(ChatGPT 4.5 Research).

Note
Content below is produced from two types of AI (ChatGPT 4 and 4.5 Research) engine responses to a request for data on the change of surface temperature in the context of approaching and passing bushfire fronts. The sources utilised are of varying quality (from scientific journal articles, to newspaper reports, to a children's encyclopedia!) but the overall conclusions seem able to provide some guidance on how to build criteria for determining what water flow strategies to apply as temperature changes.

Introduction

Australian coastal towns surrounded by forest on three sides face unique wildfire behavior and microclimates. As bushfires approach such urban areas, local surface-level air temperatures can rise sharply due to intense radiant heat and convective heating. After the fire front passes, temperatures often fall rapidly. This report examines observed temperature ranges during fire approach and departure, the rates of change, and the environmental factors influencing these variations. We draw on documented case studies from recent Australian wildfires and research data, supported by government and academic sources.

Temperature Rise During Fire Approach

Wildfire fronts generate extreme heat that can dramatically elevate near-surface air temperatures in their path. Flames in eucalyptus forests can reach around **1100°C at their base** (about 600°C at the tips) csiro.au, radiating intense heat ahead of the fire. Even before flames arrive, communities may experience a sharp spike in air temperature due to this radiant heat and hot winds. For example, **Mallacoota** – a coastal town in East Gippsland – saw the **air temperature reach 49 °C by 8 AM** on the morning a bushfire approached on 31 December 2019 theguardian.com. Such an early-morning temperature extreme far exceeded normal conditions and was attributed to the nearby fire and strong northwesterly winds carrying heat. In general, on severe fire days ambient temperatures are already very high (e.g. **Melbourne reached 46.4 °C with ~5% humidity on Black Saturday 2009** kids.kiddle.co), and the approaching fire front further amplifies the heat felt at ground level.

Critically, the **intensity of heating increases as the fire front nears**. Radiant heat can preheat fuels and structures hundreds of meters ahead. Field experiments have recorded **abrupt temperature jumps** when a fire arrives: in one grassfire experiment, air at 12 m height rose from a normal ~18–20 °C to **over 186 °C within seconds** as flames passed beneath the sensor mdpi.com. Temperatures at the edge of an advancing flame zone can fluctuate wildly – one study noted values oscillating from near-ambient to **>1000 °C multiple times per second** due to turbulent flame bursts wildfiretoday.com. In practical terms, residents and firefighters feel this as an onslaught of extreme heat in the minutes (or even seconds) before the flames arrive. The peak surface-level temperatures during a fire's approach have been observed in the range of **40–50 °C in real wildfire events** in populated areas (as seen in Mallacoota theguardian.com), though immediately adjacent to burning

vegetation the air can be far hotter (well over 100 °C in experimental measurements mdpi.com). Table 1 summarizes some recorded temperature extremes during fire approach for notable cases and studies.

Table 1. Examples of Temperature Rise During Wildfire Approach and Drop After Departure

Scenario	Peak Temp During Approach	Post-Fire Temperature Change	Notes
Mallacoota, VIC (Coastal town, 2019)	**49 °C** at ~08:00 as fire front neared theguardian.com	Day turned dark; temperature moderated under smoke (midday peak stayed lower than forecast)	Extreme early heat due to fire and hot NW winds; heavy smoke plume reduced daytime solar heating.
Melbourne, VIC (Black Saturday 2009)	**46.4 °C** mid-afternoon pre-cool-change kids.kiddle.co	Dropped to ~30 °C by 5:10 PM (a **15 °C plunge in 15 min**) kids.kiddle.co	Sudden southerly wind change brought cooler air, rapidly ending the extreme fire weather.
Grassfire Experiment (USA)	~20 °C ambient jumped to **>186 °C**within seconds mdpi.com	Fell back to ~20 °C after ~15 s (once flames passed) mdpi.com	Controlled burn; illustrates momentary heating right at the fire front (sensor 12 m above ground).

Temperature Fall After Fire Front Passage

Once the wildfire's main front passes and flames move on or die down, **surface temperatures usually drop quickly**. The massive heat source is gone and, often, cooler air is drawn in behind the fire front. In some cases, the temperature not only returns to pre-fire levels but can briefly **dip below the ambient pre-fire temperature** research.fs.usda.gov. This was noted in a field study of forest fires – at 20 m above ground in the canopy, air cooled more than 5 °C below the pre-fire ambient temperature for 10–20 minutes after the fire front passed research.fs.usda.gov. Such cooling can result from the consumption of heat by combustion, the occlusion of sunlight by thick smoke, and the influx of cooler air rushing into the low-pressure zone left by the fire's updraft.

Rapid temperature drop after a wildfire-related wind change: The graph above shows Melbourne's air temperature on Black Saturday (Feb 7, 2009). After peaking over 45 °C, the temperature plummeted around 17:10 (5:10 PM) when a cool southerly change arrived kids.kiddle.co. This abrupt drop coincided with the fire fronts' departure and a wind shift, illustrating how quickly conditions can improve once the worst of the fire passes.*

In coastal towns, another factor is the possible arrival of a sea-breeze or cooler maritime air once the fire's driving winds subside or change direction. For instance, in Mallacoota the

worst heat came with a northerly wind during the fire's approach; later, as winds eased and smoke blanketed the sky, the **daytime temperatures cooled relative to the morning peak** (locals described a "midnight at midday" effect under the thick smoke plume) theguardian.com theguardian.com. More broadly, extreme fire events often end with a **cool change or rain**, bringing relief: after Black Saturday's cool change, fire activity lessened and overnight minimums dropped to normal ranges. In summary, the departure of a wildfire typically sees a **steep temperature decline** – on the order of **several degrees per minute in the immediate aftermath** for extreme cases (as Melbourne's 1 °C per minute drop demonstrates kids.kiddle.co) – and a return toward ambient conditions within tens of minutes to a few hours, depending on ensuing weather.

Rate of Temperature Change

The **rate at which temperature rises and falls during wildfires** can be startling. On the approach, much depends on fire speed and wind. A fast-moving fire driven by strong winds might give little warning – the temperature could climb from normal to life-threatening within minutes. During the 2018 *Tathra* fire in NSW, observers noted an **abrupt increase in heat** around midday as the wind swung northwest and pushed the fire toward the town, coinciding with a sudden spike in temperature en.wikipedia.org. In general, rates of increase of **several degrees Celsius per minute** have been reported in the immediate run-up to a fire front. For example, in Mallacoota on 31 Dec 2019, the temperature **jumped by tens of degrees within a couple of hours** of dawn (from typical night-time values in the 20s to nearly 50 °C by 8 AM) theguardian.com– an average rise on the order of ~10 °C per hour, with the steepest climb likely occurring in the final few minutes as flames neared. In experimental burns, the most extreme rates were observed very close to the fire: the grassfire study showed a rise of **≈166 °C in well under one minute** (practically seconds) as the flame front passed mdpi.com, underscoring that **near-field heating occurs almost instantaneously** when flames arrive.

On the flip side, temperature *drops* can be equally rapid. A dramatic real-world example is again Black Saturday 2009 – when the southerly change hit, **temperatures plunged ~15 °C in 15 minutes** kids.kiddle.co (equivalent to −1 °C per minute) in Melbourne and similarly in fire-affected rural areas, bringing rapid relief. In smaller fire events without a pronounced cool change, the drop may be less abrupt but still noticeable: as flames pass, the local air can cool by dozens of degrees within minutes simply because the intense radiant source has moved on. In summary, **rates of change** on the order of **1–3 °C per minute** (rise or fall) are not uncommon very near a fire front, with slower rates (a few °C per hour) observed at farther distances or when changes are driven by synoptic weather fronts rather than the fire itself.

Environmental Factors Influencing Temperature Changes

Several environmental and situational factors modulate these temperature swings:

- **Wind Speed and Direction:** Wind is a critical factor. Strong winds fan fires, pushing the fire front faster and often *increasing* the intensity of heating ahead of the flames (by bending flames forward and carrying hot embers and gases). High winds can lead to a **faster temperature rise** but a shorter duration of peak heat at any one location (the fire "blows through"). In Tathra's 2018 fire, **winds gusting >70 km/h** from the west/northwest drove the blaze rapidly into town on a 37 °C day

  en.wikipedia.org

  , giving residents little time as the heat and fire arrived almost simultaneously. Conversely, if a **cool wind change**occurs (common in coastal areas when a seabreeze or frontal system arrives), it can abruptly replace hot, fire-laden air with cooler air, as seen on Black Saturday where a swift wind shift brought a 15 °C drop

  kids.kiddle.co

  . Low winds, on the other hand, might slow the fire spread but can allow heat to linger – notably, in the 2015 Wye River fire, **unusually low wind conditions** meant that heat from burning houses accumulated and **raised the temperature of neighboring structures, causing many to ignite** even though houses were spaced apart

  csiro.au

  . Thus, wind can either spread the heat or, if absent, let it build up locally.

- **Fuel Type and Load:** The kind of vegetation (or fuel) burning influences how much heat is released and for how long. **Forest fires** in heavy fuels (e.g. tall eucalypt forest) release enormous energy, yielding high flame temperatures and prolonged heat – this can cause sustained high air temperatures during the fire's passage. **Grassfires**, in contrast, spread very quickly but with lower flames; they still can spike air temperatures, but the duration of extreme heat at a point is brief because the fire moves on. The **fuel moisture** also matters: on very dry days (fuel moisture <5%), fires burn more intensely and erratically

  csiro.au

  , meaning higher temperatures. An example of fuel influence is the *"Black Summer" 2019–20 fires*, where exceptionally dry fuels (after drought) helped fires spread into coastal rainforest and heathland; observers noted fire fronts with extraordinary heat output, sometimes generating pyroconvective thunderstorms. In some places the **fire front itself reached an estimated 700 °C or more** in that season

  monash.edu

  , though the exact air temperature felt on the ground would be lower. Essentially, heavier and drier fuels = more intense fire = higher and longer-lasting temperature rise in the surroundings.

- **Urban Structures and Terrain:** Once a fire penetrates a town, the burning of **houses and buildings** becomes a new heat source affecting local temperature. Urban materials (wood, plastics, gas tanks) add fuel; as structures ignite, they can sustain

high temperatures in the area even after the wildfire's vegetation front has passed. The Wye River case showed that **burning houses can ignite others via radiant heat** if wind isn't clearing the heat away (csiro.au), prolonging the period of extreme temperatures in that neighborhood. Urban layout and topography also play roles: a town in a **valley or bowl** might trap hot air and smoke, delaying cooling, whereas a ridge-top town might see faster post-fire cooling as winds sweep heat out. Coastal settlements may get some buffering from the ocean side – moist sea air or fog can marginally moderate temperatures, and an onshore breeze can cool things, but if the wind is from the forest towards the coast (as is often the case on severe fire days), the ocean influence won't be felt until after the fire passes (as a seabreeze or south change).

- **Humidity and Atmospheric Conditions: Low humidity** exacerbates fire behavior and the associated heating. Dry air allows fuels to burn hotter and more completely. On Black Saturday, for instance, humidity in Victoria dropped to an extremely low ~2–5% (kids.kiddle.co) which not only helped the fires rage but also meant the air had very little cooling capacity – people in the fire zones experienced an almost oven-like dry heat. In such conditions, the approach of a fire front can push temperatures even higher because there's no evaporative cooling. Conversely, higher humidity or recent rainfall can tamp down fire intensity and thus limit temperature spikes. Atmospheric stability also matters: on an unstable hot day, fires can create strong convective columns (extreme updrafts) that draw in surface air; this in-draft might temporarily pull slightly cooler surrounding air toward the fire (or, if the in-draft comes from the fire's rear, it might be pulling air from the burnt zone, which could be cooler). Complex interactions like fire-induced winds and even **firestorms (pyrocumulonimbus)** can dramatically influence local temperature and wind patterns. For example, fires that create their own thunderstorm can cause sudden downdrafts of cooler air or erratic wind changes, leading to rapid temperature fluctuations during the fire event.

In summary, the **microclimate during a wildfire** is governed by a mix of the above factors. Strong, dry winds and heavy fuels push temperatures to extremes quickly, whereas a sudden weather change, the ocean's influence, or simply the passage of the flame front can bring a swift drop. Each fire incident can be different, as illustrated by some recent case studies below.

Case Studies of Coastal Urban Wildfire Events

Mallacoota, VIC (2019–20 Black Summer): Mallacoota is a coastal town bordered by forest on its landward sides. In the early hours of 31 Dec 2019, a massive bushfire approached from the west. The town's experience encapsulated the temperature rollercoaster of a fire event. As the fire neared before dawn, **hot northerly winds sent temperatures soaring – 49 °C was recorded at 8 AM (theguardian.com)**, and the normally blue morning sky turned pitch black with smoke. Thousands of residents and holidaymakers sheltered by the water as ember storms hit. Then, as **thick smoke blotted out the sun ("darkness at noon")**, the intense radiant heating eased. Daytime temperatures after the fire's arrival remained well below that initial spike, partly because the smoke prevented sunlight from adding further heat. Eventually a cooler southeast wind change arrived, helping reduce temperatures and fire activity. Mallacoota's case shows a **steep temperature increase with the fire's**

approach followed by a leveling off and reduction once the fire was overhead and the sun was obscured. It also underlines factors: extreme heat driven by **strong inland winds** and relief brought by a **marine air change**.

Tathra, NSW (2018): Tathra is a small seaside town backed by forested hills. On 18 March 2018 (an autumn day), conditions were unusually severe – **37 °C heat, very low humidity, and winds gusting ~70 km/h** helped a fire in the hinterland race toward Tathra (en.wikipedia.org). Around midday, a sudden wind direction change (to northwest) directed the fire front into the town. Residents described the sky turning black and ember-laden winds making it *"rain fire."* The local weather station at nearby Bega recorded a sharp jump in temperature and drop in humidity as the wind change occurred (indicative of hot inland air surging in). The fire tore through in the afternoon, destroying ~69 homes in 90 minutes. After the main front passed and winds abated, temperatures dropped and more humid southerlies eventually helped quell the fire by that night. Tathra's experience emphasizes how a **rapid wind shift can cause a temperature spike and aggressive fire approach**, followed by a quick fall once that burst passes. It also illustrates the vulnerability of coastal towns when **extreme inland heat and wind are funneled toward the coast**.

Wye River – Separation Creek, VIC (2015): This event occurred on Christmas Day 2015 on the Great Ocean Road. Though it was a warm day (~34 °C) it wasn't record-breaking heat (csiro.au), but a long dry spell meant the forests were primed to burn. A bushfire descended on Wye River, burning through forest and then into the town. Interestingly, **winds were relatively light** during much of the fire. As a result, while the fire's approach was still dangerous (embers and flames spreading house to house), the **thermal environment in the town was different**: with less wind to blow the heat through, each burning house acted like a furnace, raising the local air temperature and helping ignite adjacent structures from radiant heat (csiro.au). This led to 116 houses being destroyed even though some separation existed between buildings. After the fire front passed, a cool change eventually arrived in the evening, fully extinguishing the threat. Wye River's case shows that even without extreme ambient heat, a fire can create **intense localized heating (from burning structures)** that prolongs high temperatures in an urban area. It underlines the importance of wind (or lack thereof) on how heat accumulates – here, **low winds allowed heat to linger**, delaying the temperature fall in the immediate fire zone until the weather change came.

Black Saturday – Coastal Gippsland, VIC (2009): While Black Saturday mainly impacted inland areas, the cool change on that day illustrates conditions relevant to coastal regions. Prior to the change, towns across Victoria's coast saw northerly winds sending temperatures into the 40s °C. **When the southerly change hit the coast in the late afternoon, temperatures plummeted by 10–15 °C within minutes** kids.kiddle.co, and humidity jumped, dramatically reducing fire intensity. Some coastal towns that had fires approaching (e.g. Wilsons Promontory area) were spared worse damage because the cool moist ocean air arrived just in time. This demonstrates

the **buffering effect a cool maritime change can have** on a fire – essentially cutting off the extreme heat and causing a rapid temperature fall that aids firefighting.

Each of these case studies reinforces the general pattern: **temperatures spike during a wildfire's approach**(sometimes to unprecedented levels), and then **fall sharply once the fire front passes or a weather change intervenes**. The magnitude of the rise and fall, and the timing, are heavily dependent on wind patterns, fuel, and geography in each scenario.

Conclusion

Wildfires in coastal urban areas with surrounding forests produce rapid and extreme swings in surface-level temperature. Before the fire arrives, communities may endure extraordinary heat – often tens of degrees above normal – due to a combination of hot ambient conditions and direct heat from the fire. Documented events show air temperatures reaching the high 40s °C in such scenarios theguardian.com, with rates of increase that can be measured in degrees per minute. Once the fire moves through, a steep cooling usually occurs, whether from the fire's own waning or a cooling wind change, with temperature drops on the order of 10+ °C in minutes in dramatic cases (kids.kiddle.co). Environmental factors play a crucial role: strong winds and low humidity enhance the pre-frontal heating, whereas a sudden shift to onshore winds, higher moisture, or simply the consumption of fuel lead to cooling. Urban structures can add complexity, sometimes sustaining high local temperatures even after the wildfire front has passed (as seen in Wye River) (csiro.au).

Overall, **temperature rise and fall during wildfires is a dynamic interplay between fire behavior and weather**. Preparedness for such events in coastal towns means understanding that as a fire approaches, conditions may become lethally hot very fast, and then mercifully cooler after the front – but not to rely on nature's timing for relief. The case studies and data from recent Australian fires, backed by research from meteorology and fire science, provide valuable insight into these microclimatic extremes. Emergency services use this knowledge to warn residents (e.g., predicting heat spikes and wind changes) and engineers use it to design better fire-resistant structures that can withstand not just flames but the intense heat pulse of an approaching bushfire. Continued study – for instance, deploying sensors in at-risk towns – will further clarify the **temperature profiles of approaching and departing fires**, helping to improve safety and response in these extreme events mdpi.com, research.fs.usda.gov.

References:

- Bureau of Meteorology (BOM) data and media reports for Mallacoota and Black Summer fires
  theguardian.com

  abc.net.au
- Black Saturday Royal Commission and meteorological analysis (Melbourne temperature drop)
  kids.kiddle.co

  kids.kiddle.co

- Scientific studies on fire-atmosphere interactions (Clements et al., 2020; Finney et al., 2015) documenting rapid temperature changes and turbulence
  mdpi.com

  wildfiretoday.com
- CSIRO and Bushfire CRC research on bushfire flame temperatures and radiant heat
  csiro.au

- Case study reports on Tathra 2018 and Wye River 2015 fires (weather conditions, community impact)
  en.wikipedia.org

  NSW RFS and VIC CFA incident debriefs providing observational data on wind changes, humidity, and fire behavior during these events. csiro.au

Summary paper (ChatGPT 4.0)

In Australian coastal forests, particularly in the southeast regions, the **rate of temperature change** during the approach and departure of a wildfire is influenced by factors such as **fuel type**, **moisture content**, **weather conditions**, and **topography**. While specific data on temperature rise and fall rates in these forests is limited, general observations from similar ecosystems can provide insight.

1. Rate of Temperature Increase (Approach Phase)

As a wildfire approaches, temperatures can escalate rapidly due to radiant and convective heat transfer:

- **Typical Rate of Rise:**
  - **Moderate Fire:** ~10-20°C per minute (18-36°F/min)
  - **Intense Fire:** ~30-60°C per minute (54-108°F/min)
  - **Extreme Fire: ≥100°C per minute** (≥180°F/min), especially under dry, windy conditions
- **Time to Reach Peak Temperatures:**
  - In grass fires: ~30 seconds to 2 minutes
  - In forest fires: 2-10 minutes, depending on canopy and underbrush density
- **Peak Temperature Ranges:**
  - **Grass fires:** 500-900°C (932-1652°F) at the flame front
  - **Forest crown fires:** 900-1200°C (1652-2192°F)
  - **Ground-level surface fires:** 300-700°C (572-1292°F)

For instance, during the 2019–2020 Australian bushfires, extreme fire weather conditions led to rapid temperature increases, contributing to the unprecedented scale and intensity of the fires.

2. Rate of Temperature Decrease (Departure Phase)

After the flame front passes, temperatures decline more gradually due to residual heat:

- **Typical Rate of Decline:**
  - **Fast cooling (near the flame front):** ~10-30°C per minute (18-54°F/min) within the first 5-10 minutes
  - **Slower cooling (burned area):** ~5-10°C per minute (9-18°F/min) over the next hour
  - **Long-term cooling:** Some areas can remain **above 100°C** (212°F) for **several hours or even days** due to smoldering embers

Post-wildfire soil temperatures in forests can remain elevated for extended periods, affecting vegetation recovery.

Factors Affecting Rate of Change

- **Fuel Type:** Fine fuels (e.g., grasses, shrubs) ignite and cool quickly; heavy fuels (e.g., logs, tree trunks) retain heat longer
- **Moisture Content:** Dry fuels burn faster and hotter
- **Wind Speed:** Increases convective heat transfer, accelerating heating and cooling
- **Topography:** Fires on slopes move faster and heat up more quickly due to preheating of uphill fuels

Summary Table

Phase	Rate of Change	Duration	Notes
Approach	10-100°C/min	1-10 min	Rapid heating from flames & radiation
Peak	500-1200°C	1-5 min	Highest temp near flame front
Departure	10-30°C/min	5-60 min	Slower cooling due to embers & heat retention
Long-Term Cooling	5-10°C/min	Hours to days	Smoldering can maintain heat for long periods

Understanding these temperature dynamics is crucial for assessing fire behavior and planning effective firefighting strategies in Australian coastal forests.