Fire-atmosphere modelling provides insights for bushfire behaviour

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New research offers insights into the destructive bushfires of 2019–20 in Australia, which were driven by complex interactions between the fire and the atmosphere that produced extreme local fire behaviour.

Cutting-edge research uses advanced computer simulations that combine bushfire behaviour and meteorology to investigate why the bushfires were so extraordinary and challenging for firefighters. The research, led by Dr Mika Peace from the Bushfire and Natural Hazards CRC and the Bureau of Meteorology, examined the fires at Badja Forest (New South Wales), Green Valley Talmalmo/ Corryong (NSW and Victoria), Kangaroo Island (South Australia), Stanthorpe (Queensland) and Yanchep (Western Australia).

Dr Peace said, 'The research uses 2 linked models to help us understand the processes driving these challenging and destructive fires; one which simulates the fire and one which simulates the weather. So, by combining them, we can see how both the fire and weather change in response to each other.

'It's only possible to research the fire behaviour resulting from these, such as extreme, local winds and rotating fire plumes, through work like this.

'As we learn and share these findings, we can apply our knowledge to future bushfires. Right now, we can use the findings to help fire behaviour analysts and fire meteorologists recognise the conditions that lead to extremely dangerous localised bushfire behaviour,' she said.

Research shows that the long drought and heatwave conditions experienced in the lead-up to and during all 5 fires were a significant factor in priming the landscape for extreme fire behaviour. But local weather conditions were important when combined with the very dry vegetation.

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Unusual fire activity occurred in the overnight period, when fire intensity and rate of spread is typically expected to decrease. Interactions between strong winds above the ground, topography and the fire plume circulation accelerated surface fire spread at night.

'The conventional understanding of bushfire behaviour tells you that fire activity will decrease overnight as the temperature drops, humidity rises and winds become lighter.

'Modelling shows that very strong low-level winds descending to the ground behind the fire plume were a critical reason why the Badja Forest and Corryong bushfires burnt so fast overnight,' she explained.

Pyrocumulonimbus (pyroCb) clouds, sometimes called fire-generated thunderstorms, featured in the 2019–20 fire season. The number of pyroCb clouds recorded was the highest in Australia in any one season. However, the 5 fires examined were not all associated with pyroCb clouds. This showed that it is not the only weather phenomenon that was associated with the extreme fire behaviour that season.

Fires in the Badja Forest of New South Wales created pyroCb clouds that can cause erratic winds and dry lightning.
Image: NSW Rural Fire Service Facebook

The simulations showed that the fire-affected wind near a fire plume can be much stronger than the background winds and that destructive winds can occur, including extreme fire-front winds and fire-generated vortices.

'For the bushfires that occurred close to the coast, for example Yanchep in Western Australia and on Kangaroo Island, the combination of heatwave conditions, the temperature difference between the hot land and the cooler water and local topography led to complex winds that changed the bushfire behaviour,' Dr Peace explained.

Sea breezes, the local environment and the fire caused erratic, variable winds along active fire lines, which stretched for several kilometres.

The bushfire simulations undertaken through this research use the Australian Community Climate and Earth System Simulator Fire (ACCESS-Fire) model and are run on the National Computing Infrastructure supercomputer in Canberra. The results show the benefits of enhanced simulation capability and supercomputer power. Due to the level of detail, data and the computer power required, it is not possible to model bushfire behaviour like this when bushfires are burning.

This research was conducted in collaboration with Australian fire and land management agencies. The project highlights the complexity of the fire environment and fire management and shows how a coordinated and multi-disciplinary approach can make fire behaviour predictions.

This research is funded by the Australian Government and the Bushfire and Natural Hazards CRC to investigate issues arising from the 2019–20 bushfire season. The team comprised Dr Mika Peace, Barry Hanstrum, Dr Jesse Greenslade, Dr Dragana Zovko-Rajak, Dr Abhik Santra, Dr Jeffrey Kepert, Dr Paul Fox-Hughes, Dr Harvey Ye, Tasfia Shermin and Jeffrey Jones from the Bureau of Meteorology.

The research report, *Coupled fire-atmosphere simulations of five Black Summer fires using the ACCESS-Fire model*, is available at www.bnhcrc.com.au/publications/black-summer-fire-modelling.