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LINKING LOCAL WILDFIRE DYNAMICS TO PYROCB DEVELOPMENT

Research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference
Adelaide, 1-3 September 2015

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Version	Release history	Date
1.0	Initial release of document	03/09/2015

Publisher:
Bushfire and Natural Hazards CRC

September 2015

ABSTRACT

There has been a significant international collaboration studying the most extreme form of wildfire – pyroCbs (pyro-cumulonimbus or fire thunderstorm). Owing to their massive atmospheric impacts, the researchers include wildfire specialists, meteorologists and atmospheric scientists. There is a wide range of tools being used, including satellites, weather data, weather radar and fire ground observations. As a result, a comprehensive picture of these events is emerging.

One of the greatest challenges has been bridging the gap between what is seen on the fireground and what is seen in the middle layers of the atmosphere.

On November 22, 2006, two pyroCb events occurred in the Greater Blue Mountains, west and northwest of Sydney. These were in the Grose Valley in Blue Mountains National Park and near Mount Coricudgy in Wollemi National Park. These two case studies have been the subject of recent scientific studies aimed at addressing the gap.

The Wollemi Fire was the first extreme wildfire to be directly passed over by NASA's A-Train flotilla of earth observation satellites. Between them, these satellites recorded data from imagers, lidar, radar and UV backscaterring instruments. Useful data was collected for the Grose Valley Fire as well. This allowed confirmation that these were pyroCb events, and allowed detailed analysis of their structure and dynamics.

Later satellite data was used to track the downwind movement of the smoke at the upper troposphere – lower stratophere (UTLS). These elevated aerosol plumes are significant features on a global scale, and are studied in parallel with raised dust and volcanic plumes.

Satellite data was corroborated by radar data, which showed echotops up to nearly 12 km a.s.l. Radar data also showed that both fires had multiple pulses of convective intensity. Plume pulsing had been seen in satellite imagery previously in pyroCbs from Australia, Canada, the US and Russia, though the drivers of this pulsing were not clear. It was considered likely that variations in fireground energy release were involved.

The radar data also made it clear that both fires being studied escalated before noon but in association with a trough line, suggesting both the involvement of unusual surface weather and a role for atmospheric instability.

The NSW Rural Fire Service flew an airborne multispectral linescanner over the two fires a number of times. This permitted detailed assessments of changes in fire intensity with time, as well as assessment of the fire dynamics driving the fire's evolution.

The results for the Grose Valley Fire permitted a very detailed picture to be developed. Burning for some days over plateaux and in the incised Grose Valley, the fire exhibited expected behaviour in response to changes in surface weather. Fire spread was by means of a fireline of variable rate of spread and intensity.

Around noon on a dissected sandstone plateau, the fire exhibited atypical lateral spread. At a similar time much of the Blue Gum Forest area was consumed by dense mid-range spotting, with the spotfires rapidly coalescing. Radar data showed that this produced the first plume pulse that reached the UTLS.

Three hours later instance of atypical lateral spread occurred in the gorge of Govetts Creek. Radar data showed that this caused another plume pulse that reached the UTLS. Similar, events in the Wollemi Fire were also found to align with plume pulses that reached the UTLS.

The timing of the escalation of the fires was of interest. Weather records for the region indicated a foehn effect the night before. This caused significant deviations from the expected diurnal cycle for both temperature and relative humidity. The effects of these deviations would be to keep fuel moisture contents lower overnight, thereby priming the landscape for the occurrence of dangerous fire behaviour earlier in the day than would normally have been the case.

These studies clearly showed that the full information content of weather radar data is often underutilised, especially with respect to the characteristics of fire propagation. Radar allowed the bases of intense convection columns to be linked to places and times where distinctly dynamic modes of fire propagation were underway. The role of dense spotting was equally shown to be important.

In terms of the typical indices of surface fire activity, these case studies raised concerns. Fire danger indices on the blow-up day were not elevated, and were only slightly above those of the previous days when the fires burnt without any significant escalation. Australian fire danger indices only consider fuel flammability dynamics on hourly time scales (temperature and relative humidity) and on daily time scales (drought factor). The multi-hour time scale over which the foehn effects may persist on the landscape is not considered. There is an implication that this persistence involves fuel that is heavier than the normally-considered fine fuels.

Radar data showed that fire blow-up coincided with the passage over the fires of a trough-line. This developed normal thunderstorms in places, and new fire ignitions due to lightning were recorded in the region.

The studies also examined the Continuous Haines Index (C-Haines) for the fires. C-Haines peaked on the blow-up day, although only slightly above values for the preceding two days. The peak C-Haines values were reflected in both the stability and moisture components of C-Haines. It is thus evident that the fire danger and C-Haines indices, even when considered in combination, failed to unambiguously indicate that this day, and only this day, would exhibit blow-up fire behaviour.

These case studies have confirmed the significance of dynamic modes of fire spread (e.g. vorticity-driven lateral spread, aka: fire channelling) in fire escalation. Discovered only after the 2003 Canberra Fires, fire channelling has been confirmed or suspected in a number of key wildfire blow-ups in rugged landscapes. It is becoming clear that IMTs must be aware of the threat that dynamic fire spread poses as part of their dynamic risk assessments under AIIMS 4 doctrine.

These case studies have shown that blow-up fire events result from a combination of fire dynamics, fire weather and atmospheric instability. Consideration of one or two of these factors alone can provide an incomplete appraisal of the potential for blow-up fire behaviour. Similar case studies in the future will further aid our ability to anticipate pyroCb events, and the risks that they pose.

These case studies also indicate the value of detailed remote sensing data, whether it is from ground-based instruments (radar), airborne instruments (linescanners) or satellites. With the anticipated commissioning of the Himawari-8 weather satellite it is timely for us to improve our collective skill-levels in these respects.