26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Climate change will accelerate seasonal fire weather severity by 8–24% in Southeastern Australia

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Abstract: Fire weather activity is influenced by interannual climate variability, extreme events, and changes in fire dynamics. This is expected to be accelerated due to climate change. However, the future severity and spatial extent of fire weather, along with their sensitivity to meteorological variables, remain insufficiently studied.

This study aims to investigate future fire weather using the Forest Fire Weather Danger Index (FFDI), based on key daily meteorological variables (daily maximum near-surface air temperature, near-surface wind speed, near-surface relative humidity, drought factor) derived from an ensemble of five CMIP6 models. Two Shared Socioeconomic Pathway (SSP) scenarios are considered: a low-emission scenario (SSP126) and a high-emission scenario (SSP370), across three time periods: near future (2015–2034), mid-century (2035–2054), and far future (2055–2074) in southeastern Australia. We analysed the sensitivity of the FFDI to changes in key meteorological variables using an ensemble of Random Forest (RF) and Extreme Gradient Boosting (XGBoost) algorithms, combined with Shapley values for interpretability.

For the reference period (1995-2014), the simulated seasonal averages of the 99th percentile FFDI were 23.54 in summer, 14.01 in autumn, 4.79 in winter, and 19.00 in spring. The projected findings reveal that, under SSP126 and SSP370 scenarios, fire weather severity is projected to intensify, with a 9-19.9% rise in summer, 13.3-16% in autumn, 7.7-23.6% in winter, and 8.8-21.9% in spring by the 2040s and 2060s compared to the reference period. Notably, under both scenarios, the spatial extent of high-severity FFDI is projected to expand, indicating an increased fire danger in the Upper Murrumbidgee River Catchment. Shapley value analysis identified near-surface relative humidity as the most influential factor in changing fire weather within the catchment, with the drought factor, temperature, and wind speed ranking second, third, and fourth, respectively.

These findings provide valuable insights into the severity, extent, and sensitivity of the FFDI to meteorological variables, highlighting the efforts required to mitigate its impact and enhance fire resilience in the catchment.

Keywords: *fire weather, CMIP6, multi-model ensemble, machine learning, Murrumbidgee River catchment*