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Mantras of bushfire behaviour modelling

Generalised statements about the state of a science are often given in publications to provide a simplified context for the reader. When such statements are repeated without the necessary critical assessment to determine if the statement is still valid, it can become a mantra. In bushfire science, such statements have impacted research directions, end-user expectations and the value of applied research results. A recent article analysed the truthfulness of five such statements about bushfire behaviour modelling commonly found in the literature.

Bushfire modelling

Models to describe the behaviour and spread of free-burning wildland fires have been under development for more than 70 years. Such quantitative fire behaviour research has involved numerous methods within two contrasting research approaches: one empirical, based on the observation of field experimental fires and wildfires and the establishment of simple relationships between fire behaviour characteristics and key environmental variables; the other a physical- or process-based approach, based on descriptions of fundamental physical and chemical processes underpinning combustion, fluid flow and heat transfer.

Each modelling approach has its advantages and disadvantages. Many authors include simplified statements about the perceived weaknesses or strengths of a modelling approach when presenting new work. Often, either through omission or lack of understanding, many of us restate previously published statements without due regard to the meaning, validity or intent of its original use. When these are repeated subsequently in the literature, they can gain currency as if they were facts.

Even though such statements (or variations of them) often seem to make intuitive sense, they are often not verified or supported by documented evidence, becoming “urban legends”. Here we highlight some of the most prominent mantras found in the bushfire modelling literature and discuss their validity with the hope that in the future we will not repeat them blindly.

Fire modelling mantras

The five mantras of fire modelling are:

M1. Empirical models work well over the range of their original data.
M2. Empirical models are not appropriate for and should not be applied to conditions outside the range of the original data.
M3. Physical models provide insight into the mechanisms that drive wildland fire spread and other aspects of fire behaviour.
M4. Physical models give a better understanding of how fuel treatments modify fire behaviour.
M5. Physical models can be used to derive simplified models to predict fire behaviour operationally.

M1: Empirical models work well for the original data

Empirical fire-spread models developed from field data are often considered to be a direct reflection of real-world fire behaviour and should work well within the bounds of the original dataset. While intuitively valid, empirical models can work well over the range of the original dataset provided two conditions are met. First, the data used in model development are well balanced (i.e not biased). Second, the functional forms used in the model must be representative of the bulk effect of the controlling variables involved. M1 is thus not necessarily true.

M2: Empirical models are not useful outside the original range of data

This common fire modelling mantra makes intuitive sense; however, studies evaluating empirical models against independent data have shown this is not necessarily true (Figure 1). It was found that the suitability of a model to be extrapolated beyond the bounds of the model's development dataset depends upon the functional forms used in its development. Nonetheless, new models should be evaluated thoroughly against a broad range of data before being used to support operational decisions.

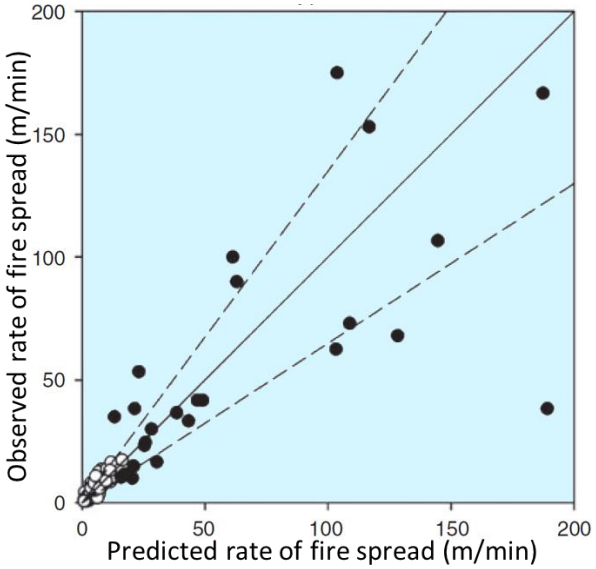

Figure 1. Example of observed rate of spread versus predicted for model development (○) and evaluation data (mostly wildfire) (●) for eucalypt forest fires. Dashed lines around solid line of perfect agreement represents ±35% error interval.

M3+M4: Physical models provide insight into wildfire spread mechanisms

It is widely believed that physical models, being based on fundamental laws of nature, can tell us much about the behaviour of bushfires and how they spread. However, the large number of assumptions (required to overcome gaps in our knowledge of the detailed physics and chemistry), simplifications and approximations to make the problem tractable and the relatively large spatial resolutions over which the model equations are solved, mean that such models are not complete representations of a bushfire. When combined with the detailed data required to run such models, model outputs must be treated cautiously. Physical models have not yet been shown to adequately simulate observed bushfire behaviour.

M5: Simplified models can be derived from physical models

The concept of reducing a full physical model to one that captures the fundamental behaviour without the detail, mainly by excising noncritical elements, is common in the field of computational simulation. The validity of developing viable simplified models from an existing physical model appears dubious at this time due to the limitations given in M3+M4 and the heavy dependence on empiricism. As a result, the use of such simplified models for operational purposes must be treated with caution given the uncertainty encapsulated in their formulations and solutions.

Physical models are said to hold great promise for improving our understanding of bushfires. However, further research is needed to understand their limitations and to improve the descriptions of critical processes not yet adequately characterised, with the goal of producing models that will accurately describe bushfire processes, dynamics and behaviour. After more than 30 years of physical fire behaviour modelling, operationally-relevant results are still elusive.

Further reading

Cruz MG, Alexander ME, Sullivan AL (2017) Mantras of wildland fire behaviour modelling: facts or fallacies? International Journal of Wildland Fire 26, 973–981. doi:10.1071/WF17097.

Other reading

Cruz MG, Alexander ME, Sullivan AL (2018) A response to 'Clarifying the meaning of mantras in wildland fire behaviour modelling: reply to Cruz et al. (2017)'. International Journal of Wildland Fire 27, 776–780. doi:10.1071/WF18161.

Mell W, Simeoni A, Morvan D, Hiers JK, Skowronski N, Hadden RM (2018) Clarifying the meaning of mantras in wildland fire behaviour modelling: reply to Cruz et al. (2017). *International Journal of Wildland Fire* 27, 770–775. doi:10.1071/WF18106.

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