STATISTICAL CHARACTERISATION OF WIND FIELDS OVER COMPLEX TERRAIN FOR BUSHFIRE MODELLING

bushfire&natural HAZARDSCRC

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INTRODUCTION

The spread of bushfires is highly sensitive to wind speed and direction; in particular, sudden changes in wind characteristics across the landscape can result in drastic changes in the rate and direction of fire spread. Accurate estimation of wind fields across the landscape and over time is thus a crucial component of bushfire spread modelling. However, estimation of wind fields across rugged terrain is far from trivial. The complex interactions between prevailing winds and varying landscape features are often over-simplified within operational bushfire models due to computational constraints.

The research conducted throughout this PhD aimed to improve the understanding of wind flow over complex terrain through developing a statistical characterisation. This improved understanding complements current approaches to provide a more informed wind modelling framework, including considerations of variability and uncertainty, for bushfire prediction. This aim is achieved through four key contributions to the scientific research community.

(1) Contribute a new wind field dataset

- Wind speed and direction data were collected using 5 metre high Davis Vantage Pro 2 portable automatic weather stations across two case studies of complex and undulating terrain.
- In 2007 and 2014, data were collected across Flea Creek Valley, NSW, allowing for analysis of the affects of post-fire vegetation regrowth on wind fields in rugged topography. This developed research conducted by Sharples et al. [1].
- In 2015, data were collected at the National Arboretum Canberra (NAC, **Figure 1**) with an experimental design enabling more controlled assessment of both vegetation and topographical affects on wind fields.

(2) Recast wind fields in probabilistic terms

- The development of probabilistic wind field prediction is better suited for input into emerging ensemble-based or stochastic fire prediction frameworks which account for uncertainty in fire spread across the landscape.
- Typically, current ensemble-based fire models simplify the probabilistic nature of wind characteristics to standard probability distribution functions. However, data collected throughout this research show more complex probabilistic structures.
- Probabilistic wind direction response distributions were developed using observed wind direction data (**Figure 2**, [2]). These distributions represent how the direction of the prevailing wind responds to changes in topography and vegetation at the surface.
- From these distributions, there are clear thresholds in aspect and vegetation (or surface roughness) for the production of wind behaviours such as regions of recirculation beneath the canopy on leeward slopes.
- Wind behaviours can be characterised in terms of likelihood or probability, with such information used to complement current physical wind modelling techniques.

(3) Statistical comparison of wind direction

- Statistical comparison tests were used to formally identify areas where surface roughness has a statistically significant impact on wind direction response.
- Vegetation and aspect were found to have significant, but varying, impacts on wind response across complex terrain [3]. The variation in impacts is vital to better understanding uncertainty in wind modelling for fire prediction.
- Evaluation of the non-parametric statistical techniques used for comparison of wind direction distributions also allowed for improved interpretation of statistical test results, and definition of significance thresholds in terms of wind direction changes [3,4].

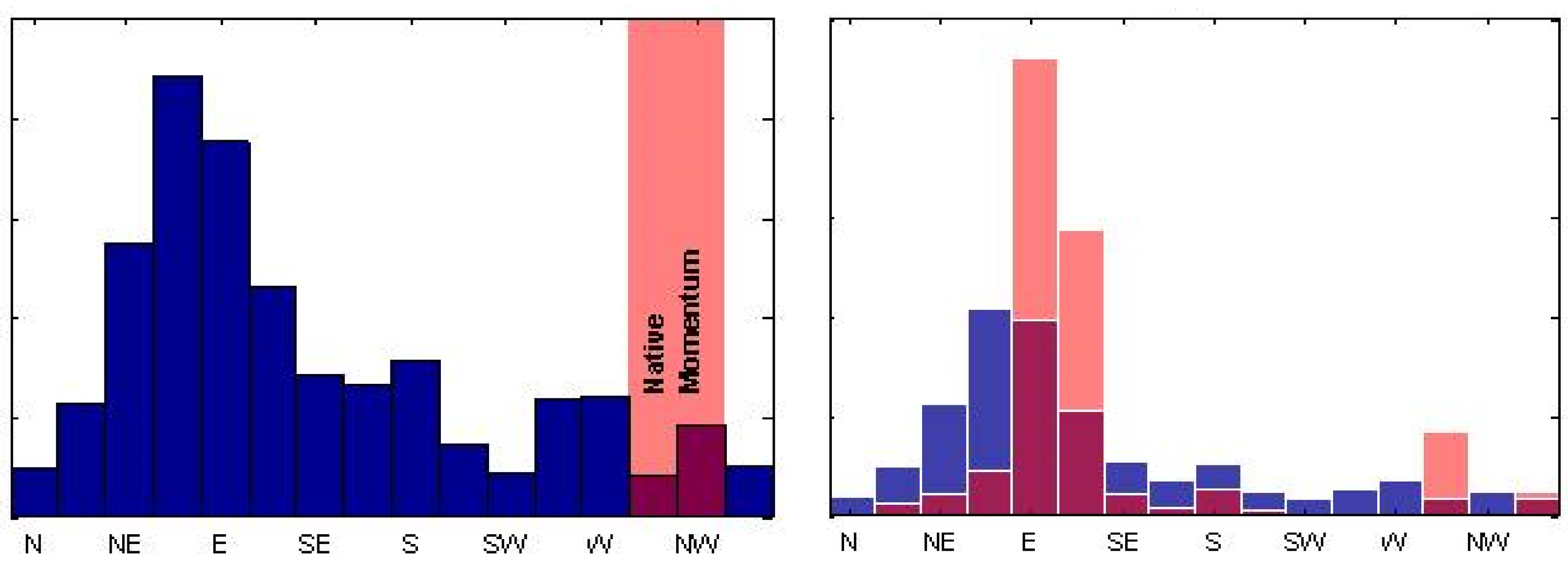

Figure 3: Prediction of wind direction on a leeward slope using (left) deterministic application of WindNinja with native and momentum solvers, and (right) a new probabilistic application of WindNinja.

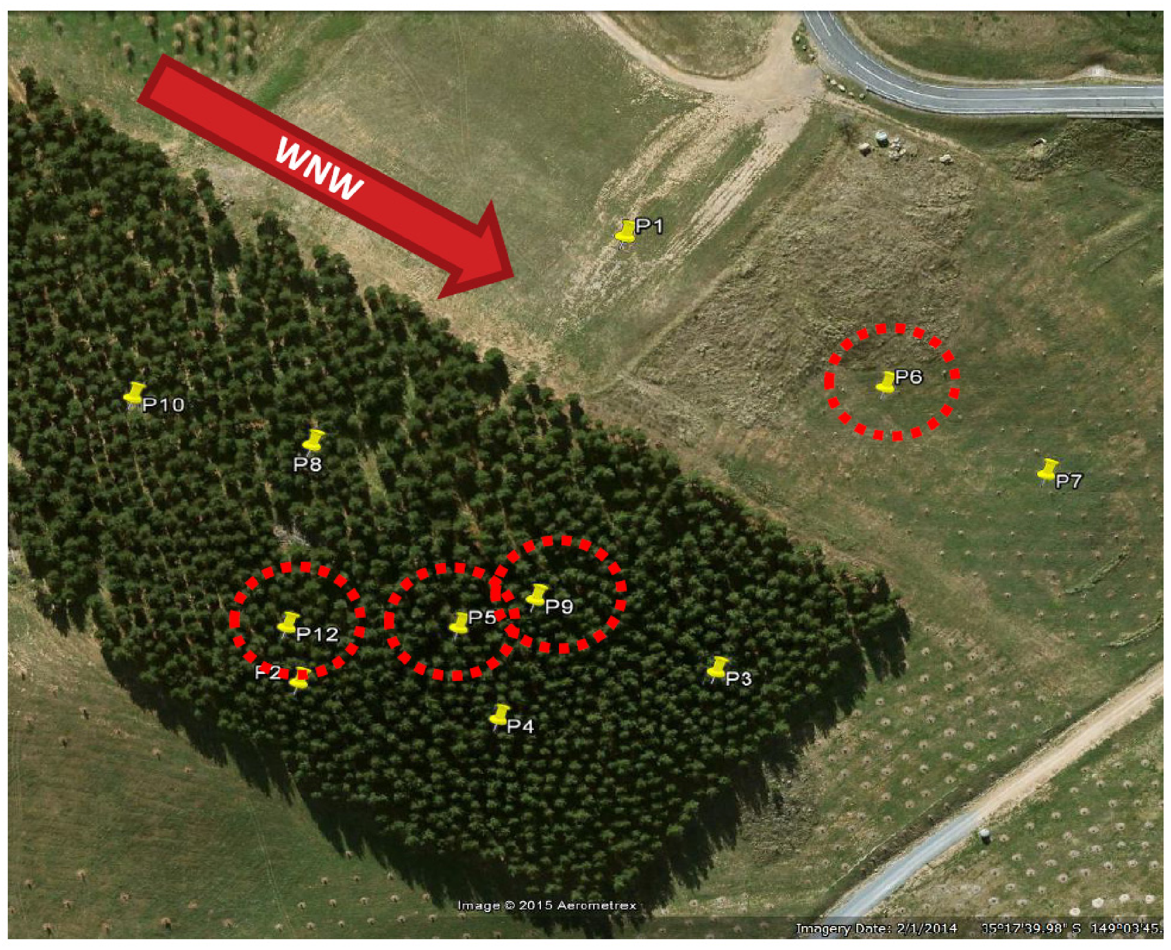

Figure 1: Data collection at the National Arboretum Canberra, 2015.

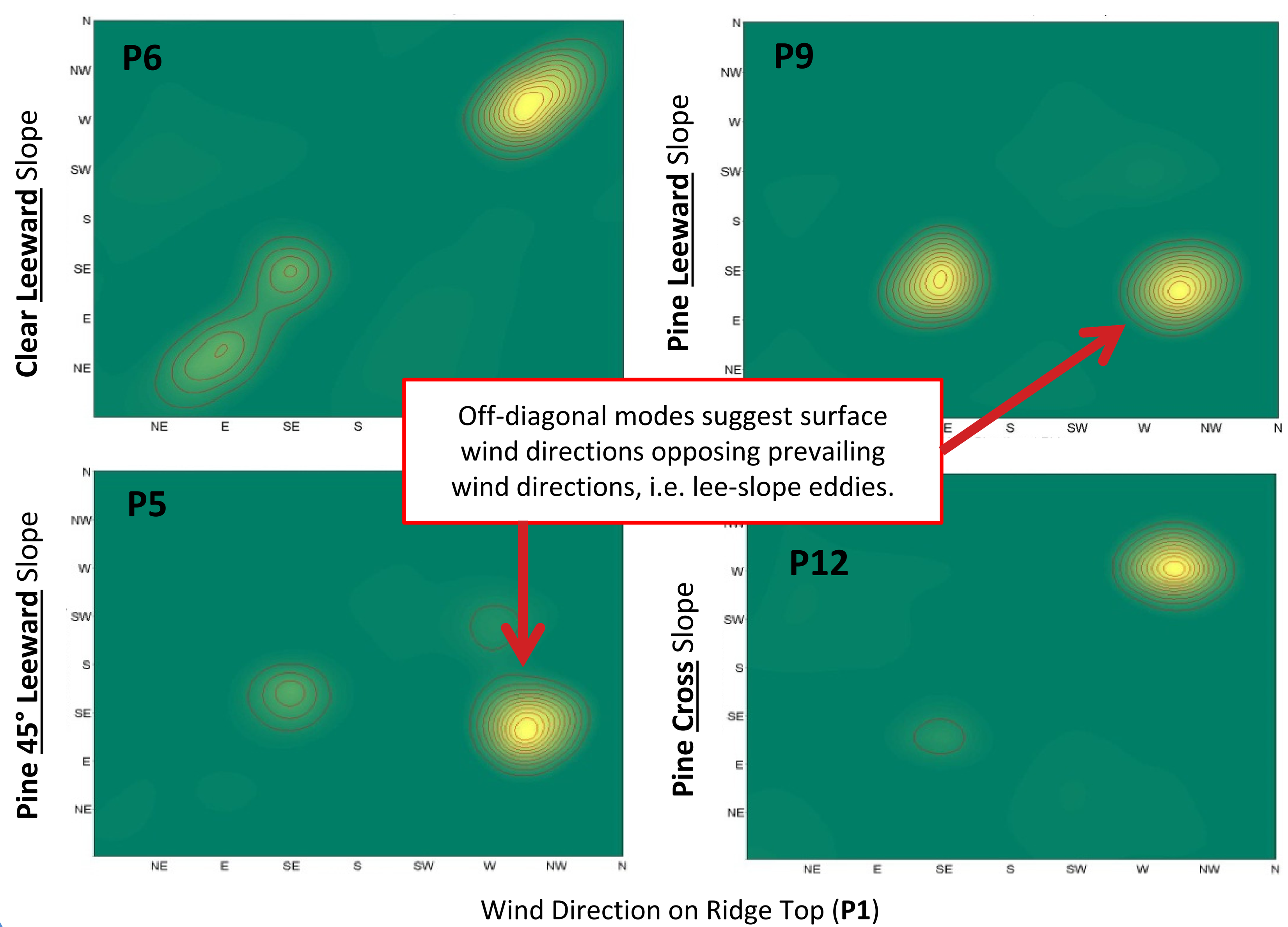

Figure 2: Joint wind direction distributions across the NAC.

(4) Evaluate operational wind models

- Current wind modelling techniques used in operational fire prediction are applied deterministically, or used to form standard probability distributions to allow for uncertainty.
- Again, data from this project clearly show that wind fields are inherently probabilistic and adhere to more complex (non-standard) distributional structures that can vary across the landscape (**Figure 2**).
- Probabilistic application of deterministic models can better capture the spread of wind response across complex landscapes (**Figure 3**).
- It has been shown in this research that it is possible to predict key wind behaviours that are currently not well captured by deterministic application, such as bimodal distributions or recirculation regions observed on leeward slopes within complex terrain [5].

CONCLUSION

This research highlights the potential for a hybrid approach to wind modelling for fire spread prediction; combining current physics-based models with new probabilistic approaches. With better understanding of wind variability, better analysis of the uncertainty in fire prediction can be made using emerging probabilistic frameworks, leading to more informed bushfire management.

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