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Evolution of a pyrocumulonimbus event associated with an extreme wildfire in Tasmania, Australia

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S1 Atmospheric profile during the fire

S1.1 Synoptic weather associated with the fire

See text in Section 3.1.2 of the main article for details.

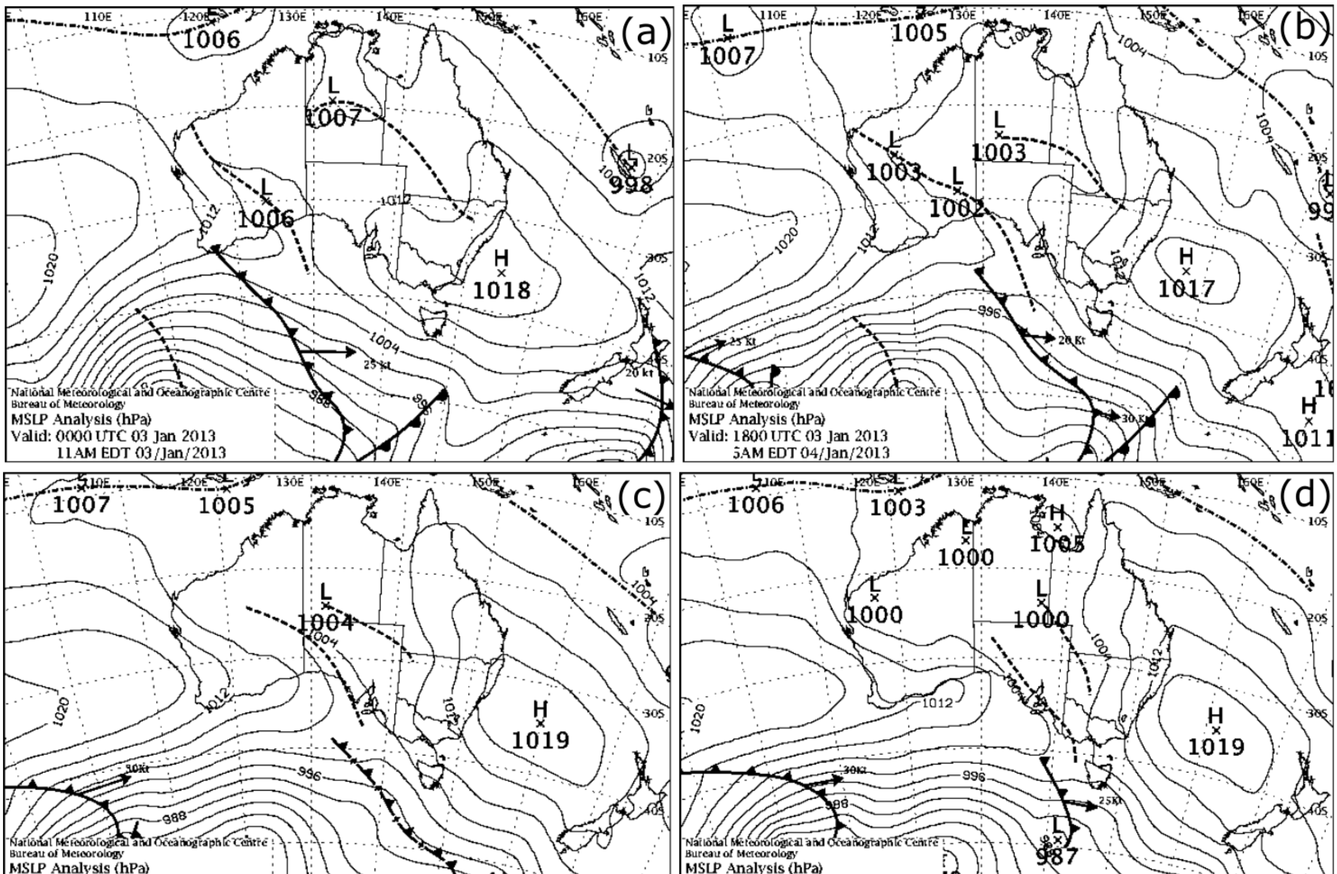


Fig. S1: Mean sea level pressure charts for 3-4 January, adopted from Bureau of Meteorology (2013). (a) represents synoptic conditions at 11:00 LT on 3 January, while b-d represent conditions at 05:00, 11:00 and 17:00 LT on 4 January 2013.

S1.2 BARRA soundings

In the BARRA pseudo-soundings (vertical profiles sampled from the reanalysis data) on 4 January, the atmosphere was unstable, as indicated by a sharp decrease in air temperature with height through the troposphere (Figs. S2a-b). The tropopause (often evident as a strong inversion) was not clearly defined, at least to approximately 200 hPa (11.7 km), thus contributing to the vertical development of the pyroCb. It is worth noting that the mid- to upper-level moisture in the figures is higher, suggesting cloud formation near 400 hPa (7.1 km), consistent with background cloud evident in Fig. 1. The Convective Available Potential Energy (CAPE) as well as the maximum unstable CAPE (MUCAPE) during this period were zero, suggesting a lower potential for thunderstorm development. It is likely that much of the energy that lifted the air parcel and produced the pyroCb came from the fire itself rather than the unmodified atmosphere. By contrast, the sounding at a similar time (15:00 LT) on 9 January (when daily C-Haines was low during the fire period, Fig. S5) shows a temperature inversion occurring at around 850 hPa (1.3 km), with the air immediately above that level being moderately dry and stable (Fig. S2c).

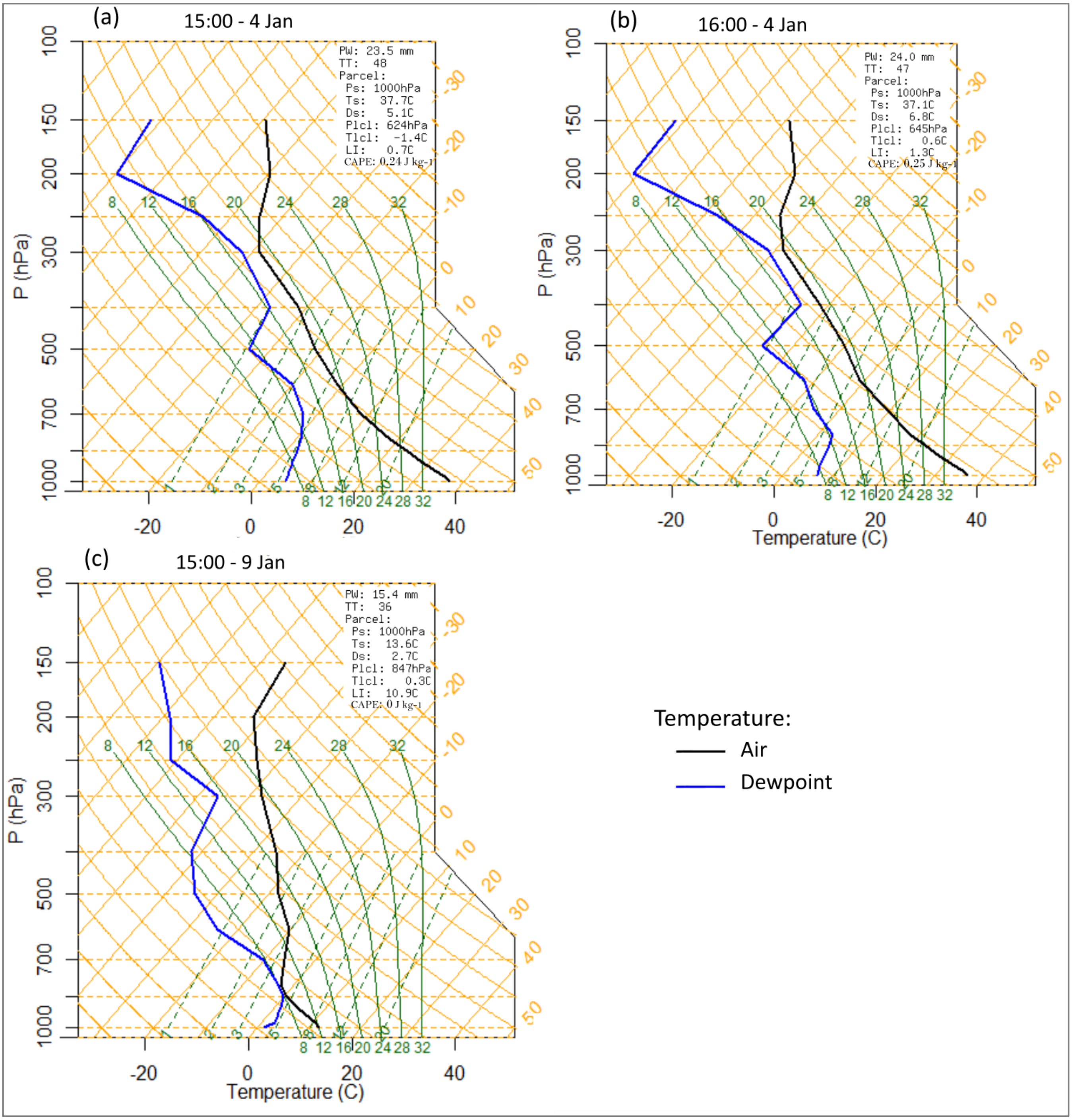


Fig. S2: BARRA soundings for Hobart Airport on 4 and 9 January 2013 representing period of highest and lowest C-Haines respectively during the early days of the fire. P is atmospheric pressure in hPa. (a-b) Sounding at 15:00 and 16:00 LT on 4 January during rapid plume growth and pyroCb development, and (c) sounding at 15:00 on 9 January when smoke plume was not visible on the weather radar.

S1.3 Temperature lapse rate at lower atmosphere

Figure S2 shows a time series of air temperature lapse rate calculated from BARRA gridded air temperature at the 850 and 500 hPa pressure levels (or 1.3-5.5 km height) for January 2013 at Hobart Airport. The 850-500 hPa lapse rate gives an indication of the (in)stability of the lower half of the troposphere. In Fig. S3, LR was highest at the start of the fire, peaking at 8.6ºC km^{-1} at 15:00 LT on 4 January 2013. LR >7.5ºC km^{-1} is considered very unstable (Peterson *et al.*, 2014) while LR of 6-7.5 ºC km^{-1} is conditionally unstable, depending on the saturation level of the air. For saturated air parcels, >6 ºC km^{-1} is unstable while for dry parcels, 6-7.5 ºC km^{-1} is stable. Convection is likely to be severe when the LR is above 7.5 ºC km^{-1}. Under such conditions, there is a likelihood of strong updrafts, thunderstorms and convective downdrafts, subsequently increasing the severity of fire weather, and ultimately fire behaviour when surface conditions are elevated. Values of LR <6 are generally stable. In Fig. S3, beyond 4 January, the lower half of the troposphere fluctuated between stable and conditionally unstable (from 5-31 January), with the afternoon (15:00) and night-time (21:00) having higher lapse rates than in the morning (09:00) for most days, as is typically the case.

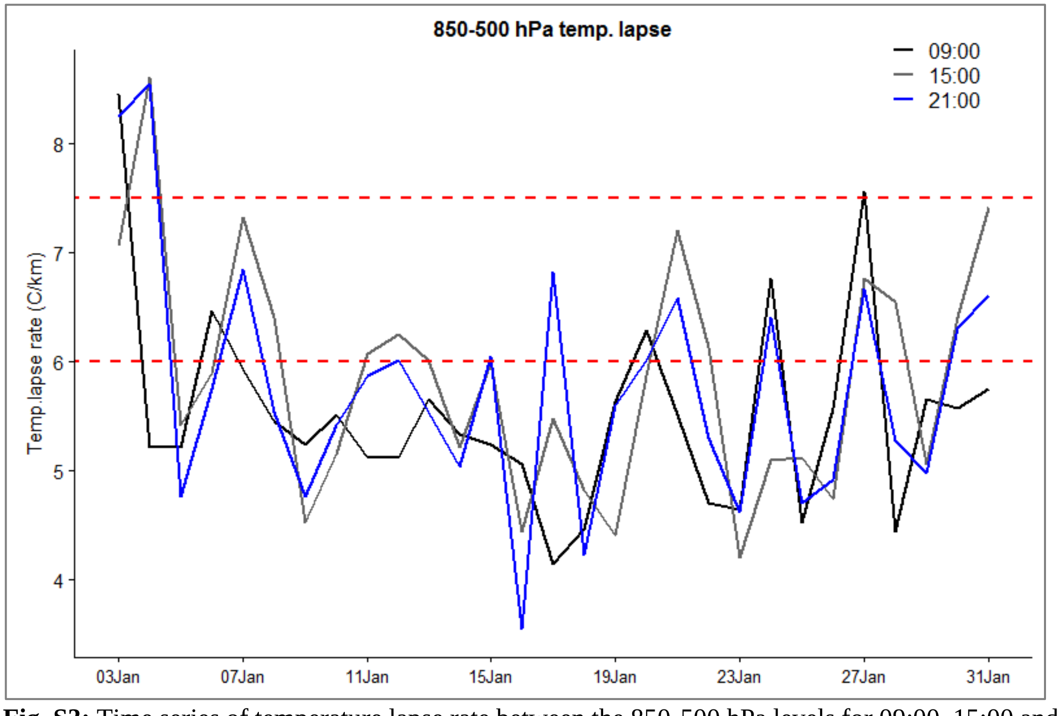


Fig. S3: Time series of temperature lapse rate between the 850-500 hPa levels for 09:00, 15:00 and 21:00 LT in January 2013 at the Hobart Airport.

S2 Temporal smoke/pyroCb dynamics in Vorticity-driven Lateral Spread (VLS) prone areas

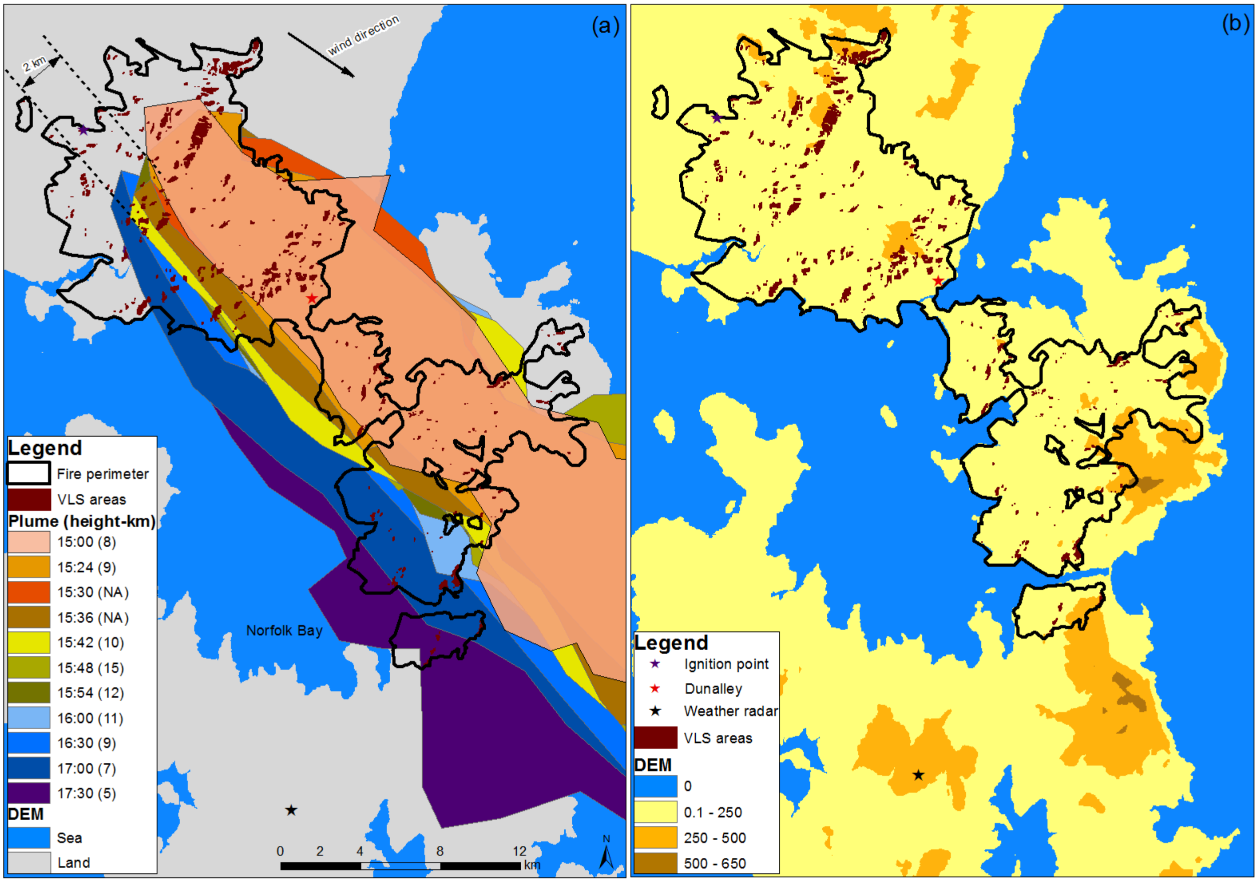
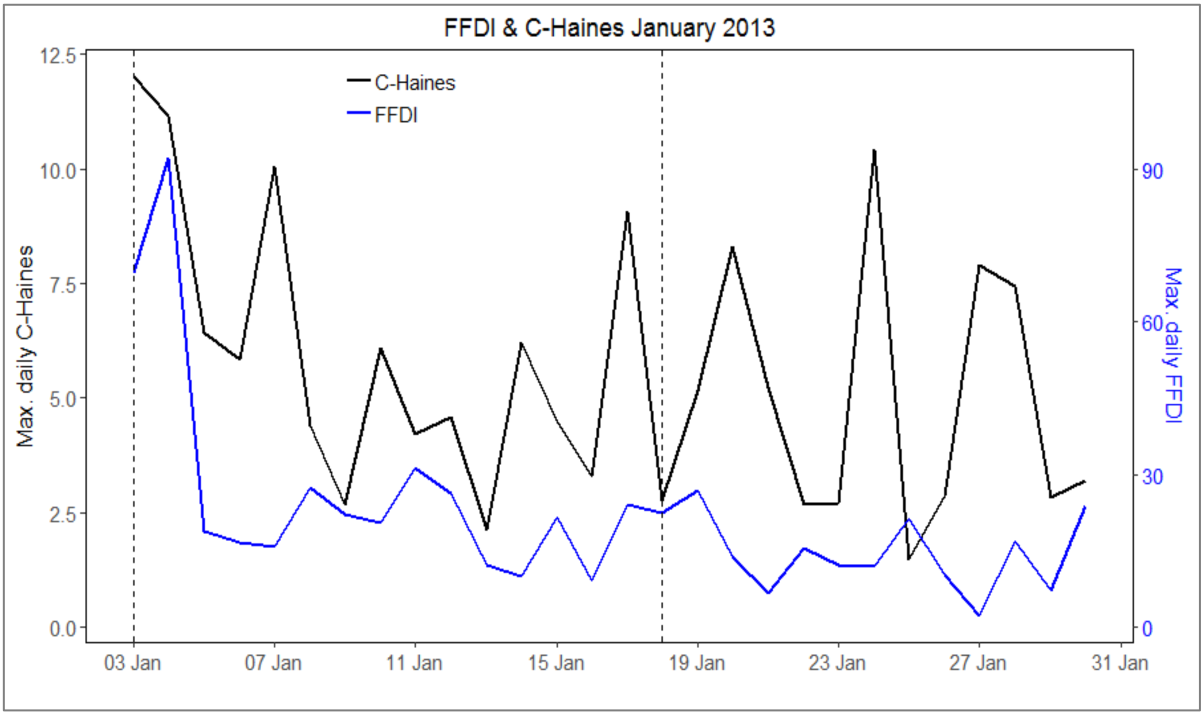


Fig. S4: A map of VLS-prone areas within the Forcett-Dunalley fireground overlaid with smoke plume progression and DEM/contours during the period (15:00-17:30 LT on 4 January) that includes peak fire behaviour. The dashed lines in panel (a) represent a southwest (2 km) expansion of the upwind edge of the plume perpendicular to the prevailing northwest winds.

S3 Time series fire weather (C-Haines & FFDI) during January 2013, including the Forcett-Dunalley fire period



60 **Fig. S5:** Time series of daily maximum FFDI (calculated from 30-min weather data: air temperature, relative humidity, wind speed and soil moisture at Hobart Airport AWS) and daily maximum C-Haines (calculated from gridded BARRA model for Hobart Airport) in January 2013. Black vertical lines represent the start and end dates of the Forcett-Dunalley fire.

S4 Time series of elevated fire weather and area burnt per fire management area (FMA) in Tasmania

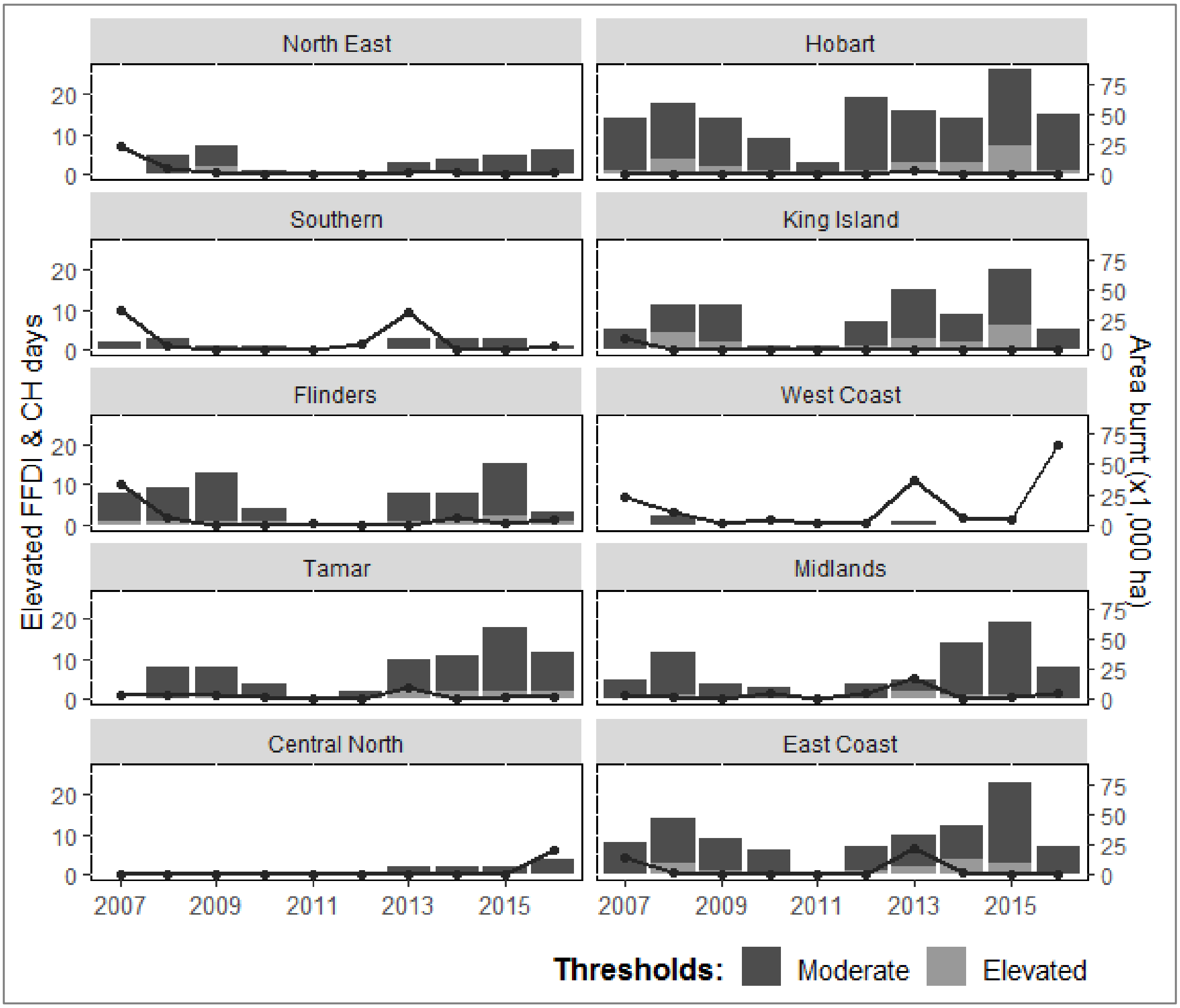


Fig. S6: Interannual variation of elevated fire weather days and area burnt in each fire management region in Tasmania. The bar graph represents number of days annually with elevated regional means of daily FFDI and C-Haines exceeding the following thresholds (FFDI>15 & C-Haines >7; and FFDI>25 & C-Haines >9). The line graph represents annual area burnt by wildfires irrespective of the ignition source.

S5 Likely pyroCb pathway during the period of violent pyroconvection in Forcett-Dunalley fire

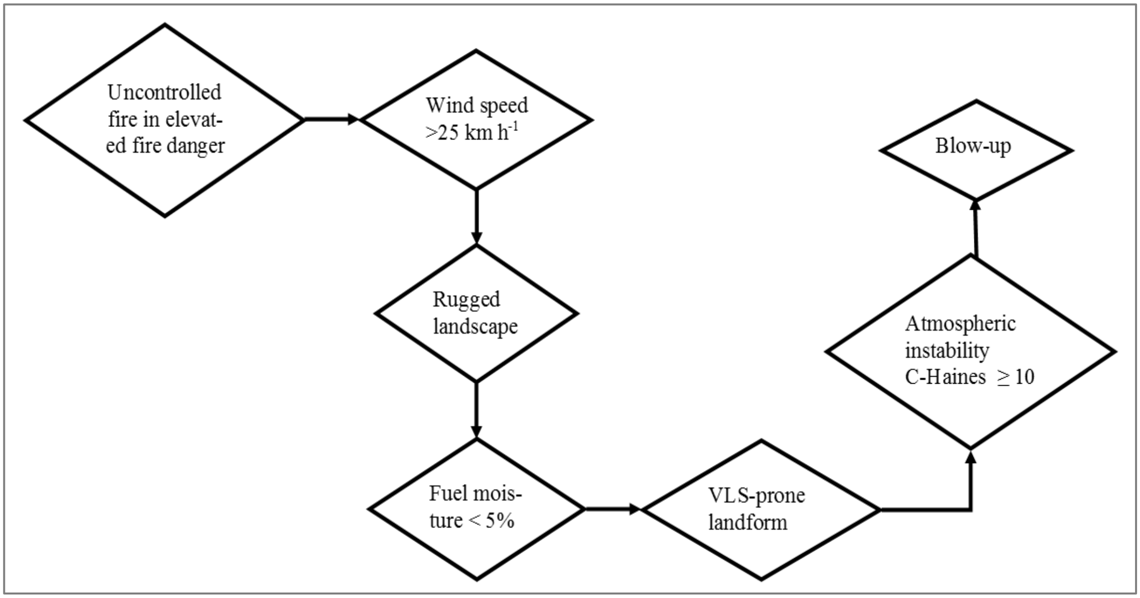


Fig. S7: Blow-Up Fire Outlook (BUFO) model pathway for parts of the Forcett-Dunalley fire during the period of violent pyroconvection on 4 January 2013, adapted from McRae *et al.* (2018).

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