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Modelling the probability of lightning-caused ignitions in Australia

Li Zhao [a], **Marta Yebra** [a,b] **and Colleen Bryant** [a]

[a] *Fenner School of Environment and Society, The Australian National University, Canberra, Australia*
[b] *School of Engineering, The Australian National University, Canberra, Australia*
Email: li.zhao@anu.edu.au

Abstract: Lightning-initiated wildfires are the dominant contributor to large areas burned, accounting for 80-90% of the total area burned in south-eastern Australia. However, lightning ignitions remain one of the most unpredictable aspects of the fire environment. Although there have been significant efforts to identify the critical factors that influence the likelihood of fires caused by lightning, there is still ongoing debate about these factors, which may vary depending on the location and study area. Moreover, the ability to predict lightning fires remains comparatively poor, particularly when compared to human-caused ignitions. This research aims to better understand the complex interactions between different variables (e.g., weather, vegetation, topography, and lightning characteristics) that influence lightning ignitions in the Australian Capital Territory and New South Wales, Australia. To achieve this goal, the study seeks to identify the key drivers of lightning-caused ignitions in this region as well as develop a model that can predict the probability of lightning-caused fire occurrence based on these key drivers.

Data from a variety of sources are used in this study from 2017 to 2021, including fire ignitions data (location, date, cause, and size) obtained from the New South Wales Rural Fire Service, lightning data (location, time, polarity and amplitude), weather variables (temperature, humidity, rainfall, soil moisture, etc.) and fuel attributes (dead and live fuel moisture, fuel types, etc.). We use a 3-day window and a 2 km radius around the ignition point to match the lightning strikes to ignition events. A proximity index that combines the time delay and spatial distance between the ignition and lightning stroke is used to identify the lightning strike candidates for each ignition. Environmental variables are also extracted at both the ignition date and during the 3-day window period, including daily maximum temperature, minimum humidity, vapour pressure deficit, rainfall, soil moisture and dead fuel moisture content.

Our preliminary results highlight a strong correlation between hot, dry weather conditions and lightning-induced fires. Typically, such fires occur following consecutive days of hot and dry weather and minimal rainfall. Over the course of the three days prior to the ignition, we observed a consistent decrease in humidity, soil moisture, and dead fuel moisture, as well as a trend of increasing daily maximum temperatures. This pattern is consistent with the strong influence of the passage of cold fronts on weather patterns in south-eastern Australia, with thunderstorm activity commonly coinciding with the thermal instability associated with the arrival of cold fronts. In addition, negative polarity lightning strikes with a current of around −10 kA were found to be more likely to trigger fires. Our ongoing work involves identifying the interaction between fires, lightning strikes and other factors such as topography, vegetation types, structure and moisture, and developing a machine-learning model to predict the probability of fires caused by lightning. Our predictive model will help enhance forest fire risk assessment systems by providing lightning-caused ignition forecasts.

Keywords: *Lightning, ignition, probability, fire occurrence*