INSIGHTS FROM ACCESS-FIRE SIMULATIONS OF A DESTRUCTIVE FIRE-GENERATED TORNADIC VORTEX AT GREEN VALLEY (NSW) ON 30 DECEMBER 2019

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Introduction and motivation

A fire-generated vortex with tornado-strength winds (fire-generated tornadic vortex; FGTV) occurred in the late afternoon during the Green Valley/Talmalmo fire in southern NSW and flipped over a 12-tonne fire truck causing the death of a firefighter. Wind speeds in the range 250-350 km/h were estimated based on the impact on the truck. The FGTV occurred on a day of extreme forest fire danger within a deep, dry, well mixed boundary layer.

Left: Video still of the cyclonically rotating pyro-convective column at Green Valley at 0630 UTC. The column is ~ 1-2 km across. [Photo credit: Mr Ashley Drummond]

Right: Photograph of the FGTV emerging from the main fire front at 0637 UTC. The vortex is ~ 50-100m across. [Photo credit: Mr Scott Anderson]

FGTV ingredients:
- Buoyant updrafts co-located with localised vertical vorticity – leads to stretching and 'spinning up' of the vortex

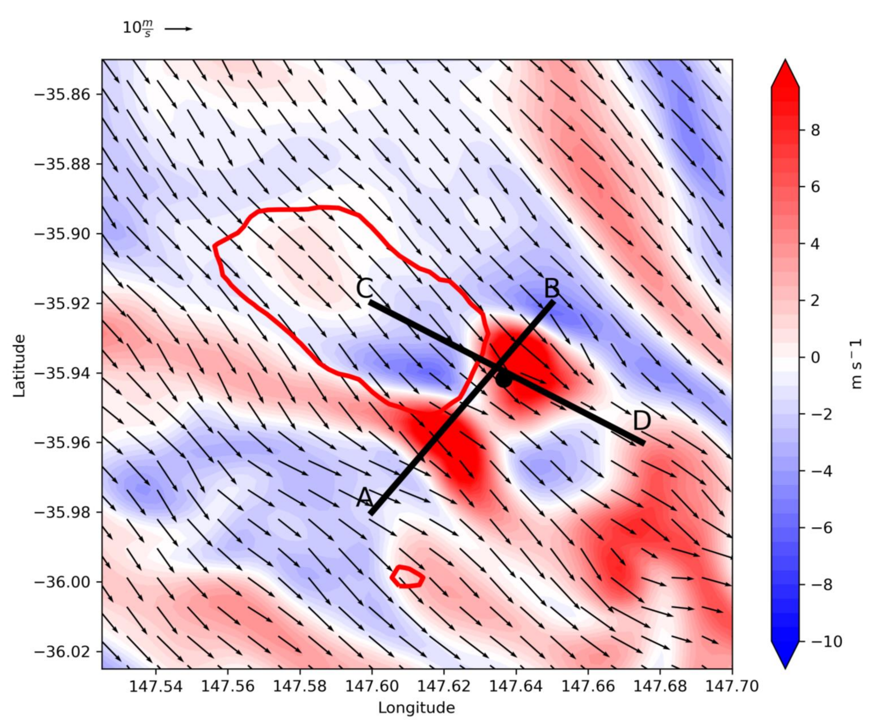
Favourable environments:
- Neutral stability in the lower troposphere
- Vertical wind shear in the lowest kilometre above ground level (AGL)

Modelling set-up

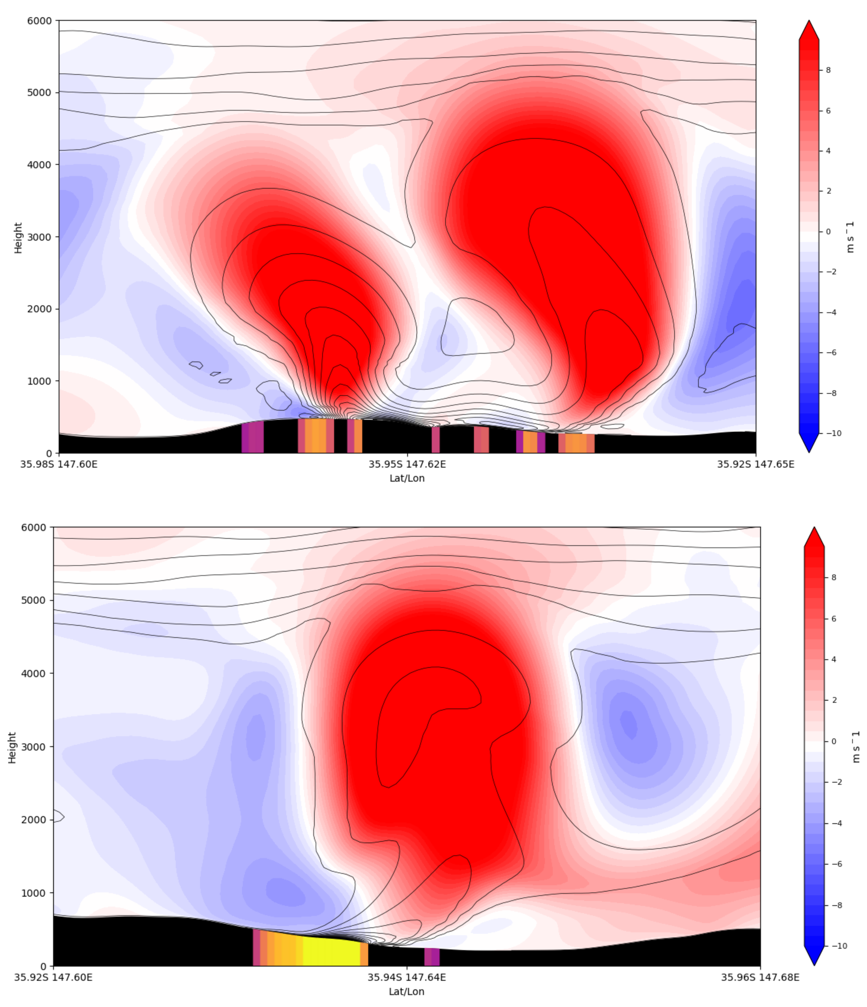
- High-resolution simulations (300 m horizontal resolution) using the coupled-fire atmosphere model ACCESS-Fire. For more details on ACCESS-Fire see Harvey Ye's talk Tuesday afternoon.
- Simulation initialised at 0300 UTC (1400 LT) 30 December 2019; fire start time is 0500 UTC (1600 LT) 30 December 2019.
- Initialised using fire polygons based on available line scan imagery and constant forest fuel amounts of 20 t/ha. It is likely that fuel loads were higher in some of the forested areas and-lower in the grazed grass farmlands in the valley.
- The simulated fire perimeter showed good agreement with observations of the fire front position near Green Valley.

What are the simulations showing regarding FGTV ingredients?

a) Updraft stretching



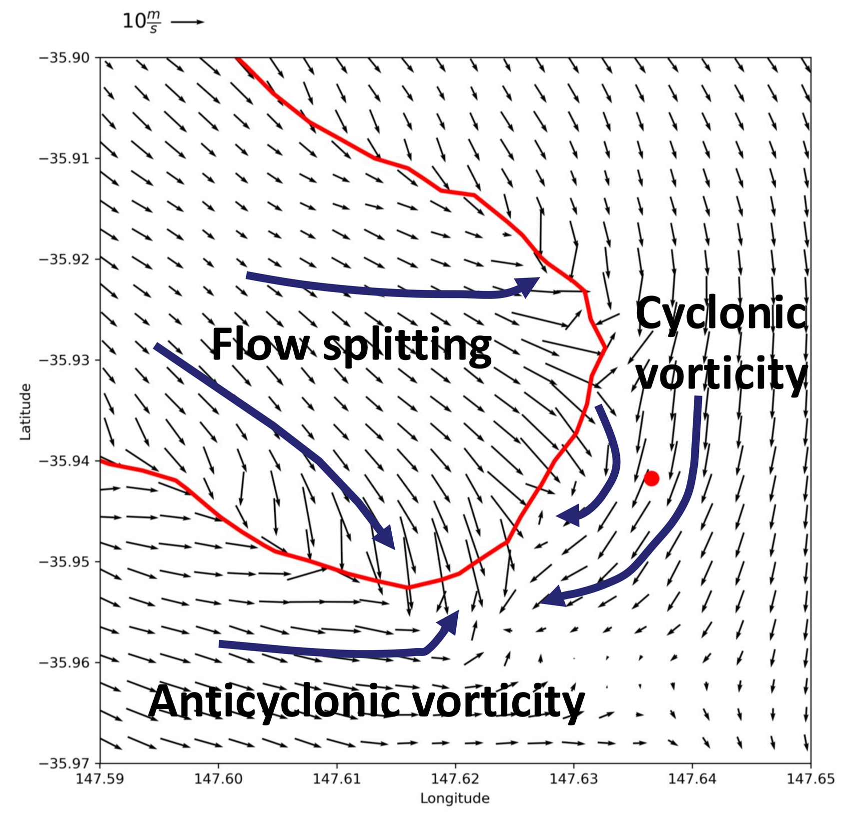
0640 UTC horizontal winds and vertical velocity (shading) at 1.5 km AGL show split updrafts at the head flanks of the fire front (red contour). Black dot shows location of the observed FGTV.



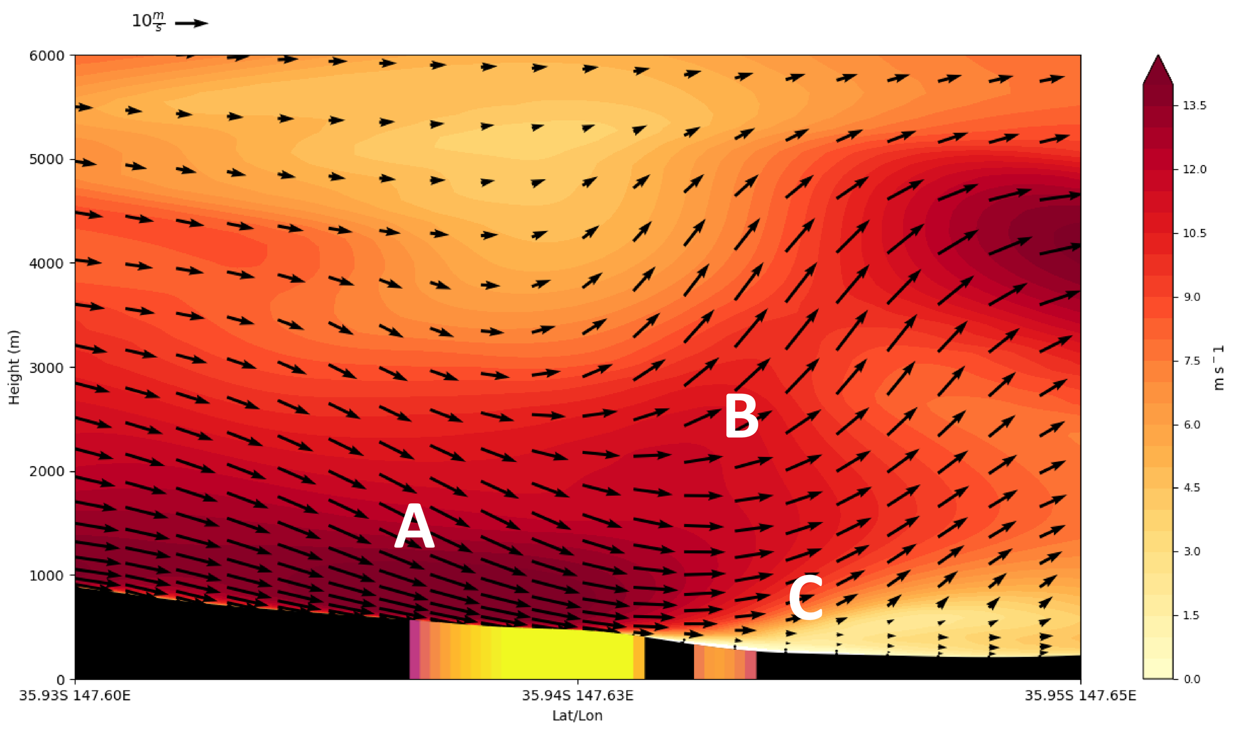
Vertical cross-section of vertical velocity (top) along the fire front (A-B); (bottom) across the fire front (C-D). Red shading shows updrafts, and blue shading shows compensating downdrafts around updraft cores. Shading in the topography shows the area of active fire.

Model output showed two separate pulses in the fire updraft, each lasting around 10 minutes. The second, stronger pulse reached a height of ~6km. It began as a distinct updraft core near the northeastern fire flank then strengthened and moved close to the location where the FGTV was observed (black dot). The bifurcated fire updraft in the model simulation matches the satellite observations and photographic image of the transient rotating pyro-convective column.

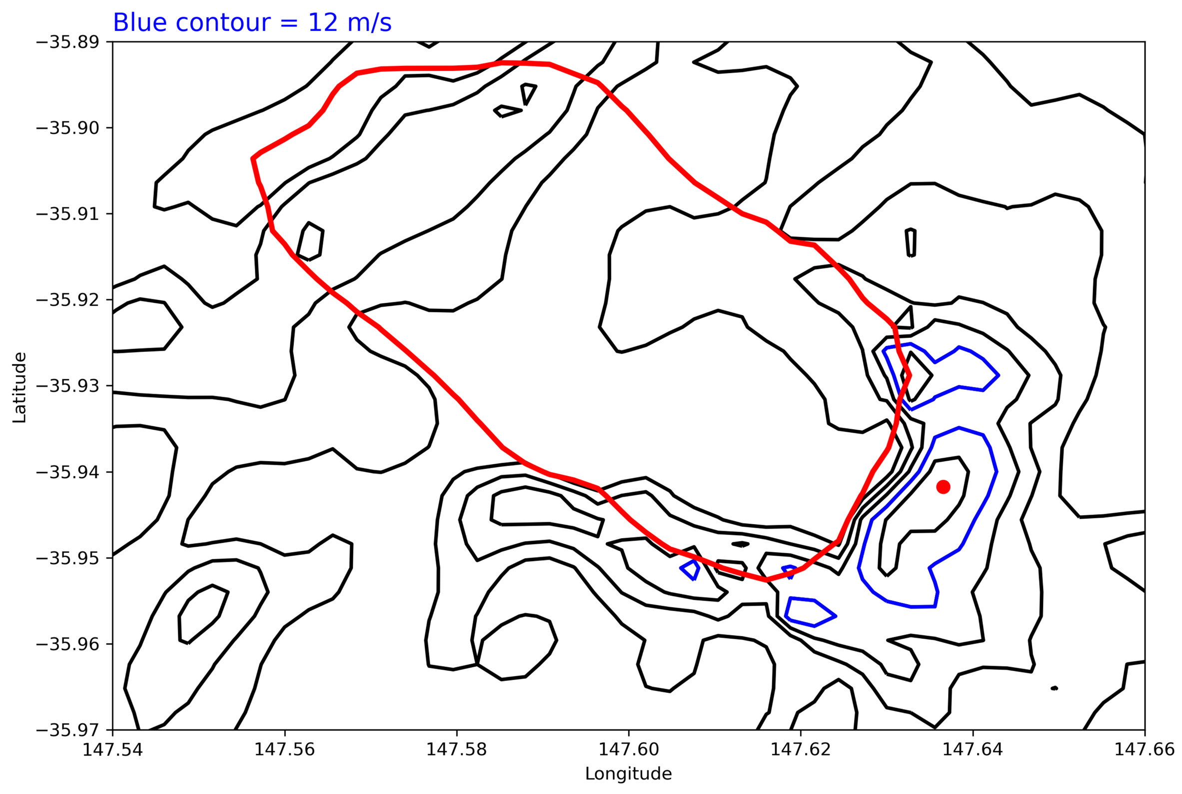
b) Vorticity (spin) component



0640 UTC 10m winds show split flow behind the fire front and cyclonic and anticyclonic vorticity (arrows) along the fire front (red contour). This agrees with recent observational studies of FGTV characteristics.



Vertical cross-section of wind through the centre of the fire front shows (A) descending rear inflow, (B) strong fire updraft and (C) region of strong near-ground wind shear.



Contours of surface to 1 km wind shear, blue contour is 12 m/s. Maximum shear value is ~ 15 m/s close to the location where FGTV was observed (red dot).

FGTV formed near the axis of strong low-level wind shear in the lowest kilometre AGL, a likely source of strong horizontal vorticity to be ingested, tilted into the vertical and stretched by the fire updraft.

How do the simulations improve our knowledge of FGTVs?

- The meteorological features resolved in the simulations are consistent with real-world observations, showing the coupled model can provide insights into local-scale dynamics.
- Using ACCESS-Fire to run high resolution case studies identifies the ingredients to look for during future events. This leads to improved situational awareness and fireground safety.

What are the future opportunities using ACCESS-Fire?

- The mesoscale and micro scale environment changes when an intense fire is present. Understanding local feedbacks is essential for accurate fire predictions.
- High resolution numerical weather prediction simulations can test future operational capabilities and explore events in more detail than possible in real time.
- Learnings from the simulations translate to more accurate fire behaviour predictions, resulting in improved outcomes for firefighter and community safety.