the mean values of each class and the error bars are ± one standard deviation.

The Dominance of Wind Speed During Severe Burning Conditions

The results of Cruz and Alexander (2019) and Cruz *et al.* (2020) have substantiated the strong dominance that wind speed has on the forward spread rate of wildfires when fuels are critically dry (i.e. fine dead fuel moisture and long-term landscape dryness) and winds are strong. These burning conditions produce fire behaviour that typically catches emergency response agencies and communities by surprise due to the fast spread rates and corresponding high fireline intensity levels.

Despite the high energy release rates associated with wildfires burning during these conditions, the high degree of convective plume tilt associated with strong winds leads to a decoupling between the advancing flame front at the surface and the updraft of the plume downwind of the fire that seems to reduce fire-plume interactions and the associated uncertainty with respect to weather conditions at the surface.

Further reading

Cruz MG, Alexander ME, Fernandes PM, Kilinc M and Sil Â (2020) Evaluating the 10% wind speed rule of thumb for estimating a wildfire's forward rate of spread against an extensive independent set of observations. *Environmental Modelling & Software* 133: 104818. 15 p. doi:10.1016/j.envsoft.2020.104818

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Cruz MG and ME Alexander (2019) The 10% wind speed rule of thumb for estimating a wildfire's forward rate of spread in forests and shrublands. *Annals of Forest Science* 76(2): 44. 11 p

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Harris S, Anderson W, Kilinc M, Fogarty L (2011) Establishing a link between the power of fire and community loss: the first step towards developing a bushfire severity scale. Report 89: Victorian Department of Sustainability and Environment, Melbourne, Vic. 75 p.

Kilinc M, Anderson W and Price B (2012). The applicability of bushfire behaviour models in Australia. DSE Schedule 5: Fire Severity Rating Project Technical Report 1.: Victorian Department of Sustainability and Environment, Melbourne, Vic. 60 p.

CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

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Land and Water
Dr Andrew Sullivan
t +61 2 6246 4051
e Andrew.Sullivan@csiro.au
w www.csiro.au/en/Research/LWF

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