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Research Article

Social media messaging by climate action NGOs: a case study of the 2019–2020 Australian Black Summer bushfires

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Abstract

Researchers are increasingly examining discourses associated with climate change and extreme weather events across different communication channels. However, further research is needed to examine how environmental non-governmental organizations (NGOs) frame extreme weather events and their relationship to climate change on social media platforms. This is an important topic as these groups play a significant role communicating science and driving environmental action. Here, we examine how Australian climate action NGOs framed the relationship of the 2019–2020 Black Summer bushfires to climate change on Twitter/X. Analyzing 2,077 bushfire-related tweets from a sample of 102 climate group accounts through manual content analysis, we found that these groups frequently linked bushfires with climate change, representing 59% of their bushfire-related tweets during the period of the fires. Forty-two percent of tweets mentioned climate change without describing how it relates to bushfires; 16% described specifically how climate change influences the frequency and intensity of bushfires; and only 1% suggested inaccurately that climate change causes bushfires to occur. Fifteen percent of tweets discussed risk factors beyond climate change that influence bushfire impacts, such as firefighting, emergency responses, hazard reduction, and community vulnerabilities. Only seven accounts mentioned an extreme event attribution study of the Black Summer fires. Based on these findings, we discuss opportunities and challenges of climate science communication in the extreme weather context, and describe promising directions for future research.

Lay Summary

Non-governmental organizations (NGOs) play a significant role communicating climate change and mobilizing climate action. This study explores how Australian climate action NGOs communicated about climate change on Twitter during the 2019–2020 Australian Black Summer bushfires. This is an important topic for research as there are nuances around how climate change relates to extreme weather events. Climate change makes bushfires more frequent and intense, but it does not directly cause bushfires to occur. Additionally, risks from bushfires do not only result from climate change—firefighting, landscape dynamics, emergency communications, evacuation procedures, and other types of responses shape the impacts of these events. The NGOs we examined overall did not inaccurately claim that climate change causes bushfires (only 1% of total tweets). However, only 15% of the tweets mentioned non-climate change factors (such as firefighting) that shape bushfire risks. Fourty-two percent of tweets mentioned climate change but did not explain how it relates to bushfires. Based on these findings, we discuss opportunities, challenges, and ongoing questions around climate science communication in the extreme weather context.

Keywords: extreme weather; bushfire; Black Summer; Twitter; NGOs; climate change; communication

Background

Climate change is altering the frequency, duration, and intensity of many kinds of extreme weather events around the world [1]. Higher concentrations of greenhouse gases in the atmosphere lead to more frequent and more intense heatwaves, heavy rainfall events, and fire weather conditions, among impacts on other types of weather. Extreme event attribution (EEA) techniques allow climate scientists to go beyond describing how climate change affects types of extreme weather to assess how climate change affects the frequency and/or intensity of specific extreme weather events [2]. For example, researchers found that climate change increased the likelihood of a heatwave like the November/December 2022 event in South America by about 60 times [3]. At the same time, not every extreme weather event is necessarily affected by climate change. For example, researchers found that the potential influence of climate change on the 2021 drought in Madagascar was negligible compared to natural variability—poverty and strong reliance on rainfall were the key

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factors that caused food insecurity associated with the drought [4].

As scientists continue to assess how climate change alters extreme weather, environmental communication scholars are increasingly examining discourses associated with these events across different communication channels. A growing body of literature has assessed to what extent and how weather events are linked to climate change in news media. In general, journalists are increasingly connecting extreme weather events to climate change and offering more coverage to climate change in general [5, 6]. For instance, Hopke (2020) found a growing number of climate change mentions in articles about heatwaves and wildfires from 2013–2018 across several countries [7]. Media coverage of the 2022 summer heatwave in the United Kingdom included significant discussion of climate change, which was often situated in the context of politics and climate policies [8].

There have also been analyses of climate change and extreme weather discourses on social media platforms. Examining social media is an important area for climate change communication research as these platforms (such as Facebook, Reddit, TikTok, and Twitter/X) are key spaces for climate change contestation, discussion, mobilization, and science communication [9, 10]. Social media discourse can differ significantly from news media coverage of the same topics [11]. Social media platforms are also a major news source, especially for young people [12]. Researchers have shown that the occurrence of extreme weather events is associated with an increase in social media posts that mention climate change [13, 14], with different kinds of weather events generating varying amounts of attention to climate change [15–17]. For instance, Olynk Widmar *et al.* (2022) found that posts about hurricanes mentioned climate change less often than wildfires [18]. Other analyses have examined the roles of social media for emergency communication, disaster response, and relief coordination during extreme events [19–23].

Framing climate change and extreme weather relationships

Amid increasing attention to the relationship between climate change and extreme weather events, some researchers have cautioned that a sole focus on climate change could displace attention from the roles of vulnerability, adaptation, exposure, and disaster risk reduction strategies in shaping risks from hazards [24–26]. As described in the IPCC Special Report on Global Warming of 1.5C, 'Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence' [27, p. 557]. Put simply, while climate change can affect meteorological aspects of extreme weather events, how well communities and governments prepare for these events ultimately determines if hazards become disasters [28].

Likewise, the phrase 'natural disaster' is problematic as it implies that the impacts of extreme weather events are purely due to meteorological aspects [29]. Policymakers can exploit this idea to divert attention from local planning decisions and failures [26]. Understanding and communicating the connections of climate change to extreme weather events remains crucially important; however, focusing entirely on climate change could sideline 'local ways of reducing vulnerability to extreme weather and … end up absolving policymakers of their own failures to climate-proof their citizens' [30, p. 1]. A key point is the interconnectedness of risk dimensions [31]. Climate change, in combination with changing levels of exposure and vulnerability, has increased costs associated with many weather-related disasters around the world for several decades [32]. Perceptions of these risk factors can also differ among citizens in the Global North and Global South [33].

The concept of framing offers a helpful theoretical lens to explore different ways that communications about extreme weather events can focus on climate change, vulnerability, exposure, disaster risk reduction strategies, or other risk aspects. Framing refers to the act of emphasizing certain salient characteristics while neglecting others when describing any phenomena [34, 35]. Experimental studies have shown that contrasting climate change frames can generate different audience responses, including a range of climate attitudes, emotions, and behavioral intentions [36–38]. How communicators frame the risks of extreme weather events, their underlying causality, and their impacts makes certain types of solutions more applicable (i.e. climate mitigation versus disaster risk reduction strategies) and assigns blame to different actors.

The framing of extreme weather events is particularly relevant because when they occur, they are often described as focusing events or teachable moments to reduce risks from such events in the future [39]. The motivation to conduct this study was partly informed by our prior research in which we presented non-climate scientists in the UK with results of an EEA study showing how climate change affected the 2019 United Kingdom summer heatwave [40]. We found that EEA was overall an attention grabbing and helpful climate change communication tool. However, when asked about actions to reduce future heatwave risks, participants only discussed climate mitigation, rather than a range of other adaptative strategies to reduce risks. Framing the event only in terms of climate change primed participants to only discuss climate change mitigation as the way to reduce risks. This is one example of how the ways in which communicators frame extreme weather events may influence subsequent learning—in other words, what an event 'teaches' and to whom.

Environmental NGOs as climate change communicators

In analyzing discourse around extreme weather events and associated disasters, it is important to distinguish between different kinds of actors and communication channels. Compared to news media analyses, there has been less examination of how environmental non-governmental organizations (NGOs) engage with and communicate about extreme weather events. This topic merits further research as NGOs play a significant role in driving environmental action [41]. They also act as 'alternative science communicators', increasing societal awareness of scientific research and utilizing this information to advocate for their causes [42–45]. In doing so, they broaden discourse around scientific evidence to connect knowledge with political action [46]. As described by Eden (2010, p. 224), NGOs 'widen the circulation of information and ideas about policy, ethics and practical application in order to mobilize other actors and publics, raise awareness and encourage purposeful scientific input to key debates' [47].

Researchers have previously examined how NGOs use social media platforms such as Facebook and Twitter as part of their campaign strategies [48–50]. Bazago *et al.* (2020) examined tweets from environmental NGOs during hurricanes Harvey, Irma and Maria that occurred in 2017 in the United States [51]. They found that climate change was frequently mentioned, often in association with critiques of political figures. Vu *et al.* (2020) examined how environmental NGOs frame climate change in their communications on Facebook, finding that posts focused more on

climate change problems than climate solutions [52]. To our knowledge, there have not been studies specifically examining how these groups frame the relationship between extreme weather events and climate change on social media platforms. In contrast to a growing number of studies examining EEA coverage in news media [53, 54], there is also yet to be research examining the prevalence of EEA studies being shared by these (and other) actors on social media.

Case study: the 2019–2020 Australian Black Summer bushfires

This study advances our understanding of extreme weather and climate change NGO discourses through an analysis of how Australian climate groups communicated on Twitter/X during the 2019–2020 Australian Black Summer bushfires. Although fires are an inherent feature of the Australian landscape, the 2019–2020 bushfire season involved a series of unusually intense bushfires that severely affected all Australian states and territories, especially eastern Australia [55]. Over 30 people were killed as a direct result of the fires and an estimated 429 more people died due to smoke exposure, along with thousands of buildings destroyed and over 30 million hectares of land burnt [56–58]. The fires led to billions of dollars of damage and affected billions of animals [59–61]. They also disproportionately affected socio-economically disadvantaged communities [62]. The most significant fires occurred from the beginning of September 2019 to the end of January 2020, which is part of a trend of longer bushfire seasons [63].

The fires received substantial global news coverage, especially at key moments during the season such as when smoke blanketed Sydney [64], when Victoria declared catastrophic levels of fire weather [65], and when citizens of Mallacoota, Victoria, evacuated to beaches on New Year's Eve, generating dramatic photos and videos [66]. Burgess *et al.* (2020) analyzed Australian news coverage of the Black Summer and found that about 50% of articles mentioned climate change, compared to only 5% of articles about the 2009 Black Saturday fires; 29% of articles included in-depth discussion of climate change; and 10% of articles described failures to adequately plan for the fires [67]. Different Australian news outlets pushed contesting narratives about the connection (or not) of climate change to the fires [67, 68].

The fires also received significant attention on social media. Weber *et al.* (2020) examined the spread of misinformation on Twitter that arson caused the Black Summer fires, revealing polarization of different online communities that sought to either propagate or debunk these claims [69]. Ogie *et al.* (2022) examined disaster recovery on Twitter during and after the Black Summer fires, finding that different types of Twitter users (e.g. citizens, governments, NGOs) discussed various aspects of bushfire recovery at different periods, such as rebuilding infrastructure, supporting mental health, and filing insurance claims [70]. Users also discussed the impacts of the fires on biodiversity [71].

Although climate change does not directly cause fires, it is making fire weather—the conditions in which fires begin and spread—more frequent and more intense in many regions across the world [63, 72]. Climate change amplified the Black Summer fires: they happened after three consecutive years of drought and dry winters [73], and occurred during Australia's hottest and driest year on record [55]. An EEA analysis found that climate change made the fire weather conditions like those that occurred during the Black Summer at least 30% more likely (initially published on the World Weather Attribution on 10 January 2020 and later as a peer-reviewed study [74]).

Beyond climate change, the Black Summer exposed a variety of ways in which Australia could have more effectively averted the harmful impacts of the fires. As Chester (2020, p. 245) describes, 'the scale and catastrophic impact of these bushfires were caused—and exacerbated—by a conjunction of cumulative events, (in)actions, and institutions' [24]. This includes under-resourced firefighters, most of whom are volunteers [75]; a lack of preparation of the Australian healthcare system [76]; long-term land-management decisions, such as insufficient hazard reduction through planned and cultural burns (practiced by Indigenous Australian Peoples), although scientists debate the impact of fuel loads on the fires [77–79]; insufficient early warning and emergency communication systems; ecological dynamics such as the dominance of highly flammable eucalyptus trees [80]; and, as some have argued, a failure to implement lessons from prior governmental bushfire inquiries [81], among other factors. The Australian government's 2020 Royal Commission into National Natural Disaster Arrangements offers an array of recommendations based on a review of the Black Summer fires, including improving government emergency mobilization, enhancing air quality monitoring, increasing climate change adaptation and mitigation, providing additional firefighting resources and support, and improving emergency communication systems [59].

Research questions

The Black Summer demonstrates how a combination of climate change, along with planning decisions at federal, state, and local levels, can shape the impacts of bushfires. These dynamics, as well as the significant amount of attention the fires generated, make the Black Summer a highly topical case study to analyze how climate action NGOs framed the event in their social media communications. Three research questions structure our analysis.

First, we examined how these groups framed the bushfire-climate change relationship on Twitter during the Black Summer bushfires:

> *RQ1. How did Australian climate action NGOs frame the relationship between bushfires and climate change in their tweets during the Black Summer bushfires?*

Building on research tracking news media coverage of EEA studies, for our second research question, we measured how frequently the groups shared results of the van Oldenborgh *et al.* (2021) Black Summer extreme event attribution study (described earlier [74]):

> *RQ2. To what extent did Australian climate groups share on Twitter the results of the van Oldenborgh et al. (2021) extreme event attribution study of the Black Summer bushfires?*

Third, we examined how these groups framed the Black Summer in terms of climate change versus other risk dynamics that affect bushfire impacts:

> *RQ3. To what extent did Australian climate groups mention non-climate change factors, such as disaster risk reduction, emergency responses, firefighting, and vulnerability, in shaping bushfire risks in their tweets during the Black Summer bushfires?*

Method

To answer our research questions, we first identified climate action groups that met the following criteria: (i) is based in Australia; (ii) is a non-governmental organization that has addressing climate change as part of its core mission; and

(iii) has a Twitter account. We used Climate Action Network Australia—the largest available online list of Australia-based climate advocacy groups—to create our initial sample [82]. The list contained 149 organizations in November 2022 when the sample was created. It included organizations of a large diversity of sizes located around the country; community, regional, national, and Australia-based offices of international groups; as well as groups representing diverse cultural backgrounds, such as First Nations Indigenous Australian Peoples and various religious affiliations. We then removed all groups that did not have a Twitter account, which narrowed the sample to 102 groups (see Supplementary Materials for list). For simplicity, we use the terms NGO and climate action groups interchangeably, although we acknowledge that there are a wide variety of different kinds of groups, including significant differences between local, grassroots community associations versus international organizations, and that groups may have different aims, approaches, and methods (e.g. policy engagement, litigation, protests, etc.). A detailed overview of Australian climate action groups is beyond the scope of this paper, but we refer readers to Gulliver *et al*. (2020) for further information [83].

Using the Twitter API, we collected all posts from these accounts from 1 July 2019 to 31 March 2020, which are the dates used by the Australian government's Royal Commission into National Natural Disaster Arrangements [59]. We analyzed tweets during the period of the fires as a reflection of how the occurrence of these events provides an opportunity window for climate change communication while they remain matters of public attention. The API returned 49,229 tweets, retweets, and comments. Only original tweets were kept (rather than retweets or comments) as we sought to uncover how organizations themselves framed the relationship between bushfires and climate change, rather than reposts of content written by others. The only exception to this was for RQ2, for which we included retweets given significant news coverage about the Black Summer EEA study and the possibility that groups might retweet these articles, rather than writing new tweets about the study.

All tweets that did not mention terms such as 'fire', 'Black Summer', 'burn', and other related phrases were removed (see Supplementary Materials for full query list). In total, 2,507 tweets from 59 of the 102 accounts remained. This list was then manually checked to remove false positives irrelevant to the topic of bushfires, such as those that mentioned fires happening elsewhere in the world. This resulted in a final dataset of 2,077 tweets. Two of the co-authors manually coded these tweets following deductive content analysis informed by the research questions [84]. Although we did not conduct a visual discourse analysis, we checked visual imagery associated with tweets for any images containing text or symbols associated with the coding criteria (e.g. protestors holding signs that said 'climate action now'). This helped ensure we did not miss important context on tweets that relied more on visuals than text to express their messages. Please see the Supplementary Materials for the codebook and further methodological details.

We used a manual coding approach as it helped facilitate a fine-grained discourse analysis to assess subtle nuances in the framing of extreme weather events and climate change. We conducted two rounds of intercoder reliability checks between the two coders on 25 random tweets from the dataset, with differences discussed between rounds. This ultimately resulted in reliability scores of 0.920 for Cohen's kappa and 0.921 for Krippendorff's alpha, which represent strong agreement. The full analysis then commenced. At a reflexive level, we acknowledge our own researcher subjectivity in interpreting frames, as well as inherent power dynamics assessing the communications of others who may not have benefitted from the same level of access to environmental education, resources, and training.

Findings

Framing the bushfire and climate change relationship

During the Black Summer bushfire season, our sample of Australian climate action group accounts tweeted a total of 2,077 times about bushfires (excluding retweets and comments). Mentions of bushfires corresponded closely with the bushfire season as the fires ramp up over time, with peaks during significant fire events, and begin to taper off as the season ends (Fig. 1).

Of the total sample, 1,227 tweets (59%) mentioned climate change or related phrases such as global warming, climate emergency, and climate crisis. In contrast, 872 tweets (42% of total sample, 71% of climate change-related tweets) mentioned climate change but did not specify the relationship between climate change and bushfires (Fig. 2). Tweets in this category often added hashtags such as #climatecrisis, #climateaction #climateemergency; made vague statements such as 'this is climate change'; mentioned fossil fuels/fossil fuel companies; or discussed political inaction on climate change. Several examples are included below:

> *Catastrophic bushfires across South Australia as the state swelters through 40+ degrees—this is climate change. This is the impact of mining and burning fossil fuels.*

> *This summer's devastating bushfires have made the #ClimateCrisis impossible to ignore for millions of people. Join us at the Climate Crisis National Day of Action event in Melbourne! See you there Sat Feb 22, 2pm State Library.*

> *September: thousands of students strike for climate action. November: 600 NSW schools closed due to catastrophic fire risk. #ClimateChangeIsReal*

There were 327 tweets (16% of total sample, 27% of tweets that mentioned climate change) that specified that climate change worsens bushfires by making them more likely and/or more intense. These tweets often linked to news articles and included quotations from climate scientists and fire experts. Several tweets went into precise details of how climate change has these effects on bushfires (e.g. by drying out the landscape), but most stated more simply that climate change exacerbates bushfire frequency and/or intensity:

> *Thousands of people are watching their homes burn as dangerous bushfires race across NSW and QLD, and our government are still failing to acknowledge the direct link between the climate crisis and more extreme bushfires and drought.*

> *Victoria's climate has changed in recent decades, becoming hotter and drier.*
>
> - *an overall increase in the frequency of unusually hot days*
> - *a decline in cool season rainfall over the last 30 years.*
> - *greater number of very high fire danger days in spring*

> *@BOM_au reports Australia has officially recorded its warmest, driest year on record, and the outlook points to increased catastrophic fire weather. #AustraliaFires #AustraliaisBurning #ActOnClimate*

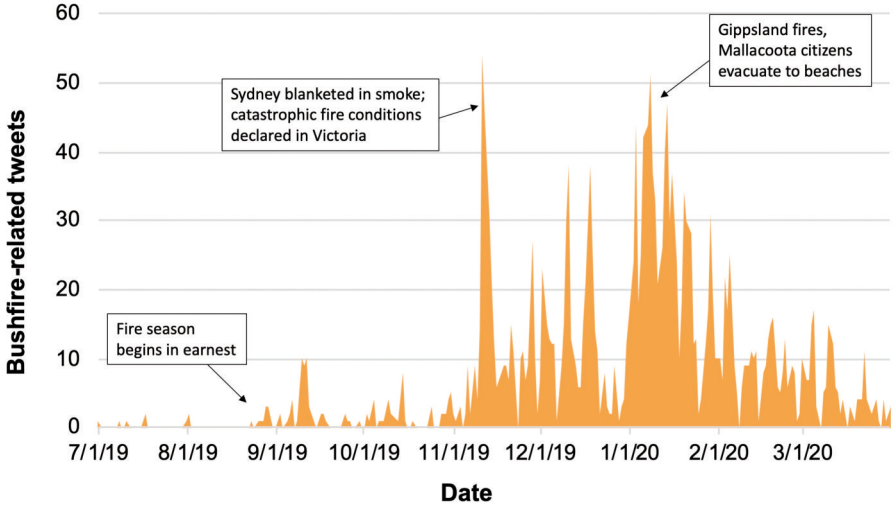

Figure 1. Timeline and frequency of NGO tweets about bushfires ($n = 2077$), which correspond with significant fire events during the Black Summer season (1 July 2019–31 March 2020). Three examples of these events are indicated.

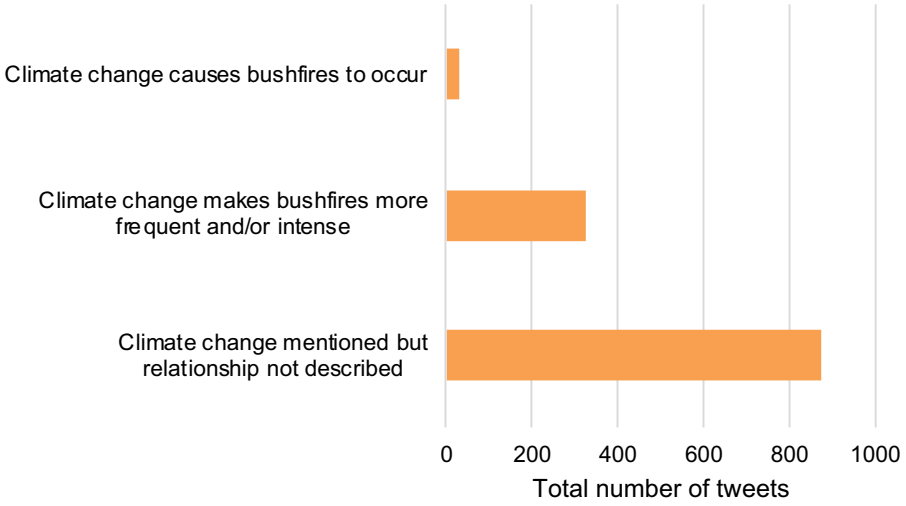

Figure 2. Bar chart showing frequency of tweets (excluding retweets and comments) for three different frames describing how climate change relates to bushfires ($n = 1,227$).

Only 28 tweets (1% of total sample, 2% of tweets that mentioned climate change) suggested that climate change directly causes bushfires to occur, used phrases suggesting climate change was solely to blame for their impacts (often specifically blaming former Prime Minister Scott Morrison for climate inaction), or implied that the bushfires would not have occurred without climate change:

> *This isn't normal. Bushfires rage from QLD to the NSW South Coast, again. Meanwhile, the Morrison Gov is gripped by denial. Their inability to acknowledge the cause of fires subjects communities to more suffering. To save lives, we need climate action now. #bushfires*

> *A lesson for @ScottMorrisonMP. Saying that Australia's action doesn't make a difference isn't leadership. Burning coal is setting Australian on fire and exporting climate damage to the world. #ThisIsNotNormal #NoNewCoal*

> *A group of Bega Valley residents displaced due to the current fire threat have held a cricket match on the lawns of Parliament House. 'The PM needs to do something about the cause of fires—climate change, give more resources to the South Coast'*

Black Summer extreme event attribution study

Only 15 tweets from seven accounts of our sample mentioned the van Oldenborgh *et al.* (2020) extreme event attribution study of the Black Summer fires [74]. Eleven of these tweets were posted directly by the groups and four were retweets. Most of these tweets quoted from, and linked to, news media articles reporting the study's key findings:

> *The devastating bushfires were at least 30% more likely because of climate change. Risks of a repeat will rise four-fold if global temperatures exceed two-degrees. Call on @DanielAndrewsMP to set #VicTargets to limit warming to 1.5 degrees.*

> *A report has found that Human-driven climate change increased the likelihood that Australia would experience extreme heat, setting the stage for this summer's fires. 'It was at least 30%, but likely much higher as models underestimate extreme heat trends'*

Framing bushfire risks beyond climate change

There were 312 tweets (15% of total sample) that mentioned factors that influence the risks and impacts of bushfires other than

climate change. Frequent topics of discussion included firefighting and emergency responses; disaster risk reduction and hazard reduction strategies (e.g. planned and cultural burns, personal bushfire evacuation plans, emergency communication systems); healthcare systems; climate change adaptation; and how certain populations were more vulnerable than others to bushfires, such as children and the elderly. For example:

> *Elderly and vulnerable people should never feel abandoned during a crisis. But that's how Marion felt, trapped in her home for months during the bushfire crisis this summer.*

> *Data shows that 'Premium Grade Buildings' can reduce the outdoor bushfire smoke contaminants by up to 90 per cent. Improving the standard of our homes will make them safer and more liveable, especially as our bushfires intensify.*

> *'Our biggest challenge with hazard reduction burning is the weather and the windows available to do it safely and effectively.' #Bushfirecrisis*

These actions were frequently described in the context of politics, especially the actions of Scott Morrison, and pointed out actions they felt elected officials had failed to pursue prior to the onset of the fires that would have reduced risks. There were 143 tweets (6%) that mentioned one or more of these risk factors as well as climate change, such as interactions between the effects of climate change on bushfires and the need to support firefighting efforts:

> *#SydneySmoke from the bushfires reached its worst level yet today, clocking in at 11 times the hazardous level. Yet Our PM Scott Morrison has seen fit to knock back calls for more funding for the firefighters on the frontline of the #ClimateEmergency*

> *'Scientists and former emergency service chiefs say the increased threat demands both greater resources to fight fires and urgent action to cut emissions.'*

Discussion

This study provides new empirical insights into how climate action groups communicate about extreme weather events on Twitter/X and how they frame the relationship of these events to climate change. We found that 1,227 (59%) of tweets mentioned climate change, compared to 49% of Black Summer articles in Australian news media [67]. That Australian climate groups more frequently raised the issue of climate change than news media amid the fires is unsurprising—they sought to use the Black Summer as an opportunity for climate mobilization while public attention was directed to the topic and as shown, peaks in tweet activity correspond with key moments during the fire season. The frequent mentions of politics/elected officials in their tweets aligns with prior analyses of climate change Twitter discussions [11]. It also suggests that Australian climate NGOs tied the bushfires to their existing political aims, namely, to counter perceived climate inaction on the part of former Prime Minister Scott Morrison and political leaders at the time.

However, our findings offer novelty and value by showing how these groups framed the bushfire-climate change relationship and to what extent they incorporated climate science in their tweets. Only 28 tweets (1% of total) suggested inaccurately that climate change directly causes bushfires to occur. The notion that climate change directly causes extreme weather events misleadingly implies that if climate change were to be fully stopped, fires (and resulting consequences) would no longer occur. In contrast, 327 tweets (16%) made scientific statements that specifically described how climate change affects bushfire frequency and severity, whereas 872 tweets (42%) simply mentioning climate change without detailing how it relates to bushfires. Comparatively, 29% of Australian news media coverage articles of the Black Summer covered climate change in depth and with accuracy [67]. Only seven accounts shared the van Oldenborgh *et al.* (2020) extreme event attribution study a total of 15 times [74].

These findings suggest that Australian climate groups could more frequently draw upon climate science related to bushfires to provide further scientific evidence backing up their arguments for climate action. Additionally, our prior research has shown that EEA results—by providing a specific quantitative estimate of how climate change influenced a weather event—can be attention-grabbing and engaging for non-climate scientists [40]. To be sure, simply communicating scientific information is not necessarily an effective strategy to encourage climate action; nonetheless, that 95 of the 102 groups did not tweet about the Black Summer EEA study is potentially a missed opportunity to call further attention to the relationship between climate change and bushfires.

We also examined to what extent these groups mentioned factors beyond climate change that affect bushfire impacts, including disaster risk reduction strategies, emergency responses, hazard reduction, and vulnerabilities. In the bushfire context, this includes firefighting, emergency communications, evacuations, planned burns, and other strategies that seek to reduce fire impacts. We found that climate action groups mentioned these aspects of bushfire risks in a relatively low percentage of tweets (312, 15%). Although it remains crucial to communicate how climate change can affect different kinds of extreme weather events, climate action groups should be aware of potential issues of framing these events as solely a climate change issue, even if promoting climate action is their main objective. The effects of climate change on bushfires are only one aspect that ultimately shaped the impacts of the Black Summer [59]. As shown in other contexts, such as flooding in Brazil, public officials may strategically blame global climate change to avert responsibility for local decision-making and planning failures [26]. The most holistic communications about potential risk factors would incorporate the role of climate change in combination with other dynamics that affect the impacts of extreme weather events. We found only 143 tweets (6% of total) that accomplished this in the bushfire case.

Directions for future research and study limitations

Given that NGOs play a significant role as science communicators [42], these findings raise questions about how NGOs engage with climate science/scientists and risk experts, and how they draw on these resources in their communications and campaigns. Forging better links between these actors could help facilitate stronger knowledge exchange and dialogue about communication strategies in the extreme weather context. For instance, surveys, interviews, and other methods could further examine the channels by which climate action advocates access and make sense of scientific information and for what kinds of campaigns (and other goals) they utilize it [85]. This would provide practical guidance to help facilitate stronger knowledge exchange and accessible science communication among diverse actors. Future research could also more closely examine the

science communication role perceptions of NGOs in the extreme weather context, especially to what extent they perceive communicating climate science as part of their missions, objectives, and campaigning strategies.

Another promising direction for future research would be to explore how other types of nuances around extreme weather events and their attribution to climate change are communicated by diverse actors across different communication channels. For instance, there are varying levels of scientific confidence and understanding about the impacts of climate change on the duration, frequency, and intensity of different types of extreme weather [72]. There are also other nuances and uncertainties around specific aspects of different types of extremes, such as how climate change may affect short-duration versus longer-duration extreme rainfall events [86]. Likewise, future studies could compare how climate action NGOs frame extreme weather events in their communications to other types of organizations, such as media outlets across the political spectrum, private sector companies, and thinktanks. Other actors may seek to downplay and/or ignore climate change in the extreme weather context.

This study has several important limitations. First, we examined tweets from a limited number of organizations in response to one type of extreme weather event—our dataset is only subset of climate action NGO communications from a single context. We also did not distinguish between different types of NGOs which may hold a range of different strategies and priorities. Future research could explore climate change communication differences between local grassroots groups versus larger top-down organizations [87], as well as how such groups engage with different types of extreme weather events. Larger groups may have more communication resources, which in turn could inform how they frame the topic.

Second, this study looked only at Twitter/X rather than other online platforms—future research could build on our findings to examine extreme weather-related communications from these groups across other websites and communication channels. Such research might find significant differences as character-length limitations on tweets encourage brevity, which could mean that groups chose not to provide more detailed scientific statements due to a lack of space and were constrained in their content decisions. Additionally, ongoing changes to the Twitter/X platform could affect how NGOs use the platform in both the content and frequency of their posts.

Third, although we inspected tweet images for relevant text or symbols associated with our coding criteria, we did not conduct a visual discourse analysis. Researchers are increasingly examining visuals in the context of extreme weather and climate change, and recent studies have revealed striking differences in emotional tones between text and visual narratives in news media coverage of heatwaves [88]. A robust visual analysis could add important insights into how climate groups use visuals to frame extreme weather events, their relationship with climate change, and their impacts.

Fourth, we analyzed tweets within the 2019–2020 fire season in connection with the notion that extreme weather events open a limited opportunity window for climate change communication while they remain a focus of public attention. Future research could offer a more longitudinal perspective on how climate groups engage with extreme weather events before, during, and after their occurrence; however, most Twitter activity during extreme weather events has been shown to occur during the active phase of the event and rapidly drops off after [70]. This study also focused on communication providers rather than recipients—more research is needed to examine how diverse audiences respond to different frames of extreme weather events and climate change, as well as dynamics of other communication channels in conveying this information.

Conclusion

This study examined how Australian climate action NGOs communicated on Twitter about climate change during the 2019–2020 Australian Black Summer bushfires. Fifty-nine percent of bushfire-related tweets mentioned climate change during the period of the fires. Forty two percent of tweets mentioned climate change without describing how it relates to bushfires; 16% described specifically how climate change influences the frequency and intensity of bushfires; and 1% implied inaccurately that climate change causes bushfires. Fifteen percent of tweets discussed factors beyond climate change, such as vulnerability and disaster risk reduction strategies, that influence bushfire impacts. Only seven accounts mentioned an extreme event attribution study of the Black Summer fires. These findings suggest that although these groups largely did not tweet scientifically inaccurate information, they could further draw upon climate science to offer more precise climate change attribution statements and more often incorporate a broader range of risk factors that shape the impacts of bushfires. As populations around the world continue to confront many kinds of intensified extreme weather, assessing the framing of these events—and how different frames promote different kinds of actions—will grow in importance.

Ethics statement

The study did not require IRB review in accordance with guidelines of the University of Oxford's Central University Research Ethics Committee.

Supplementary data

Supplementary data are available at *Oxford Open Climate Change* online.

Conflict of interest

The authors report there are no conflict of interests to declare.

Authors' contributions

Joshua Ettinger (Conceptualization [lead], Formal analysis [lead], Methodology [lead], Writing—original draft [lead]), Mary Sanford (Formal analysis [supporting], Methodology [supporting], Writing—review & editing [equal]), Peter Walton (Methodology [supporting], Supervision [equal], Writing—review & editing [equal]), David Holmes (Methodology [supporting], Writing—review & editing [equal]), and James Painter (Methodology [supporting], Supervision [equal], Writing—review & editing [equal])

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