

**Seizing the teachable moment:  
Extreme weather events as catalysts for climate  
change dialogue, learning, and action**



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9 October 2023

## **Abstract**

Researchers have long examined how extreme weather events affect climate-related attitudes, beliefs, and behaviours among the public, with mixed results. However, proactive communication strategies to engage diverse members of the public about climate change when extreme weather events occur are comparatively under-researched. Further research is needed on the best practices, dynamics, and effects of communicating links between climate change and extreme weather. This topic is particularly timely given the recent development of extreme event attribution (EEA) techniques that assess how climate change affects the frequency and/or intensity of specific extreme weather events.

This interdisciplinary thesis examines how climate communicators such as activists and scientists can encourage individual climate action among members of the public in the wake of extreme weather events. Potential climate actions could include personal adaptive behaviours to reduce weather-related risks; lifestyle decisions to reduce one's greenhouse gas emissions; and activism to advocate for climate adaptation and mitigation policies. Across four papers, I map the opportunities and challenges of this public engagement strategy using the 2019-2020 Australian Black Summer bushfires and the 2019 summer heatwaves in the United Kingdom as case studies.

Paper 1 uses focus groups to explore how non-climate scientists engage with EEA results related to the 2019 United Kingdom summer heatwaves. Paper 2 analyses discourses of tweets posted by Australian climate action groups during the 2019-2020 Black Summer bushfires. Paper 3 explores through narrative interviews how Australian bushfire experiences influence climate change perceptions and participation in climate activism among Australian adults. Paper 4 adapts the Teachable Moments Communication Process – a healthcare communication

strategy – to offer a flexible framework for facilitating climate-related discussions after extreme weather events. An additional two commentary papers offer further guidance and reflections on dialogue-based climate change communication strategies, drawing particularly on *Talk Climate Change* – a student-led climate action campaign I co-founded that tracked climate conversations among 1,000 people across 40 countries.

The findings suggest that EEA can be an attention-grabbing climate change communication tool; that communicators should strive to differentiate the factors that shape extreme weather risks, including climate change, exposure, hazards, and vulnerability, and capture other climate science nuances; and how extreme weather trauma can support or inhibit climate activism participation for different people. Overall, efforts to promote individual climate action after extreme weather events should incorporate a variety of socio-cultural and psychological considerations, especially how diverse individuals engage with climate change in terms of their attitudes, beliefs, behaviours, and emotions. Ultimately, this thesis argues that extreme weather events provide vital opportunities for dialogue, learning, and action to help chart a safer and more prosperous future.

## Table of contents

<b>Abstract</b> .....	<b>2</b>
<b>List of figures</b> .....	<b>8</b>
<b>List of tables</b> .....	<b>8</b>
<b>Acknowledgments</b> .....	<b>9</b>
<b>1. Introduction</b> .....	<b>10</b>
<i>1.1 Background</i> .....	10
<i>1.2 Research aim and research questions</i> .....	15
<i>1.3 How this thesis is structured</i> .....	17
<b>2. Literature review</b> .....	<b>19</b>
<i>2.1 Climate change and extreme weather events</i> .....	20
2.1.1 Climate change – a very brief introduction.....	20
2.1.2 How climate change affects extreme weather events .....	21
2.1.3 Extreme weather risk dynamics .....	26
<i>2.2 Public engagement with climate change and extreme weather</i> .....	28
2.2.1 Why the public matters for climate action.....	28
2.2.2 Climate change communication.....	30
2.2.3 Extreme weather events and climate change issue engagement.....	32
2.2.4 Communicating extreme weather and climate change links.....	36
<i>2.3 Literature review summary and research gaps</i> .....	41
<b>3. Theoretical framework</b> .....	<b>43</b>
<b>4. Methodology</b> .....	<b>46</b>
<i>4.1 Research paradigm</i> .....	46
<i>4.2 Mixed methods</i> .....	47
4.2.1 Focus groups .....	48
4.2.2 Narrative interviews.....	50
4.2.3 Case studies.....	51
4.2.3.1 The 2019 United Kingdom summer heatwaves.....	52
4.2.3.2 The 2019-2020 Australian Black Summer bushfires.....	53
4.2.4 Using social media data for research .....	57
<i>4.3 Sample</i> .....	58
<i>4.4 Analysis</i> .....	59
<i>4.5 Ethics and risks</i> .....	60
4.5.1 Implications of COVID-19 .....	61
4.5.2 Anonymity and informed consent.....	61
4.5.3 Psychological risks.....	62
4.5.4 Funding disclosures .....	62
4.5.5 Normative dimensions of climate change communication.....	63

4.6 Reflexivity and power dynamics.....	63
4.7 Research quality.....	65
<b>5. Paper 1: “What’s up with the weather?” Public engagement with extreme event attribution in the United Kingdom.....</b>	<b>67</b>
<i>Abstract</i> .....	68
<i>Introduction and literature review</i> .....	69
<i>Methods and materials</i> .....	77
<i>Results</i> .....	80
<i>Discussion</i> .....	86
<i>Conclusion</i> .....	92
<i>Acknowledgments</i> .....	95
<i>Data availability statement</i> .....	95
<i>References</i> .....	95
<i>Supplementary material</i> .....	102
<b>6. Paper 2: Social media messaging by climate action NGOs: A case study of the 2019-2020 Australian Black Summer bushfires .....</b>	<b>112</b>
<i>Abstract</i> .....	113
<i>Background</i> .....	114
<i>Findings</i> .....	124
<i>Discussion</i> .....	128
<i>Conclusion</i> .....	133
<i>References</i> .....	134
<i>Supplementary materials</i> .....	140
<b>7. Paper 3: Examining contrasting influences of extreme weather experiences on individual climate activism.....</b>	<b>145</b>
<i>Abstract</i> .....	146
<i>Introduction</i> .....	147
<i>Case study background</i> .....	152
<i>Study aims and methods</i> .....	153
<i>Findings</i> .....	157
<i>Discussion</i> .....	164
<i>Conclusion</i> .....	168
<i>Acknowledgements</i> .....	169
<i>References</i> .....	169
<i>Supplementary material</i> .....	175

<b>8. Paper 4: Extreme weather events as teachable moments: Catalyzing climate change learning and action through conversation.....</b>	<b>182</b>
<i>Abstract.....</i>	<i>183</i>
<i>Introduction.....</i>	<i>184</i>
<i>Teachable moments for climate change.....</i>	<i>186</i>
<i>Teachable moments in healthcare research .....</i>	<i>191</i>
<i>A teachable moments communication process for climate change .....</i>	<i>194</i>
<i>Discussion.....</i>	<i>200</i>
<i>References.....</i>	<i>206</i>
<b>9. Discussion .....</b>	<b>214</b>
<i>9.1 Key findings from papers.....</i>	<i>214</i>
<i>9.2 Opportunities and challenges for climate change communication (research question 1) .....</i>	<i>216</i>
<i>9.3 Maximising public engagement opportunities and addressing challenges (research question 2).....</i>	<i>226</i>
<b>10. Conclusion .....</b>	<b>233</b>
<b>11. References.....</b>	<b>238</b>
<b>Appendix A: Breaking the climate spiral of silence: Lessons from a COP26 climate conversations campaign.....</b>	<b>263</b>
<i>Abstract.....</i>	<i>264</i>
<i>Introduction.....</i>	<i>265</i>
<i>Deficit versus dialogue .....</i>	<i>266</i>
<i>The Talk Climate Change campaign.....</i>	<i>270</i>
<i>Campaign outcomes.....</i>	<i>273</i>
<i>Lessons for climate change communication .....</i>	<i>276</i>
<i>Conclusion .....</i>	<i>282</i>
<i>Acknowledgements.....</i>	<i>283</i>
<i>References.....</i>	<i>284</i>
<b>Appendix B: The science of climate conversations .....</b>	<b>288</b>
<i>Abstract.....</i>	<i>289</i>
<i>Introduction.....</i>	<i>289</i>
<i>The importance of climate conversations .....</i>	<i>292</i>
<i>Further developing research on climate conversations.....</i>	<i>295</i>
<i>References.....</i>	<i>297</i>

**Appendix C: Extreme weather events are exactly the time to talk about climate change  
– here’s why .....302**

**Appendix D: Co-authorship information .....308**

## List of figures

Figure 1.1: Example of a news media headline covering an EEA study.....	14
Figure 2.1: IPCC (2022) visual representation of how disaster risk arises from complex interactions among exposure, hazards, vulnerability, and responses.....	26
Figure 6.1: Timeline of NGO tweets about bushfires (n = 2,077) which correspond with significant fire events during the Black Summer season.....	125
Figure 6.2: Frequency of tweets (excluding retweets and comments) for three different frames of how climate change relates to bushfires (n=2,077).....	127
Figure 8.1: Flocke et al.'s (2012) teachable moment communication process in the context of smoking cessation (reproduced with permission).....	193
Figure 8.2: Adaption of the healthcare Teachable Moments Communication Process (Flocke et al., 2012) for environmental communication.....	195
Figure 9.1: Conceptual visualisation of factors that can influence subjective attribution of extreme weather to climate change.....	227
Figure 9.2: Teachable moment communications process (TMCP) adapted for climate change and extreme weather events (from paper 4, chapter 8).....	229
Figure A1: Example of a submission to the campaign's interactive conversation map.....	273
Figure A2: Example of a climate conversation submission from the London Science Museum family activity.....	282

## List of tables

Table 4.1: Eight big-tent criteria for excellent qualitative research (Tracy, 2010).....	66
Table 5.1: Key benefits and challenges of utilizing EEA results as a climate change communication and public engagement tool .....	87
Table 7.1: Participant demographics.....	155
Table 7.2: Analysis themes, subthemes, and associated research questions.....	156
Table 9.1: Summary of paper findings and connections to thesis research questions.....	215
Table A1: The top 10 (of 46 total) thematic tags campaign participants most frequently used to describe the content of their conversations.....	274

## Acknowledgments

First, I express my deepest gratitude to my three supervisors, Peter Walton, James Painter, and Friederike Otto. Thank you, Pete, for helping me transform rough ideas into robust research plans and for reminding me to keep smiling throughout this adventure. Thank you, James, for being a constant source of spot-on advice and feedback, as well as for facilitating an array of wonderful opportunities over the past four years. Thank you, Fredi, for pushing my research to the strongest possible level and for assistance with many project management and administrative tasks.

I am indebted to the 46 participants in the United Kingdom and Australia who made my research possible. Thank you for your generosity, time, and openness to share your experiences and thoughts with me.

I have been fortunate to work with many brilliant and kind research collaborators on various components of this thesis – thanks so much to Kelly Fielding, Robyn Gulliver, Susan Flocke, Shannon Osaka, and the Talk Climate Change team.

Thank you to David Holmes and the Monash Climate Change Communication Research Hub for hosting me for an excellent research visit in Melbourne, as well as to other Australian colleagues who welcomed me to Adelaide, Brisbane, Canberra, and Kangaroo Island.

Thanks to Worcester College for providing travel funding support and beautiful gardens that helped sustain my mental well-being over the last four years. Thanks to Lisa Wedding, my college advisor, who assisted at key stages. I also express my thanks to Cumberland Lodge for offering an enriching fellowship, a peaceful retreat in Windsor, and supportive community of scholars.

Thanks to John and Brenda Boardman for their mentorship; to Lisa Schipper and Rachel James for feedback in the first year of my thesis; to Ben Clarke for helping me make sense of the physical science of extreme weather events; to Kim Polgreen for providing a quiet space to work in Wytham Woods during my final writing phase; and to Fredrik Eriksson, Kevin Soubly, and Vaishali Rao for their advice, friendship, and travel expertise.

Thank you to Marcus Spiegel, Colin Hill, and Sophie Cheng for being the best COVID lockdown companions one could ever hope for. I am also lucky to have many supportive colleagues at the School of Geography and the Environment and former classmates from the Environmental Change and Management MSc course.

I thank Julia for her encouragement throughout this entire journey, celebrating the successes with me, and for helping me get through the tougher moments. To Jon for his creative ideas, writing advice, and providing endless laughs. To our golden retriever Winnie for always being willing to receive a belly rub and sometimes being willing to play fetch. Finally, I thank my parents for believing in me at every step along the way.

# 1. Introduction

## 1.1 Background

Despite decades of warnings from a consensus of climate scientists, humanity's response to climate change remains woefully inadequate (Stoddard et al., 2021). As noted by the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (2023, p.24):

“There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all...The choices and actions implemented in this decade will have impacts now and for thousands of years.”

To successfully actualise climate policies and solutions as quickly as possible, public participation and support are crucial (Demski, 2021; Devine-Wright et al., 2022). Members of the public can pressure policymakers to act on climate change, offer valuable input toward designing and implementing climate solutions, and adopt low-carbon lifestyle behaviours that help mitigate climate change, among other actions.

Accordingly, climate change communication researchers have long strived to understand the factors that shape how diverse members of the public perceive and engage with climate change. Researchers are particularly interested in the extent to which extreme weather events could act as “teachable moments” or “focusing events” for climate change (e.g., Birkland & Schwaeble, 2019; Wright et al., 2013; Zanocco et al., 2019). Whereas climate change is often described a psychologically distant or perceptually abstract problem, weather is more perceptually concrete – it is one of the fundamental ways humans interact with their local physical environment and surroundings (Barry et al., 2020; Keller et al., 2022). Extreme weather events could therefore

heighten climate concerns and mobilise climate action by countering the perceived invisibility and abstract risks of climate change (McDonald et al., 2015; Rudiak-Gould, 2013).

As climate change continues to increase the frequency, intensity, and duration of many types of extreme weather events (such as droughts, fire weather conditions, heatwaves, and heavy rainfall) in many regions around the world, researchers have examined how these events influence climate attitudes, beliefs, and behaviours. Across dozens of studies, results are mixed: some find that individuals in regions affected by extreme weather become more concerned about climate change and more supportive of climate policies (e.g., Hazlett & Mildenerger, 2020), whereas others find no effects (e.g., Gärtner & Schoen, 2021), or that they only last for a limited duration (e.g., Ray et al., 2017). A variety of factors, including the attribution of weather events to climate change, political views, and prior attitudes and beliefs, can shape how, and to what extent, these events influence public opinion and behaviours at individual, community, and national levels (Boudet et al., 2020; Marlon et al., 2021; Ogunbode et al., 2019). Overall, a review of 73 studies on this topic offers “some support for a weak effect of local temperature and extreme weather events on climate opinion”, but comparisons remain difficult due to contrasting methods (Howe et al., 2019, p.1).

In comparison to literature examining to what extent extreme weather events influence climate change opinions and behaviours, more proactive approaches for catalysing climate action after these events are comparatively under-researched (Sisco, 2021). This entails empowering climate action advocates, scientists, and other communicators with evidence-based communication strategies to engage citizens about climate change in their aftermath of extreme weather events and encourage individual climate action. For instance, there are ongoing efforts to support television weathercasters as climate change communicators, which has proven

valuable for public education and reaching new audiences with climate information (Maibach et al., 2022). However, an analysis of environmental advocacy in the United States found that environmental groups are generally not conducting climate change campaigns in communities recently affected by extreme events, which is described as a “serious missed opportunity” (McAdam, 2017, p.204).

If extreme weather events are to act as teachable moments, the crucial question is what exactly they teach and to whom. A wide variety of relevant actions at both individual and policy levels can help address risks from extreme weather events and climate change (see chapter 2, section 2.1.3). A significant complexity concerns the relationship between natural hazards, vulnerability, and exposure. Climate change is only one aspect of extreme weather risks: while climate change influences natural hazards, exposure and vulnerability ultimately determine the impacts of hazards and whether they become disasters (Raju et al., 2022). If communicators frame disasters as being entirely caused by climate change, this could divert attention from local planning and disaster risk reduction decisions (Lahsen & Ribot, 2021). For example, climate change can increase the severity of wildfires, while emergency responses help protect the health and safety of affected communities. Minimal published guidance exists on how to effectively communicate relationships across these risk factors that together shape the impacts of extreme weather. Additionally, it can be difficult to express nuances around scientific uncertainty and the varying ways in which climate change affects (or does not affect) different kinds of weather events – this is a communication challenge that affects many types of scientific research (Fischhoff & Davis, 2014).

As described in chapter 3, another important yet relatively under-examined dynamic in the context of extreme weather and climate change is the role of one-way versus two-way

communication approaches (e.g., reading news articles versus participating in conversations). It is important to make scientific evidence available and accessible to guide evidence-based thinking and decision-making on climate change and other societal issues; however, diverse individuals may engage differently with information in terms of risk perceptions, emotional responses, and associated behaviours (Douglas and Wildalvsky, 1982). The basic provision of climate information will not necessarily drive increased climate concerns and actions (Simis et al., 2016). While prior research offers helpful guidelines for communicating links between climate change and extreme weather events (e.g., Hassol et al., 2016), there is a need for greater research on dialogue-oriented public engagement approaches for encouraging individual climate action in the wake of extreme weather events.

As extreme weather experiences can be traumatic (Bryant et al., 2014) – especially during a time of substantial climate-related anxiety (Clayton, 2020; Whitmarsh et al., 2022) – the topic of climate change could trigger potentially unpleasant or harmful emotional reactions among some individuals after these events. Climate-related anxiety has in some cases been shown to help encourage individual climate action; however, it can also generate feelings of ‘eco-paralysis’ that may inhibit individual pro-environmental behaviours (Innocenti et al., 2023; Verplanken et al., 2020). Therefore, climate-related emotions are another highly relevant consideration.

Scholarly research and discussion of these dynamics associated with public engagement with climate change after extreme weather events is fragmented across different bodies of literature and disciplines. Gathering these research strands together would be beneficial for more holistically understanding their interplay. This topic is particularly timely given the recent emergence of the science of extreme event attribution (EEA), which assesses to what extent

climate change affects the frequency and/or intensity of specific weather events (Stott et al., 2016). For example, the research group World Weather Attribution found that climate change made the 2019 UK summer heatwave at least 3 times more likely to have occurred (Vautard et al., 2020), and the 2019-2020 Australian bushfires at least 30% more likely to have occurred (van Oldenborgh et al., 2020).

Beyond potential implications for climate litigation and climate adaptation, EEA may offer unique communicative value by providing scientific information on links between climate change and specific extreme events relatively quickly. The World Weather Attribution project strives to share its results within several weeks of an event or sooner, which often receive substantial international media coverage (Painter et al., 2021). Figure 1.1 shows an example of the headlines these studies typically generate. Further research on communication and public



**Figure 1.1:** Example of a news media headline covering an EEA study

engagement dimensions of EEA would be beneficial (National Academies of Sciences, Engineering, and Medicine, 2016). This includes how best to communicate EEA findings to non-climate scientists; to what extent this information can influence whether the public perceives a connection between extreme events and climate change (i.e., ‘subjective attribution’); and in what ways this information might support efforts to generate climate change dialogue and action after extreme events.

## **1.2 Research aim and research questions**

Bridging the fields of climate science, climate change communication, environmental psychology, and human geography, this thesis aims to assess the opportunities and challenges of leveraging extreme weather events to encourage climate change dialogue, learning, and action among the public. This thesis focuses on actions individuals can pursue to help address extreme weather and climate change risks at individual and societal levels, as well as the potential role of climate action groups in helping facilitate individual actions. This includes personal adaptive measures and disaster risk reduction strategies (e.g., creating fire evacuation plans or informing oneself on strategies to cope with heatwaves); changing one's lifestyle behaviours to reduce personal greenhouse gas emissions; and advocating for policy-level adaptation and mitigation actions to address climate-related risks. Although this represents a broad array of actions, local circumstances can differ significantly and often require tailored actions to effectively address risks in diverse contexts. Additionally, diverse individuals may be inclined to pursue different types of actions.

I use the 2019 summer heatwaves in the United Kingdom and 2019-2020 Australian Black Summer bushfires as case studies. I selected these specific extreme weather events as case studies due to substantial public discussion and media coverage about how climate change relates to them (e.g., Burgess et al., 2020; Watts, 2019); the availability of attribution analyses finding a climate change effect for both events (Vautard et al., 2020; van Oldenborgh et al., 2020); and their occurrence in two relatively socio-economically similar, English-speaking countries. These case study events help ground theoretical concepts in concrete circumstances.

I use mixed methods to assess the opportunities and challenges of this public engagement approach. The methods include focus groups to gauge responses to EEA results among non-

climate scientists (paper 1, chapter 5); an analysis of tweets by Australian climate action groups during the Black Summer bushfires to examine how they frame the relationship between the fires and climate change (paper 2, chapter 6); interviews with bushfire survivors and climate activists to explore how their weather experiences influenced their climate change perceptions and activism behaviours (paper 3, chapter 7); and an adaptation of the Teachable Moments Communication Process (Flocke et al., 2012) – a dialogue-based communication framework from healthcare literature – for the extreme weather/climate change context (paper 4, chapter 8). I also include two peer-reviewed commentary articles in the appendix. Paper 5 (appendix A) offers insights for climate change communication from an international campaign I co-founded and directed called Talk Climate Change ([www.talkclimatechange.org](http://www.talkclimatechange.org)) that tracked interpersonal climate change conversations among 1,000 people across 40 countries. Paper 6 (appendix B) is another commentary piece that discusses the need for more research on dialogue-based approach in climate change communication, with reflections on how I integrated this approach into my thesis.

In total, this thesis includes three empirical studies, a theoretically oriented study, and two commentary pieces (six papers in total). Additionally, although not a direct part of this thesis, I also connect my findings with four studies to which I contributed alongside my supervisors which relate to news media coverage of climate change and extreme weather events (O'Neill et al., 2022; Painter et al., 2020; Painter et al., 2021; Strauss et al., 2022).

Synthesising the findings across these studies, this thesis contributes to literature on public perceptions of extreme weather events, climate activism, climate change communication, and public engagement with climate change. It also helps advance theoretical discussions around the knowledge deficit model of science communication and more participatory, dialogue-

driven approaches for climate change communication. At a more practical level, it provides evidence-based communication strategies to support the efforts of environmental advocates, communicators, practitioners, and scientists seeking to engage the public about climate change in the wake of extreme weather events to encourage individual climate action. The following research questions guide this thesis:

*RQ1: What are the opportunities and challenges associated with leveraging extreme weather events to facilitate climate change dialogue, learning, and individual action among members of the public?*

*RQ2: How can climate change communication practitioners engage members of the public about climate change after extreme weather events in ways that maximise opportunities and address challenges associated with this public engagement strategy?*

Each of this thesis's empirical papers offer more specific research questions targeted to the case study extreme weather events. The discussion chapter (chapter 9) weaves together the findings across the papers to answer the overarching research questions. Short introductions before each paper offer further context into how they each fit into this thesis.

### **1.3 How this thesis is structured**

**Chapter 2** provides a background literature review. **Chapter 3** describes the public engagement with science and technology concept, which forms the theoretical framework that underpins this thesis. **Chapter 4** outlines the overall methodological approach and case studies. **Chapters 5 - 8** contain the four papers and their supplementary materials. **Chapter 9** synthesises the research findings to answer the central research questions. **Chapter 10** provides

a brief conclusion. The **appendix sections** contain two published commentary articles and a related article I published in *The Conversation*.

## **2. Literature review**

This literature review chapter contains three sections:

- Section one describes the relationship between climate change and extreme weather events, with a focus on extreme event attribution. This section also examines risk dynamics, including how complex interactions between exposure, natural hazards, vulnerability can together shape the impacts of extreme weather events.
- Section two introduces literature on climate change communication, environmental psychology, and public engagement with climate change. It reviews studies examining the effects of extreme weather events on climate attitudes, beliefs, and behaviours among the public, as well as research on communicating links between extreme weather and climate change.
- Section three summarises the literature review and describes how this thesis builds upon and contributes to existing research.

Please note that some parts of this chapter appear verbatim in the literature reviews of the publications (chapters 5 - 8), as do some sections of the case studies and theoretical framework chapters (chapters 3 and 4).

## **2.1 Climate change and extreme weather events**

### *2.1.1 Climate change – a very brief introduction*

Since the industrial revolution, the burning of fossil fuels including coal, natural gas, and oil has supported development and prosperity for billions of people around the world. However, burning fossil fuels and other human activities (e.g., agriculture, deforestation, and land-use change) have increased concentrations of greenhouse gases (GHGs) in the atmosphere to levels unseen for millennia and at an unprecedented pace (NASA, 2023). GHGs such as carbon dioxide, methane, nitrous oxide, and water vapour absorb and emit infrared radiation, which traps heat and in turn warms the planet. This is known as global warming or the greenhouse effect.

Human-driven or anthropogenic global warming causes climate change, which encompasses alterations in global temperatures, extreme weather, sea level rise, ocean acidification, biodiversity loss, and a large variety of other effects that have major economic, health, and social consequences (IPCC, 2023). The extent of these impacts is contingent on how much warming occurs in the future. GHG emissions are cumulative; the planet will continue warming unless emissions reach net zero, defined by the 2016 United Nations Paris Agreement as a balance between GHG sources and GHG sinks (i.e., natural landscapes such as forests or technologies that capture and store GHGs) (UNFCCC, 2016). Human activities have already warmed the planet by about 1.1 degrees C since 1880 (IPCC, 2023).

Climate change is broader than a scientific issue. Climate discourses over the last several decades have broadened to include arts, economics, ethics and justice, humanities, politics, psychology, social science, and numerous other dimensions. Diverse actors frame climate change in contrasting ways, demonstrating the multifaceted nature of the problem. Some

describe it as an economic crisis (Stern, 2006); a national and international security issue (Busby, 2008); a technological challenge (Gates, 2021); an ethical or moral dilemma (Gardiner, 2011); a matter of justice and equity (Bullard, 2000); part of a new epoch of human-driven planetary change called the Anthropocene (Lewis & Maslin, 2015); a societal issue requiring engagement from the arts and humanities (Boykoff, 2020; McKibben, 2006); a form of colonialism (Sultana, 2022); and many other perspectives.

Addressing climate change requires both climate mitigation and adaptation. Mitigation refers to efforts to directly slow or stop climate change, including by switching away from fossil fuel energy sources to renewable energy technologies, increasing energy efficiency, and protecting and restoring natural carbon sinks such as forests (Hawken, 2017). Adaptation refers to steps to reduce the harms of climate change, such as investing in mechanisms to protect communities from sea-level rise and extreme weather events, effectively managing water resources to ensure access during droughts, and protecting food systems (Bierbaum et al., 2012). There are frequent debates about the relative importance of individual actions (e.g., ways of reducing one's GHG emissions through personal lifestyle decisions) versus policies and regulations such as carbon taxes. This thesis adopts the perspective that individual and systems-level actions are interrelated, necessary, and “two sides of the same coin” (Capstick et al., 2020, p.75). As described in section 2.2 below, social dimensions, especially related to effective communication and public engagement, play a crucial role in successfully addressing climate change.

### *2.1.2 How climate change relates to extreme weather events*

Before examining how climate change relates to extreme weather events, it is helpful to distinguish between the definitions of climate versus weather. Climate refers to long-term

weather trends, whereas weather refers to daily atmospheric phenomena. More precisely, climate is “the statistical properties of possible weather, with the actual observed weather being just one realization of many possible realizations . . .” (Stone et al., 2009, p.2). There are various analogies scientists use to describe this relationship, such as “climate is what you expect, weather is what you get” and “climate is your personality, weather is your mood”. The notion of climate is also a social construction (Hulme, 2017; see section 2.2 below).

For as long as humans have existed, we have contended with natural hazards across our dynamic planet, including extreme weather events such as cold snaps, droughts, floods, heatwaves, and tropical cyclones (a.k.a., hurricanes or typhoons, depending on where they occur). Extreme weather can cause loss of life and public health crises, destroy infrastructure, harm natural and cultural heritage, and spark a range of secondary social consequences and feedback loops. For instance, gender-based violence has been shown to increase in their aftermath (van Daalen et al., 2022). Poorer populations and minority groups are often disproportionately affected, exacerbating existing social inequalities (World Bank, 2020). Multiple simultaneous or consecutive hazards and other drivers of risk can also combine to create compound events (Zscheischler et al., 2020).

Climate change does not directly cause extreme weather events to occur, but it is increasingly altering the frequency, duration, and intensity of many kinds of extreme weather events across many parts of the world (IPCC, 2021). For example, 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 in many regions (Clarke et al., 2022). The term intensity (sometimes referred to as magnitude or severity) has different weather-specific definitions (e.g., referring to wind speed, amount of rainfall, or temperatures

during a heatwave). Climate change affects distinct types of weather in different ways and scientists have varying levels of confidence in their understanding of these effects in different areas. For instance, there is a strong level of understanding and consensus regarding the effects of climate change on heatwaves (Perkins-Kirkpatrick & Lewis, 2020). In contrast, there is greater uncertainty concerning the effects of climate change on tropical cyclone frequency (Sobel et al, 2021). Additionally, climate change does not necessarily affect every extreme weather event. For example, researchers found that the role of climate change in the 2021 Madagascar drought was negligible compared to natural variability (Harrington et al., 2021).

Climate scientists typically examine these effects through detection and attribution analyses. Detection is the “process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense without providing a reason for that change”, whereas attribution refers to “the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence” (Hegerl et al., 2010, p.2). Put simply, detection examines if the climate has changed, whereas attribution examines the factors causing these changes and their respective effects.

Attribution techniques have dramatically advanced over the last two decades (van Oldenborgh et al., 2021). Allen (2003) initially proposed calculating the changing risk of specific extreme weather events due to climate change. Since that time, climate scientists have developed techniques to estimate the extent to which human-driven climate change might have influenced an extreme weather event’s likelihood and magnitude, known as extreme event attribution (EEA) (National Academies of Sciences, Engineering, and Medicine, 2016). EEA is rapidly growing with an increasing number of studies each year, greater recognition by the scientific community, and significant international media coverage. Its key novelty is that it offers a

significantly more granular perspective of how climate change influences specific extreme events that move beyond general descriptions of meteorological relationships (i.e., statements such as “climate change makes this kind of weather more likely”). Potential applications of attribution include supporting loss and damage mechanisms (James et al., 2019), climate litigation (Marjanac, Patton & Thornton, 2017), and climate adaptation planning (Clarke et al., 2023).

There are several EEA methods (Easterling et al., 2016; Hay & Williams, 2023; Shepherd et al., 2018). In this thesis, I focus mostly on the risk-based approach in which scientists explore how climate change altered the probability or likelihood of an event occurring. For this method, scientists develop comparative climate models to assess how a specific extreme weather event plays out in simulations of our planet with all the GHGs we’ve added to the atmosphere, versus simulations where every factor remains the same except GHGs are removed to pre-industrial levels (or another comparable baseline). This enables a counterfactual comparison to isolate the effects of climate change on the event.

The robustness of attribution analyses depends primarily on three factors: accuracy and records of weather observations; fitness for purpose of climate models to simulate weather; and a strong scientific basis of atmospheric processes and how climate change affects them (Marjanac, Patton & Thornton, 2017). Scientific confidence in the results varies across different types of extreme weather. Certain aspects of heat and cold extremes, for example, are generally simpler to attribute, whereas wildfires and tropical and extratropical cyclones are more difficult (National Academies of Sciences, Engineering, and Medicine, 2016), although the science continues to advance. Currently, the evidence available from attribution research is biased towards high-income countries, mainly because of a lack of high-quality observational data

and research capacity in many countries of the Global South – a situation researchers are trying to rectify (James et al., 2014; Otto et al., 2020).

Importantly, how researchers define extreme weather events and frame their research questions can lead to different answers. For instance, two separate studies of a 2010 Russian heatwave appeared to provide contradictory results, which were only reconciled when it was shown that they explored different questions – one explored event likelihood while the other tested magnitude (Otto et al., 2012; Stott et al., 2016). Researchers may also consciously or unconsciously have a selection bias regarding which events they choose to analyse because of limits on the quality of climate models, time, and resources, or because of prior interest in a particular event (National Academies of Sciences, Engineering, and Medicine, 2016).

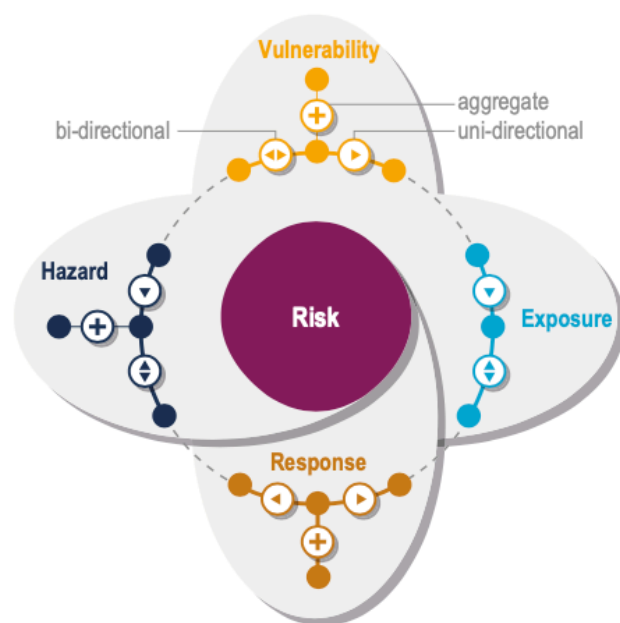
Scholars across disciplines continue to debate various aspects of EEA. Some scientists have argued over which types of attribution techniques are more appropriate and accurate (e.g., Allen, 2011; García-Portela & Maraun, 2023; Olsson et al., 2022). Nonetheless, these different approaches are not mutually exclusive and can complement one another (Jézéquel et al., 2018). Some researchers also argue that EEA overall is too conservative and understates the effects of climate change (Lloyd et al., 2021). I acknowledge the importance of these debates concerning EEA methodologies and applications; however, this thesis focuses on public engagement aspects of EEA, rather than physical science dimensions.

Beyond aspects of the physical science, other scholars have challenged EEA's utility for supporting climate adaptation decisions (Hulme et al. 2011), arguing that investments in adaptation should be made based on vulnerability (see following section), rather than meteorological aspects of weather events. Likewise, there are concerns that EEA results may

displace attention from vulnerability and disaster risk reduction, enabling policymakers to strategically blame climate change to evade responsibility for local planning failures (Lahsen & Ribot, 2021). In fairness, attribution scientists do not disregard other factors that affect risk, but rather seek to “add to the wider pool of evidence of climate change impacts” (Parker et al., 2017, p.544) and are increasingly incorporating vulnerability into their studies. For instance, the study of the 2021 Madagascar drought mentioned earlier found that poverty and a strong reliance on rainfall, rather than climate change, predominantly fuelled food insecurity associated with the drought (Harrington et al., 2021). Scientists can also use vulnerability to guide their extreme event definitions, e.g., examining the effects of climate change on heat events that exceed a certain temperature threshold that is associated with substantial health impacts (Clarke et al., 2022). Still, the notion that focusing on meteorological dimensions of extreme weather could distract from considerations of vulnerability is one of several important questions around communication aspects of EEA and extreme weather events more generally.

### 2.1.3 Extreme weather risk dynamics

Risks from extreme weather events are shaped by complex interactions between four key factors – climate-related hazards, exposure, vulnerability, and responses (IPCC, 2022, figure 2.1). A hazard is “the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well



**Figure 2.1:** IPCC (2022) visual representation of how disaster risk arises from complex interactions among exposure, hazards, vulnerability, and responses.

as damage and loss to property” (IPCC, 2023, p.9); exposure refers to assets that can be impacted by hazards; and vulnerability describes the extent to which assets exposed to hazards are susceptible to being adversely affected. Perceptions of these risk factors may differ across countries and between citizens in the Global North and Global South (Lizarradle et al., 2021). While climate change affects meteorological aspects of extreme weather events, the damages wrought by these events depend on who and what is in harm’s way, and their ability to withstand hazards (sometimes referred to as resilience).

The impacts of extreme weather events and other types of hazards, such as industrial accidents and pandemics, interact with levels of development and poverty, and can exacerbate existing inequalities and vulnerabilities. Development may also increase the assets exposed to hazards. Conversely, addressing poverty and development challenges may help improve resilience to hazards (Codjoe & Atiglo, 2020; Leichenko & Silva, 2014). This especially includes the implementation of disaster risk reduction measures to reduce the impacts of hazards, including through emergency responses, early warning systems, evacuation plans, infrastructure plans, and other strategies (UNDRR, 2015). These strategies (ideally) take into account that children, elderly individuals, people of colour, low-income communities, and marginalised groups are often more vulnerable to extreme weather events than the general population (Benevolenza & DeRigne, 2018). Moreover, the impacts of these events are fundamentally interrelated with social structures, power dynamics, and intersectional aspects of identity such as age, ethnicity, gender, and sexual orientation.

As mentioned earlier, some researchers have cautioned that a focus solely on climate change could displace attention from the roles of adaptation, exposure, disaster risk reduction strategies, and vulnerability in shaping risks from natural hazards (Chester, 2020; Kelman et

al., 2015; Lahsen & Ribot, 2021). Although climate change remains a crucially important consideration, there are concerns that focusing entirely on the climate change signal in extreme weather events “sidelines local ways of reducing vulnerability to extreme weather and that it can end up absolving policymakers of their own failures to climate-proof their citizens” (Pearce, 2022, p.1). Likewise, there have long been critiques of the phrase “natural disaster” as it belies the role of planning in limiting harmful impacts of extreme events (Chmutina & von Meding, 2019). How well communities and policymakers prepare for these events ultimately determines if hazards become disasters (Raju et al., 2021).

A key point is the interconnectedness of risk dimensions: climate change, in combination with exposure and vulnerability, has increased costs associated with many weather-related disasters around the world for several decades (Bouwer et al., 2019; Ebi et al., 2021). Limited research has explored how to effectively communicate these nuances. Most empirical studies seem to focus either on communicating climate change or communication aspects of disaster risk reduction (DRR) measures (e.g., evacuation procedures).

## **2.2 Public engagement with climate change and extreme weather**

*“Public sentiment is everything. With it, nothing can fail; against it, nothing can succeed.”*

*Abraham Lincoln*

### *2.2.1 Why the public matters for climate action*

Members of the public (i.e., individuals who do not have an academic and/or professional career background related to climate change) play a crucial role in climate action. First, individuals can act on climate change through their lifestyle decisions, including behaviours related to one’s diet, transportation choices, and energy use (Wynes & Nicholas, 2017). The public can also shape the ways in which people around them and their communities engage

with climate change. For example, climate activists engage in discussions with family and friends to help translate existing concerns about climate change into taking individual action (e.g., through lifestyle decisions), seeking to overcome what is sometimes referred to as the value-action gap or concern-action gap (Fine, 2022). Although a majority of people in most surveyed countries report feeling concerned about climate change, this does not necessarily translate into the adoption of personal behaviours to address climate change (Fagan & Huang, 2019).

Many decarbonisation and adaptation solutions require public buy-in and participation to ensure their success (Hügel & Davies, 2020). To name one example, transitioning energy systems away from fossil fuels, such as through the construction of renewable energy infrastructure, can encounter significant opposition without community support (Perlaviciute et al., 2018). Cultural and social norms can also have a profound influence on individual behaviours. Bergquist et al. (2023) conducted a meta-analysis of climate mitigation behaviour interventions. They found that interventions were most effective when “based on social comparisons or financial incentives, but least effective when based on education or feedback alone” (p.4). For these reasons, a report commissioned by the United Kingdom’s Department for Business, Energy, and Industrial Strategy notes that effective public engagement is essential for successfully achieving net zero targets (Demski, 2021).

In terms of addressing climate change at a policy level, public opinion informs and influences policymaking, and can affect societal emissions pathways (Brulle et al., 2012; Moore et al., 2022). Public support for climate action provides a policy mandate that helps facilitate political actions to address climate change, especially those that impose societal costs (i.e., use of taxpayer money, new regulations and taxes, etc.). By voting on candidates with different kinds

of policy platforms, citizens may also influence policy outcomes and societal emissions pathways. Through climate activism, citizens can apply pressure on policymakers, the private sector, and other actors to help catalyse systems-level changes to address climate change (Farmer et al., 2019). Activism, also known as collective action, refers to actions taken by individuals to advance the interests, status, power, or conditions of a group (Van Zomeren & Iyer, 2009). Although activism is often associated with protests, it can include many different activities and be practiced in a wide variety of ways (Dalton, 2015). Common expressions of climate activism include participating in protests and strikes, signing petitions, blockades of fossil fuel infrastructure, acts of nonviolent civil disobedience, contacting elected officials, and donating to environmental organisations. Activism may help counter lobbying efforts by fossil fuel companies and other special interest groups that have obstructed climate action in many countries for decades (Supran & Oreskes, 2021).

### *2.2.2 Climate change communication*

Effective communication is vital for engaging the public (and other actors) about climate change. Thus, climate change communication has emerged as a significant field of research over the last several decades, evolving from a “wild west” to a formal research landscape (Moser, 2016, p.346). It is highly interdisciplinary, drawing on anthropology, climate science, geography, political science, psychology, and science communication/risk communication more broadly. In general, the field has three overarching research strands. First, researchers track attitudes, beliefs, and behaviours related to climate change at local, regional, national, and international levels and the potential factors that drive changes in these variables. They have developed nuanced frameworks that segment citizens into distinct climate attitudinal groups that go beyond the simple binary whether one believes in climate change or not. Indeed, the term “the public” belies a diversity of attitudes, beliefs, cultural backgrounds, opinions, and

values (see chapter 3). For instance, the Six Americas of Global Warming framework categorises Americans along a spectrum of feeling alarmed to dismissive of climate change, with nuanced categories in between (Leiserowitz et al., 2023). Researchers have developed similar climate attitude segmentation frameworks for other countries (e.g., Wang et al., 2020).

Second, researchers analyse climate-related content across different communication channels, especially news media and social media (e.g., the prevalence of climate change scepticism/denial, misinformation, and other related issues). Third, researchers adopt a strategic communication approach to test how different audiences respond to different ways of framing climate change – the act of emphasising certain salient characteristics while neglecting others when describing phenomena (Entman, 1993). They also explore dynamics around different kinds of communication channels and formats (e.g., text, video, virtual and augmented reality), different communication styles (e.g., scientific text, journalistic formats, narrative storytelling, emotional narratives), and different types of messengers. These studies primarily use experimental designs conducted with surveys, interviews, and focus groups, and often test climate messages that are tailored to the beliefs and values of distinct climate attitude groups.

Over the last several decades, studies across these three research strands have together revealed a wide variety of communication dynamics and psychological nuances that can influence the ways individuals engage with climate change information. Examples of these psychological factors include distinct emotions such as anger, anxiety, fear, hope, and guilt (Brosch, 2021; Ettinger et al., 2021; Smith & Leiserowitz, 2013); cultural identity, politics, and worldviews (Newman et al., 2018); qualities of the messenger/source of information and perceptions of personal identity (Fielding et al., 2020); and a variety of cognitive biases including

confirmation bias (seeking information that supports one's beliefs and opinions) and motivated reasoning (processing information in ways that support one's beliefs and opinions) (Borick & Rabe, 2017), although some researchers challenge the assumptions of motivated reasoning (Druckman & McGrath, 2019). Individuals are also embedded in complex communications ecosystems with many messages coming across many different channels at once. These insights have contributed to a broader shift in science communication from a public understanding of science model to a public engagement with science model (see chapter 3). Many of these concepts, effects, and implications for communication continue to be debated.

Scholars have critiqued several aspects of the climate change communication field. A significant challenge facing this field (and many other disciplines) is the need to better diversify the regions in which this research is conducted, which most often focuses on Australia, Canada, the United States, and western Europe (Chadwick, 2017). Other limitations concern the external validity of climate change communication research (which affects other types of communication research as well), including difficulties incorporating longitudinal components, as well as to what extent the effects (or lack thereof) found in controlled experiments are an accurate reflection of reality.

### *2.2.3 Extreme weather events and climate change issue engagement*

Weather is one of the fundamental ways humans engage with, and make sense of, the physical environment (Barry et al., 2020). Spanning religious interpretations to scientific understandings, cultures around the world have sought to explain, predict and, in some cases, control the weather (Endfield & Veale, 2020; Hulme, 2017). Weather is a universally relatable phenomenon, helping form one's sense of place and inspiring a quip often attributed to Oscar Wilde: "conversation about the weather is the last refuge of the unimaginative" (Jackson,

2017). Likewise, how humans interact with weather is a central theme across the arts and humanities (Duxbury, 2010; Lindborg, 2018; Thornes et al., 2010). There is also growing interest among cultural and human geographers in critically assessing narratives (typically western) that delineate people from weather and nature (Bawaka Country et al., 2018; Hepach & Lüder, 2023 Jackson, 2021; Wright & Tofa, 2021).

At a more pragmatic level, many researchers have hypothesised that extreme weather events could counter the abstract qualities or psychological distance of climate change (Halperin & Walton, 2017; Zanocco et al., 2019). Construal Level Theory (CLT) proposes four dimensions of psychological distance, including proximity (i.e., how close an event feels in physical space), social aspects (to whom an event occurs), temporality (when an event occurs in time), and a hypothetical component (perceptions of whether an event is likely to happen) (Trope & Liberman, 2010; Spence et al., 2012). According to CLT, by virtue of its tangible, visceral and local impacts, extreme weather could act as a wake-up call or “sentinel” of climate change that makes risks more visible, concrete, and psychologically close across these four dimensions, which in turn could prompt stronger support for climate action (Hamblyn, 2009; Rudiak-Gould, 2013). Researchers have also examined whether extreme weather events can also influence subsequent policymaking, often referred to as focusing events or teachable moments (Birkland & Schwaeble, 2019).

Accordingly, a growing body of research has sought to examine how extreme weather events might shape how the public engages with climate change in terms of attitudes (e.g., Spence et al., 2011), beliefs (e.g., Whitmarsh, 2008) and, in more limited studies, behaviour (e.g., Hazlett and Mildemberger, 2019). Researchers have particularly focused on the role of direct extreme weather experiences in shaping public opinion about climate change (e.g., Akerlof et al., 2012;

Albright & Crow, 2015; Demski et al., 2017). In terms of methods, studies exploring potential relationships between extreme weather experience and climate change perceptions typically survey people in regions affected by a weather event and try to ascertain any potential changes in a variety of different climate change engagement variables.

A meta-analysis by Howe et al. (2019) examined 73 of such studies. Although significant differences in study methodologies limited comparisons, they found mixed results: some studies suggest that weather experiences can increase climate change attention (salience) and beliefs (e.g., Shao, 2017; Spence et al., 2011; van der Linden, 2014), but the extent of these effects may change over time (Konisky et al., 2016; Ray et al., 2017). Other studies find no measurable impact of extreme weather experiences on climate change perceptions (e.g., Mildenberger & Leiserowitz, 2017; Sun & Han, 2018; Whitmarsh, 2008). Since Howe et al.'s (2019) meta-analysis, newer studies have continued to offer mixed results. For instance, Wong-Parodi and Rubin (2022) found that wildfire experiences in the United States were associated with stronger pro-environmental attitudes and intentions, whereas Gärtner and Schoen (2021) concluded that flooding experiences in Germany were not associated with any changes in climate change attitudes or support for climate policies.

These mixed results may be partly explained by individual psychological dynamics. Aligned with observations across the broader science communication literature, studies examining public engagement with extreme weather have noted the role of contextual socio-cultural factors and psychological dynamics in shaping how individuals interpret relations between weather events and anthropogenic climate change (Borick & Rabe, 2017). Motivated reasoning can lead individuals to process extreme weather events in ways that support their pre-existing beliefs about climate change, guiding whether individuals subjectively attribute phenomena to

climate change (Capstick & Pidgeon, 2014; Reser et al., 2014; Thaker & Cook, 2021; Wong-Parodi & Rubin, 2022). In the United States, for example, 60% of Democrats reported that they have personally experienced the effects of global warming compared to 22% of Republicans (Marlon et al., 2021).

Similarly, Ogunbode et al. (2019) found that prior climate change beliefs and political views influenced whether members of the public attributed UK floods in the winter of 2013/2014 to climate change. Boudet et al. (2019) studied 15 US communities that experienced extreme weather between 2012 and 2015 and concluded that a variety of factors influenced discussions about climate change after the event, including educational levels, political views, as well as the scientific understanding of links between the kind of event and climate change. Zanocco et al. (2018, p.363) noted a similar process occurring among members of the public, stating: “If policymakers and scholars are looking to turn extreme weather events into teachable moments, the educational window appears to be context dependent.” Smith and Jenkins (2013) point out, however, that extreme weather might be able to transcend political divisions and other individual ideological barriers by focusing on bipartisan matters of concern (i.e., harm from weather).

There are several important limitations across this body of literature examining how extreme weather events affect public engagement with climate change. Most studies focus on responses to single specific weather events rather than compound, multiple overlapping events. It is reasonable to assume that multiple extreme weather events (and other climate-related experiences and observations) can combine to affect how people perceive and act upon climate change. Likewise, most research on this topic focuses on direct experiences, rather than vicarious experiences at a distance such as reading about extreme weather in the news (Ballew

et al., 2022). Noting that public opinion polls show that most people perceive climate change as happening presently and in close proximity, Van Valkengoed et al. (2023) argue that the importance of seeking to reduce the psychological distance of climate change is overstated. On the other hand, as described, these perceptions vary substantially among individuals with dissimilar climate change views and political beliefs.

It is also important that researchers consider a more longitudinal perspective – although climate concerns may be heightened in the immediate aftermath of a weather-related disaster, in some instances there is a stronger motivation to move on from an event, rather than address the underlying risks, so concerns may quickly fade (Crow & Albright, 2019). The regular occurrence of more frequent and severe extreme weather events could also become more normalised over time as part of a shifting baseline process (Groff, 2022; Soga & Gaston, 2018).

#### *2.2.4 Communicating extreme weather and climate change links*

Although studying potential climate-related attitude, belief, and behaviour shifts in the wake of direct extreme weather experiences merits continued examination, more proactive communication efforts for engaging the public on connections between climate change and extreme weather are comparatively under-researched (Sisco, 2021). In contrast to dozens of studies in which researchers examine public perceptions of extreme weather events, there exists significantly less research into whether and how climate change communication could play a more direct role in facilitating learning and action among the public in the wake of extreme events. This need was recently pointed out by the United States Federal Emergency Management Agency (FEMA), which identified climate change communication after extreme weather events as a key strategic priority for improving disaster risk management (FEMA, 2022). As noted by Ogunbode et al. (2019, p.38), “Public engagement efforts could be

significantly aided by placing scientific evidence of the connection between extreme weather and climate change, where available, at the fore of climate change communication.”

Researchers have examined several different aspects of communicating links between extreme weather events and climate change. First, there has been significant interest over the past 10 years into the role of television meteorologists/weathercasters as climate change communicators and educators (Feygina et al., 2020; Holmes et al., 2017; Maibach et al., 2022). Television meteorologists are seen as familiar and trusted messengers and thus are well-positioned to add climate change-related content into their programming to boost climate literacy among viewers in the context of daily weather (Myers et al., 2020). However, they may be somewhat constrained in their professional reporting context in the extent to which they directly advocate for specific individual and policy-level actions to address climate change.

Next, there are various publications that offer guidance for effectively and accurately communicating links between climate change and extreme weather links. Hassol et al. (2016) provide communication principles to help climate scientists more effectively share their findings on this topic, including using phrases such as “a range” rather than “uncertainty”, leading with what information is known, and using metaphors such as “weather on steroids” or “loaded dice”. Lewis et al. (2019) suggest communicating EEA results using calibrated language and levels of confidence in a similar manner to IPCC reports. Seeking to move toward a more participatory communication model, other researchers have experimented with board games and other visual demonstrations to portray how climate change can influence extreme weather events (Dryden & Morgan, 2020; Parker et al., 2016). MacIntyre et al. (2019) reviewed articles related to extreme weather communications in a public health context – they found that

studies overall support the notion that these events present a unique climate change communication opportunity. However, Dixon et al. (2019) found that messages highlighting the ways in which climate change influences different types of weather extremes triggered resistance in audiences sceptical of climate change. The organisation Climate Outreach suggests that messages related to extreme weather and climate change should go beyond the science by tapping into shared values and human dimensions, such as community solidarity and resilience in the aftermath of disaster (Marshall, 2014).

Third, a growing body of literature has assessed to what extent and how weather events are linked to climate change across different communication channels. Journalists are increasingly connecting extreme weather events to climate change and generally offering more coverage to climate change than in the past several decades (Boykoff et al., 2022; Painter & Hassol, 2020). On the other hand, some researchers and climate action advocates argue that journalists are still not covering climate change with a level of quantity and/or quality commensurate with the scale of threats it poses (End Climate Silence, 2023; Perga et al., 2023). Among media studies focused specifically on extreme weather events, Berglez and Lidskog (2017) noted variations in the frequency of climate change mentions in coverage of wildfires in media outlets across different countries. Hopke (2020) found a growing trend of climate change mentions in articles about heatwaves and wildfires from 2013-2018. Different outlets – especially across the political spectrum – often report on this link differently, with climate change scepticism being more prevalent among politically conservative outlets (Carbon Brief, 2018; Painter et al., 2023). There is growing interest in climate visuals. O’Neill et al. (2023) analysed visuals associated with media coverage of the European 2019 summer heatwaves, finding that positive “fun in the sun” photos contrasted with headlines and article content on the risks of climate change.

There have also been analyses of extreme weather discourses on social media platforms. These studies have shown that the occurrence of weather events is associated with an increase in posts that mention climate change (Kirilenko et al., 2015; Sisco et al., 2017), with different kinds of weather events generating varying amounts of attention to climate change (Berglez & Al-Saqaf, 2019; Moernaut et al., 2022; Roxburgh et al., 2019). For example, Olynk Widmar et al. (2022) found that posts about hurricanes mentioned climate change less often than wildfires. Other analyses have examined the role of social media as an emergency communication and disaster response tool during extreme events (e.g., Kankanamge et al., 2020; Liu et al., 2018; Zander et al., 2022).

Research on communication aspects of extreme event attribution continues to be published and EEA's potential communication value is often pointed out (e.g., Messling et al., 2015; National Academies of Sciences, Engineering, and Medicine, 2016; Sippel et al., 2015; Stott & Walton, 2013). By quantifying climate change's effect on a specific weather event, attribution studies could make the risks of climate change less abstract, going beyond descriptions of general meteorological relationships between global warming and weather. This is why representatives of environmental organisations have previously expressed an interest in using attribution for their public campaigns and communications (Sippel et al., 2015).

Others have examined aspects related to media coverage of EEA. Osaka and Bellamy (2020) conducted interviews and focus groups with scientists, journalists, policymakers, farmers, and environmentalists to examine reactions to media coverage of attribution studies examining the 2011-2017 California drought. They found that participants tended to doubt the rigour of the science when presented with a range of attribution studies of the same event. Painter et al.

(2020) examined media coverage of extreme rainfall and a heatwave that occurred in 2015 in India (in Chennai and Andhra Pradesh, respectively). The analysis showed that politicians and environmental organisations frequently blamed climate change, yet EEA studies were rarely cited in news reporting. In a subsequent study, Painter et al. (2021) examined media coverage of the 2019 European heatwaves across news outlets in France, Germany, the Netherlands, and the United Kingdom. EEA studies of the heatwaves (see chapter 4, section 4.2.3) received a large volume of coverage, but there were significant differences in how much attention climate change received in articles across different countries and outlets.

Audience characteristics may influence how individuals respond to attribution information. The organisation Practical Action tested EEA communication approaches in Kenya and India, examining responses to different wording choices and visuals to describe probability, intensity, frequency, and uncertainty dimensions of EEA (Budimir & Brown, 2017). They found that local decision-makers, media officials, and members of the public responded differently to distinct word choices and visuals used to describe EEA results, suggesting a more tailored communication approach. Hai and Perlman (2022) tested in an experiment how Americans responded to a statement from a politician that attributed wildfires to climate change (though the treatment material did not include a specific EEA study). Republicans reacted negatively, expressing less confidence in the politician's ability to address extreme weather events and offering less support to reduce risks from wildfires in the future. This demonstrates the importance of considering one's audience when designing climate communication approaches and materials.

### **2.3 Literature review summary and research gaps**

Extreme weather events present a potentially promising opportunity to engage the public about climate change and promote climate action, and extreme event attribution results might support such efforts. Prior research has predominantly focused on measuring effects of extreme weather events on public opinion about climate change retrospectively, rather than testing more proactive communication strategies (i.e., efforts to engage the public about climate change when these events occur). Further research is needed as there are an array of associated challenges such as what actions climate communicators should encourage in the wake of these events; how communicators can effectively disentangle the complex interactions between exposure, hazards, vulnerability, and responses; the potential utility of extreme event attribution findings as part of public engagement strategies; and interactions between personal experiences of extreme weather, subjective attribution to climate change, and emotional responses with individual climate action. There are also uncertainties around the optimal timing of such interventions, how long audiences may remain receptive to climate information after extreme weather events, and whether the increased frequency and intensity of many types of extreme weather could become perceptually normalised over time (Hersher, 2022; Moore et al., 2019).

Furthermore, researchers have focused almost entirely on one-way communication channels – I found minimal publications that specifically examined two-way dialogue-based climate change communication strategies after extreme weather events. As noted by MacIntyre et al. (2019, p.153), “Despite many authors highlighting that risk communications should be understood as a ‘two-way exchange between parties,’ the current literature suggests that most communication is a uni-directional warning from decision makers to an uninvolved public, rather than a dialogue”. There is a need for further research on dialogue-based public

engagement approaches in the extreme weather context (e.g., interpersonal conversations among family and friends).

Given the wide array of dynamics and potential issues associated with engaging the public on how climate change relates to extreme weather events to encourage individual climate action, it is important that environmental advocates, communicators, and scientists more holistically understand benefits and challenges of this strategy. This is the central aim of this thesis, which is grounded in two case studies – the 2019-2020 Black Summer Australian bushfires and the 2019 UK summer heatwaves (see chapter 4.2) – to examine how climate communicators such as activists and scientists can help encourage a variety of individual climate actions in the wake of extreme weather events.

### **3. Theoretical framework**

I use the concept of public engagement with science and technology (PEST), also known as the dialogue model, as the theoretical framework underpinning this thesis (Stilgoe et al., 2014). To explain the PEST model, it is easiest to first describe the public understanding of science (PUS) model, also referred to as the knowledge deficit model or information deficit model. Although the acronyms PEST and PUS are not particularly appealing, these concepts have fundamentally important implications for the relationship between researchers and members of the public (Hulme, 2009). The deficit model assumes that non-experts have deficits in their understanding and communicating information can help fill these gaps – individuals will, in turn, accept this information and make logical decisions based on it (Sturgis & Allum, 2004). For instance, health professionals may communicate research findings that demonstrate the effectiveness of vaccines to encourage individuals to vaccinate themselves.

The basic transfer of knowledge remains fundamentally important. As we live in an era of widespread misinformation and disinformation, communicating facts about which there is a high degree of scientific consensus is vitally important to inform evidence-based decision-making. However, scholars have long critiqued the deficit model as it assumes that attitudes, beliefs, and behaviours are based solely on knowledge, rather than a complex array of personal contextual, cultural, and value-driven factors (Simis et al., 2016). It also tends to treat the public as a single entity when it is in fact composed of diverse groups and individuals. The plural “publics” is therefore more accurate than singular phrase “public”. However, for simplicity I use the singular public throughout this thesis.

In contrast to the deficit model, the public engagement approach does not view communication as a one-way transfer of knowledge from expert to lay person. Instead, it seeks to break down

divisions between technical and public spheres to facilitate spaces for the exchange of ideas, opinions, and information (Suldovsky, 2017). It acknowledges that we are more complex than information processing machines; subjective factors such as our existing attitudes, political views, and cultural backgrounds influence how we respond to information and engage with societal issues. Public views may also inform research aims and practices.

At a practical level, public engagement can entail direct exchange between experts and non-experts, such as through science exhibitions and fairs, town halls, citizen science projects, and citizen assemblies (Akin & Schuefele, 2017). Moreover, this approach also recognises that there is more to scientific issues than science alone, seeking to create spaces in which individuals can express a wide range of attitudes, beliefs, emotional responses, ethical perspectives, moral values, and prior experiences related to pressing societal challenges (Dietz, 2013). Public views can (and should) inform decision-making about issues at the interface of science, technology, and society (Weingart et al., 2021). However, public engagement also has its own set of limitations. Conducting public engagement activities can be time and resource intensive, and it can be difficult to reach individuals not already interested in the topic (Scheufele, 2018). The concept is often deployed vaguely in a wide variety of contexts and theoretical discussions can be divorced from practical applications (Weingart et al. 2021).

In utilising public engagement as a theoretical framework in the climate context, a foundational assumption of this thesis is that climate science is one piece of a broader mosaic of perceptual, political, psychological, and socio-cultural dynamics that shape climate change knowledge, emotions, and behaviour (Whitmarsh et al., 2013). I particularly focus on the notion of dialogue – and specifically interpersonal discussions – as part of how the public engages with climate change. The public engagement model informed my research by encouraging me to incorporate

qualitative research methods to better understand the nature of extreme weather experiences and public perceptions of climate change, as well as to focus on dialogue-based climate change communication approaches. I also do not dismiss the basic premise of deficit-style knowledge transfer. I view public engagement as further diversification of the ways researchers engage with society about climate change (and other issues), rather than a replacement of one-way communication structures.

## **4. Methodology**

This chapter provides an overview of the methodology of this thesis. This includes a description of the two thesis case studies, (the 2019 UK summer heatwaves and 2019-2020 Australian Black Summer bushfires), an assessment of the strengths and limitations of the methods used in each of the papers, the study samples, and the analysis approach. I also reflect on ethics, risks, reflexivity, and power relationships, and explain the steps I took to address these issues. Finally, I show how I used the “Eight ‘Big-Tent’ Criteria for Excellent Qualitative Research” to support a high level of research quality throughout the process of conducting this work.

### **4.1 Research paradigm**

A research paradigm is “a set of assumptions and perceptual orientations shared by members of a research community” that influence the selection of research methods to examine phenomena (Given, 2008, p.8; Kuhn, 1962). Research paradigms are generally situated along a continuum between constructivism and positivism. Constructivism views the world and knowledge as being entirely subjectively created, thus encouraging qualitative methods to understand how individuals make sense of the world; positivism views reality as objectively “true” and mostly lends itself to quantitative methods (Guba & Lincoln, 2005).

This thesis subscribes to the research paradigm of pragmatism, which offers a practical middle ground between constructivism and positivism. The theory is rooted in the writings of Charles Peirce, William James, and John Dewey (Leary, 2009), and has been adapted for contemporary applications, especially in the context of mixed methods research (Biesta, 2010; Feilzer, 2010; Morgan, 2014). Pragmatism avoids becoming entangled in metaphysical debates about the nature of reality (ontology) and human knowledge (epistemology). Instead, it acknowledges

that there may indeed be an objective world, but it can only be observed and interacted with through subjective human experiences and perceptions (Johnson & Onwuegbuzie, 2004). It also seeks to ground research more directly in its practical implications (Bacon, 2012). As described by Weaver (2018, p.2), pragmatism “focuses on ‘what works’ rather than what might be considered absolutely and objectively ‘true’ or ‘real’.”

Pragmatism supports mixed methods given its flexibility and focus on research questions and implications, rather than invoking rigid methodological requirements (Kaushik & Walsh, 2019). However, it has been critiqued on the basis that whether mixed methods work effectively in specific contexts cannot be determined prior to conducting the research (Weaver, 2018). With its long history, the concept of pragmatism has also been criticised for a lack of clarity and for offering competing definitions (Mounce, 1997). Nonetheless, as this thesis uses mixed methods to inform practical public engagement strategies while drawing on both positivist-oriented disciplines (i.e., climate science) and more constructivist-oriented disciplines (i.e., human geography), pragmatism is a highly suitable research paradigm. It enables this thesis to acknowledge researcher reflexivity and the subjectivity of knowledge (see chapter 4.6), while still offering evidence-based practical guidance for climate change communication strategies.

## **4.2 Mixed methods**

This thesis adopts a mixed methods approach using both quantitative and qualitative research techniques (Bryman, 2006). Using a combination of methods can offer a rich, well-rounded understanding of a topic by leveraging the strengths of different methodologies while offsetting their limitations (Creswell & Clark, 2018). It also provides flexibility to incorporate diverse kinds of data. On the other hand, mixed methods require significant background knowledge

and training to use contrasting approaches, bear in mind the limitations of each, and successfully synthesise the findings (Fiezler, 2010). Implementing a variety of methods can also require substantial time and resources (Creswell & Clark, 2018). Some researchers argue that mixed methods can help triangulate findings and enhance research validity (e.g., Longhurst, 2016). However, other scholars have pointed out that some methods are more appropriate than others in specific research contexts (Bloor, 2001). Therefore, it should not be presumed that the more methods a researcher uses, the better.

Deployed carefully and strategically, mixed methods enable an exploration and synthesis of a variety of dynamics related to extreme weather and public engagement with climate change. The methods enabled me to draw connections across different kinds of data, which increased the breadth of the analysis and provided a variety of rich and valuable insights. For instance, paper 1 captured in focus groups potential issues around framing the relationship between extreme weather events with climate change without incorporating aspects of climate adaptation, disaster risk reduction, and vulnerability. This finding then informed the research questions of paper 2, which showed that only 15% of tweets by Australian climate action groups mentioned these risk dynamics in the context of the Black Summer bushfires.

Each empirical chapter (chapters 5 - 7) contains a detailed methodology section. However, I offer below a brief discussion of the major strengths and limitations of the methods applied across the thesis, along with justifications for why I used them.

#### *4.2.1 Focus groups*

For paper 1 (chapter 5), I facilitated focus groups to explore how non-climate scientists engage with extreme event attribution results. Focus groups gather small groups of people, typically

between 5-10 participants, to share their opinions about a topic in a group discussion. Researchers have used focus groups as a qualitative research method for the last several decades to examine a wide array of social phenomena, including in the environmental context (e.g., Hares et al., 2010; Nyumba et al., 2018).

Focus groups offer the ability to explore wide-ranging aspects of a topic, capture group interactions, and for researchers to encourage discussions relevant to the research questions (Bloor, 2001). They are especially useful in the early stages of research to examine a wide variety of dynamics around a topic with relatively low cost, e.g., versus paying hundreds or thousands of survey participants (Morgan, 1997). The results in turn can inform subsequent surveys and other research methods. Rather than providing an objective understanding of what people think, focus groups capture “how people talk about what they think, know, or feel” (Secor, 2010, p.195). Focus groups can also inform the design of products and programs, which is why they have a long history in advertising and marketing (Krueger & Casey, 2000; Silverman, 2016).

Focus groups have several methodological limitations. Social desirability bias can lead individuals to respond in ways they believe will make others view them favourably, rather than expressing their actual opinions (Grimm, 2010). The presence of a researcher can also affect participant responses. Focus groups typically use relatively small sample sizes that are not generalisable, and they also generate large amounts of data with multiple speakers expressing a wide range of views that may or may not align, making the analysis process more complex. Focus groups also require careful moderation to ensure that no participant overwhelmingly dominates a discussion.

Focus groups proved a suitable and valuable method for this thesis as they helped mirror the concept of social discussions about the weather, further supporting my emphasis on two-way dialogue in this thesis. Using focus groups for the first study also revealed a variety of dynamics related to climate change communication and extreme weather events early on, which informed all the subsequent studies.

#### *4.2.2 Narrative interviews*

For paper 3 (chapter 7), I conducted interviews to explore how bushfire experiences influenced individual climate change attitudes and activism. Interviews involve a discussion between a person or group and one or more researchers who seek to elicit information from them (Longhurst, 2016). Interviews have similar benefits and limitations as focus groups. Interviews are a flexible method that can generate in-depth exploratory data around individual attitudes, behaviours, experiences, motivations, and perceptions, but they are also subject to social desirability bias and potential interviewer influences on participant responses. They represent how individuals perceive and present themselves, rather than providing objective and verifiable behaviours and experiences. For this reason, in paper 3 I frequently use the phrase “reported” behaviours.

There are a variety of interview approaches, ranging from highly structured formats with a rigid set of questions to more unstructured interviews, such as an oral history (Dunn, 2016). I used narrative interviews, which is a semi-structured interviewing technique that seeks to encourage participants to tell stories with relatively minimal interference from the researcher, except for points of clarification (Anderson & Kirkpatrick, 2015; see chapter 7). As paper 3 focused on diving deep into experiences of extreme weather and personal journeys of how

these experiences may have influenced individual participation in climate activism, this interviewing approach was a suitable and valuable method.

#### *4.2.3 Case studies*

Social scientists have long used case studies to “understand the concrete and practical aspects of a phenomenon or place” and to offer theoretical insights on contemporary phenomena (Baxter, 2016, p.144). Case studies typically incorporate a mix of quantitative and qualitative approaches and are well-suited to support how and why style research questions (Yin, 2014). A key challenge of case studies is their generalisability. Researchers must exercise caution in generalising from case studies to other circumstances. Yin (2014, p.21) notes that the goal of a case study is “to expand and generalize theories (analytic generalizations) and not to extrapolate probabilities (statistical generalizations).” In other words, case studies can help advance theoretical understandings of a topic, but researchers should not imply that the findings are necessarily representative of other populations that have not been studied in a similar manner.

As the topic of climate change communication and public engagement after extreme weather events is quite broad and interdisciplinary, I use two case studies to narrow my focus and ground high-level theoretical concepts in specific events and geographical locations. There are different types of case study methodologies (Yin, 2014). This thesis uses instrumental case studies, which are helpful for testing existing theories and examining concrete, pragmatic dimensions of broader phenomena (Baxter, 2016).

Importantly, researchers often use multiple case studies in a comparative manner. This is not the case in this thesis. The initial thesis research plan used the 2019 summer heatwaves in the

United Kingdom as a sole case study. However, the findings of paper 1 showed that individuals can view heatwaves in the UK as beneficial and enjoyable, despite being aware of their negative health and social impacts (see chapter 5). This positive perception poses challenges for turning these events into teachable moments to encourage climate action (see chapters 5 and 9). I therefore widened my focus to include the 2019-2020 Australian Black Summer bushfires as a secondary case study to incorporate an extreme weather event with more ubiquitously negative public perceptions. In the discussion (chapter 9), I reflect on some of the case study differences and their implications; however, a robust comparative case study analysis would have entailed a duplication of identical methods across both case studies, which was beyond the scope of this thesis. The case studies are briefly described below and discussed at greater length in the papers.

#### *4.2.3.1 The 2019 United Kingdom summer heatwaves*

In June and July 2019, Europe experienced two distinct summer heatwaves with varying intensity and impacts across different countries. The heatwaves were caused by a high-pressure system over the European continent and low-pressure systems to the east and west that drove hot air from Africa north (Copernicus, 2019). This phenomenon is known as an omega block because its shape visually resembles the Greek letter omega ( $\Omega$ ). Heat records were broken in many locations, including in Cambridge, UK, where a weather monitoring station measured the country's highest ever temperature of 38.7C (Walker, 2019) – a record broken again during the July 2022 heatwave, when the station recorded a temperature of 40.3C (Holton & Ravikumar, 2022).

Although many citizens enjoy the heat as an opportunity for swimming and other outdoor recreational activities, heat events can be deadly for vulnerable populations including infants,

elderly individuals, people with pre-existing health conditions, outdoor workers, and other marginalised individuals (Kovats & Ebi, 2006; McLoughlin et al., 2022; O’Neill et al., 2022). According to measurements of excess mortality, the heatwaves caused more than 2,500 deaths across Belgium, France, the Netherlands, and the UK, making the heatwaves the deadliest extreme weather event of 2019 (CRED & USAID, 2020). Extreme heat can also cause water shortages, harm the agricultural sector (affecting livestock welfare and crops), damage transportation infrastructure and power grids, and lead to other negative economic and social impacts – all of which occurred in the UK during the summer 2019 heatwaves (Knapton, 2019; Watts et al., 2019).

There were four EEA studies of the heatwaves (Ma et al. 2020; Van Oldenborgh et al. 2020; Vautard et al. 2020). Every study found that climate change made the heatwaves more likely to have occurred. In the UK, Vautard et al. (2020) found that climate change increased the likelihood of the heatwaves by at least three times. To reduce personal risks from heatwaves, individuals can take preparedness steps such as avoiding dehydration and sunburn, managing heatwave risks in buildings and homes, and ensuring the safety of particularly vulnerable family and friends, such as elderly individuals (Howarth et al., 2023).

#### *4.2.3.2 The 2019-2020 Australian Black Summer bushfires*

Bushfires are a natural feature of the Australian environment, playing both destructive and regenerative roles in Australian ecosystems (Sharples et al., 2016). Australian citizens, communities, and officials have long responded to and managed bushfires, and First Nations Indigenous Australians have practised cultural fire management techniques for millennia. However, conditions associated with heightened bushfire risks have been increasing over the past 70 years in Australia (Abram et al., 2021). Climate change is making many parts of

Australia hotter and drier, which in turn makes bushfires more frequent and intense. Climate change is increasing fire weather conditions in many regions around the world (Jones et al., 2022). Pyne (2020) refers to this global fire increase as the “pyrocene.” At the same time, a wide range of factors play roles in shaping the impacts of bushfires, particularly disaster risk reduction, community planning, and emergency responses (Chester, 2020; O’Neill & Handmer, 2012).

Bushfires pose significant dangers. They threaten public health and safety, property, infrastructure, biodiversity, and natural and cultural heritage. In addition to loss of life and severe injury from direct exposure, bushfire smoke can cause a wide range of harmful health effects (Yu et al., 2020). Bushfire experiences are associated with significant psychological impacts, including post-traumatic stress disorder and depression, and recovering from a direct bushfire encounter, such as losing one’s home, can take many years (Bryant et al., 2014). Indigenous Australians may experience unique forms of bushfire trauma and grief associated with their deep ancestral ties and sense of personal identity connected to the landscape (Allam, 2020; Godden et al., 2021).

The Black Summer refers to the 2019-2020 Australian summer bushfire season, which ran from July 2019 to the end of March 2020. Although fires are an inherent feature of the Australian landscape, during this period, a series of unusually intense bushfires severely affected all Australian states and territories, especially eastern Australia (Abram et al., 2021). Over 30 people were killed as a direct result of the fires and modelling suggests over 400 more people died due to smoke exposure, along with thousands of buildings destroyed and over 30 million hectares of land burnt (Filkov et al., 2020; Johnston et al., 2021; Dickman, 2021). The fires led to billions of dollars of damage and affected billions of animals (Geary et al., 2021).

They also disproportionately affected socio-economically disadvantaged communities (Akter & Grafton, 2021).

The fires received substantial global news coverage, especially at key moments during the season such as when smoke blanketed Sydney (Australian Associated Press, 2019), Victoria declared catastrophic levels of fire weather (Australian Institute for Disaster Resilience, 2023), and when citizens of Mallacoota, Victoria, evacuated to beaches on New Year's Eve, generating dramatic photos and videos (Henriques-Gomes, 2020). Burgess et al. (2020) analysed 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 2010 Black Saturday fires; 16% of articles directly described the relationship of climate change with the fires; and 10% of articles described failures to adequately plan for the fires. Different Australian news outlets pushed contesting narratives about the connection (or not) of climate change to the fires (Burgess et al., 2020; Mocatta and Hawley, 2020). 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 polarisation of different online communities that sought to either propagate or debunk these claims. Ogie et al. (2022) examined disaster recovery on Twitter during and after the Black Summer fires, finding that distinct 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.

Climate change amplified the Black Summer fires: they happened after three consecutive years of drought and dry winters (King et al., 2020), and occurred during Australia's hottest and driest year on record (Abram et al., 2021). An EEA analysis found that climate change made

the fire weather conditions during the Black Summer at least 30% more likely to have occurred (van Oldenborgh et al., 2020). The Black Summer also 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.” This includes under-resourced firefighters, most of whom are volunteers (Smith et al., 2022); a lack of preparation of the Australian healthcare system (Cousins, 2020); long-term land-management decisions, such as insufficient hazard reduction through planned and cultural burns (practised by Indigenous Australian Peoples), although scientists debate the impact of fuel loads on the fires (Bradstock et al., 2020; Levin et al., 2021; Steffensen, 2020); insufficient early warning and emergency communication systems; and, as some have argued, a failure to implement lessons from numerous prior governmental bushfire inquiries (Tolhurst, 2020), 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 mobilisation, enhancing air quality monitoring, increasing climate change adaptation and mitigation, providing additional firefighting resources and support, and improving emergency communication (Commonwealth of Australia, 2020). Individuals can also act to reduce their own personal risks by clearing vegetation around their properties, creating their own bushfire plans, monitoring fire danger ratings, and taking other precautionary steps (Country Fire Service, 2023).

#### 4.2.4 Using social media data for research

In paper 2, I analyse tweets posted by Australian climate action groups during the period of the Black Summer bushfires (see chapter 6 for full methodological details). Social media platforms offer enormous amounts of unique and valuable data that can support research on a multitude of diverse topics (Andreotta et al., 2019). In comparison to elicited discourses – i.e., focus group discussions and interviews, as conducted for papers 1 and 3, respectively – revealed discourses on social media offer a direct window into *in situ* “real world” exchanges that happen as societal events unfold (House, 2018). Social media datasets also enable the collection of longitudinal data and are typically low-cost or free to acquire.

Social media data have important limitations. Social media posts do not necessarily represent the attitudes, beliefs, and opinions of those who post them (whether individual or group accounts), nor do such posts capture internal motivations for posting them – elicited data is better suited for examining these internal dynamics. Social media posts only show how individuals/groups chose to communicate in text and other multimedia content at the time of posting. Social media platforms can provide massive amounts of data and thus require strategic and careful data collection, curation, and analysis methodologies to ensure datasets are suitable for one’s research questions. There are also ethical questions around the use of social media posts for research, especially in cases in which users are not necessarily aware that their content can be used for research purposes (Townsend & Wallace, 2016).

I incorporated these limitations into paper 2 in several ways, which are described further in chapter 6. First, I avoided making claims regarding possible underlying goals, intentions and processes of climate action groups in tweeting about the Black Summer bushfires. Second, I followed a thorough plan to collect and curate the dataset to ensure it was suitable for my

research aims (see chapter 6 methodology section and supplementary materials). Third, I followed the University of Oxford's Central University Research Ethics Committee internet-mediated research guidelines to ensure my study aligned with strong ethical protocols for data collection, management, analysis and publication.

### **4.3 Sample**

This thesis uses purposive sampling, also known as theoretical sampling, in which researchers utilise carefully selected, non-random and non-generalisable populations to study a specific type of phenomenon and advance theoretical understanding (Silverman, 2021). The participants in paper 1 were mostly already concerned or highly concerned about climate change (chapter 6). As part of research ethics planning, I determined that informed consent required telling participants that the focus groups related to environmental issues. Therefore, this may have led to a selection bias toward participants interested in environmental topics. However, it may also be indicative of the fact that only 4% of the UK public report feeling not at all worried about climate change, making it difficult to find participants who are not concerned about it (DESNZ, 2023). As the study's key research aim was to explore how non-climate scientists respond to extreme event attribution findings, this purposive sample remains valid for the purposes of answering the research questions.

Paper 3 also deliberately recruited individuals who had previously participated in climate activism, so a high degree of concern about climate change was essentially guaranteed. I discuss the reasons for this decision in chapter 7. An additional note regarding the paper 3 sample is that the initial plan was to only recruit individuals who directly experienced the 2019-2020 Black Summer bushfires. However, it became quickly evident through the recruiting process that many of these individuals were unlikely to participate because many at the time

(in 2021) were still recovering from the fires. Difficulties finding available and willing participants who experienced these fires were further compounded by attempting to conduct the research virtually from the UK. I therefore widened the sample to include Australian adults who had directly experienced any bushfire event, although several of the 33 participants had indeed experienced the Black Summer fires.

A key limitation regarding the samples of this thesis is the lack of participants who were indifferent to or dismissive of climate change (though I do consider these groups in paper 4). The participants in papers 1 and 3 are also not representative of the United Kingdom and Australian populations, respectively, and the climate action groups sampled in paper 2 are not representative of climate action groups across Australia or globally. Each of the three empirical papers and their associated supplementary materials describes the sampling procedures in detail (chapters 5 – 7).

#### **4.4 Analysis**

I used both quantitative and qualitative content analysis methods to analyse the data generated in papers 1, 2, and 3 (focus group transcripts, tweets, and interview transcripts, respectively). Content analysis is “a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use” (Krippendorff, 2004, p.18). It can examine manifest aspects (surface-level aspects such as words) or latent aspects (deeper meanings) (Kleinheksel et al., 2020). A wide variety of content analysis techniques exist, but they generally involve three steps – preparation/selection of data, coding the data, and reporting results. Deductive content analysis is guided by pre-existing concepts, whereas inductive content analysis is more ground-up/exploratory. Content analysis can be a flexible and useful approach to systematically interpret a wide variety of datasets, including those not created for

research purposes, e.g., social media posts (Drisko & Maschi, 2015). The paper chapters offer further methodological details; however, I briefly note below the analysis techniques used for each paper.

Paper 1 (chapter 5) uses qualitative deductive content analysis to group statements in the focus group transcripts into distinct categories based on the research questions (e.g., “communication benefits” and “communication challenges”). An inductive approach was then used to code statements falling within these categories (Bengtsson, 2016). This approach enabled the analysis to remain exploratory while constrained to the research questions. Paper 2 (chapter 6) involved a quantitative deductive content analysis of tweets from Australian climate action groups during the period of the 2019-2020 Black Summer bushfires. Each tweet was coded for the presence or not of pre-identified criteria based on the research questions. Paper 3 used reflexive thematic analysis to analyse the interview transcripts to explore the influences of bushfire experiences on individual climate activism (Braun & Clarke, 2019). Reflexive thematic analysis is a popular qualitative analysis approach. It was a strong fit for this paper as it is particularly useful to “describe the ‘lived experiences’ of particular social groups” and “examine the ‘factors’ that influence, underpin, or contextualize particular processes or phenomena” (Braun et al., 2019). Paper 4 is a theoretically oriented article that did not involve any data analysis.

#### **4.5 Ethics and risks**

Each of this thesis’s studies raised different ethical concerns and risks. These are described in each of the papers and their supplementary materials. This section discusses some of the overarching ethical concerns and risks across this thesis. I followed the American Association

of Geographers (AAG) statement of professional ethics as a guide in addressing these issues (AAG, 2021).

#### *4.5.1 Implications of COVID-19*

The COVID-19 pandemic had significant methodological implications for the health and safety of participants, my supervisors and collaborators, and myself. I started this thesis in October 2019. When the lockdowns began in March 2020, I shifted my approach entirely to desk-based research (and occasionally living room sofa-based research). All focus groups, interviews, and meetings took place online following government guidance. Conducting focus groups and interviews online offers benefits in terms of easier participant recruitment and convenience; however, online formats can also inhibit the exchange of paralinguistic cues, meaning non-verbal expressions such as body language and facial expressions which are a major aspect of interpersonal interaction (Dunn, 2016). Online discussions may also present technical barriers and difficulties, such as connectivity issues, access to adequate equipment, and limited technical comfort, experience, and training. Pilot focus groups for paper 1 showed that a slightly smaller focus group size than typically advised – 3-5 participants, as opposed to 6-8 (Bloor, 2001) – would enable more fluid and natural discussions online. Smaller focus groups are also not unprecedented and are in fact preferred by some researchers (Morgan, 1996; Bloor, 2001). For the individual interviews conducted for paper 3, participants were allowed to use video and audio or audio only, if they preferred it for personal reasons, and to use their preferred online communication software (e.g., Teams, WhatsApp, Zoom, etc.).

#### *4.5.2 Anonymity and informed consent*

Papers 1 and 3 involved human participants. The University of Oxford's Central University Research Ethics Committee (CUREC) provided ethical approval for these studies. The

participants were assigned pseudonyms to protect their identities. I also did not publish the anonymised transcripts because participant identities could theoretically be ascertained through publicly available details of their interviews (e.g., if a participant described their employer and job title, a contribution to an article or report, etc.). All participants provided consent to participate. For the analysis of tweets as part of paper 2 (chapter 6), I followed the University of Oxford's internet-mediated research ethics guide and CUREC guidelines. As the study focused on publicly available tweets from organisations rather than individuals, ethical review and informed consent were not required. I also confirmed this via personal correspondence with CUREC administrators. The rest of the research was exempt from ethical review in accordance with CUREC guidelines.

#### *4.5.3 Psychological risks*

The topics of climate change and extreme weather events can be emotionally distressing for some individuals. Bearing this in mind, I therefore moderated the focus groups and interviews carefully and with sensitivity to emotional risks. For instance, participants were reminded that they could decline to answer any question and leave the interview/focus groups at any point for any reason. As there were potential discussions of climate-related trauma in paper 3, I also created a list of psychological resources to share in case of any adverse reactions (e.g., links to official governmental mental health websites). For both studies, adverse reactions were unlikely (and did not end up occurring) as individuals not comfortable discussing environmental topics were unlikely to opt to participate.

#### *4.5.4 Funding disclosures*

The research in this thesis was supported financially in part by an academic grant from the Royal Bank of Canada (grant number ENV20197234). Various research costs were also

supported by funding from several University of Oxford organisations, including the School of Geography and the Environment, Environmental Change Institute, Worcester College, Van Houten Fund, and Oxford Climate Society.

#### *4.5.5 Normative dimensions of climate change communication*

Inherent to the aim, research questions, and methods of this thesis is a normative assumption that climate change poses substantial risks, demands urgent action, and that stronger public engagement with climate change is desirable. Environmental communication more generally has been called a “crisis discipline”, as it was born out of the goal of addressing environmental challenges (Cox, 2007). It is akin to many other research disciplines that adopt normative stances, such as health-related research that not only monitors health trends but also seeks to promote positive health outcomes (e.g., research testing communication strategies to increase uptake of vaccinations). I also view climate change communication in similar manner as Pezzullo (2017), who states that environmental communication is not only a crisis discipline but also a “care discipline” that seeks to prevent harm and promote broader goals of positive societal transformation. I return to this concept in the discussion section (chapter 9).

#### **4.6 Reflexivity and power dynamics**

Reflexivity refers to how one’s personal identity, positionality, and subjectivity can influence all stages of a research project, especially regarding how researchers relate to their research subjects (England, 1994; Olmos-Vega et al., 2022). I reflect below on various dimensions of my own identity, how these aspects may have influenced power relationships and other interpersonal dynamics, and steps I took to address power imbalances, where possible. I also write in first person throughout this thesis to reinforce the central role of myself as a researcher conducting this work (Mansvelt & Berg, 2016).

My age (30s), gender (male), cultural identity (American living in the UK), university affiliation (University of Oxford), and other personal characteristics unquestionably influenced my interactions with participants. For example, Australian participants in paper 3 occasionally used phrases that were unfamiliar to me (e.g., “firies” for firefighters). The participants sometimes asked whether I understood what they meant by such terms, which suggests a potential cognisance of my cultural background during the interview. Demographic and cultural differences may have established barriers between myself and my participants.

It is important to note, however, that cultural diversity can offer substantial value to research and provide novel insights and perspectives. Moreover, every individual has multiple overlapping personal identities – researchers are “never simply an insider or an outsider” (Cantugal & Dowling, 2016, p.40). Like my participants, I am personally concerned about climate change and have previously engaged in various forms of climate activism. It is also worth acknowledging that these characteristics of my identity were a central influence on my selection of this research topic, research design, and underlying motivation to pursue this line of research. During the interviews, I sought to limit bias when possible by adopting an open-ended approach with relatively limited researcher interference (see section 4.2.2 above).

There are also inherent power differentials between a researcher and research participant in any study (Secor, 2010). As a researcher, I gained a benefit from my participants, whereas my participants were not compensated for their participation. Paper 2 also involved assessing the communications of groups who may not have benefitted from the same level of access to environmental education, resources, and training I have had. It is not possible to entirely change these underlying power dynamics, but I did take several steps to help empower my participants. First, I always sought to express gratitude for participants’ support of my research and treat

each of them "as an expert whose knowledge is valued" (Secor, 2010, p.203). Using narrative interviews and focus groups encouraged participants to take a leading role in discussions with less researcher control than more strongly structured qualitative methods. I also sought to foster reciprocity by offering debrief discussions after concluding the formal interviews in which I explained the broader research context and goals, as well by subsequently sharing the research findings with participants.

#### 4.7 Research quality

To ensure a high level of research quality, I used the "Eight 'Big-Tent' Criteria for Excellent Qualitative Research" framework to guide my decisions at key thesis intervals, especially during the transfer of status process during year 1 and the confirmation of status process during year 3 (Tracy, 2010). Table 1 shows how this thesis meets these eight criteria.

<b>Marker of Quality</b>	<b>How this thesis meets these criteria</b>
<i>Worthy topic</i>	As climate change makes many types of extreme weather increasingly frequent and intense around the world, this topic is very timely.
<i>Rich rigour</i>	I build upon a large body of multidisciplinary literature and use mixed methods to offer robust, well-rounded findings. The methods are appropriately suited to answer the research questions.
<i>Sincerity</i>	I reflect upon my positionality and subjectivity in the methodology chapter and within the papers. I also write in first person to identify the central role of myself as a researcher throughout the thesis.
<i>Credibility</i>	I critically assess limitations associated with each of the studies and across the overall thesis.
<i>Resonance</i>	The findings are relevant beyond academia, with significant practical implications for climate change communication strategies.
<i>Significant contribution</i>	The findings offer novel and useful insights on climate change communication, environmental psychology, and public engagement.

<i>Ethics</i>	I exercised caution with human subjects and data management across each study and consider broader ethical questions related to the thesis.
<i>Meaningful coherence</i>	Each of the papers are interrelated. The discussion chapter synthesises findings across the papers to answer the central research questions.

**Table 4.1:** Eight big-tent criteria for excellent qualitative research (Tracy, 2010)

## **5. Paper 1: “What’s up with the weather?” Public engagement with extreme event attribution in the United Kingdom**

This qualitative study helped set the stage for the rest of the thesis by exploring how non-climate scientists in the United Kingdom engage with extreme event attribution findings. Three 1-hour focus groups were conducted in summer 2020. Participants read a short text explaining the science of EEA, with a focus on an attribution study of the 2019 UK summer heatwave. A series of open-ended questions encouraged group discussion about the topic. Participants were then asked to comment on a variety of verbal and visual framings of attribution results. The findings offered a rich variety of insights into how non-climate scientists respond to EEA results and informed the research directions of the subsequent studies.

# **What's Up with the Weather: Public Engagement with Extreme Event Attribution in the United Kingdom**

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*Weather, Climate and Society*

Published 09 Apr 2021

Available from: <https://journals.ametsoc.org/view/journals/wcas/13/2/WCAS-D-20-0155.1.xml>

## **Abstract**

The science of extreme event attribution (EEA) – which connects specific extreme weather events with anthropogenic climate change – could prove useful for engaging the public about climate change. However, there is limited empirical research examining EEA as a climate change communication tool. In order to help fill this gap, we conducted focus groups with members of the UK public to explore benefits and challenges of utilizing<sup>1</sup> EEA results in climate change advocacy messages. Testing a range of verbal and visual approaches for communicating EEA, we found that EEA shows significant promise for climate change communication because of its ability to connect novel, attention-grabbing and event-specific scientific information to personal experiences and observations of extreme events. Communication challenges include adequately capturing nuances around extreme weather risks, vulnerability, adaptation and disaster risk reduction; expressing scientific uncertainty without undermining accessibility of key findings; and difficulties interpreting mathematical aspects of EEA results. Based on our findings, we provide recommendations to help address these challenges when communicating EEA results beyond the climate science community.

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<sup>1</sup> I use British spelling throughout this thesis but used American spelling for the papers given journal requirements.

We conclude that EEA can help catalyze important dialogues about the links between extreme weather and human-driven climate change.

### **Introduction and literature review**

Weather is one of the fundamental ways humans engage with, and make sense of, the physical environment. Spanning religious interpretations to scientific understandings, cultures around the world have sought to explain, predict and, in some cases, control the weather (Hulme, 2017; Endfield & Veale, 2020). Weather is a universally relatable phenomenon, inspiring a quip often attributed to Oscar Wilde: “conversation about the weather is the last refuge of the unimaginative” (Jackson, 2017). However, researchers are increasingly exploring how the weather might prove more valuable than just a conversation starter. As climate change continues to influence the frequency and severity of different kinds of weather extremes around the world (IPCC, 2018), some researchers have hypothesized that extreme weather events might serve as ‘teachable moments’ that could counter the abstract qualities or psychological distance of climate change (Wallace, 2012; Halperin & Walton, 2017; Zanoocco et al., 2019). This notion relates to construal-level theory, which considers how individual engagement with an object or event can be shaped by spatial, temporal, social and uncertainty perceptions (Bar-Anan et al., 2006; Jones et al., 2017). According to this perspective, by virtue of its tangible, visceral and localized impacts, extreme weather could act as a wake-up call or ‘sentinel’ of climate change that makes risks more visible and concrete, stimulating stronger support for climate action (Hamblyn, 2009; Rudiak-Gould, 2013).

A growing body of research has therefore sought to examine how extreme weather events might shape public engagement with climate change in terms of attitudes (e.g., Spence et al., 2011), beliefs (e.g., Whitmarsh, 2008) and, in more limited studies, behavior (e.g., Hazlett and

Mildenberger, 2019). Researchers have particularly focused on the role of direct extreme weather experiences in shaping public opinion about climate change (e.g., Akerlof et al., 2012; Albright and Crow, 2016; Demski et al., 2017). A meta-analysis by Howe et al. (2019b) examined 73 studies exploring potential relationships between extreme weather experience and climate change perceptions. Although significant differences in study methodologies limited comparisons, they found mixed results: some studies suggest that weather experiences can increase climate change attention (salience) and beliefs (e.g., Spence et al., 2011; van der Linden, 2014; Shao, 2017), but the extent of these effects may change over time (Hamilton & Stampone, 2013; Konisky et al., 2016). Other studies find no measurable impact of extreme weather experiences on climate change perceptions (e.g., Whitmarsh, 2008; Mildenberger & Leiserowitz, 2017; Sun & Han, 2018).

Aligned with observations across the broader science communication literature, studies examining public engagement with extreme weather have noted the role of contextual socio-cultural factors and psychological dynamics in shaping how individuals interpret relations between weather events and anthropogenic climate change (Borick & Rabe, 2017). A cognitive bias known as ‘motivated reasoning’ can lead individuals to process information in ways that support pre-existing beliefs (Reser, et al., 2014) and the ‘availability heuristic’ can lead individuals to assign more importance to topics that are more easily brought to mind (Redelmeier & Ng, 2020). For example, it has been found that individuals express stronger beliefs about global warming when asked about the issue on days with warmer temperatures outside (Li et al., 2011). The ‘social amplification of risk’ framework likewise explores how socio-cultural factors can play an important role in shaping risk perceptions (Kasperson et al., 1988). Media attention can also influence how long an event remains at the forefront of public awareness (Massumi, 2011).

In terms of climate change and extreme weather, Ogunbode et al. (2019) found that prior climate change beliefs and political views influenced whether members of the public attributed UK floods in the winter of 2013/2014 to climate change. Boudet et al. (2019) studied 15 US communities that experienced extreme weather between 2012 and 2015 and concluded that a variety of factors influenced dialogues about climate change after the event, including educational levels, political views, as well as the scientific understanding of links between the kind of event and climate change. Zanocco et al. (2018, p.363) noted a similar process occurring among members of the public, stating: “If policymakers and scholars are looking to turn extreme weather events into teachable moments, the educational window appears to be context dependent.”

Smith and Jenkins (2013) point out, however, that extreme weather might be able to transcend political divisions and other individual ideological barriers by focusing on bipartisan matters of concern (i.e., harm from weather). Recent surveys indicate that belief in global warming among Americans is at a record high and researchers suspect that extreme weather is a significant factor behind this shift (Schwartz, 2019; Leiserowitz et al., 2020). Importantly, the extent to which an individual or institution connects an individual weather event to climate change can also be a strategic political decision, which Lahsen et al. (2020) refer to as the ‘politics of disaster framings.’ As noted by Sarewitz (2011), rather than necessarily determining climate policies, climate science can become enmeshed in political processes.

Although studying potential climate change attitude, belief and behavior shifts in the wake of direct extreme weather experience merits continued examination, more proactive communication efforts for engaging the public on connections between climate change and

extreme weather are comparatively under-researched. In other words, beyond examining if the public draws their own perceived connections between extreme weather events and climate change, educational campaigns could help facilitate an understanding of these links. Indeed, climate activist groups frequently utilize extreme weather events as opportunities for public outreach and calls for climate action (e.g., Earthjustice, 2020). Similarly, there is growing research on the role of television weathercasters as climate change communicators and educators (Maibach et al., 2016; Feygina et al., 2020). Such public engagement initiatives are liable to the cognitive biases described above, including motivated reasoning and confirmation bias. Dixon et al. (2019) demonstrated this, finding that messages highlighting the ways in which climate change influences different types of weather extremes triggered resistance in audiences skeptical of climate change.

As noted by Ogunbode et al. (2019, p.38), “Public engagement efforts could be significantly aided by placing scientific evidence of the connection between extreme weather and climate change, where available, at the fore of climate change communication.” Yet a long-standing challenge of using extreme weather as a communication tool is that despite a firm scientific basis concerning the physical principles of how climate change can influence different kinds of extreme weather events, the connections between human-induced climate change and specific weather events have crucial nuances; every weather event always has many different drivers, and the damages wrought by such events depend on who – and what – is in harm’s way. Moreover, there are longstanding critiques around the framing of natural hazards as ‘natural disasters’ that belie the role of human decision-making in shaping vulnerability to extreme events (Chmutina & von Meding, 2019; Kelman, 2020). It can be misleading to overstate the role of climate change and portray it as the sole cause of sudden-onset weather events or their resulting damages. Climate science can generally only demonstrate how climate

change has altered the probability and/or magnitude of such events (and in some cases, to a very large degree (Ciaverella et al., 2020)), among other factors. Scientists and science communicators have therefore relied on metaphors to help explain the changing climate-weather relationship such as ‘loaded dice,’ in which climate change increases the odds of extreme events happening (Hansen, Sato & Ruedy, 2012), or state that ‘this is the sort of event that we expect to become more likely as a result of climate change’ (Painter et al., 2020).

However, the scientific capabilities to understand how climate change affects specific weather events have recently evolved (Otto, 2017). Since Allen (2003) initially proposed calculating the changing risk of extreme weather events due to climate change, climate scientists have developed techniques to estimate the extent to which human-driven climate change has influenced recent weather extremes, which is known as extreme event attribution (EEA) or probabilistic event attribution (National Academies, 2016). There are two main methods to EEA: a likelihood-based approach in which scientists explore how climate change altered the likelihood and/or intensity of an event occurring by comparing models of our planet today and counterfactual worlds with different levels of anthropogenic greenhouse gas emissions; and another in which scientists explore whether climate change was a necessary condition for an event to develop (Easterling et al., 2016). This paper focuses on the likelihood approach as it is more widely applied in international contexts. For example, the research group World Weather Attribution found that climate change made the 2019-2020 Australian bushfires at least 30% more likely to have occurred (van Oldenborgh et al., 2020) and the 2020 heatwave in Siberia at least 600 times more likely to have occurred (Ciavarella et al., 2020).

The robustness of attribution analyses depends primarily on three factors: quality of weather observations; ability of climate models to accurately simulate weather; and a strong scientific

basis concerning the relationship of atmospheric processes and climate change (Marjanac, Patton & Thornton, 2017). Scientific confidence in the results varies across different types of extreme weather. Heat and cold extremes, for example, are generally simpler to attribute, whereas wildfires and tropical and extratropical cyclones are more difficult (National Academies, 2016). Currently, the evidence available from attribution research is strongly biased towards high-income countries, associated with a lack of high-quality observational data and research capacity – a situation researchers are trying to rectify (Otto et al., 2020). Nevertheless, EEA offers a significantly more granular perspective of how climate change influences specific extreme events that moves beyond general descriptions of meteorological relationships. This study focuses exclusively on potential communication applications of EEA, rather than methodological aspects and debates around the science of attributing of extreme events to anthropogenic influences. We acknowledge the importance of these debates but note that our study, by virtue of its aims and methods, is not positioned to address these issues.

The attribution field itself is rapidly growing with an increasing number of studies each year and significant media interest (Painter & Hassol, 2020; Pidcock et al., 2020). Scholars continue to explore potential applications of attribution, including the development of climate loss and damage policy mechanisms (James et al., 2014), climate litigation (Marjanac, Patton & Thornton, 2017; Minnerop & Otto, 2020) and climate adaptation planning (Hulme et al., 2011; Betts, 2021). Researchers are also increasingly exploring how attribution results are reported in the media (Osaka et al., 2020; Painter et al., 2020). Yet despite ongoing interest in attribution's potential applications, there has been limited exploration of attribution from a public engagement perspective, although its potential communication value is frequently pointed out (e.g., Stott & Walton, 2013; Messling et al., 2015; Sippel, Walton & Otto, 2015; National Academies, 2016). By quantifying climate change's effect on a specific weather

event, attribution studies could make the risks of climate change less abstract, going beyond descriptions of general meteorological relationships between global warming and weather. EEA focuses on actual observed events, which differs from other types of climate science projections that are not explicitly linked to real-world experiences and subject to uncertainties around emission trajectories and changes in future vulnerability/exposure.

Sippel, Walton and Otto (2015) found that representatives of environmental organizations felt attribution could prove helpful for their public campaigns and communications. Yet communicating attribution presents significant challenges and risks. Osaka and Bellamy (2020) conducted interviews and focus groups with scientists, journalists, policymakers, farmers and environmentalists in order to examine reactions to attribution studies of the 2011-2017 California drought. They found that focus group participants experienced difficulties understanding scientific uncertainty associated with EEA and tended to doubt the rigor of the science when presented with a range of attribution studies of the same event. Similar to studies of extreme weather perceptions described above, they also found that attribution results are subject to a motivated reasoning process in which individuals assess the accuracy of EEA based on their pre-existing views about climate change. Others have expressed concerns that attribution's focus on the changing risk of a meteorological hazard could detract from considerations of other societal dynamics associated with the impacts of weather events, including adaptation, exposure and vulnerability (Hulme et al., 2011; Janković & Schultz, 2017). Lusk (2020) argues that using attribution as a public communication tool could lead to detrimental misunderstandings of climate science. He describes how EEA might lead audiences to erroneously believe climate change directly causes extreme weather events, rather than altering an event's likelihood or magnitude. In order to avoid misunderstandings of climate science and causality, Lusk suggests climate change messages focus on the broader change in

risk of weather event types, rather than an assessment of human-induced climate change's influence upon a specific event.

Aligned with these communication issues, there is growing guidance on how to effectively communicate links between climate change and extreme weather. Hassol et al. (2016) offer communication principles for climate scientists to more effectively share their findings, including using phrases such as 'a range' rather than 'uncertainty.' Lewis et al. (2019) suggest communicating attribution results using calibrated language and levels of confidence in a similar manner as Intergovernmental Panel on Climate Change (IPCC) reports. Seeking to move toward a more participatory communication model, other researchers have experimented with games and 'spinner boards' to portray how climate change can influence extreme weather events (Parker et al., 2016; Dryden & Morgan, 2020). Among gray literature, the organization Practical Action tested EEA communication approaches in Kenya and India, examining responses to different wording choices and visuals to describe probability, intensity, frequency and uncertainty dimensions of EEA (Budimir & Brown, 2017). They found that local decision-makers, media officials, and members of the public responded differently to particular word choices and visuals used to describe EEA results, suggesting a more tailored communication approach. The organization Climate Outreach suggests that messages related to extreme weather and climate change should go beyond the science by tapping into shared values and human dimensions, such as community solidarity and resilience in the aftermath of disaster (Marshall, 2014).

Given the growing volume of EEA studies, as well as continued development towards the operationalization of EEA to provide rapid information on potential links between climate change and extreme events shortly after they occur (Copernicus, 2019), there remains a need

for further insights into communication aspects of EEA. As stated in the U.S. National Academies review of attribution (2016, p.25): “. . . a careful and comprehensive treatment of the many issues associated with science communication related to climate attribution could be a study in its own right.” It is therefore timely to further explore how non-climate scientists respond to EEA findings and in what ways EEA can be beneficial, neutral, or detrimental as a climate change communication tool. This qualitative study is guided by two key research questions:

1. What are the benefits and challenges of communicating EEA findings with non-climate scientists in order to promote stronger public engagement with climate change?
2. How can strategic word choices and data visualizations enable greater understanding and stronger engagement with EEA findings among non-climate scientists?

### **Methods and materials**

In this study, we explored responses to recent EEA results among non-climate scientists based in the county of Oxfordshire, UK. A focus group approach was selected as it can facilitate a deep exploration of attitudes and meaning-making processes around a particular topic, as well as guide the development of products and programs (Krueger & Casey, 2000). Although focus groups are not statistically representative of a population, they can offer rich, in-depth data on the reasons why individuals respond in particular ways to information. Additionally, given the prominence of conversations about the weather in cultural life, a focus group approach helped incorporate the role of social exchange and dialogue in shaping views on the attribution of weather events to climate change. Participants were recruited through advertisements in

Oxfordshire community social media groups, resident associations, sports clubs, university groups and snowball sampling procedures.

Due to the coronavirus, the focus groups were held via online video chat. Given that focus groups are traditionally held in person, two pilot focus groups were conducted. From these tests, we ascertained that a slightly smaller group size than typically advised for focus groups – 3-5 participants, as opposed to 6-8 (Bloor, 2001) – would enable more fluid and natural discussions online. Smaller focus groups are also not unprecedented and are actually preferred by some researchers in certain contexts (Morgan, 1996; Bloor, 2001). Rather than a single large group, we therefore opted for a larger quantity of smaller focus groups. Four online focus groups with 4, 3, 3, and 3 participants respectively were held in summer 2020. Each focus group lasted between 70 to 90 minutes. Recordings of the focus group sessions were transcribed, anonymized and analyzed in NVivo by the lead author using a deductive content analysis to group themes according to our research questions, including the categories of communication benefits and communication challenges (research question 1), as well as considerations for accessible communication (research question 2). An inductive approach was used to code and organize statements falling within these categories (Bengtsson, 2016). This study's supplementary information provides the full list of codes used in the analysis.

An important limitation of this study's sample is that all participants reported a high or extremely high level of climate change concern prior to their participation (demographic characteristics of the participants are available in this paper's supplementary materials). This may reflect characteristics of the UK population which, according to recent polling, is exhibiting increased levels of concern about climate change (Capstick et al., 2019). It may also be associated with the recruitment process in which individuals passionate about environmental

issues are more likely to register for an environmentally themed focus group. We determined that informed consent procedures required potential participants to know that the focus group concerned an environmental topic, but participants were not aware of the specific EEA focus. Given that the key research objective is to explore responses of non-climate scientists to EEA, rather than test the efficacy of EEA as a persuasive device for reaching individuals skeptical or dismissive of climate change, the composition of the groups remains valid for the purposes of this study.

Upon joining the call and after introductions, participants read a short text that briefly explained EEA and highlighted several recent attribution findings showing a climate change influence on the likelihood or magnitude of extreme events around the world. Participants were then asked to respond to a series of open-ended questions exploring a broad range of reactions to the material, such as to what extent the information aligned, altered or conflicted with their beliefs about climate change; to what extent they understood EEA results; and any other reflections they had about the material. Following a product development focus group approach (Krueger & Casey, 2000), participants were then presented with language and visual options for describing EEA results (see supplementary materials) and asked to discuss their opinions. The verbal phrasings were compiled based on a systematic review of the ways in which attribution findings have been typically reported in publications of the World Weather Attribution research group (World Weather Attribution, 2020), with additional input from climate scientists who conduct these attribution analyses, as well as prior literature on EEA communication (Budimir and Brown, 2017). Visual representations were selected based on a review of prior visuals used in World Weather Attribution group publications, from Lewis et al. (2019), as well as from the website [www.datavizproject.com](http://www.datavizproject.com), which provides a comprehensive list of data visualization approaches. The selection of the visuals was guided by three criteria:

1. *Suitability*: visuals should be appropriate for depicting EEA results (i.e., able to express a change in likelihood/intensity of a meteorological event).
2. *Clarity*: visuals should be engaging and accurate, while also not overly technical.
3. *Replicability*: visuals should not be so complex that a scientist or science communication officer would have difficulty creating it.

Based on these criteria, five visuals were identified for focus group testing. The visuals included: an icon and number chart; an icon and number chart including emoji faces to test icons that are more playful and relatable; a pictorial unit chart to express event frequency; an angular gauge based on Lewis et al. (2019); and a linear process diagram describing how attribution results fit in a broader meteorological context in which climate change influences extreme events (all visuals can be seen in this paper's supplementary materials). We also included a box plot to test how participants would respond to a data visualization taken directly from an academic publication. All text and visuals were tested using results from an EEA study of the UK 2019 summer heatwave (Vautard et al., 2019), specifically Oxford-regional data, which was selected given its local relevance to the participants.

## **Results**

### *Benefits of communicating EEA to the public*

12/13 participants felt that EEA can be useful for climate change communication by connecting scientific data to personal experiences and observations of extreme weather events. *“People who see it [extreme weather] portrayed on the news and the media quietly wonder, ‘is this because of climate change?’ and if that’s a question the attribution studies can help to answer,*

*then that's a good thing.*" There was a sense that EEA findings can demonstrate that climate change is not just a future threat and that it is happening here and now. *"It's interesting that in the early days this has always [been a] theoretical possibility that will happen in the future and as time has gone past, it's become more and more [clear that it's] actually happening right now. So it becomes more stark and the numbers are helpful to reinforce that."*

Beyond describing general meteorological relationships between climate change and extreme weather events, 9/13 participants felt that providing a specific number on how climate change may have influenced an event was more persuasive and attention-grabbing than a more general description of how climate change relates to the event. *"I think it shows . . . that you are being exact and that you're not making it up."* Another participant noted: *"Instead of being like 'oh, this will affect this or whatever' and deniers or people might say you're just talking out of your ass, you can actually say 'well, here's this.'"* Several participants alluded to advertisements in which products are marketed using technical statistics that are not well understood by the public, but nevertheless make a product appear more robust from a marketing perspective. *"I do think it [an EEA finding] does resonate with people. I mean when you look at a lot of products like shampoo, you know, it will say '4 times shinier'. . . it's used a lot in advertising and provided it's simple, I think it can hook more into the way people think."*

8/13 participants reported that comparisons of today to the past and details about what the future holds for extreme weather events, were helpful for understanding the impacts of climate change. The notion of comparing counterfactual worlds particularly stuck out to some participants. One participant alluded to the novel *The Little Prince*, in which the main character visits alternate worlds. Some felt strong emotional impacts from these imaginative comparisons. *"I think it was having the parallels between two worlds, we are missing out on a*

*world that's healthy and thriving and I feel quite angry about that.*” While they didn't distrust the overall EEA technique, some participants questioned how accurately scientists could model a world without greenhouse gases. 7/13 participants expressed a general appreciation that climate science was advancing: *“I think it's important, I don't think it's irrelevant or redundant or anything. I think it kind of gives you more context and accuracy to the things you already believe.”* About half of the participants felt that EEA provided further validation of their climate change beliefs. One participant described her reaction as *“vindication . . . I guess because it's more proof.”*

#### *Challenges of communicating EEA to the public*

All participants were emphatic that audience characteristics would significantly shape reactions to EEA findings and that EEA results would be much more accessible to those with a scientific background. The notion of changing likelihood was described as a *“strange concept for people.”* Cultural differences were also discussed. For example, some findings, such as an increase in the temperature and frequency of heatwaves, could be perceived as a positive effect. As one participant described, *“Why are these people complaining? It's lovely . . . but I get it, it's not normal.”* No participants made any distinctions concerning the changing risks of hazards due to climate change and the roles of adaptation measures and disaster risk reduction in reducing vulnerability and exposure to extreme events. The focus group conversations focused exclusively on mitigation as the key action required to respond to changing extreme weather events associated with climate change. Participants discussed ways of reducing their individual greenhouse gas emissions by flying less and changing their modes of transportation, but they did not mention ways they or others could prepare for or adapt to extreme events (with the exception of air conditioning).

All participants felt that any expression of scientific uncertainty was unnecessary and confusing. *“It’s really, really tricky for just normal people unless you are just really studying this.”* Although participants seemed to recognize that this information can be relevant in certain contexts, all four focus groups discussed how the inclusion of uncertainty made their engagement with EEA more challenging and could undermine the public’s confidence in the EEA results. *“I understand from a scientific point of view you can’t say it is this number [i.e., provide a single result without uncertainty] but for a person that don’t [sic] have scientific literacy at all . . . it’s like you don’t know what you’re doing.”*

#### *EEA verbal and numerical framings*

Although some participants suggested that large percentages to describe a change in risk (e.g., ‘the Oxford 2019 heatwave was made 300% more likely’) could provide shock value to capture attention, most participants (10/13) found the ‘X times more likely’ framing easier to understand. Increasing likelihood ‘by a factor of X’ was generally perceived as too academic and wordy. Likewise, most participants (11/13) were in favor of the term ‘intensity’ or ‘strength’ rather than ‘magnitude’ to describe the severity of weather events. Magnitude was perceived as too academic and disconnected from everyday language. Participants held contrasting views about the terms ‘likelihood,’ ‘risk,’ ‘odds,’ ‘chances’ and ‘probability.’ It was generally agreed that probability was, like the term magnitude, too divorced from everyday language, but participants debated the merits of the other terms. Likelihood was found to be the simplest, but some participants thought odds and chances would be more familiar to the general public. All participants found the phrase ‘return time’ to describe extreme weather frequency unclear. However, many in principle saw value in learning how the frequency of a weather event changed within a given time frame. Given the participants’ overall position

against the inclusion of uncertainty for a public audience, they did not express clear support for any of the particular options for communicating uncertainty.

### *EEA Visuals*

No EEA visual was preferred across the focus groups, but participants unanimously disliked the usage of a box plot to portray EEA results as it was generally not understood and disengaging. One participant described it as “*clinical*.” All focus groups felt that symbols and icons were engaging but warned that communicators should be careful with their utilization. For example, the usage of a sun as a symbol for a heatwave was perceived with positive emotions by some participants, reminding them of sunny weather forecasts, which they felt could undermine the risks of a heatwave. Participants closely scrutinized the colors and sizes of the icons, expressing a wide range of diverse views and picking up on numerous details. Emoji icons testing the role of more playful communications received mixed responses. Some participants felt they undermined the seriousness of the topic, describing them as “*juvenile*” or “*patronizing*,” in the sense that the science was simplified too much. Others thought it made the data more relatable by connecting to human experiences of weather (e.g., an emoji with a red face in response to hot temperatures): “. . . *it’s actually got some emotion and some experience in here.*” The gauge chart representing EEA results was generally familiar and comprehensible to participants, but participants in all focus groups warned against unintended consequences. In the case of the Oxford 2019 summer heatwave, the gauge only pointed to ‘more likely,’ which was one category away from no effect from climate change, giving the impression that the impact of climate change was negligible.

### *Other findings*

3/13 participants had heard of EEA or about an EEA result prior to participating in the study. All participants agreed that specific word choices and visuals used to describe EEA results made a significant difference in how they engaged with the data. Several participants noted that the size of the EEA finding itself mattered significantly in shaping their reactions. For instance, this study utilized the example of the UK 2019 summer heatwave (made 4x more likely in Oxford), whereas showing participants the recent finding that climate change made the 2020 Siberian Heatwave 600 times more likely might have evoked different responses (Ciavarella et al., 2020). As one participant described, *“It wasn't shocking enough. I think maybe if it said like 17 times or like 100 times more likely, I would have been like, wow, but three or four times didn't really make an impact on me.”* Another participant noted: *“it's about how people evaluate the size of these numbers for their own life . . .”* 3/4 focus groups discussed how human stories and local consequences could more effectively demonstrate the impacts of heightened risks of extreme weather. *“Just saying that as a weather event occurs more or less likely kind of thing, so what? But if you start tying it to people's lives, X number of people will have died, X number of people will have been admitted to the ER for breathing difficulty, then it starts to become human doesn't it?”*

Most participants (10/13) supported the provision of broader context to EEA results with information about meteorological processes (i.e., how global warming makes heatwaves more frequent and powerful), as well as the impacts of a more likely/intense weather event. EEA results, on their own, can be *“. . . a bit isolated. If you give a series of steps—oh well, I know why we're getting this—so giving a context can be useful.”* 7/13 of the participants reported that they experienced negative emotions such as anxiety, sadness and *“just more despair”* in response to the EEA findings. *“It's more evidence, I know the things that I believe are true and*

*this is more proof of that, but again, what can I do about it? . . . it creates anxiety every time that instead of having a solution, I just have the problems like a list of things that are going wrong.”*

## **Discussion**

Researchers have previously pointed out the potential public engagement value of EEA (e.g., Sippel, Walton & Otto, 2015; Messling et al., 2015; National Academies, 2016). Our findings provide new empirical evidence in support of these claims, while also highlighting several communication challenges (table 1). Overall, the focus group participants found EEA interesting, relevant and attention-grabbing. For many participants, it provided additional proof that climate change is happening now and a feeling of validation for their concerns. Participant statements indicate a process of sensemaking in response to extreme events, in which participants connected attribution findings to their personal experiences and observations of extreme weather, and in turn, perceived a stronger connection to climate change (Tisch and Galbreath, 2018). Several participants described feeling a change in the weather and they interpreted EEA findings as scientific verification of these perceptions.

<b>EEA Benefits for Public Engagement</b>	<b>EEA Challenges for Public Engagement</b>
<ul style="list-style-type: none"> <li>- Resonates with individual experiences and/or observations of specific extreme weather events.</li> <li>- Quantification of climate change impacts can be attention-grabbing and persuasive.</li> <li>- Comparing counterfactual worlds can be thought-provoking and engage the imagination.</li> <li>- Provides further compelling scientific evidence on the connections between extreme events and anthropogenic climate change.</li> </ul>	<ul style="list-style-type: none"> <li>- EEA’s focus on hazards may detract from considerations of vulnerability, disaster risk reduction and adaptation.</li> <li>- Changing probabilities and likelihoods can be difficult to interpret; the magnitude of an EEA result may also influence responses.</li> <li>- Scientific uncertainty can be difficult to communicate and may undermine accessibility of EEA results.</li> <li>- Motivated reasoning can lead audiences to interpret EEA results through the lens of their pre-existing ideologies.</li> </ul>

**Table 5.1:** Key benefits and challenges of utilizing EEA results as a climate change communication and public engagement tool

As described earlier, Lusk (2020) suggests that communicators focus on general relationships between climate change and extreme weather, rather than sharing a number on how a specific event was influenced by climate change because it could lead to scientific misunderstandings of causality. It remains unclear from our results to what extent participants fully understood the nuances of what attribution can and cannot say about the role of anthropogenic climate change in extreme events, so this remains a potential risk. Nevertheless, neglecting to utilize EEA in climate change communication campaigns could be a missed opportunity to call greater attention to the role of climate change in influencing specific weather events. According to our focus groups, EEA results are more engaging and persuasive than simply communicating general climate change and extreme weather relationships—which, as pointed out by one participant, has already been done for decades by scientists and activists. Participants felt that providing a specific number of how climate change influences extreme events offered an impression that the science was more robust and precise. It was also more attention-grabbing. Several participants alluded to advertisements that cite statistics about a product’s effectiveness

to demonstrate its quality. The participants' appreciation of EEA's specificity helps explain why they reacted negatively to language that they felt watered down EEA findings with uncertainty ranges or academic jargon. Additionally, statements often found in media reporting such as 'this is the sort of event which scientists say will become more common' (Painter et al, 2020; Betts, 2021) may not resonate as strongly with readers as a specific number.

Many participants were interested in the counterfactual component of attribution (comparing models of the planet today vs. a planet with a different level of anthropogenic greenhouse gas emissions). That the counterfactual component of EEA stuck out to participants mirrors decades of research in psychology around the importance of counterfactual thinking – “mental representations of alternatives to the past” (Roese, 1997, p.133) – as part of human cognition (Kahneman and Tversky, 1982). Reflecting on alternate versions of reality enables individuals to consider the causal impacts of prior choices, 'what if' questions, which can be useful for guiding future decisions. EEA seems capable of activating this cognitive process in the context of anthropogenic climate change.

On the other hand, our findings highlight significant challenges associated with communicating EEA to non-climate scientists. First, participants felt that EEA results can be difficult to interpret without training in climate science or strong numeracy skills (Painter, 2013). Furthermore, many participants pointed out how their personal backgrounds shaped their responses to the data, which could limit generalizations concerning how diverse individuals would respond to EEA. Participants also acknowledged how they interpreted EEA based on their pre-existing beliefs about climate change. This aligns with prior research demonstrating how individuals can engage in motivated reasoning of EEA results (Osaka & Bellamy, 2020), hold diverse cultural constructions of climate and weather (Hulme, 2017), and filter

information through contextual subjective ideologies (Moser, 2016; Maesele & Pepermans, 2017).

Crucially, we found significant evidence of a related concern about the way EEA results are often framed in communications: that focusing exclusively on natural hazards could detract from considerations of other crucial components of extreme events, including vulnerability, exposure, adaptation and disaster risk reduction (Hulme et al., 2011). It was striking that no participants made any distinctions between changing meteorological risks of extreme weather and steps that can be taken to reduce vulnerability to these events. Greenhouse gas mitigation is only part of the story of resilience to extreme weather risks. Importantly, we did not raise this point as part of our focus group materials in order to examine if participants independently considered these nuances around extreme events, which they did not whatsoever. This is not a flaw inherent to EEA itself; as we note in our communication guidelines below, such misunderstandings can be reduced or avoided through careful messaging strategies that seek to provide a more holistic view of extreme weather risks and vulnerability.

Regarding communication strategies, participants unanimously agreed that the words used to communicate EEA mattered a great deal, which underscores the need for standardized language (Lewis et al., 2019). Participants emphasized the importance of using everyday, simple phrases wherever possible to describe EEA results, which supports the recommendations of Hassol et al. (2016) and Budimir and Brown (2017). Many participants felt that pairing EEA findings with local stories and human impacts would boost the effectiveness of EEA for climate change engagement. Their emphasis on storytelling reflects the importance of narratives around extreme weather and climate change (Marshall, 2014; Ettinger et al., 2021). EEA results should be made personally relevant to individuals and their

experiences—according to our participants, numbers alone are less likely to have a memorable and meaningful impact on climate change engagement. Recent research has found that telling personal stories of harm can be effective for engaging members of the public across political and ideological divides about societal issues (Kubin et al., 2021).

All participants supported using visuals to communicate EEA, which they felt helped express EEA results more effectively. However, it is clear from our results that visuals need to be used with significant caution. Participants expressed a wide range of reactions to specific details of the visuals, including the iconography, colors, direction of charts and amount of text alongside the diagrams. As described above, they reacted positively to a gauge visual because of its familiarity but urged caution in its use because of the confusing colors and scale, whereas a box plot taken directly from an academic publication was perceived extremely negatively. Our results therefore support the conclusions of Budimir and Brown (2017) that visuals can be useful learning aids for EEA but require careful utilization to ensure the proper message is conveyed.

It was notable that all participants were adamant that the communication of scientific uncertainty associated with EEA findings was unnecessary and even detrimental in terms of accessibility and engagement. This sentiment aligns with participants' views that EEA should be communicated as simply as possible and for maximum clarity. Participants generally understood that uncertainty was inherent to science, but they felt it made EEA more challenging to understand without relevant expertise. Some recent studies have found that expressing uncertainty can increase or have no effect on public trust in science (Howe et al., 2019a; van der Bles et al., 2020). Nevertheless, the strong views among participants against the inclusion of uncertainty raises questions on how this information can be expressed without

undermining the accessibility of key EEA conclusions. Perhaps, like the communication of health safety behaviors during the coronavirus pandemic, situating EEA in the context of risk management frameworks could potentially help participants understand how particular behavioral interventions can mitigate risks despite inherent uncertainties (Pigeon, 2012; Painter, 2013).

#### *Implications for public engagement with climate change*

It is crucial to consider our findings in light of well-documented flaws associated with the information deficit model of science communication – the notion that the provision of scientific information can remedy gaps in public knowledge (Sturgis & Allum, 2004). As described above, a variety of socio-cultural and psychological mechanisms shape how the public engages with information. Therefore, based on our results and with acknowledgment of these complex dynamics, we view EEA as a useful, attention-grabbing tool to help catalyze and inform dialogues about the relationships between climate change and extreme events, opening a door for further engagement on this issue and perhaps increased support for climate action. It is also worth mentioning that about half of our participants reported negative emotional responses to the EEA materials, such as sadness and despair. This highlights the importance of including solutions in climate messages in order to avoid apathy and support feelings of efficacy to fight climate change (Hart & Feldman, 2016).

#### *Study limitations and directions for future research*

As a focus group study, our sample size is not statistically representative of the UK population. Given limitations of our focus group methodology, we cannot claim whether EEA can directly influence public attitudes or behaviors in response to climate change. All participants were also highly concerned about climate change prior to participating, so we cannot make any claims

regarding the potential ability of EEA to reach skeptical audiences. Beyond sample characteristics, opinions expressed in a research focus group may differ from how participants would react to EEA in a non-experimental context. For instance, participants were asked which EEA communication options they preferred and why – this open manner of questioning can elicit participants opinions but is not suited to robustly measure changes in attitudes, emotions, or behaviors in response to information (which could be tested in a controlled experiment). Additionally, only one EEA study was utilized to test communication options – different weather events and different attribution results may be perceived differently.

This exploratory study offers several promising directions for future research, especially through methods involving a greater number of participants than a focus group can permit. For instance, can EEA results help raise climate concerns among audiences disengaged or skeptical about climate change? How do audiences respond to EEA results that find no anthropogenic influence on the likelihood or intensity of an extreme event? Continued research into communications aspects of EEA would provide more valuable insights on how to make EEA results accessible beyond the climate science community.

## **Conclusion**

EEA shows considerable promise as a climate change communication tool because of its ability to provide novel, engaging and precise scientific information connecting specific extreme weather events to climate change. Its attention-grabbing results could prove useful as a way of sparking dialogues about the relationship between different kinds of extreme weather events and anthropogenic climate change. Major communication challenges include adequately conveying nuances about the roles of climate change mitigation and adaptation in shaping risks associated with extreme weather events; expressing scientific uncertainty without undermining

the accessibility of key findings; and overcoming numeracy difficulties among audiences to interpret EEA results. We offer the following recommendations for communicating EEA beyond the climate science community.

#### *Center messages around vulnerability*

Communicators should focus their messages on the concept of vulnerability to extreme weather and through this lens, incorporate the roles of climate change (including EEA results) and other dynamics that shape risks, such as exposure, adaptation, disaster risk reduction and community preparedness. This will help clarify that EEA results demonstrate the changing likelihood/intensity of meteorological hazards and how mitigation can address the meteorological component of extreme events, alongside other important ways societal decision-making and planning can reduce risks. Additionally, centering messages around vulnerability helps incorporate tangible, on-the-ground impacts and stories associated with these events, reminding audiences why this topic is crucially important for human well-being.

#### *Communicate using everyday language*

Language used to communicate EEA to the public should be simple, concise and avoid technical and academic jargon (Hassol et al., 2016). Words such as ‘likelihood’, ‘intensity’ and ‘frequency’ are more relatable than terms such as ‘probability’, ‘magnitude’ and ‘return-time’. Our results show that communicating scientific uncertainty can be a challenge for public engagement with EEA. One strategy to provide this information in the EEA context is to “lead with what is known” rather than beginning a message with uncertainties and limitations (Somerville & Hassol, 2011; Hassol et al., 2016, p.8). Messages can also seek to reinforce an audience’s understanding of probabilities and uncertainty by emphasizing how they regularly make decisions under conditions of uncertainty (e.g., choosing an outfit to wear based on a

weather forecast). Furthermore, instead of describing uncertainty as an obstacle to understanding, communicators could seek to reframe it as an opportunity to engage the public on how the scientific process works and build credibility through transparency (van der Bles et al., 2021).

#### *Use familiar and evocative visuals*

Our results support the usage of visuals such as simple scales, gauges and iconography that are already familiar to public audiences. More technical data visualizations taken directly from scientific publications could be confusing and disengaging to those without appropriate expertise to interpret them. Imagery that evokes the severity of extreme weather through the strategic use of color, size and content can make a message more engaging. Pilot testing visuals with target audiences can help ensure they convey intended messages.

#### *Emphasize the counterfactual aspect of EEA*

Counterfactual thinking, i.e., the imagination of alternate realities, is an important part of human cognition. Therefore, the counterfactual component of EEA methodologies can be compelling to audiences. By emphasizing the role of counterfactuals in EEA studies — modelling virtual worlds with different levels of anthropogenic greenhouse gas emissions — scientists and communicators can demonstrate the impacts of prior societal decisions on today's environment and how our decisions now shape future risks. It is key that communicators emphasize that these models can never perfectly construct the world; they can nevertheless be useful for considering alternate possibilities and guiding decision-making.

With a careful communication approach, EEA could prove a valuable resource for those seeking to engage the public about the risks of climate change and help facilitate 'teachable

moments' in the wake of extreme weather events. In particular, focusing solely on the meteorological hazard, without highlighting the roles of vulnerability and exposure in shaping disasters, offers audiences an important but incomplete perspective of how humanity can chart a safer and more resilient future.

## Acknowledgments

We express our gratitude to our focus group participants for their support of this research during the challenging time of the coronavirus. We also thank Stephanie Ferguson of the Oxford University Environmental Change Institute for additional support with the visual components of this study. This work was supported by a grant from the Royal Bank of Canada.

## Data availability statement

The materials utilized in this study and content analysis codes are available for reference in this paper's supplementary materials.

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## Supplementary material

The following supplementary materials are available below:

1. Extreme event attribution verbal descriptions used in focus groups
2. Extreme event attribution visuals used in focus groups
3. Codes used in content analysis
4. Focus group participant demographics
5. Participant consent information

### 1. EEA verbal descriptions

The following verbal descriptions of extreme event attribution results were shown as part of the focus group materials.

*Slide 1*

**Which do you prefer?**

Climate change made the 2019 summer heatwave in Oxford:

1. more likely to have occurred
2. 4 times more likely to have occurred

*Slide 2*

**Which do you prefer?**

Climate change made the 2019 summer heatwave in Oxford:

1. 300% more likely to have occurred
2. 4 times more likely to have occurred
3. More likely to have occurred by a factor of 4

*Slide 3*

**Which do you prefer?**

Climate change increased \_\_\_\_\_ of the 2019 summer heatwave in Oxford occurring by 4 times.

1. the chances
2. the likelihood
3. the probability
4. the risk
5. the odds

*Slide 4*

**Which do you prefer?**

Climate change increased the \_\_\_\_\_ of the 2019 summer heatwave in Oxford.

1. Intensity
2. Magnitude
3. Strength

*Slide 5*

**Which do you prefer?**

Climate change changed the 2019 summer heatwave in Oxford:

1. by making the weather event less rare.
2. from occurring once about every 50 years to once every 5 to 10 years.
3. By altering the return time from once about every 50 years to once every 5 to 10 years.

*Slide 6*

**Which do you prefer?**

Climate change made the 2019 summer heatwave in Oxford:

1. 4 times more likely to have occurred.
2. Between 2 times to 30 times more likely, with a best estimate of 4 times more likely.

*Slide 7*

**Which do you prefer?**

Climate change made the 2019 summer heatwave in Oxford:

1. A best estimate of 4 times more likely to have occurred.
2. Between 2 times to 30 times more likely to have occurred, with a best estimate of 4 times more likely.
3. 4 times more likely to have occurred, with a range of 2 times to 30 times more likely.
4. 4 times more likely to have occurred, with uncertainty between 2 times to 30 times.

*Slide 8*

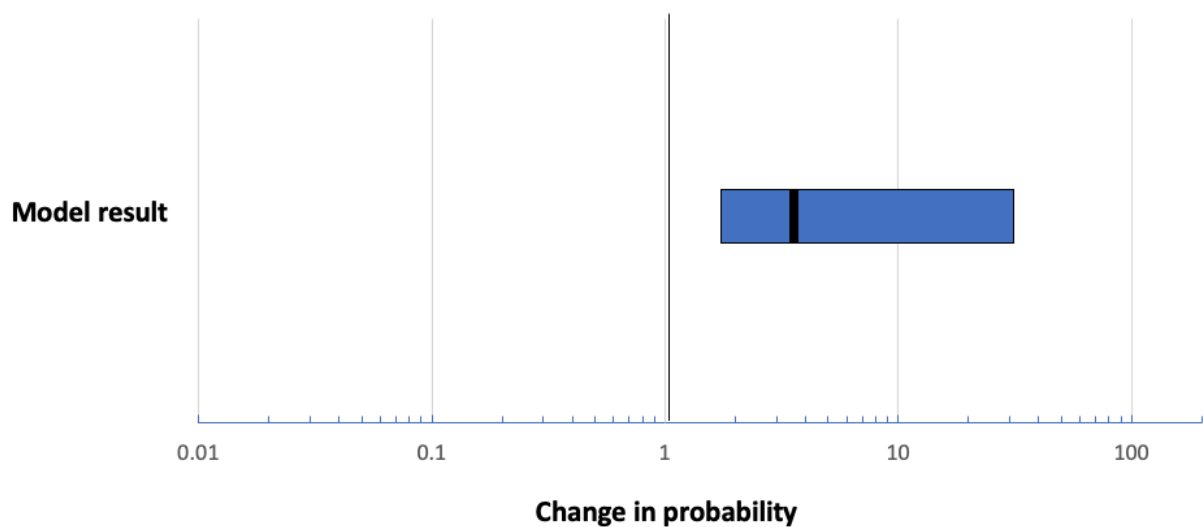
**Do you find this additional context helpful?**

As humans emit greenhouse gases, we prevent heat from escaping Earth, warming the planet. A warmer planet means more frequent and intense heatwaves. Because of this effect, climate change made the 2019 summer heatwave in Oxford 4 times more likely to have occurred and 2 °C hotter.

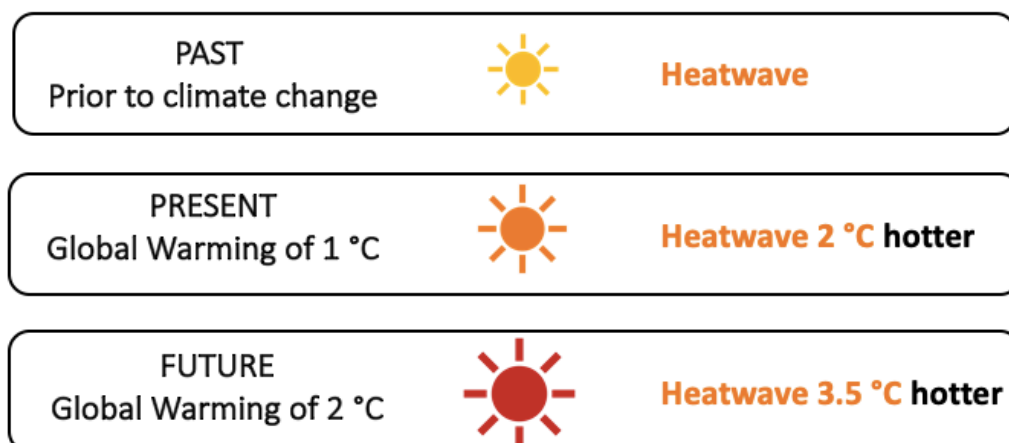
## 2. EEA Visuals

The following visualizations of extreme event attribution results were shown as part of the focus group materials. As noted in the manuscript, these visuals are basic prototypes for testing purposes and would ideally be designed with greater detail and professionalism in their actual implementation.

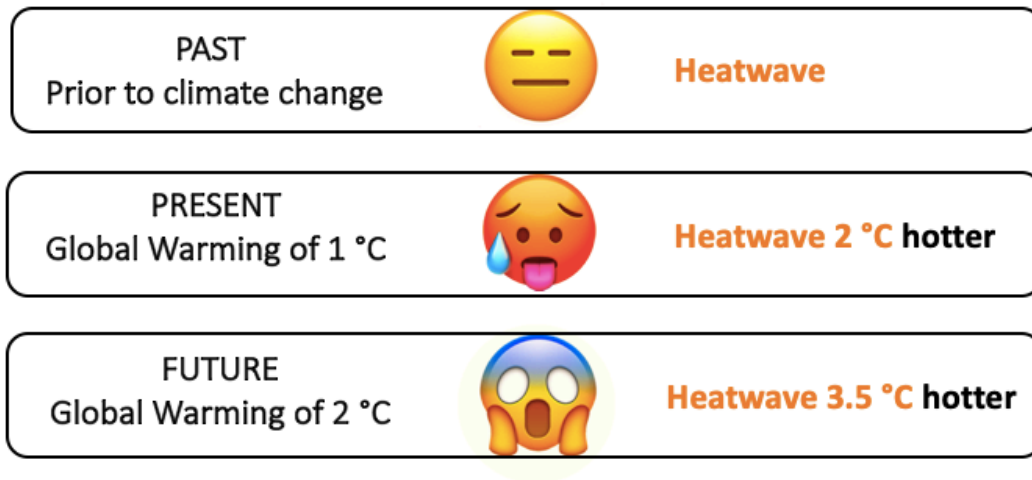
*Visual 1 – boxplot*



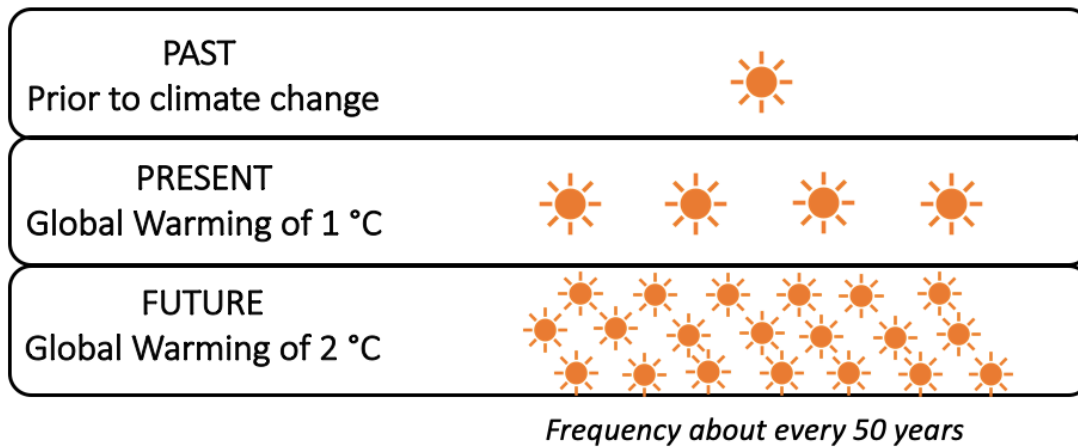
*Visual 2 – icons + numbers*



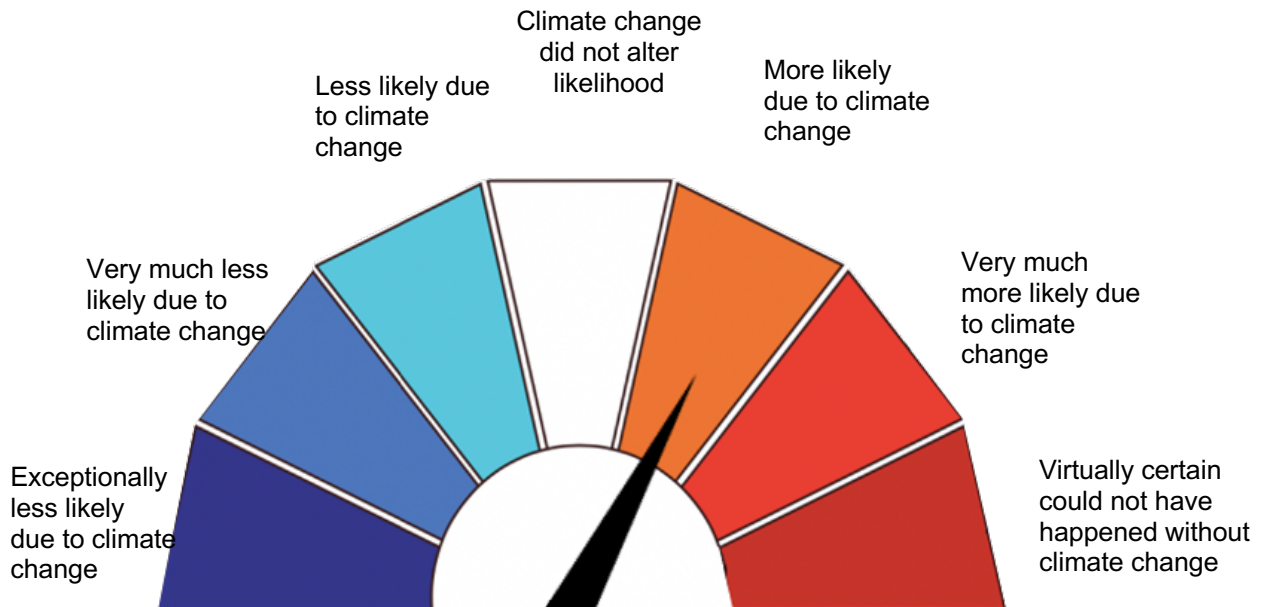
Visual 3 – alternate icons + numbers



Visual 4 – Pictorial unit chart



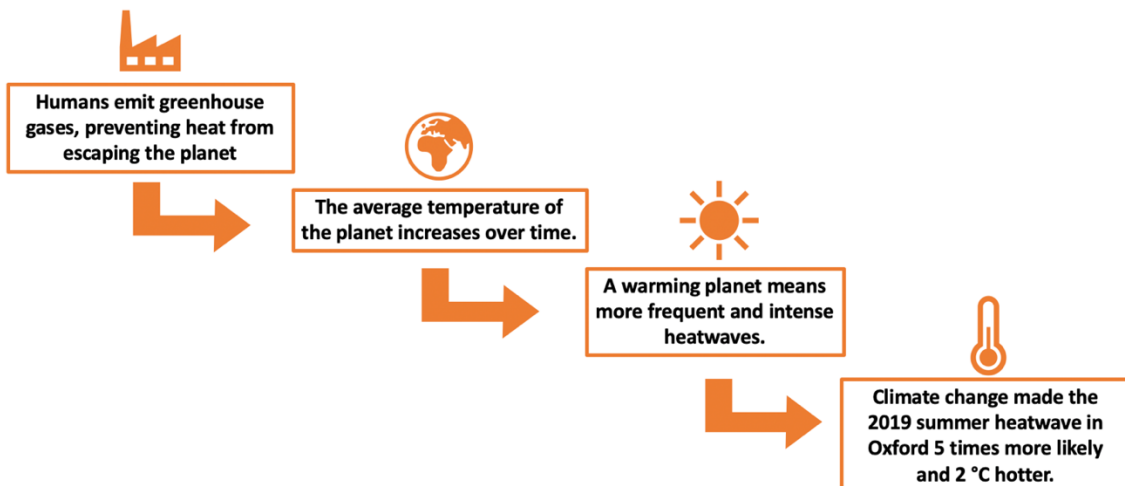
Visual 5 – angular gauge (adapted from Lewis et al., 2019)



Adapted from: Lewis, S.C., King, A.D., Perkins-Kirkpatrick, S.E., and Wehner, M.F., 2019. Toward Calibrated Language for Effectively Communicating the Results of Extreme Event Attribution Studies. *Earth's Future* 7, 1020–1026. <https://doi.org/10.1029/2019EF001273>

Visual 6 – Linear process diagram

### Summer 2019 Heatwave in Oxford



### 3. Content analysis codes

Below are the codes utilized in this study's content analysis.

#### *Communication benefits*

- EEA results are attention-grabbing/persuasive/useful
  - Comparison to marketing/advertisements using numbers
- EEA provides further proof/evidence of climate change
  - Perception that climate change is happening here and now
- Connecting back to personal extreme weather experiences or observations
- Counterfactual aspects (imagining alternative worlds)

#### *Communication challenges*

- Audience characteristics influence engagement
  - Confirmation bias/motivated reasoning
  - Responses among members of public 'in the middle' when it comes to climate change concerns
- Issues with scientific uncertainty/concerns about accuracy of models or results
- Difficulty understanding or making sense of results
- Difficulty understanding personal relevance or what can be done in response to climate change (efficacy)
  - Shifting baselines around extreme events
  - Lack of climate change solutions in materials

#### *Communication suggestions/miscellaneous observations*

- Role of visuals
- Role of storytelling
  - Need to highlight local impacts
- Negative emotional responses to further evidence of climate change
  - Anger
  - Anxiety
  - Fatigue
  - Sadness
- Magnitude of EEA result matters

#### 4. Participant demographics

4 online focus groups were held with 4, 3, 3 and 3 participants respectively in summer 2020.

Only participants 18 years or older were invited to participate. Basic demographic information is available below.

<b>Sample Characteristic</b>	<b>Representation in sample</b>
<i>Gender</i>	
Female	6 (46%)
Male	7 (54%)
<i>Age</i>	
18-29	6 (46%)
30-49	4 (31%)
50-69	3 (23%)
70+	0 (0%)
<i>Ethnicity</i>	
Mixed	1 (8%)
Other	2 (15%)
White	10 (77%)
<i>Highest level of education</i>	
O level/GCSE	0 (0%)
A level/vocational	0 (0%)
Higher Education (e.g., university degree)	5 (38%)
Post-graduate or doctoral degree	7 (54%)
Prefer not to say	1 (8%)
<i>Perceived urgency of climate change action</i>	
No urgency	0 (0%)
Low urgency	0 (0%)
Moderate urgency	1 (8%)
High urgency	3 (23%)
Extremely high urgency	9 (69%)
Total participants	13

## **5. Participant Information Sheet and Consent Form**

### ***About this study***

We appreciate your interest in participating in this online focus group. The aim of this study is to explore the reactions of U.K. citizens to information about climate change and extreme weather events. You have been invited to participate as you are a U.K. citizen age 18 or older and reside in the U.K. Please read through these terms before agreeing to participate by ticking the 'yes' box below. You may ask any questions before taking part by contacting the researcher (details below).

The focus group will last for 1 hour. You will be presented with scientific information about climate change and asked about your reactions to this information. No background knowledge is required. However, some participants may find discussion of climate change distressing. By agreeing to participate, you also agree to treat other participants respectfully and that the researcher reserves the right to remove you from the online chat if you do not comply.

Other participants will be able to see you and engagement between participants will be encouraged. However, only your first name or your own chosen nickname will be visible in the chat and other participants will not have access to your contact information. The session will also be video and audio recorded. This will then be converted into a transcript and the recordings subsequently deleted. All participants will be assigned a pseudonym; therefore, your remarks will remain completely anonymous.

### ***Do I have to take part?***

Please note that your participation is completely voluntary. You may withdraw from the focus group at any point for any reason.

### ***How will your data be used?***

Research data will be stored for a minimum of three years after publication or public release. The data that we collect from you may be transferred to, and stored or processed at, a destination outside the European Economic Area ("EEA"). Video and audio recordings will be stored in a password protected folder on the researcher's computer as well as backed up to a protected folder online. After they are transcribed with pseudonyms provided for each participant, the recordings will be deleted.

### ***Who will have access to your data?***

This focus group is part of a doctoral thesis. The principal researcher is Joshua Ettinger, School of Geography and the Environment at the University of Oxford. Members of the University of Oxford may be given access to anonymised data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. This project has been approved by the University of Oxford Central University Research Ethics Committee.

### ***What if there is a problem?***

If you have a concern about any aspect of this project, please contact the researcher (Joshua Ettinger ([joshua.ettinger@ouce.ox.ac.uk](mailto:joshua.ettinger@ouce.ox.ac.uk))). The researcher will respond to your concern within 10 working days. If you remain unhappy or wish to file a formal complaint, please contact the Chair of the Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: [ethics@socsci.ox.ac.uk](mailto:ethics@socsci.ox.ac.uk); Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD. The Chair will seek to resolve the matter in a reasonably expeditious manner.

Please note that you may only participate in this survey if you are 18 years of age or older.

I certify that I am 18 years of age or older

If you have read the information above and agree to participate with the understanding that the data you submit will be processed accordingly, please check the relevant box below to get started.

Yes, I agree to take part

### **Focus group oral consent**

Before starting the focus group exercise, participants were asked the following:

*Do you agree to participate in this focus group, acknowledging that the session will be video and audio recorded and that your comments may be used as part of doctoral research and academic publications? Do you also agree to treat fellow participants respectfully and that the researcher reserves the right to remove you from the call should you fail to do so?*

## **6. Paper 2: Social media messaging by climate action NGOs: A case study of the 2019-2020 Australian Black Summer bushfires**

This paper sought to explore how Australian climate action groups communicated with their audiences on Twitter about the relationship between climate change and the 2019-2020 Australian Black Summer bushfires. The research questions were informed by the findings of paper 1 to examine whether ‘real world’ communications from climate groups evoked some of the opportunities and challenges identified in the prior study.

## **Social media messaging by climate action NGOs:**

### **A case study of the 2019-2020 Australian Black Summer bushfires**

Joshua Ettinger, Mary Sanford, Peter Walton, David Holmes, James Painter

*Oxford Open Climate Change*

Published 13 October 2023

Available from: <https://academic.oup.com/oocc/article/3/1/kgad011/7311736>

#### **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 issue 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 offer directions for future research.

## **Background**

Climate change is altering the frequency, duration, and intensity of many kinds of extreme weather events around the world (Masson-Delmotte et al., 2021). 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 (Swain et al., 2020). 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 (Arias et al., 2022). 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 factors that caused food insecurity associated with the drought (Harrington et al., 2021).

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 (Boykoff et al., 2022; Painter & Hassol, 2020). For instance, Hopke (2020) found a growing number of climate change mentions in articles about heatwaves and wildfires from 2013-2018 across several countries. 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 (Dunne et al., 2022).

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 (Hautea et al., 2021; Treen et al., 2022). Social media discourse can differ significantly from news media coverage of the same topics (Chen et al., 2022). Social media platforms are also a major news source, especially for young people (Newman et al., 2022). Researchers have shown that the occurrence of extreme weather events is associated with an increase in social media posts that mention climate change (Kirilenko et al., 2015; Sisco et al., 2017), with different kinds of weather events generating varying amounts of attention to climate change (Berglez & Al-Saqaf, 2019; Moernaut et al., 2022; Roxburgh et al., 2019). For instance, Olynk Widmar et al. (2021) found that posts about hurricanes mentioned climate change less often than wildfires. Other analyses have examined the roles of social media for emergency communication, disaster response, and relief coordination during extreme events (Kankanamge et al., 2020; Liu et al., 2018; Martínez-Rojas et al., 2018; Takahashi et al., 2015; Zander et al., 2022).

### *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 (Chester, 2020; Kelman et al., 2015; Lahsen & Ribot, 2021). 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” (IPCC,

2018, 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 (Raju et al., 2021).

Likewise, the phrase ‘natural disaster’ is problematic as it implies that the impacts of extreme weather events are purely due to meteorological aspects (Chmutina & von Meding, 2019). Policymakers can exploit this idea to divert attention from local planning decisions and failures (Lahsen & Ribot, 2021). 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” (Pearce, 2022, p.1). A key point is the interconnectedness of risk dimensions (Bouwer et al., 2019). 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 (Ebi et al., 2021). Perceptions of these risk factors can also differ among citizens in the Global North and Global South (Lizarradle et al., 2021).

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 (Entman, 1993; Guenther et al., 2023). Experimental studies have shown that contrasting climate change frames can generate different audience responses, including a range of climate attitudes, emotions, and behavioral intentions (e.g., Gifford & Comeau, 2011; Morton et al., 2011; Marlon et al., 2019). 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 (Birkland & Schwaeble, 2019). 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 (Ettinger et al., 2021). 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 (Doyle, 2009). They also act as ‘alternative science communicators’, increasing societal awareness of scientific research and utilizing this information to advocate for their causes (Fäehnrich, 2018;

Maesele, 2009; Rödder, 2020; Yearley, 2017). In doing so, they broaden discourse around scientific evidence to connect knowledge with political action (Jasanoff, 1997). 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.”

Researchers have previously examined how NGOs use social media platforms such as Facebook and Twitter as part of their campaign strategies (e.g., Bortree & Seltzer, 2009; Comfort & Hester, 2019; Lovejoy & Saxton, 2012). Bazago et al. (2020) examined tweets from environmental NGOs during hurricanes Harvey, Irma and Maria that occurred in 2017 in the United States. 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. 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 (e.g., Osaka et al., 2019; Painter et al., 2021), 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 (Abram et al., 2021). 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 (Filkov et al., 2020; Johnston et al., 2021; Dickman, 2021). The fires led to billions of dollars of damage and affected billions of animals (Binskin et al., 2020; Van Eeden et al., 2020; Geary et al., 2021). They also disproportionately affected socio-economically disadvantaged communities (Akter & Grafton, 2021). 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 (Jones et al., 2022).

The fires received substantial global news coverage, especially at key moments during the season such as when smoke blanketed Sydney (Kidd, 2019), when Victoria declared catastrophic levels of fire weather (Australian Institute for Disaster Resilience, 2023), and when citizens of Mallacoota, Victoria, evacuated to beaches on New Year's Eve, generating dramatic photos and videos (Henriques-Gomes, 2020). 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. Different Australian news outlets pushed contesting narratives about the connection (or not) of climate change to the fires (Burgess et al., 2020; Mocatta and Hawley, 2020).

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. 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. Users also discussed the impacts of the fires on biodiversity (Leimbach & Palmer, 2022).

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 (IPCC, 2021; Jones et al., 2022). Climate change amplified the Black Summer fires: they happened after three consecutive years of drought and dry winters (King et al., 2020), and occurred during Australia’s hottest and driest year on record (Abram et al., 2021). 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 – van Oldenborgh et al., 2021).

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.” This includes under-resourced firefighters, most of whom are volunteers (Smith et al., 2022); a lack of preparation of the Australian healthcare system (Cousins, 2020); 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 (Bradstock et al., 2020; Levin et al., 2021; Steffensen, 2020); insufficient

early warning and emergency communication systems; ecological dynamics such as the dominance of highly flammable eucalyptus trees (Fletcher et al., 2021); and, as some have argued, a failure to implement lessons from prior governmental bushfire inquiries (Tolhurst, 2020), 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 (Binskin et al., 2020).

### *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 environmental 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):

*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?*

## **2. Method**

To answer our research questions, we first identified climate action groups that met the following criteria: (1) is based in Australia; (2) is a non-governmental organization that has addressing climate change as part of its core mission; and (3) 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 (CANA, 2022). 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.

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 2020 Royal Commission into National Natural Disaster Arrangements (Binskin et al., 2020). 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.

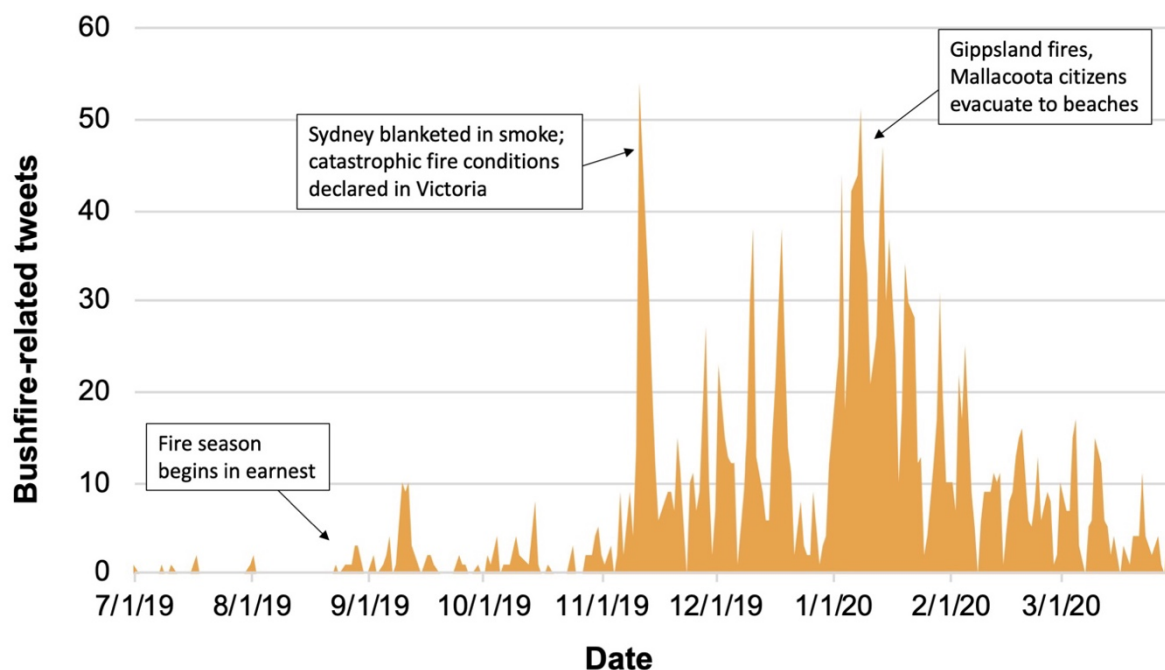
All tweets that did not mention terms such as "fire", "Black Summer", "burn", and other related phrases were removed (see supplementary materials for full query list), and the resulting dataset was then manually checked to remove false positives irrelevant to the topic of bushfires, such as those that mentioned fires happening elsewhere in the world. This resulted in a final dataset of 2,077 tweets from 59 accounts. Two of the co-authors manually coded these tweets following deductive content analysis informed by the research questions (Kynge & Kaakinen, 2019). 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 (Pearce et al., 2018). 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 .920 for Cohen's kappa and .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 (figure 6.1).



**Figure 6.1:** Timeline of NGO tweets about bushfires (n = 2,077) which correspond with significant fire events during the Black Summer season (1 July 2019 – 31 March 2020). Three examples of these events are indicated.

Of the total sample, 1,228 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 (figure 2). Tweets in this category most 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*

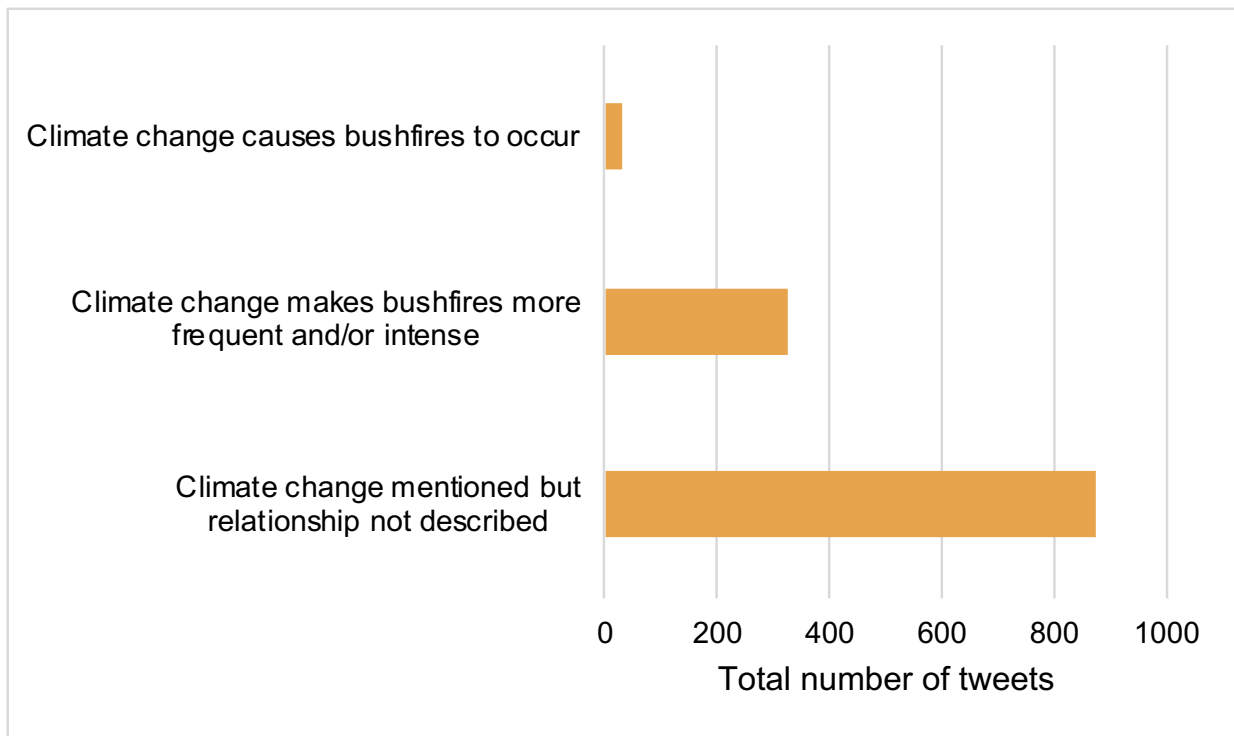
*@BOM\_au reports Australia has officially recorded its warmest, driest year on record, and the outlook points to increased catastrophic fire weather. #AustraliaFires #AustraliaisBurning #ActOnClimate*

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*

*What we need is a prime minister who acknowledges that this isn't another normal fire season, that the cause of this is climate change! Lives and homes have been taken while Morrison lies on a tropical beach with his head in the sand.*

*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'*



**Figure 6.2:** Bar chart showing frequency of tweets (excluding retweets and comments) for three different frames of how climate change relates to bushfires (n=2,077).

#### *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. 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 1,228 (59%) of tweets mentioned climate change, compared to 49% of Black Summer articles in Australian news media (Burgess et al., 2020). 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 (e.g., Chen et al., 2022). 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 (Burgess et al., 2020). Only seven accounts shared the van Oldenborgh et al. (2020) extreme event attribution study a total of fifteen times.

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 (Ettinger et al., 2021). 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 (Binskin, 2020). 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 (Lahsen & Ribot, 2021). 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 (Fäehnrich, 2018), 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 (Thierry, 2023). This would provide practical implications to 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 (IPCC, 2021). 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

(King et al., 2023). 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 a 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 (Lovejoy et al., 2012), 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 (O'Neill et al., 2022). 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 (Olynk Widmar et al., 2022); 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 (Ogie et al., 2022). 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% claimed 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.

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## Supplementary material

### 1. Sample

The corpus of tweets for this study were gathered from members of Climate Action Network Australia (<https://www.cana.net.au>). The list contained 149 organizations in November 2022 when the sample was created. 102 had twitter accounts. These 102 organizations and their Twitter handles are listed below, as well as their total number of tweets that mentioned bushfires during the Black Summer period.

<b>Name of organization</b>	<b>Twitter handle</b>	<b>Number of tweets that mentioned bushfires and percentage of total</b>
Climates	_Climates	0 (0%)
Make Your Change	_makeyourchange	0 (0%)
1 Million Women	1millionwomen	13 (1%)
350.Org Australia	350australia	59 (3%)
Actionaid Australia	actionaid	4 (>1%)
Australian Forests And Climate Alliance	afca_forests	47 (2%)
Australian Parents For Climate Action	ap4ca	20 (1%)
Arid Lands Environment Centre	AridLandsEC	0 (0%)
Australian Religious Response To Cc	arrcc1	9 (>1%)
Action For Agriculture	Art4ag	0 (0%)
Australian Conservation Foundation	AusConservation	34 (2%)
Centre For Australian Progress	ausprogress	0 (0%)
Australasian Centre For Corporate Responsibility	austccr	1 (>1%)
Australian Marine Conservation Society	AustMarConsSoc	6 (>1%)
Australia Remade	AustraliareMADE	2 (>1%)
Australian Youth Climate Coalition	aycc	6 (>1%)
Bathurst Community Climate Action Network	bccan	0 (0%)
Better Renting	BetterRentingAU	0 (0%)
Beyond Zero Emissions	beyondzeronews	4 (>1%)
Bushfire Survivors For Climate Action	BSCA_Aus	15 (1%)
Cairns And Far North Environment Centre	cafnc	0 (0%)
Climate Action Moreland	camoreland	6 (>1%)

CAN Australia	can_australia	0 (0%)
Climate Change Balmain-Rozelle	CCBalroz	22 (1%)
Citizens' Climate Lobby Australia	CCL_Aus	2 (>1%)
Changemakers	changemakers99	1 (>1%)
Climate Action Burwood / Canada Bay	ClimateBCB	3 (>1%)
Climate Council Of Australia	climatecouncil	270 (13%)
Climate Justice Programme	climatelaw	0 (0%)
Climate Action Newcastle	climatenc1	0 (0%)
The Climate Reality Project	ClimateRealityA	5 (>1%)
Climate Justice Union	climateunionwa	0 (0%)
Climateworks Australia	ClimateworksCtr	7 (>1%)
Common Grace	commongraceaus	0 (0%)
Comms Declare	CommsDeclare	2 (>1%)
Community Power Agency	communitypowerA	0 (0%)
Conservation Council Act	ConservationACT	21 (1%)
Conservation Council Of South Australia	ConservationSA	1 (>1%)
Conservation Council Of Western Australia	conservationwa	0 (0%)
Citizens Own Renewable Energy Network Australia (Corena)	CORENAfund	0 (0%)
Darebin Climate Action Now	darebinca	0 (0%)
Doctors For The Environment Australia	DocsEnvAus	143 (7%)
The Next Economy	economy_next	1 (>1%)
Environmental Justice Australia	ej_aus	52 (3%)
Energetic Communities Association	EnergeticComms	0 (0%)
Environment Centre Of The Northern Territory	EnviroCentreNT	2 (>1%)
Environs Kimberley	EnviroKimberley	8 (>1%)
Environment Victoria	EnviroVic	195 (9%)
Edmund Rice Centre	ercaus	1 (>1%)
Farmers For Climate Action	farmingforever	35 (2%)
Friends Of Latrobe Water	flowlatrobe	0 (0%)
Friends Of The Earth Australia	FoEAustralia	46 (2%)
Getup!	getup	88 (4%)
Gladstone Conservation Council	gladconscouncil	4 (>1%)
Green Music Australia	GreenMusicAU	0 (0%)

Greenpeace Australia Pacific	greenpeaceap	65 (3%)
Gudanji For Country Aboriginal Corporation	Gudanji4country	0 (0%)
Climate And Health Alliance	healthy_climate	97 (5%)
Healthy Futures	HealthyFuturez	31 (1%)
Iclei: Local Governments For Sustainability	iclei	1 (>1%)
Planet Politics Institute	InstitutePlanet	0 (0%)
Jubilee Australia Research Centre	Jubilee_AU	0 (0%)
Kooyong Climate Change Alliance	KooyongVotes	0 (0%)
Lighter Footprints	litefootprints	1 (>1%)
Melbourne Playback Theatre	melbplayback	0 (0%)
Nature Conservation Council Of Nsw	naturensw	145 (7%)
North Queensland Conservation Council	NQCC	0 (0%)
Outdoors People For Climate	outdoorsclimate	0 (0%)
Oxfam Australia	oxfamaustralia	114 (5%)
Peoples Climate Action Coalition	PCA_Australia	18 (1%)
Plan International Australia	PlanAustralia	8 (>1%)
Psychology For A Safe Climate	psychologysafe	0 (0%)
Public Transport Users Association	ptua	0 (0%)
Publish What You Pay	PWYPAustralia	0 (0%)
Queensland Conservation Council	qldconservation	0 (0%)
Re-Alliance	reallianceaus	7 (>1%)
Reef Ecologic	reefecologic	0 (0%)
Renew	reneworgau	2 (>1%)
Sustainable Living Armidale	SLArmidale	3 (>1%)
Smart Energy Council	SmartEnergyCncl	3 (>1%)
Solar Citizens	solarcitizens	7 (>1%)
School Strike 4 Climate Australia	strikeclimate	161 (8%)
Student Voice Network	studentvoiceaus	0 (0%)
Surfers For Climate	surfers4climate	7 (>1%)
Sweltering Cities	SwelteringCity	0 (0%)
Sydney Alliance	sydneyalliance	0 (0%)
Tear Fund	Tearfund	0 (0%)
The Australia Institute	theausinstitute	109 (5%)
Tomorrow Movement	tomorrowmvmt	0 (0%)
Totally Renewable Yackandandah	TotalRenewYack	0 (0%)

Totally Renewable Beechworth Inc.	TRBeechworth	0 (0%)
Uniting Church In Australia, Synod Of Victoria And Tasmania	ucavictas	4 (>1%)
United Workers Union	unitedworkersoz	10 (>1%)
Veterinarians For Climate Action	Vets4climateact	2 (>1%)
Vote Earth Now	voteearthnow	0 (0%)
Wa Climate Leaders Inc.	WA_Climate	0 (0%)
Uniting Nsw.Act	weareuniting	5 (>1%)
Women's Environmental Leadership Australia Ltd	wela_au	0 (0%)
The Wilderness Society	wilderness_au	27 (1%)
Women's Climate Congress	womensclimatec1	0 (0%)
World Wide Fund For Nature (WWF)	WWF_Australia	78 (4%)
Extinction Rebellion Australia	xrebellionaus	37 (2%)

## 2. Data filtering process

Using the above list of 102 climate groups, the Twitter API returned 49,229 tweets, retweets, and comments from the time period of 1 July 2019 to 31 March 2020. These tweets were then filtered to only keep those that mentioned at least one of the following terms: “fire”, “bush”, “bushfire”, “Black Summer”, “burn”, “burnt”, “burning”. 2,507 tweets remained. This list was then manually checked to remove any false positives unrelated to the Black Summer or bushfires (e.g., tweets about fires happening elsewhere in the world). This ultimately left a final corpus of 2,077 tweets from a total of 59 accounts.

## 3. Codebook

1. Tweet identifier:
2. Coder initials
3. Organization Twitter handle:
4. Date of tweet:
5. Does the tweet mention climate change (or related terms/concepts such as global warming, climate crisis, climate emergency, greenhouse gas emissions, etc.)? This can include hashtags, but not does not include tagging an account with climate in its name.
  - a. Yes (1)
  - b. No (put 0 for questions 2a, 2b, 2c and 3, skip to 4)
6. How does the post frame the relationship between the fires and climate change?
  - a. Direct causality - stating clearly that climate change caused the bushfires or that they would not have occurred without climate change
  - b. Altered likelihood or intensity (including terms such as intensifying, making more likely, more dangerous, higher risks, worsening, fires hitting areas it previously has not, etc.)

- c. Generally linked/related without specifying details, including adding climate-related hashtags to bushfire tweets or bushfire hashtags to climate tweets. This also includes vague statements like climate change is “driving” bushfires.
7. Does the post reference the 2020 Van Oldenborgh et al. Black Summer attribution study?
    - a. Yes (1)
    - b. No (0)
  8. Does the tweet mention vulnerability/planning/disaster risk reduction/emergency responses in shaping the impacts of bushfires? (e.g., protecting homes, firefighting/firefighters, planned burns, evacuation, emergency response measures, etc.)
    - a. Yes (1)
    - b. No (0)

The following two questions were also included in the codebook – they were not part of the formal analysis but were included to gather data to support potential future research.

9. Does the tweet mention First Nations Australian Indigenous Peoples? For instance, tweets may relate to the impacts of bushfires on Indigenous Peoples or cultural burning techniques.
  - a. Yes (1)
  - b. No (0)
10. Does the tweet mention the impacts of the bushfires on biodiversity?
  - a. Yes (1)
  - b. No (0)

We found that 45 tweets (2%) mentioned First Nations Australian Indigenous Peoples. 345 tweets (17%) mentioned biodiversity.

## **7. Paper 3: Examining contrasting influences of extreme weather experiences on individual climate activism**

This study explores through interviews how personal direct experiences of bushfires in Australia influenced individual participation in climate activism. By working retrospectively to examine reported experiences of extreme weather and how these experiences may have influenced participation in climate activism, this study sought to uncover psychological dynamics relevant to campaigns seeking to mobilise others in climate action after extreme weather events.

# **Examining contrasting influences of extreme weather experiences on individual climate activism**

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Published 30 April 2024

Available from: <https://gep.psychopen.eu/index.php/gep/article/view/10829>

## **Abstract**

Researchers have examined how extreme weather experiences influence climate change attitudes, beliefs, and behaviors, with mixed results. However, limited research has explored how extreme weather experiences may affect climate-related perceptions and behaviors among climate activists. Given the significant role activism plays in climate action, it is important to understand to what extent, how, and why extreme weather can catalyze or inhibit individual climate activism. This study explores reported influences of extreme weather experiences on climate perceptions and activism through interviews with 33 Australian adults who directly experienced bushfires and previously engaged in climate activism. All participants felt more vulnerable to climate change after experiencing bushfires. Fifteen participants (45%) increased their activism; 13 (39%) maintained the same activism level; and 5 (15%) decreased their activism. Participants who increased their activism sought to share their bushfire stories with news media, policymakers, and through artistic projects. Climate activism helped several participants cope with their bushfire-related trauma, whereas several other participants reduced their activism because their experiences undermined self-efficacy (perception that one can act on climate change). These findings show the divergent ways individuals may respond to extreme weather experiences and have implications for climate action mobilization strategies.

## **Introduction**

As climate change continues to alter the frequency and intensity of many types of extreme weather events around the world, researchers are increasingly exploring how extreme weather experiences influence climate change attitudes, beliefs, and behaviors among the public. Extreme weather events are meteorological phenomena such as fires (or more precisely, fire weather conditions), floods, heatwaves, and tropical cyclones that are “rare at a particular place and time of year” (IPCC, 2018, p.549). These events can cause loss of life and public health crises, destroy infrastructure, harm natural and cultural heritage, and spark a range of secondary social consequences and feedback loops. It is hypothesized that extreme weather events can counter the abstract qualities (i.e., ‘psychological distance’) of climate change and increase climate change beliefs, concerns, and behaviors (Keller et al., 2022). This perception in turn could alter attitudes about climate change, including heightening perceptions of vulnerability to climate impacts (likelihood that climate change could negatively impact them), and building stronger support for action on climate change (Zanocco et al., 2019).

However, minimal research has examined how extreme weather experiences influence individual participation in climate activism. This is an important area for research given the important role climate activism plays in climate action, significant dropout and burnout among activist groups, and growing interest in the relationship between trauma and pro-environmental behaviors. This study helps advance this body of literature through interviews with 33 Australian adults who have directly experienced bushfires and previously participated in climate activism. Using a qualitative approach, we explore to what extent, how, and why bushfire experiences influence subsequent perceptions of climate change and engagement in climate activism. The findings have important implications for efforts to mobilize citizens into climate action in the wake of extreme weather events.

### *Extreme weather experiences and climate change perceptions*

Dozens of studies have examined relationships between extreme events and how the public conceptualizes, and acts upon, climate change (Howe et al., 2019). Most studies measure personal experiences of extreme weather events through self-reports that one has been in close physical proximity to a specific weather event, which is sometimes triangulated with observational weather data. These studies are often grounded in Construal Level Theory (CLT), which proposes four dimensions of psychological distance, including proximity (how close an event feels in physical space), social aspects (to whom an event occurs), temporality (when an event occurs in time), and a hypothetical component (perceptions of whether something is likely to happen) (Trope & Liberman, 2010). According to CLT, by virtue of its tangible, visceral and local impacts, extreme weather could make the risks of climate change more visible, concrete and psychologically close across these four dimensions, which in turn could prompt stronger climate-related beliefs, risk perceptions, and behaviors (Keller et al., 2022).

Results on this topic are mixed (Howe et al., 2019; Reser & Bradley, 2020; Sambrook et al., 2021; Sisco, 2021). Some researchers have found that extreme weather events increase climate change beliefs, risk perceptions, and pro-environmental behaviors, whereas others have found that increased concerns last for only a limited duration, or have no effects on climate attitudes or policy support (Howe et al., 2019). For instance, Demski et al. (2017) found that flooding experiences in the UK increased attention to climate change and behavioral intentions around personal climate change mitigation and adaptation actions. In contrast, Gärtner and Schoen (2021) concluded that extreme weather events in Germany were not associated with any changes in climate change attitudes or support for climate policies.

There is a growing recognition of the complexities and factors that can influence the effects of extreme weather experiences on individual climate change perceptions and behaviors. A key dynamic is whether individuals and communities subjectively attribute extreme weather events to climate change (Ogunbode et al., 2019; Sambrook et al., 2021; Thaker & Cook, 2021). Motivated reasoning, which leads individuals to interpret information in ways that support their existing beliefs, worldviews, and identities, may affect whether individuals perceive a connection between climate change and an extreme event (Reser et al., 2014). Characteristics of the weather event also matter – Marlon et al. (2021) found that Americans tend to associate only hot dry days with global warming.

#### *Extreme weather experiences, trauma, and climate activism*

While many studies have examined the topic of extreme weather and public perceptions, there has been significantly less research into potential interactions between individual climate activism and extreme weather. Activism (also known as collective action) refers to actions taken by individuals to advance the interests, status, power, or conditions of a group (Van Zomeren et al., 2018). Although activism is often associated with protests, it can include participating in protests and strikes, signing petitions, blockades of fossil fuel infrastructure, acts of nonviolent civil disobedience, contacting elected officials, supporting environmental organizations, and other actions. Individuals may hold contrasting opinions on whether they identify themselves as activists, participate in forms of activism suited to their personal circumstances, and be mobilized into action through recruitment efforts of environmental groups (Fielding et al., 2008).

Researchers have proposed many theoretical models for understanding factors that predict individual participation in activism, including the value-belief-norm model, collective interest

model, theory of planned behavior, and social identity model of collective action (Fielding et al., 2008; Lubell, 2002; Stern et al., 1999; van Zomeren et al., 2018). Less is known about what motivates individuals to engage in sustained collective action over longer periods of time (Gulliver et al., 2022). Of most relevance to this study, there is growing interest and empirical research into relationships between environmental trauma, climate-related anxiety (a.k.a., eco-anxiety or ‘solastalgia’), and pro-environmental behaviors, including activism (Clayton, 2020; Galway et al., 2019). There are many definitions and dimensions of trauma, but it generally refers to negative emotional responses to distressing events (whereas climate-related anxiety may not be associated with specific experiences) and can lead to longer-term psychological conditions such as Post-Traumatic Stress Disorder (Kleber, 2019). Considering how trauma and anxiety may interact with individual activism is highly relevant to extreme weather events and associated disasters as they can cause substantial negative mental health impacts (Cunsolo & Ellis, 2018).

For some individuals, engaging in activism can support individual coping with trauma, emotional well-being, and post-traumatic personal growth (Rabkin et al., 2018; Strauss Swason & Szymanski, 2020). Pursuing individual action on climate change may help relieve climate-related anxiety by countering feelings of powerlessness to affect change on the issue (Godden et al., 2021; Innocenti et al., 2023; Schwartz et al., 2022). The perception of whether one can act on a challenge or respond to a situation is known as self-efficacy, which can support one’s ability to cope with hardship, stress, and trauma (Bandura, 1994). Climate researchers often narrow the theory of self-efficacy to one’s perceived ability to specifically pursue climate-related behaviors (Bostrom et al., 2019). This is distinct from response efficacy, which denotes a belief that these behaviors can make a difference, as well as collective efficacy, which focuses on a group’s ability to affect change (Van Zomeren et al., 2018). Positive psychological

outcomes associated with activism may also relate to feelings of group belonging. Muldoon et al. (2021) describe how one's personal identification with a group (e.g., activist group) confers personal benefits including a sense of connection with others, solidarity, and support, which can aid post-traumatic recovery, personal growth, and well-being. This is part of a broader field known as the social cure approach, which examines how social identity affects health (Haslam et al., 2018).

On the other hand, researchers have found that engaging in activism can prompt feelings of burnout and other emotional challenges (Vaccaro & Mena, 2011; Chen & Gorski, 2015). Some individuals choose to distance themselves from the issue when climate-related anxiety becomes too distressing (i.e., eco-paralysis) (Albrecht, 2011). Perceptions of self-efficacy may mediate whether climate anxiety encourages pro-environmental behaviors or inhibits them (Innocenti et al., 2023). Similar mechanisms could be at work with climate-related trauma, about which there is less research compared to eco-anxiety.

To summarize, trauma associated with extreme weather events could spur further individual climate activism and participation in activist groups, or it could lead individuals to turn away from it. To the authors' knowledge, there have been no studies specifically examining the extent to which trauma associated with extreme weather events may relate to activists' intentions to continue engaging in climate activism. As Brügger et al. (2021) describe, further research is needed to examine how extreme weather experiences influence different climate change actions among distinct segments of the general population, as well as the potential role of trauma in relation to these behaviors.

### **Case study background**

Although researchers have started to examine how extreme weather events affect activism at the community level (Boudet et al., 2020), it is important to further investigate to what extent and in what ways extreme weather experiences influence individual engagement in climate activism. It is likewise pertinent to investigate how extreme weather may interact with sustained individual climate activism because activist groups struggle to persist over time and maintain continued participation among members (Han et al., 2017).

Australian bushfires offer a promising case study for analyzing how individual extreme weather experiences inform climate change perceptions and activism. Bushfires are a natural feature of the Australian environment, playing both destructive and regenerative roles in Australian ecosystems (Sharples et al., 2016). Australian citizens, communities, and officials have long responded to and managed bushfires, and First Nations Indigenous Australian Peoples have practiced cultural fire management techniques for millennia. However, conditions associated with heightened bushfire risks have been increasing over the past 70 years in Australia (Abram et al., 2021). Climate change is making many parts of Australia hotter and drier, which makes bushfires more frequent and intense. A wide range of factors affect bushfire impacts, including disaster risk reduction, community planning, and emergency responses (Chester, 2020; O'Neill & Handmer, 2012).

Bushfires threaten public health and safety, property, infrastructure, biodiversity, and natural and cultural heritage. They are also associated with significant psychological impacts, including post-traumatic stress disorder and depression (Bryant et al., 2014). Indigenous Australian Peoples may experience unique forms of bushfire trauma and grief associated with a strong sense of personal identity in connection with the landscape (Allam, 2020; Godden et

al., 2021). Extreme events disproportionately impact children, elderly individuals, low-income groups, and people of color (Benevolenza & DeRigne, 2019).

The 2019-2020 Australian summer fires, known as the 'Black Summer', burnt about 19 million hectares of land; killed 33 people from direct exposure, and destroyed over 3,000 homes (Filkov et al., 2020). Climate change made the fires at least 30% more likely to have occurred (van Oldenborgh et al., 2020) and they were described as a teachable moment for climate action (e.g., Gleick, 2020). Given that the Black Summer bushfires recently prompted significant attention to links between climate change and extreme weather events, an analysis of these dynamics among Australian adults who have directly experienced bushfires and previously engaged in climate activism offers a timely and novel case for analysis.

### **Study aims and methods**

This study explores to what extent, how, and why extreme weather experiences influence subsequent perceptions of climate change and engagement in climate activism among 33 Australian adults who have both directly experienced bushfires and previously participated in climate activism. Researchers have mostly used quantitative methods in efforts to establish statistically generalizable relationships between extreme weather events and climate-related attitudes, beliefs, and behaviors (Howe et al., 2019). We use a qualitative approach as it can help uncover how, under what circumstances, and why extreme weather experiences influence individual climate change perceptions and activism in different ways, including cognitive, emotional, and behavioral dimensions (Reser & Bradley, 2020). These exploratory findings can in turn inform future quantitative research. The following research questions guided this research:

RQ1. To what extent, how, and why can experiencing a bushfire event influence perceptions of climate change among adult Australian climate activists?

RQ2. To what extent, how, and why can experiencing a bushfire event influence subsequent levels of participation in climate activism among adult Australian climate activists?

Ethical approval for the study was received from the University of Oxford's Central University Research Ethics Committee. Beginning in January 2021, participants were recruited via outreach to climate action groups across Australia identified by Google search, as well as snowball sampling. Interested individuals completed a survey which included demographic questions and two recruitment questions inquiring if respondents had (1) directly experienced a bushfire and (2) previously participated in climate activism activities. We used flexible definitions of bushfire experiences and activism, but some limiting criteria were imposed. Firsthand bushfire experiences denoted having personal property affected by fires (e.g., defending and/or evacuating one's home) or firefighting. This narrowed our focus to fire encounters in non-urban areas, although we recognize millions more Australians experienced bushfire smoke and people around the world experienced them vicariously. We defined climate activism as participating in activities such as signing climate-related petitions, contacting policymakers about climate change, and participating in climate groups, marches, and protests. Respondents who did not answer 'yes' to both questions were not invited to an interview. A total of 42 responses to the survey were received, 36 respondents met the study criteria, and 33 participated. The sample is not statistically generalizable to the Australian population; rather, it is a purposive sample designed to match the qualitative research questions fulfill the research aims. In May 2021, with frequent repetition of similar ideas and limited new information

arising in the interviews, we determined that sufficient data saturation had been reached and recruitment concluded (Saunders et al., 2018). Table 1 shows participant demographic information.

<b>Characteristic</b>	<b><i>n</i></b>	<b>%</b>
<b>Gender</b>		
Male	12	36%
Female	21	64%
Other	0	0%
Prefer not to say	0	0%
<b>Age group</b>		
18-29	5	15%
30-49	8	24%
50-69	18	55%
70+	2	6%
<b>Location (state/territory)</b>		
Australian Capital Territory	0	0%
Jervis Bay Territory	0	0%
New South Wales	15	45%
Northern Territory	0	0%
Queensland	1	3%
South Australia	2	6%
Tasmania	1	3%
Victoria	14	42%
Western Australia	0	0%
<b>Highest level of education</b>		
Secondary school	2	6%
TAFE (certificate)	3	9%
TAFE (diploma)	5	15%
Undergraduate degree	11	33%
Post-graduate degree	12	36%

**Table 7.1:** Participant demographics.

We utilized a semi-structured narrative interview approach, which encouraged interview participants to tell stories about their experiences, with limited interviewer interruption beyond points of clarification (Anderson & Kirkpatrick, 2015). This approach empowers participants to decide which aspects of their experiences are most salient to include and tell their stories in a manner of their own choosing. Participants may not accurately describe, recall, or be fully

aware of their own motivations. However, this is less of an issue for this study as we seek to uncover how individuals recollect and reflect on their experiences. Nonetheless, throughout this paper we remind the reader of this limitation by frequently writing ‘reported’ or ‘perceived’ motivations and behaviors.

Given potential discussions of trauma, special care was taken to ensure participants were comfortable speaking about the topic, reminded they could stop the interview at any time, and links to mental health resources were prepared should a participant experience emotional distress. Interviews ran between 30 - 60 minutes and were held over video chat due to the coronavirus pandemic. The interviews were transcribed and analyzed by the lead author in NVivo following reflexive thematic analysis to identify shared patterns of meaning (i.e., themes) across the data (Braun & Clarke, 2019). Co-authors provided feedback in reflective discussions during the coding process to support “a richer more nuanced reading of the data, rather than seeking a consensus on meaning” (Braun & Clarke, 2019, p.594). The supplementary materials describe in detail the recruitment, interview, and analysis procedures. Table 2 shows the themes and subthemes that resulted from the analysis and the research questions to which they relate.

<b>Theme</b>	<b>Subtheme(s)</b>
Bushfire experiences alter perceptions of climate change (research question 1)	Heightening perceptions of vulnerability  Decreasing psychological distance of climate change  Increasing urgency to act on climate change  Speaking with experts confirms perceptions of bushfire and climate change relationship
Increasing activism after bushfire experiences (research question 2)	Activism supports coping with bushfire-related trauma  Sharing stories of bushfire experiences

Sustaining activism after bushfire experiences (research question 2)	Bushfire experiences reaffirm existing climate activism motivations
Decreasing activism after bushfire experiences (research question 2)	Distancing from activism to focus on emotional recovery Distancing from activism to focus on physical recovery

**Table 7.2:** Analysis themes, subthemes, and associated research questions.

It is important to acknowledge the role of researcher reflexivity in shaping all stages of qualitative research (Olmos-Vega et al., 2022). We note our own positionality as environmental researchers, individuals concerned about climate change, and, for some co-authors, as individuals who have participated in climate activism. In alignment with assumptions of reflexive thematic analysis, we view these and other personal aspects as playing a central role in our construction of themes across participant responses, rather than suggesting that themes emerge implicitly from our dataset (Braun & Clarke, 2023). Further details about the recruitment, interview, and analysis procedures are available in the supplementary materials.

## Findings

Before examining key themes, it is helpful to briefly describe the context of our participants' bushfire experiences. Some evacuated their homes prior to a fire; others stayed and defended their properties, and some of their homes were spared, partially affected, or destroyed. Others experienced bushfires in a firefighting capacity. Participants' stories captured the danger and intensity of close-hand fire experiences. For example:

*“I remember at one stage looking up and seeing fire up in the hills and thinking, that's our house gone . . . [I saw] a car on fire and a whole lot of people watching and a couple of fire trucks trying to put the fire out . . . they thought there was someone in*

*there and they hadn't been able to get them out, and it turned out there was . . . He was going down to get fuel for the fire pump and on the way back, he'd come around the corner and he must've been panicked and didn't take it very well and went off the corner. Then the car caught fire and of course he had a thing of fuel in the car with him so you [can imagine] how it happened . . . That image stayed with me. That's one that would recur to me in dreams.” (participant 12)*

As shown above, participants' bushfire experiences were often high stress situations in which individuals were forced to make difficult decisions with potential life-or-death consequences, including if/how long to defend one's property against fires and if/when to evacuate, as well as what belongings to save under limited time. 20/33 (61%) of participants felt their experiences were traumatic (by their own definition when asked if they found their bushfire experience traumatic). Beyond threats to their personal safety, their trauma was frequently connected with feelings of personal attachment to their properties, local flora and fauna, and communities.

#### *Altered perceptions of climate change*

All participants (N=33) perceived a link between their bushfire experiences and climate change. They described how they compared their experiences with their prior observations and understandings of bushfires, and based on dialogue with others knowledgeable about climate change and bushfires. They felt that climate change had altered the bushfires (e.g., increased fire speed, extent, impacts, etc.) and frequently alluded to a broader trend of an altered, 'abnormal' Australian environment:

*“I spoke to one of the experienced firies [firefighters] and he basically said, yeah, look that was dry lightning and that's just something that . . . never used to ever have happened, you know, over all his experience dealing with fire over whatever X number of years, so that reaffirmed it [climate change] for me.” (participant 6)*

*“Everyone who was used to fires said the same thing: these are not normal fires. This is a new kind of fire.” (participant 12)*

These statements show how participants assigned importance to the opinions of peers and experts (often shared during community forums and climate action group events) in affirming their perception that climate change had altered bushfires and that they deviated from ‘normal’ environmental conditions.

Although all participants (N=33) already believed in, and were concerned about, climate change, a notable theme across all participants were statements suggesting a reduction in perceived psychological distance of climate change. Many described how their experiences changed their perception of climate change from a theoretical concept to a threat that now directly affected them:

*“It's real for me, it's not just theoretical. I know what it feels like. I know what it looks like. . . it feels a lot more personal and yeah, I definitely am accessing that with a level of like lived fear and reality that I think maybe other people are not when they're talking theoretically about it.” (participant 14)*

*“When it starts hitting personally, it's hard not to go, right, you know there's this sort of concept of climate change and you're always seeing things in the news, you're always reading articles, but when it's in your own backyard, yeah, it's hard not to go . . . this is real, this is really happening.” (participant 6)*

These statements show how participants reflected deeply on how climate change now affects them in direct physical proximity, rather than happening somewhere else, to someone else, at some point in the future. This was often described as heightening their personal vulnerability to climate change. 9/33 (27%) participants discussed how their experiences affected views of their own vulnerability to climate impacts and perceived urgency of climate action:

*“I can't keep away from the fires because they're everywhere. I can't get away from the smoke. . . knowing that there's nowhere safe, I think is a psychological stress that I had not counted on” (participant 30).*

*“Obviously like the urgency [to act on climate change] was just, it felt like it was just tripled and so there was like a real reaction afterwards . . . for me it just became like I had no choice in it anymore” (participant 33).*

Such statements show how climate change was now viewed as an issue that threatened them directly, rather than being a distant threat – even though they previously considered it an important issue. These participants now viewed their personal risks from fires and climate change as unavoidable.

*Increasing activism after bushfire experiences*

Participants were asked whether their climate activism participation had decreased, increased, or remained the same after their bushfire experiences. Almost half of the participants (15/33, 45%) reported that their bushfire experiences led them to increase their climate activism. They felt that their bushfire experiences provided them with a unique and important perspective on climate change – a voice to which others, such as politicians and media, might be more receptive. This increase frequently entailed pursuing new types of actions to communicate stories of their bushfire experiences in media interviews, at environmental events and rallies, with policymakers, and through artwork and creative writing:

*“I think there was an appetite for the media to hear firsthand from people that have been impacted . . . I found that voice that I hadn’t had before.” (participant 8)*

*“I’m a 60-year-old grandmother, we evacuated six times during these fires . . . I would always start my letter to politicians with something like that. So I had that as ammunition, if you like, as part of being able to try to explain you know how desperate things were.” (participant 15)*

*“I think our ability to talk about that [climate action] from personal experiences, is going to continue to be valuable. And it certainly makes me feel more comfortable in my activism . . . our lives have been significantly affected.” (participant 20)*

These statements show how these participants felt their experiences conferred a sense of authority, legitimacy, and responsibility to speak to the risks of bushfires and climate change. Additionally, 9/33 (27%) of participants noted psychological benefits of participating in

climate activism after their bushfire experiences. They felt activism helped them cope with the trauma of their experiences and climate-related emotions:

*“I think actually, if I didn’t act on climate, I would actually despair. . . the only thing that gets you, keeps you putting one foot in front of the other is the fact that you’re acting and plus the fact that because I’m in a group acting with other people, and being connected with other people who are caring and acting on it.” (participant 30)*

*“I learned how other people were feeling about it [climate change] and which made me realize that it wasn’t just me that could see the changes” (participant 21).*

*“It’s not always easy to tell the story [of my bushfire experience] . . . but it is also cathartic.” (participant 6)*

Beyond offering a sense of empowerment in acting on climate change, these statements show how the psychological benefits of activism are linked to identification as part of a climate activism group. Acting with others countered a sense of alienation and loneliness, and offered a community of like-minded support. Sharing bushfires stories were also seen as a way of processing their experiences.

#### *Sustaining activism after bushfire experiences*

13/33 (39%) of participants reported that they maintained the same level of engagement in activism activities after experiencing bushfires. They were already active on climate change and simply felt their experiences only reinforced their existing behaviors. As participant 2 stated, *“I didn’t really change [my activism] . . . I’ve got an environmental science degree and*

*that was probably all the motivation I need to see the direction we're heading in.* These participants tended to discuss in more depth how they felt bushfires affected climate activism of others around them, and across Australia more generally.

#### *Distancing from activism after bushfire experiences*

In contrast to those who increased or sustained their levels of activism, several participants (5/33, 15%) decreased their climate activism after experiencing bushfires. Among these participants, we noted two distinct influences of bushfires. First, the drop in activism was associated with the traumatic nature of their experiences and a reported need to emotionally distance themselves from the topic of climate change:

*“The last year, it's been a juggling act in rebuilding our lives, and just trying to maintain our own mental well-being . . . we were in a pretty traumatized, fragile state early on. So we're recovering our own emotional mental strength.” (participant 23)*

*“We sort of have a bit of anxiety around it [activism] . . . like sometimes I'll do stuff, but it's dropped off, because I'm like, okay, well, I need to get a bit of a break from it.” (participant 28)*

Such responses suggest that some individuals felt that engaging further on the issue would be too emotionally triggering while they sought to emotionally recover from their experiences. However, other participants described how physical, rather than emotional, recovery aspects played a role in why they decreased their activism:

*“None of us could actually handle anything more than just making our own home secure.” (participant 29)*

*“We're trying to rebuild . . . so I have to focus my attention on that. And, yeah, I do what I can, but I've lost a lot of energy since the fire.” (participant 4)*

These statements do not indicate that these participants reduced their climate activism due to a sense of emotional burnout about the issue. Rather, their primary focus at the time was on rebuilding their homes and/or returning to a stable living situation, with activism being perceived as secondary to their immediate needs. Responses from these five participants show how emotional and/or physical recovery aspects can play a role decreasing individual activism.

## **Discussion**

The first research question sought to examine how Australian bushfire experiences influenced subsequent perceptions of climate change. Participants overall viewed their experiences as further confirmation of their prior beliefs that human-driven climate change is occurring. This is likely indicative of a motivated reasoning process in which individuals process information in ways that support their existing views (Ogunbode et al., 2019; Reser et al., 2014). Nonetheless, participants' statements suggest their experiences reduced perceived psychological distance of climate change, reflecting the four characteristic dimensions of Construal-Level Theory (Trope & Liberman, 2010 – see literature review). Participants felt that their perception of climate change was altered from a hypothetical issue to a problem that now directly threatened them in time and space, and about which they expressed a high degree of certainty. Their experiences also made them feel more directly vulnerable to climate impacts and demonstrated the urgency of acting on climate change. This finding is not particularly

surprising as prior studies have noted similar relationship between extreme weather experiences and climate perceptions. For example, Shepard et al. (2018) found that flooding experiences in Colorado in 2013 did not change fundamental beliefs in climate change but increased feelings of vulnerability.

The second research question sought to examine to what extent, how, and why bushfire experiences influence subsequent levels of participation in climate activism. Whereas bushfire experiences generally had the same influences on climate change perceptions across participants, reported subsequent activism participation diverged. For some individuals, engaging in climate activism and sharing bushfire stories helped them cope with, and make sense of, the trauma of their bushfire experiences. This parallels findings from climate change and broader disaster research on the importance of meaning-making processes for supporting individual well-being and coping (Park, 2016). Likewise, belonging to an activist group provided feelings of solidarity and empowerment (Muldoon et al., 2021). Participants' statements suggest that these groups helped heighten perceptions of self-efficacy (one's perceived capability to act on climate change) (Bostrom et al., 2019). This highlights the significant climate activism mobilization role of environmental groups (Han et al., 2017).

In contrast, 13/33 (39%) did not change their level of activism and 5/33 (15%) of participants decreased their activism. Statements from participants who decreased their activism suggest that reduced perceptions of self-efficacy played a role. Some participants distanced themselves from climate activism because they needed time to recover emotionally from their experiences and felt activism would further exacerbate their bushfire-related trauma. Others expressed an intention to continue participating in activism, but were unable to do so given the amount of time and energy required to rebuild their homes and return to stable living conditions. In both

cases, extreme weather experiences undermined feelings of self-efficacy to act on climate change, though for different reasons. Prior studies have examined the role of self-efficacy in mediating whether eco-anxiety can cause eco-paralysis and distancing from climate action (Innocenti et al., 2023). Our findings suggest a similar mechanism could be at work in the case of climate-related traumatic experiences as well.

These findings contribute to literature on extreme weather experiences by showing how potential climate activism participation after extreme weather experiences can diverge. Similar to research showing that eco-anxiety can motivate or inhibit individual climate action for different people (Verplanken et al., 2020), our research shows how traumatic extreme weather experiences can lead some individuals to further mobilize on climate change and others to distance themselves from it. The findings thus underscore the multifaceted ways in which individuals respond to their extreme weather experiences (Brügger et al., 2021). The term ‘extreme weather experience’ itself is broad and vague– it encapsulates a wide variety of different kinds of exposures and personal impacts (e.g., losing one’s home to a fire versus firefighting). An important lesson from our analysis is the need for greater specificity in describing and examining the ways in which different people experience extreme weather and climate change. Put simply, extreme weather experiences and subjective responses to them can differ.

#### *Implications for climate change communication and mobilization*

These findings have important implications for efforts to mobilize citizens into climate action after extreme weather events. The occurrence of extreme weather events offers opportunities to engage the citizens on if/how these events relate to climate change and encourage actions to reduce future risks from these events (McAdam, 2017). Addressing these risks requires action

on climate change, as well as actions to reduce vulnerability to extreme weather and other natural hazards. Participants' understanding of climate change and bushfire links was (in part) informed by opportunities to speak with climate change and fire experts. This provides further evidence supporting the value of empowering weathercasters, journalists, and other communicators to engage audiences about connections between climate change and local weather while such events remain matters of public attention (Maibach et al., 2022). The occurrence of extreme weather events is not only an opportunity for experts to educate citizens about climate change – citizen perspectives can also inform strategies to build stronger resilience to such events in the future by revealing local dynamics of emergency responses and community vulnerabilities.

Our findings highlight the importance of considering divergent individual trauma coping mechanisms when engaging with those affected by extreme weather events and associated disasters. Some individuals may find further engagement in climate action helpful for coping with extreme weather-related trauma and group participation can offer a sense of solidarity. Likewise, encouraging individuals to share their stories could be a meaningful and empowering form of climate action. As personal stories about climate change can effectively engage audiences about climate change in ways that scientific information alone may not accomplish (Gustafson et al., 2020), they offer valuable climate change communication materials. Others may distance themselves from climate activism either because they find the topic too distressing and/or to focus on their physical recovery. Environmental advocates seeking to engage individuals who have recently experienced extreme weather should maintain an awareness and sensitivity to these subjective dynamics. Advocates should respectfully gauge individual willingness to participate and offer ways of participating suited to unique personal circumstances (Ettinger et al., 2023).

### *Study limitations and directions for future research*

Our research focused on one geographical area which frequently experiences bushfires, and our study population is not representative of communities in other geographical regions experiencing other types of extreme weather. To build on our findings, future research could examine experiences of other types of extreme weather events. Similarly, future research could consider more closely the effects of different kinds of experiences and different levels of engagement in climate activism (e.g., relatively low effort tasks, such as signing petitions versus more demanding tasks, such as organizing campaigns). Our sample also consisted of activists who had participated in activism prior to bushfire experiences – researchers could also measure the extent to which such experiences may inspire new climate activism among individuals who have never previously participated.

Researchers could track more longitudinal aspects of climate activism after extreme weather events. A question that remains unexplored is whether individuals who reduce their participation in climate activism after extreme weather experiences later return to it after a recovery period. Several participants also experienced bushfires in firefighting capacities, drawing upon their firefighting experiences in their activism. It was beyond the scope of this paper to explore climate perceptions and activism specifically in relation to firefighting, but as emergency first-responders have been found to be trusted climate change messengers (Sleeth-Keppler et al., 2017), this would be a promising area of research.

### **Conclusion**

This case study of Australian adults who have experienced bushfires and previously engaged in climate activism provides new insights on to what extent, how, and why extreme weather experiences can influence individual climate activism in different ways. Bushfire experiences reduced perceived psychological distance of climate change and increased perceived

vulnerability to climate change. They felt that climate change was now more directly affecting them, transforming the issue from a theoretical problem to a lived experience. Findings on how bushfire experiences influenced individual engagement in climate activism were mixed. 15/33 (45%) of the participants reported increasing their engagement in climate activism, 13/33 (39%) did not change their level of participation, and 5/33 (15%) decreased their activism. These divergent individual responses to bushfire experiences capture nuances of how individuals experience, make sense of, and respond to extreme weather experiences. As climate change continues to affect many kinds of extreme weather events around the world, these events offer important opportunities for climate change dialogue and action.

### **Acknowledgements**

The authors express their gratitude to this study's participants for their willingness to share their personal experiences and perspectives. They thank the organization Bushfire Survivors for Climate Action for helping recruit several participants. The authors also thank Dr. Kate Lonsdale, University of Leeds, for comments on a draft of this manuscript.

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## Supplementary material

### *1. Participant recruitment*

Participants were recruited via outreach to climate action groups across Australia. The groups were identified with Google search using terms including “climate action Australia”, “climate activism Australia”, “bushfires activism”, as well as these terms in combination with the names of Australian states (e.g., “New South Wales climate action”). Groups meeting the following criteria were contacted:

1. Organization is based in Australia
2. Activities and/or mission statement specifically references climate change action (rather than other types of environmental issues or sustainability in general)

The lead author then reached out to groups meeting these criteria and asked them to circulate among their members and social media followers a notice about the opportunity to participate in a study examining bushfires and climate change attitudes. Individuals interested in participating in the study then had to indicate their interest in a survey. After obtaining consent to participate, the survey asked several demographic questions (see below), as well as two questions checking if they met the following study criteria for an interview:

1. Individual directly experienced a bushfire (having personal property affected by fires such as defending and/or evacuating one’s home or direct experiences via firefighting)
2. Individual previously participated in climate activism activities (such as signing petitions, joining marches or protests, contacting elected officials)

Individuals who did not say yes in response to both questions were not invited to interview. Participants were also recruited via snowball sampling among participants.

## 2. Participant demographics

The following graphs show key demographic data about this study's participants (n=33).

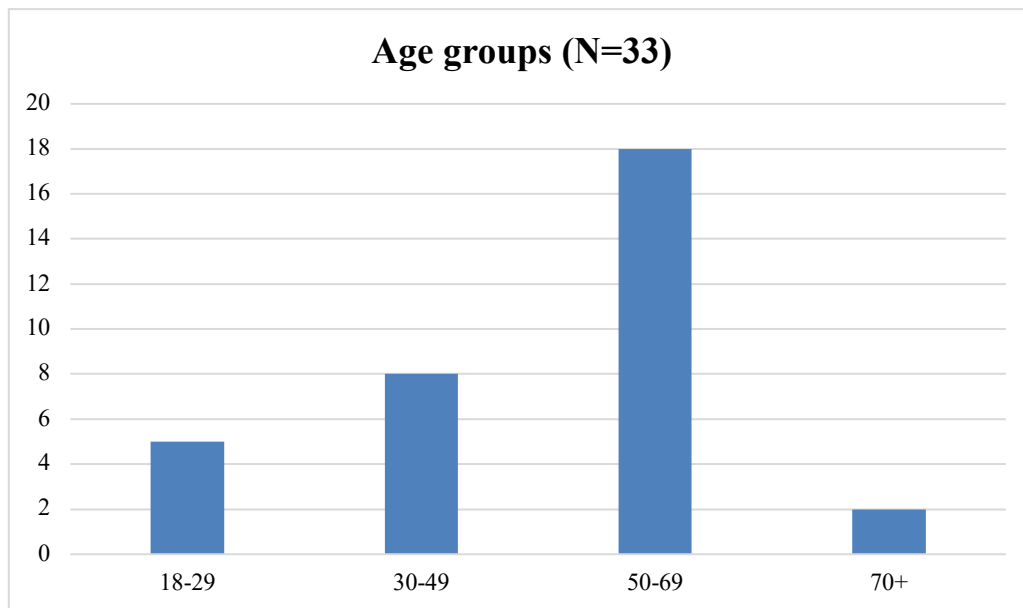


Figure 1: Ages of the participants. Only individuals 18 years or older were invited to participate.

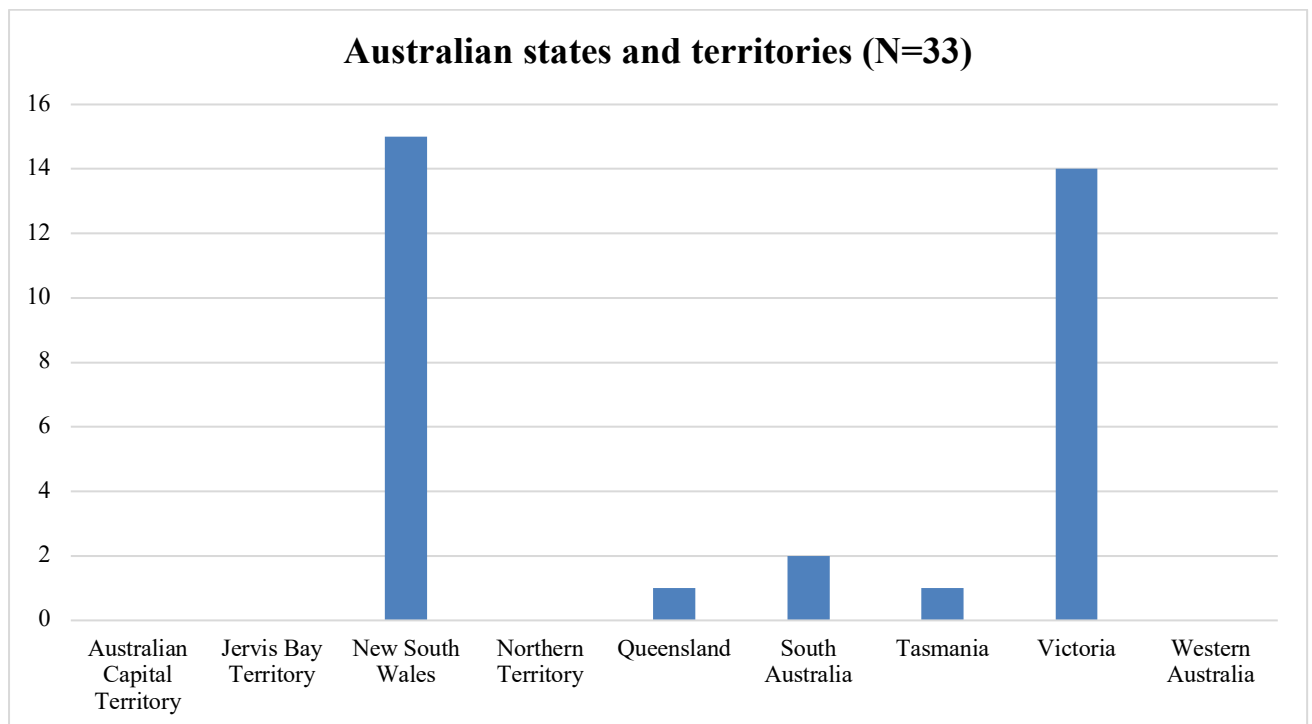


Figure 2: location of participants in Australian states and territories.

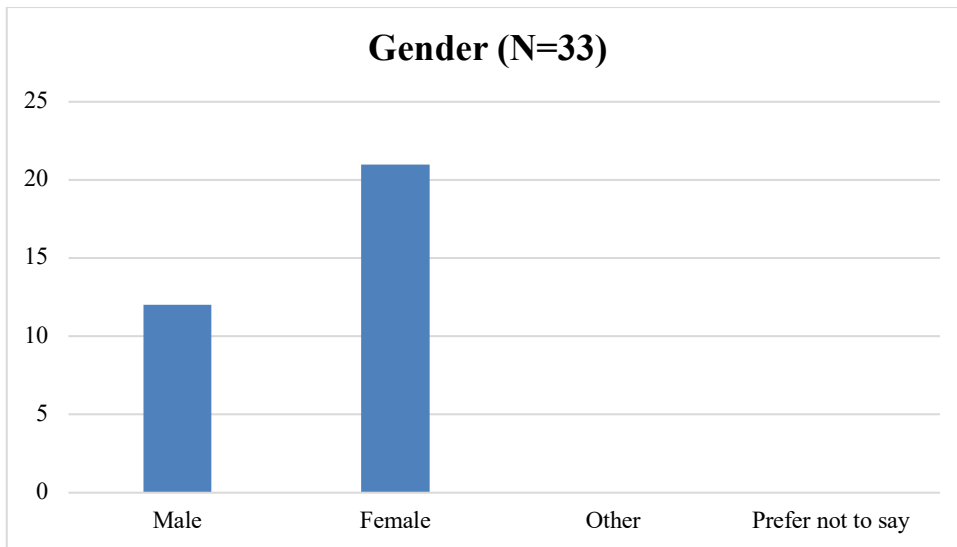


Figure 3: Gender breakdown of participants.

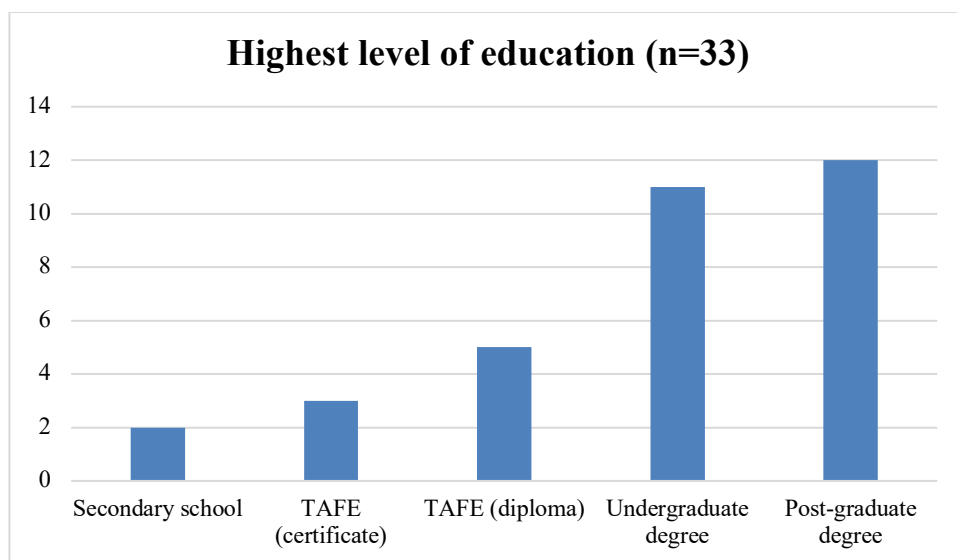


Figure 4: Highest level of education. TAFE refers to Technical and Further Education programs.

We did not collect demographic data related to our participants' ethnicities. Therefore, an important limitation of our sample is the potential lack of representation of First Nations Australian Indigenous Peoples (and of other Australian populations). However, we have cited publications in our paper's references that incorporate perspectives from First Nations Australian Indigenous Peoples on bushfires and climate change (Allam, 2020; Godden et al., 2021). Further information about Indigenous cultural burning practices can be found on the website of the non-governmental organization Firesticks (<https://www.firesticks.org.au/>).

### 3. Interview procedure

After registering their interest in participating in the study in a recruitment form, participants had already given their written consent to participate in an interview. Before starting and recording the interview, participants were asked to re-confirm the following:

Do you agree to participate in this interview, acknowledging that you are 18 years or older; that you can leave the interview at any time for any reason; that the session will be video and/or audio recorded; and that your comments may be used as part of doctoral research and academic publications?

After an introduction to the goal of the research, the lead author asked participants the following questions in a semi-structured interview, with flexibility for the researcher to ask follow-up questions:

- Can you describe for me the story of your experiences with bushfires?
- Would you say your experience was traumatic?
- What was the biggest change the bushfires had on your life?
- To what extent did you care about climate change before experiencing the bushfires?
- Can you describe for me the story of how you became involved with climate activism?
- Do you believe bushfires are related to climate change? What led you to believe this?
- Have you ever read scientific information about the relationship between bushfires and climate change? If yes, where did you come across this information?
- What do you think should be done to reduce risks associated with bushfires in the future?

Participants were not provided the option to change their responses after the interviews ended.

### 4. Reflexive thematic analysis process

We followed the six steps of reflexive thematic analysis to identify patterns of meaning across our dataset (Braun & Clarke, 2019).<sup>2</sup> The first three steps were data familiarization (transcribing the transcripts, reading them, and taking notes), coding each transcript (we used the software NVivo to code excerpts of participant interviews into categories of similar ideas/content), and generating initial themes through the collation of codes (shared patterns of meaning). The analysis was inductive insofar that the transcripts were coded in their entirety to capture all types of statements made by the participants; however, a more deductive-oriented approach was later used to refine the codes into themes that related to the research questions and leave aside codes irrelevant to the research aims (e.g., statements about farming in rural Australia). We often generated latent themes rather than descriptive themes (i.e., creating themes that go beyond the surface-level of what participants stated and connecting them with existing theories/concepts, e.g., psychological distance). The next two steps were reviewing and developing themes (combining and revising themes for greater clarity), and refining,

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<sup>2</sup> Braun, V., Clarke, V., Hayfield, N., & Terry, G. (2019). Thematic Analysis. In P. Liamputtong (Ed.), *Handbook of Research Methods in Health Social Sciences* (pp. 843–860). Springer. [https://doi.org/10.1007/978-981-10-5251-4\\_103](https://doi.org/10.1007/978-981-10-5251-4_103)

defining, and naming themes (finalizing the themes). The last step was reporting on the findings. We note that this process was not entirely linear, nor is it expected to be – for instance, the lead author began drafting initial ideas for themes during, rather than only after, coding the transcripts.

The analysis was led by the lead author, with co-authors providing feedback in reflective discussions during the coding process to support “a richer more nuanced reading of the data, rather than seeking a consensus on meaning” (Braun & Clarke, 2019, p.594). The initial coding process generated 108 codes, which was the initial basis for a final list of four themes and nine subthemes. The following table shows these themes and subthemes, to which research questions they relate, and examples of participant quotes exemplifying each of them.

*Analysis themes and subthemes*

<b>Theme and associated research question</b>	<b>Subtheme(s)</b>	<b>Example statements</b>
Bushfire experiences alter perceptions of climate change (research question 1)	Bushfires heighten perceptions of vulnerability to climate change	“I can't keep away from the fires because they're everywhere. I can't get away from the smoke. . . knowing that there's nowhere safe, I think is a psychological stress that I had not counted on” (participant 30).
	Bushfires decrease psychological distance of climate change	“When it starts hitting personally, it's hard not to go, right, you know there's this sort of concept of climate change and you're always seeing things in the news, you're always reading articles, but when it's in your own backyard, yeah, it's hard not to go . . . this is real, this is really happening.” (participant 14)
	Bushfires increase urgency to act on climate change	“Obviously like the urgency [to act on climate change] was just, it felt like it was just tripled and so there was like a real reaction afterwards . . . for me it just became like I had no choice in it anymore” (participant 33).
	Speaking with experts confirms perceptions of bushfire and climate change relationship	“I spoke to one of the experienced firies [firefighters] and he basically said, yeah, look that was dry lightning and that's just something that . . . never used to ever have happened, you know, over all his

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		experience dealing with fire over whatever X number of years, so that reaffirmed it [climate change] for me.” (participant 6)
Increasing activism after bushfire experiences (research question 2)	Activism supports coping with bushfire-related trauma	“I think actually, if I didn't act on climate, I would actually despair.” (participant 30)
	Sharing stories of bushfire experiences	“I think there was an appetite for the media to hear firsthand from people that have been impacted . . . I found that voice that I hadn't had before.” (participant 8)
Sustaining activism after bushfire experiences (research question 2)	Bushfire experiences reaffirm existing climate activism motivations	“I didn't really change [my activism]. I said I've got an environmental science degree and that was probably all the motivation I need to see the direction we're heading in.” (participant 2)
Decreasing activism after bushfire experiences (research question 2)	Distancing from activism to focus on emotional recovery	“None of us could actually handle anything more than just making our own home secure.” (participant 29)
	Distancing from activism to focus on physical recovery	“We're trying to rebuild . . . so I have to focus my attention on that. And, yeah, I do what I can, but I've lost a lot of energy since the fire.” (participant 4)

## 5. Participant Information Sheet and Consent Form (survey)

### ***About this study***

We appreciate your interest in participating in this study. The aim of this study is to explore perceptions among Australian adults about bushfires and climate change. You have been invited to participate as you are a member of Bushfire Survivors for Climate Action. The purpose of this questionnaire is to gather brief background information about you. It consists of ten multiple choice and short answer questions, which should take you no longer than 2 minutes to complete. Based on this information, we will follow up with you to schedule a 1-hour interview to be conducted over the video chat software of your choice. The interviews will be recorded but you will be asked to opt-in and provide approval for this. The recordings will only be used for analysis purposes and not shared beyond the research team. You are also permitted to opt-out of having your interview recorded.

Please read through these terms before agreeing to participate by ticking the ‘yes’ box below. You may ask any questions before taking part by contacting the researcher (details below).

***Do I have to take part?***

Your participation is completely voluntary. You may withdraw at any point during the survey or subsequent interview for any reason at any time.

***How will your data be used?***

The results of the survey will be stored in a password-protected file. Your identity be made anonymous. Your IP address will not be stored. Research data will be stored for a minimum of three years after publication or public release.

***Who will have access to your data?***

The principal researcher is Joshua Ettinger, a doctoral candidate at the School of Geography and the Environment at the University of Oxford. Members of the University of Oxford may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. This project has been approved by the University of Oxford Central University Research Ethics Committee.

***What if there is a problem?***

If you have a concern about any aspect of this project, please contact the researcher (Joshua Ettinger, [joshua.ettinger@ouce.ox.ac.uk](mailto:joshua.ettinger@ouce.ox.ac.uk)). The researcher will respond to your concern within 10 working days. If you remain unhappy or wish to file a formal complaint, please contact the Chair of the Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: [ethics@socsci.ox.ac.uk](mailto:ethics@socsci.ox.ac.uk); Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD. The Chair will seek to resolve the matter in a reasonably expeditious manner.

Please note that you may only participate in this survey if you are 18 years of age or older.

I certify that I am 18 years of age or older.

If you have read the information above and agree to participate with the understanding that the data you submit will be processed accordingly, please check the relevant box below to get started.

Yes, I agree to take part

## **8. Paper 4: Extreme weather events as teachable moments: Catalyzing climate change learning and action through conversation**

As I conducted my literature review exploring the notion of teachable moments and climate change, I kept coming across papers written about teachable moments in a healthcare context. This refers to the notion that significant life experiences (both positive and negative) such as a severe illness can lead to sudden dramatic health-related behaviour changes. Initially, I simply ignored this body of work as I perceived it as being entirely irrelevant to my research topic. Eventually, out of curiosity I decided to read some of this literature. I immediately discovered striking parallels between the concept of teachable moments in the climate change and healthcare contexts. In this theoretically oriented paper, I examine these parallels, carefully assessing key similarities and differences. I adapt the teachable moments communication process – a communication framework designed to guide physician discussions with their patients to help facilitate teachable moments (Flocke et al., 2012) – for the extreme weather and climate change context.

# **Extreme weather events as teachable moments: Catalyzing climate change learning and action through conversation**

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*Environmental Communication*

Published 02 October 2023

Available from: <https://www.tandfonline.com/doi/full/10.1080/17524032.2023.2259623>

## **Abstract**

Extreme weather events are often described as teachable moments for climate change. In this article, we explore insights about the concept of teachable moments from healthcare literature and apply them to the climate change communication context. Specifically, we adapt Flocke et al.'s (2012. A teachable moment communication process for smoking cessation talk: description of a group randomized clinician-focused intervention. *BMC Health Services Research*, 12(1), 109. <https://doi.org/10.1186/1472-6963-12-109>) Teachable Moment Communication Process to offer a new dialogue-based communication framework that leverages extreme weather events as opportunities for environmental learning and action among the public. Our framework helps facilitate discussions about extreme weather events, with the goal of channeling dialogue into actions to address extreme weather-related risks at both individual and policy levels. An important nuance is delineating how climate change can exacerbate hazards, while vulnerability and exposure ultimately determine the impacts of hazards. We account for this distinction by centering our framework around the broader goal of reducing weather-related risks in diverse contexts including, but not limited to, climate change considerations. This article describes our proposed communication approach; we conclude by outlining a research agenda to empirically test the framework and examine other dynamics of extreme weather-related dialogue.

## **Introduction**

Climate change is altering the frequency, duration, and intensity of many types of extreme weather events, including heatwaves, droughts, heavy rainfall, and fire weather conditions (IPCC, 2023). When such events occur, environmental advocates, journalists, politicians, and researchers often describe them as ‘teachable moments’ for climate change (e.g., Wright, 2012; Zanocco et al., 2019; Milman, 2021). Implicit in such statements is the notion that extreme weather could mobilize climate action by countering the perceived invisibility and psychological distance of climate change (Wallace, 2012; Rudiak-Gould, 2013; McDonald et al., 2015). Accordingly, researchers have examined how extreme weather events influence climate-related attitudes, beliefs, and behaviors among members of the public, with mixed results (Howe, 2021). Many factors, including prior beliefs, political views, and the attribution of weather events to climate change, can shape how, and to what extent, these events influence public opinion and behaviors at individual, community, and national levels (Ogunbode et al., 2019; Boudet et al., 2019; Marlon et al., 2021).

More proactive approaches toward catalyzing teachable moments (TMs) for climate change are comparatively under-researched (Sisco, 2021; Ettinger et al., 2021). Beyond retrospectively examining to what extent extreme weather events influence climate change opinion and behaviors, environmental communicators could play a more direct role in facilitating learning and action among the public in the wake of extreme events. This need was recently pointed out by the United States Federal Emergency Management Agency (FEMA), which described climate change communication after extreme weather events as a key strategic priority for improving disaster risk management (FEMA, 2022). Research on this topic has primarily focused on how to effectively communicate links between climate change and extreme events (e.g., Hassol et al., 2016; Lewis et al., 2019), especially by television weathercasters (Holmes et al., 2017; Feygina et al., 2020). Continued development and promotion of these strategies

remains important. However, further research is needed to examine how environmental communication practitioners can utilize the occurrence of extreme weather events as opportunities to more directly encourage individual and policy-level actions to reduce future risks.

In this article, we describe a new evidence-based communication framework for engaging the public in dialogue after an extreme weather event occurs. Building on efforts to bridge the fields of climate change and health (Maibach et al., 2021; Romanello et al., 2021), we look to healthcare research on the notion of teachable moments to inform our framework. In the health context, TMs are described as life events that prompt individuals to adopt beneficial health behaviors, such as a disease diagnosis leading an individual to quit smoking (McBride et al., 2003). We draw parallels between personal health events and extreme weather events, both of which can be significant life events, especially for those who are directly affected. Although the analogy has important limitations, in both cases an event is hypothesized to make an abstract risk feel more tangible, with risk-reducing behaviors becoming more personally salient and meaningful.

Our framework is inspired by Flocke et al.'s (2012) Teachable Moments Communication Process (TMCP). The TMCP is a communication tool designed for health professionals to proactively promote beneficial health behaviors among their patients amid significant life events. We explore how environmental communicators can use a similar approach to catalyze learning and action in the wake of extreme weather events. The framework is particularly designed to facilitate productive conversations among environmental advocates and experts with members of the public not as strongly engaged about environmental issues. It maintains flexibility by encouraging deliberation about actions at both individual and policy levels to

help reduce risks associated with extreme weather events. As we explain below, such actions may include, but are not limited to, addressing climate change. After describing our framework and how it could be utilized, we reflect on key benefits, challenges, and potential outcomes of our proposed approach. We conclude by outlining a research agenda to apply the framework, empirically test its effectiveness for facilitating successful discussions and driving environmental action, and examine other important dynamics of extreme weather-related dialogue.

### **Teachable moments for climate change**

The teachable moment concept appears frequently in discussions of extreme weather and climate change. Many different stakeholders including activists (e.g., Greenpeace, 2022), journalists (e.g., Fountain, 2021), politicians (Painter et al., 2020), and scientists (e.g., Ebi et al., 2022) point to extreme weather events as examples of the worrying effects of climate change. For instance, in media coverage of a summer 2021 heatwave in the US, an interviewed climate scientist notes that: “It’s a teachable moment in many ways for the public that climate change is here and now and dangerous. It isn’t our grandchildren’s problem, it’s our problem. But it’s been a teachable moment for climate scientists too” (Milman, 2021). This quote demonstrates how the TM term is operationalized for different kinds of learning. The term is similarly utilized in research on public opinion, such as Zanocco et al. (2019) who found that one's political orientation and level of personal harm may moderate the extent to which a weather event becomes a TM for climate change. The TM notion also relates to the concepts of “focusing events” and “policy windows”, which examine under what circumstances events (including but not limited to extreme weather) can serve as an impetus for policy change (Birkland & Schwaeble, 2019). Overall, a wide variety of contextual factors can shape what, how, and to what extent individuals and communities learn from weather events and associated disasters (Boudet et al., 2019; Crow & Albright, 2021).

A significant challenge concerning TMs in the climate context is what exactly an extreme event teaches and to whom. Risks from extreme events consist of primarily three factors – natural hazards, exposure, and vulnerability (IPCC, 2023). Natural hazards are natural phenomena that “may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation” (UNDRR, 2022); exposure refers to assets that can be impacted by hazards; and vulnerability describes the extent to which assets exposed to hazards can be adversely affected. Climate change affects natural hazards by altering their frequency, duration, and/or intensity, although its effects vary for different types of weather (IPCC, 2023). Multiple simultaneous or consecutive hazards and other drivers of risk can also combine to create compound events (Zscheischler et al., 2020). As populations are not uniformly impacted by extreme events, equity and justice are also major considerations (Hsu et al., 2021).

Extreme event attribution (EEA) analyses seek to assess the extent to which climate change affects specific weather events. EEA enables scientists and communicators to go beyond communicating only general relationships between types of weather and climate change – they can now provide numerical calculations of how climate change affected the frequency and/or intensity of specific extreme weather events (Betts, 2021). For example, it is nearly impossible that the 2021 Pacific Northwest American heatwave would have occurred without human-induced climate change (Philip et al., 2021). EEA findings receive significant media coverage and have been shown to be an attention-grabbing tool for communicating the increasing risks and impacts of climate change (Osaka et al., 2020; Ettinger et al., 2021).

Beyond meteorological dynamics, vulnerability, exposure, and disaster risk reduction strategies ultimately determine the impacts of hazards and whether they become disasters (Kelman, 2020; Raju et al., 2022). The impacts of extreme events are highly context-dependent, which is why some scholars criticize the term ‘natural disaster’ (Chmutina & von Meding, 2019). For example, a 2021 analysis found that poverty and a strong reliance on rainfall, rather than climate change, predominantly fueled food insecurity associated with drought in southern Madagascar (Harrington et al., 2021). How extreme events are framed influences the range of possible responses, as well as who bears responsibility for implementing them. Describing extreme weather as a TM for solely climate change masks other factors that shape the impacts of weather events. This can, in some cases, become a convenient framing for politicians seeking to divert attention away from local decision-making and planning failures. This occurred in Brazil, where scientists and environmentalists criticized policymakers for framing flooding and landslide disasters in 2008 and 2011 as climate change issues, rather than addressing inadequate disaster risk reduction strategies (Lahsen & Ribot, 2021). At the same time, others have been critical of media coverage of extreme events that neglects to mention climate change (Painter & Hassol, 2020).

Extreme events are likely to continue evoking the notion of a TM for climate change when they occur, especially when they are tied to climate change via attribution analyses (van Oldenburgh et al., 2021). This has motivated researchers to examine to what extent extreme events can influence how the public engages with climate change. Results are highly mixed: some studies find that extreme weather can lead to individuals to be more concerned about climate change, whereas others find no effects, or that heightened concerns only last for a limited duration (Howe et al., 2019; Ray et al., 2017). Although it remains important to continue investigating how extreme events influence public opinion, comparatively less

research has examined more proactive approaches for generating learning and action in the wake of extreme weather events (Sisco, 2021). In other words, rather than only retrospectively examining whether extreme events influenced support for climate action, environmental advocates may be able to increase the likelihood that this occurs through strategic communication strategies (Hassol et al., 2016; Ettinger et al., 2021).

With this goal in mind, researchers have focused on how to effectively communicate links between climate change and weather, especially by weathercasters (Myers et al., 2020). Such studies are part of the broader field of climate change communication, which has provided many important insights into factors that shape how the public engages with climate change, including media coverage, framing effects, mis/disinformation, and many other topics over the past several decades (Moser, 2016; Nisbet, 2010; Boykoff et al., 2021; Supran & Oreskes, 2021). Across this research and science communication literature more generally, there has been growing recognition of dialogue-led public engagement approaches as an important alternative to more common knowledge deficit model communication approaches (Suldovsky, 2016). Although it remains important to continue informing the public about the science of climate change, conversations encourage collaborative reflection on the multitude of different opinions, emotional responses, and meanings climate change can evoke among diverse audiences (Hayhoe, 2021). Conversations can also be effective tools for communicating climate change information (Goldberg et al., 2019).

Until recently, dialogue-based approaches for engaging the public about climate change have received relatively limited attention in comparison to research focused on one-way communication strategies (Badullovich, 2022). A growing body of literature continues to assess the merits and challenges of climate conversations (Webster & Marshall, 2019; Kelly et

al., 2020; Beery et al., 2021; Ettinger et al., 2023a). These publications overall suggest climate dialogue can help “generate knowledge, trust, and agency by connecting people and communities to local experiences and science in an effort to better understand how others do and can engage and act” (Kelly et al., 2020, p.418). For instance, conversations among family members have been shown to promote individual climate mitigation actions, such as reducing personal energy usage (Lawson et al., 2019). Climate activists often engage in discussions with family and friends to help translate existing concerns about climate change into taking individual action, seeking to overcome what is sometimes referred to as the concern-action gap (Fine, 2022). Training, preparation, and a background knowledge about climate change are important factors that may influence individual participation in climate-related discussions. Geiger et al. (2017) and Beery et al. (2021) found that increasing individual knowledge about climate change via training sessions and presentations led to a heightened individual ability, comfort, and willingness to engage in climate change conversations. Practicing effective conversational skills, such as active listening, can also be helpful (Webster & Marshall, 2019; Ettinger et al., 2023a).

Conversational approaches can offer benefits over one-way communication in the climate context to encourage individual behavior change. Relational conversations among family and friends provide an existing level of trust that can help facilitate richer discussions by creating a safe environment to express one’s opinions and “chart the difficult path forward” (Moser, 2022, p.463). Discussions enable social comparisons, which has been shown to be an effective lever for motivating individual mitigation behaviors (Bergquist et al., 2023). They may also offer a greater sense of autonomy and personal investment in behavioral decisions (i.e., self-determination theory – Sweeney et al., 2014), rather than acting solely in response to external pressure.

A dialogue-based approach could also help facilitate learning and risk-reducing action in response to extreme weather events. In a study of 15 communities affected by extreme weather in the United States, Boudet et al. (2020) found that more than half engaged in community discussions about how these events relate to climate change. Likewise, our prior case study of Australian bushfire survivors showed that local community gatherings and opportunities to speak with experts helped inform an understanding of how climate change exacerbates bushfires and reinforced the need for climate action (Ettinger et al., 2023b). Another benefit of conversations is that they can provide more time and space to explore nuanced, local dynamics of weather extremes, including the roles of vulnerability, exposure, and equity. Further evidence-based guidelines on how to effectively facilitate climate-related discussions are needed, especially in the extreme weather context (McAdam, 2017; Markowitz & Guckian, 2018).

### **Teachable moments in healthcare research**

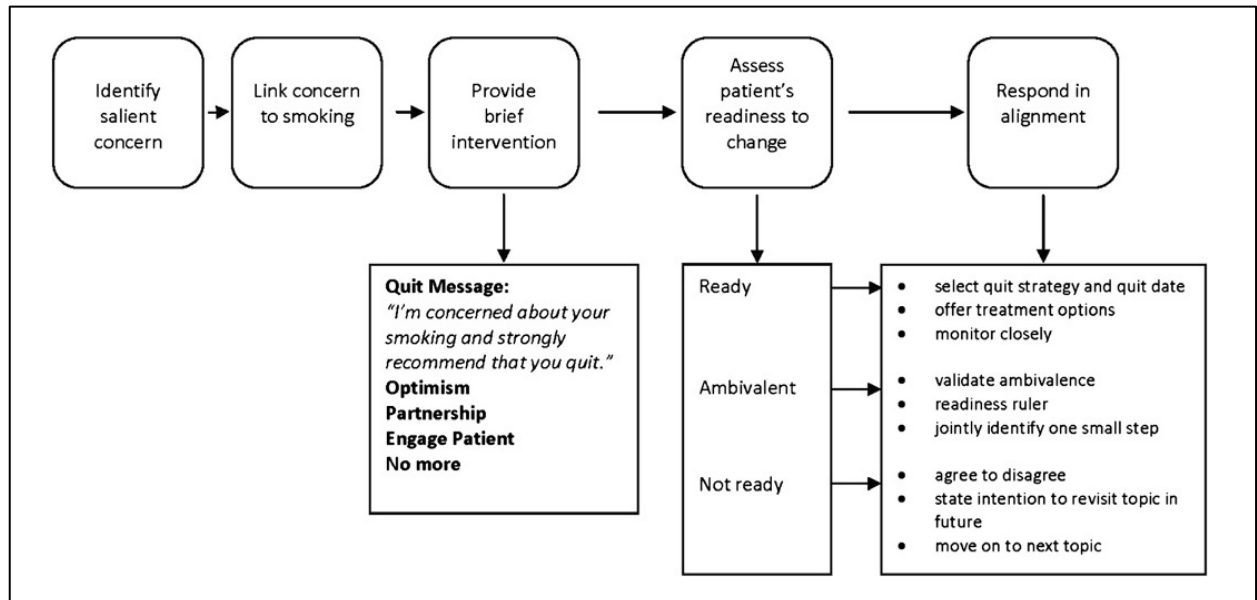
For several decades, healthcare researchers have been investigating how significant personal life experiences influence individual health decisions, which is frequently referred to as a teachable moment. There are different definitions. Some describe a TM in the health context as a personal health event, such as a disease diagnosis, irregular test result, operation, pregnancy, or other event, that prompts individuals to adopt positive health behaviors (McBride et al., 2003). It is thought that these personal circumstances lead individuals to re-evaluate their health behaviors or view them from a new perspective. Described health behavior changes often include alcohol consumption, dietary choices, exercise, and smoking (Demark-Wahnefried et al., 2005; Waddell et al., 2021). For instance, individuals may decide to quit smoking after a disease diagnosis or birth of a child. Others refer to a TM as an event that opens a window of opportunity during which health behavior interventions may prove more successful (Gritz et al., 2006), or as a learning opportunity in general (Lawson & Flocke, 2009).

A variety of subjective factors can play a role in health-related TMs such as individual risk perceptions, emotions, and social influences (McBride et al., 2003). However, questions remain concerning their prevalence and long-term sustainability of health behavior changes (Gritz et al., 2006; Bluethmann et al., 2015).

Literature on this topic initially focused on a passive, retrospective observation of TM occurrences. However, researchers have increasingly proposed that physicians play a more active role in helping facilitate positive behaviors amid significant health events. Flocke et al. (2012) suggest a stronger focus on physician-patient interactions in helping spark behavior change, rather than only identifying whether a TM has occurred. The sentiment of a more proactive role for health professionals is echoed by Cohen et al. (2011) and Demark-Wahnefried et al. (2005, p.9), who argue: “It is time for oncology care providers to not only lead their patients away from disease but also to capitalize on the teachable moment that cancer provides and guide their patients to better health.” Likewise, Bell (2012, p.584) argues that while the trauma of a cancer diagnosis can catalyze positive personal development, health professionals should help “kick-start the patient into action.” In this conception of TM, there is a stronger focus on the co-creation of a TM via a participatory process involving both patient and clinician.

Building on the notion that a TM can be co-created and acted on through communication, Flocke et al. (2012) developed the teachable moments communication process (TMCP). The TMCP is a tool designed for clinicians to recognize and act on cues that arise during a healthcare visit to facilitate an important and timely health behavior change discussion. It specifies how to develop and act on the elements of a teachable moment and builds on prior

evidence-based health behavior change strategies, such as motivational interviewing (Emmons & Rollnick, 2001). The TMCP involves five steps (figure 8.1).



**Figure 8.1:** Flocke et al.’s (2012) teachable moment communication process in the context of smoking cessation (reproduced with permission)

The TMCP begins with a physician identifying a patient’s salient concerns about a health issue. For example, in a hypothetical case involving cigarette smoking, multiple health concerns could be linked to the patient’s smoking, such as her diabetes or increased risk of other chronic diseases and cancer. However, it is the issue that the patient raises as a concern – such as difficulty breathing when exercising – that can be linked to her smoking behavior. This first step is crucial as it grounds the discussion directly in an individual’s subjective interests and values from the beginning. Next, the physician seeks to encourage the patient that they both can and should change the behavior in question. The physician assesses the patient’s response and responds accordingly: if the patient feels ready to change their behavior, the physician helps formulate behavior change strategies and monitoring plans; if the patient is ambivalent, the physician suggests small, initial steps; if a patient is not ready, the physician strives to leave open the possibility of continued discussion about it in the future. Dialogue and listening are

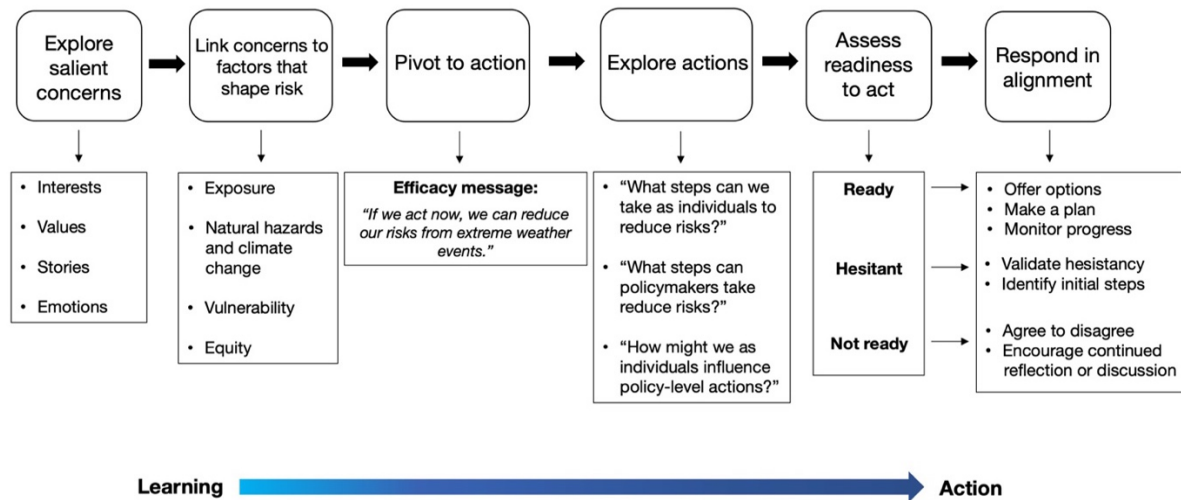
crucial to the entire patient engagement process: physicians are advised to avoid "shaming or blaming language, clinician-dominated lecture, monologue, or argument", which are ineffective and can strain the patient-physician relationship (Flocke et al., 2012, p.6). As this may be difficult to achieve in practice, researchers continue to train health professionals in how to successfully implement the TMCP in clinical settings (Flocke et al., 2014; Flocke et al., 2021).

### **A teachable moments communication process for climate change**

There are thought-provoking parallels between TMs in the healthcare and climate change contexts. In both cases, it is hypothesized that a personal experience has the capability of influencing individual risk perceptions and decision-making by making an abstract threat more personally salient. In the climate context, this is often referred to as psychological distance (Keller et al., 2022). Whether in climate or health, significant life events may provide an opportunity window during which individuals view their existing beliefs and behaviors from a new perspective. Additionally, like the extreme weather and climate change context, health researchers have proposed a more proactive role for experts in helping facilitate TMs. In both cases, individuals and groups may also engage in a process of sensemaking in which they seek to understand an event, construct a story of what happened, and derive a sense of meaning from it (Weick, 1995; Tisch & Galbreath, 2017; Vanderlinden et al., 2020). However, there are important limitations to the climate and health analogy, which we address in the following section.

As the TMCP helps physicians take advantage of opportunities to encourage positive health behaviors among their patients, it offers a promising approach for the environmental context. Our adaptation of the TMCP (figure 8.2) has two overarching goals: (1) to encourage dialogue about personal experiences of extreme weather events and factors that influence extreme

weather-related risks; (2) to channel dialogue into plans to pursue actions at both individual and policy levels to address these risks, based on one’s readiness to do so.



**Figure 8.2:** Adaption of the healthcare Teachable Moments Communication Process (Flocke et al., 2012) for environmental communication.

Our framework is designed to guide conversations between an environmental advocate, expert, practitioner, or scientist with individuals or small groups affected directly or indirectly by an extreme weather event. Such conversations might occur in informal settings among family members, friends, and colleagues, or in more formal public engagement settings such as community forums and other educational programs. Like the healthcare TMCP, our proposed framework is underpinned by a dialogue-based framework of public engagement, focusing on asking pertinent questions, practicing active listening, and responding to inputs from conversation partners, rather than an expert-dominated lecture. Every step of the framework incorporates evidence-based components that have been shown to be important for facilitating open, meaningful, and productive conversations about weather-related risks. The order of steps is also highly deliberate, although we acknowledge that conversations may not follow the exact outlined progression. If individuals decline to engage in a conversation on the topic, their disinclination to participate should be respected.

In the first step, one begins a conversation by exploring another individual's interests, values, and concerns associated with the weather event (e.g., safety of one's family or community, economic aspects, well-being, etc.). These concerns might be raised by the individual without prompting or evoked through open-ended questions asked by the environmental communicator (e.g., "What are your thoughts about the [weather event]?"). This step could also incorporate personal storytelling about weather experiences (e.g., "What were your experiences of the [weather event]?"). One can point out the values and concerns they share with their conversation participants – establishing shared values has been shown to help build trust during climate-related discussions (van Swol et al., 2022; Geiger et al., 2022).

At this stage, conversation participants may also express a variety of emotional responses associated with their extreme weather experiences such as anger, anxiety, fear, hope, guilt, and worry (Wang et al., 2018). Emotions are an important aspect of how individuals engage with, and act upon, environmental issues (Brosch, 2021), and extreme weather experiences are particularly associated with negative mental health impacts (Rataj et al., 2016). Our framework proposes an open approach to emotional responses, encouraging discussion participants to express their emotions (to the extent they feel comfortable doing so), with communicators affirming the validity of different kinds of emotional responses (Duggan et al., 2021). Validating the legitimacy of emotional responses – especially difficult feelings associated with climate-related anxiety – offers individuals an important opportunity to vocalize their emotions and feel understood (Clayton, 2020).

Next, one should incorporate information linking these concerns to the factors that shape risks from extreme events, including natural hazards and climate change, exposure, vulnerability,

and equity considerations. For this step, resources such as Hassol et al. (2016) can be helpful as they offer guidance on effectively explaining the relationship between climate change and weather, including avoiding technical jargon and leading with what is known rather than uncertainties. When engaging with individuals skeptical or dismissive of climate change, one might note the consensus among climate scientists that climate change is occurring and driven by human activities, although there is some debate among researchers whether this may cause negative reactance (Goldberg et al., 2022). In box 1, we also provide several optional questions to help prompt nuanced discussions about weather-related risks. As described, dynamics beyond the natural hazard itself such as vulnerability, exposure, and equity can influence the impacts of extreme events among distinct populations and communities. The questions in box 1 are intended to help prompt more holistic discussions about a wide range of potential risk factors.

**Box 1: Guiding conversation questions for exploring the risk dimensions of extreme weather events**

1. What happened? What were the impacts of the event? Was it a compound event involving multiple hazards?
2. To what extent were people, infrastructure, and other assets exposed to the hazard?
3. Is this *kind* of weather event related to climate change? Is this *specific* event related to climate change? Have attribution studies been carried out?
4. What steps can communities take to prepare for this kind of weather event? Were these steps taken in communities affected by this specific event?
5. Who was affected by the event? Were certain groups more vulnerable than others? Why?
6. What information do we not know? What uncertainties do we need to consider?

Third, one should encourage action to reduce risks associated with extreme weather events. As part of this effort, it is important to offer a sense of efficacy. Efficacy includes the sense that one can successfully act on a problem (i.e., self-efficacy), and that one's actions can make a difference, known as response efficacy (Jugert et al., 2016; Bostrom et al., 2018). Efficacy perceptions have been shown to predict individual engagement in collective action for climate change, especially in the context of group behaviors (van Zomeren et al., 2018). In practice, communicators can help instill a sense of group partnership by using inclusive phrases such as “*we can reduce our risks*”, rather than “*you can reduce your risks*”.

Given the highly local and contextual nature of extreme weather events and their impacts, our framework does not prescribe specific actions to address extreme weather-related risks. Rather, it aims to spark an open discussion about potential steps to reduce risks associated with extreme weather in diverse contexts, including both individual and policy-level actions in addressing risks (Newell et al., 2021). Therefore, discussions can examine steps that individuals can take to reduce personal risks through disaster risk reduction strategies, e.g., ensuring awareness of early warning emergency communication systems and creating personal evacuation plans for those in vulnerable regions. Discussions may also explore the role of policy-level actions to reduce risks, such as conducting assessments of infrastructure to withstand extreme conditions and climate change mitigation strategies to limit further intensification of many types of natural hazards. Beyond ensuring one's own safety or assisting others in one's local community, individual actions might be directed at influencing policy through activism and other forms of political engagement (Roser-Renouf et al., 2014). Communicators might prepare for discussions by building their knowledge of potential risk-reducing actions for specific kinds of extreme weather events. For example, McLoughlin et al. (2022) offer a typology of the range of individual and policy actions that can reduce heatwave risks.

One should assess their conversation partners' readiness to act on the discussed issues, keeping in mind that individuals may express a wide range of views on the effectiveness of different kinds of actions. If they indicate a willingness to act, discussions can then turn to making plans. For example, participants might agree to contact elected officials or evaluate household evacuation plans. If they are hesitant to act, one should affirm that their hesitancy is valid and suggest small initial steps, such as seeking further information more about the issue. If they are not ready to act, one can respectfully agree to disagree, express hope that they will continue to reflect upon the issue and possibly revisit it in future discussions. A valid conclusion might also be an acknowledgement of uncertainty and the need to further investigate potential responses.

*Hypothetical example of the framework in practice – Australian bushfires*

As a prior study of Australian bushfire survivors partly motivated the development of this framework (Ettinger et al., 2023b), bushfires provide a useful example of how this framework could be applied. Participants in the study felt that community forums and opportunities to engage with experts played a significant role in shaping their views on the relationship between the fires and climate change. Bushfire experts, such as climate scientists, firefighters, and other knowledgeable individuals, might find our framework helpful as a guide when engaging in these discussions with community members post-fires. The first step grounds the discussion in the interests/concerns of the affected individual (e.g., safety of their family, home, and community from fires). Discussions can explore fire experiences, e.g., whether individuals stayed at home and defended their property or chose to evacuate. Individuals may express their emotional responses to these experiences. Next, in connection to these concerns, they would explore the factors that shape bushfire risks, including the role of climate change in

exacerbating their frequency and intensity, as well as regional and community-level vulnerability (e.g., planned burns, evacuation plans, emergency communication systems, and other disaster risk reduction strategies). Utilizing questions from box 1, they might explore how these dynamics played out in their local area, inequities in terms of who was impacted, as well as any uncertainties that remain. The conversation would then pivot to examine how these risks might be reduced at individual levels such as by creating a personal bushfire emergency plan; community or regional-level actions such as hazard reduction burns and improvements to emergency communication systems; national policy-level actions including climate change mitigation and adaptation; and how individuals might influence policy decisions through, for instance, environmental activism and other forms of political engagement. Depending on their readiness to pursue one or more of these actions, conversation participants can make plans, identify initial steps, or agree to continue exploring the issue in the future. By following these steps, our framework helps ensure a nuanced, participatory, and action-oriented conversation.

## **Discussion**

In this article, we have described a new dialogue-based communication framework to help catalyze learning and action among diverse members of the public in the wake of extreme weather events. Our framework offers several advantages. First, it incorporates considerations of climate change alongside exposure, vulnerabilities, and inequities. As described earlier, this holistic approach is important as it helps avoid misleading framings that describe weather events as entirely caused by climate change or neglect to mention climate change at all (Hopke, 2019; Lahsen & Ribot, 2022; Painter & Hassol, 2020). Our framework is also flexible for a variety of extreme weather contexts and does not prescribe specific steps or actions. Rather, it seeks to catalyze collaborative exploration of a wide range of possible actions at both individual and collective levels in diverse contexts. Such actions might involve disaster risk reduction strategies at the individual level, climate adaptation and mitigation policies at the regional or

national level, and how individuals might influence policy decisions through activism, voting, and other forms of political engagement. Individuals may offer new ideas, perspectives, and insights that also generate learning among environmental experts as well – another reason for the importance of two-way dialogue.

Although our proposed framework might imply a somewhat linear notion of dialogue (i.e., that conversations will follow the order of steps we outline), discussions may not follow the exact outlined progression; in fact, every discussion will likely be unique. Nevertheless, our framework helps prepare environmental advocates with a synthesis of evidence-based strategies to facilitate a flexible, participatory, and meaningful dialogue. The beginning step of our framework deliberately grounds discussions in the concerns, interests, and values of one's conversation partners, making them more likely to feel more invested in the exchange (Hayhoe, 2021; Geiger et al., 2022). This helps tailor conversations in ways that are relevant to individuals with diverse attitudes and beliefs about climate change (Leiserowitz et al., 2022). For instance, in discussions with individuals who are dismissive of climate change, communicators may still be able to establish consensus around the importance of improving disaster risk reduction strategies, without necessarily addressing climate change. Among individuals already concerned about climate change but not currently adopting any behavioral responses, discussions could seek to overcome the concern-action gap described earlier (Fine, 2022).

A two-way communication also provides the opportunity for environmental advocates to affirm the validity of diverse emotional responses to environmental issues (Brosch, 2021), as well as promote feelings of efficacy that the problem can be addressed (Bostrom et al., 2018). These factors are being increasingly recognized for their importance as part of effective

environmental communication strategies, especially during a time of significant climate-related anxiety (Clayton, 2020). Like the TMCP, whether conversation participants are ready, hesitant, or not willing to act to reduce risks from extreme weather, our approach advocates a more long-term perspective. For community discussions or other public engagement events, personal reflection on the issue can be encouraged in the future. For discussions among those with existing relationships such as family members, friends, colleagues, neighbors, etc., the topic could be revisited in future conversations.

However, our approach has important challenges and limitations. First, there are crucial differences between TMs in the healthcare context and climate change context. Individuals have a vastly greater level of agency and power to make personal health decisions and shape their own health outcomes, whereas addressing weather-related risks and climate change requires collective action and policies from local to international levels. The factors and decisions that influence weather related risks in diverse situations are also, in general, more complex than a TM in the healthcare context. For instance, in cases where smoking is causing or exacerbating a health condition, there is a single identified problem with a clear solution (reducing or stopping smoking). Determining both the factors and appropriate actions to reduce weather-related risks can be more difficult and complex. There can be scientific uncertainties and a lack of data, such as inadequate observational data for extreme event attribution analyses (Otto et al., 2020). Climate change is not always a key driver of extreme weather events and associated crises (e.g., Harrington et al., 2021). There are also legitimate debates over the most effective and feasible actions to pursue to reduce risks, which may vary depending on local circumstances. These complexities are another reason why dialogue is crucially important. A successful conversational environment should make individuals feel safe to express their true opinions on these matters, with all participants ideally finding value in the exchange of ideas.

Likewise, there is a wide array of research into subjective determinants of individual climate-related beliefs, adaptive behaviors to extreme weather risks, and engagement in climate activism, especially aspects of personal identity, group dynamics, efficacy beliefs, and emotional responses (e.g., Masson & Fritsche, 2021; McLoughlin et al., 2022; Thomas et al., 2019; van Zomeren et al., 2018). To keep our framework concise and accessible, we were somewhat limited in the extent to which relevant research on this topic could be directly implemented as steps/considerations in the framework, particularly as adapting the healthcare TMCP was our key focus. There are also important limitations to a conversational communication approach in general. A discussion requires significant effort, time, skill, and patience (Webster & Marshall, 2019). In the health context, researchers have sought to teach the TMCP to physicians, with somewhat limited uptake in clinical settings (Flocke et al., 2014; Flocke et al., 2021). As noted earlier, climate change educational programs and training sessions can help better prepare individuals to engage in climate-related discussions (Beery et al., 2021; Geiger et al., 2017). Likewise, environmental communicators may benefit from practical training in facilitating dialogue specifically about extreme weather events, especially with sensitivity to potential trauma associated with weather-related disasters.

#### *Directions for future research*

This article has outlined our proposed communication framework; the next step is to test its effectiveness, potential applications, and strengths and weaknesses. It is important to keep in mind that the occurrence of a climate discussion can itself be considered a success insofar as providing a space for individuals to reflect upon one of the most pressing societal challenges of our time. Nonetheless, measurable post-discussion outcomes could include tracking realised behavior, e.g., engagement in environmental activism, or pursuing steps to increase personal

preparedness for hazards, such as by increasing one's awareness of early warning communication channels and making evacuation plans.

Changes in relevant attitudes could also be assessed, such as support for policies that address extreme weather-related risks and climate change-related attitudes. Participants could be instructed to engage in discussions with family and friends when an extreme weather event occurs in close geographical proximity (with the caveat that they should only do so if/when they and their conversation partners are physically safe). Outcomes could be compared among groups of environmental advocates who engage in discussions with/without training in the framework, as well as against one-way communication strategies (i.e., reading a news article or watching an informational video). Such testing will indicate if additional concepts need to be incorporated into the framework or existing components clarified. The outcomes of multiple discussions among the same participants could also be examined, which would require a more longitudinal research approach. Survey questions could examine key potential drivers of conversational effectiveness, such as reported levels of trust between participants, reported enjoyment of a conversation, reported levels of efficacy, as well as timing aspects.

Testing the framework across a variety of contexts will also be essential to robustly evaluate the utility of our proposed communication approach to help address extreme weather-related risks. Every type of extreme weather event entails different potential actions to reduce risks. Conversations among different audiences, such as family members versus more formal settings (e.g., town halls and other community forums), could have contrasting dynamics given distinct types of relationships and varying levels of trust. The framework could be particularly well-suited for climate discussions among physicians and their patients given that they would occur in a space with (typically) a substantial level of trust as well as privacy.

Along with environmental communication scholarship more broadly, there is a pressing need to better understand cross-cultural differences beyond English-speaking Global North countries and the implications of these differences for various communication strategies, including dialogue-based approaches. Additionally, there are pertinent questions regarding timing and whether there is an optimal period during which these conversations should be conducted. The concept of a TM is premised on the notion that extreme events provide an opportunity window for public engagement, yet there is evidence that individuals may experience feelings of fatigue and a desire to move on from a crisis (Crow & Albright, 2021). There may be a case for waiting to engage people about the event while affected individuals to recover physically and emotionally; yet wait too long and the teachable moment opportunity could dissipate.

Moreover, as climate change increasingly alters many kinds of extreme weather events (IPCC, 2023), their occurrence may become more normalised, reducing TM opportunities. This process is sometimes referred to as shifting baseline syndrome (Soga & Gaston, 2018). Yet perhaps a TM can in fact be galvanised at any time, irrespective of the occurrence of extreme events, by connecting salient concerns with relevant actions. It would also be promising to explore the potential applications of our communication framework for other environmental issues beyond extreme weather events. In particular, the first step in which a communicator seeks to ground a discussion in the concerns, interests, values, and emotions of their interlocutor could open the door for many kinds of environmental actions, such as actions around sustainable finance, biodiversity conservation, and energy behaviors. Empirical testing and evaluation of our conversational framework could help indicate its potential usefulness and practicality for other climate-related issues. Lastly, we constrain our focus here on the TMCP

given its relevance for teachable moments in the climate context; other concepts from health literature could offer further thought-provoking insights for climate change communication. Continued interdisciplinary collaboration can help facilitate this important knowledge exchange (Schipper et al., 2021).

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## 9. Discussion

In this chapter I review the major findings of each paper and then synthesise them to answer the central thesis research questions. I also describe the scholarly contributions of this thesis and offer practical climate change communication guidance. In the subsequent conclusion chapter, I reflect on the limitations of this thesis and potential directions for future research.

### 9.1 Key findings from papers

As this is a paper-based thesis, it is important that each paper connects back to the central research aims and questions. As a reminder, the two central research questions (RQs) are as follows:

*RQ1: What are the opportunities and challenges associated with leveraging extreme weather events to facilitate climate change dialogue, learning, and individual action among members of the public?*

*RQ2: How can climate change communication practitioners engage members of the public about climate change after extreme weather events in ways that maximise opportunities and address challenges associated with this public engagement strategy?*

Each publication contributes to answering these research questions. Table 9.1 on the following page summarises the key findings of each paper and specifies how each paper offers relevant insights for answering the research questions.

**Table 9.1: Summary of paper findings and connections to thesis research questions**

Paper number/title	Key findings	Contributions to thesis research questions
<p><b>Paper 1: “What’s up with the weather?” public engagement with extreme event attribution in the United Kingdom</b></p>	<ul style="list-style-type: none"> <li>- Non-climate scientists are interested in learning how specific extreme weather events relate to climate change.</li> <li>- Extreme event attribution findings are more attention grabbing than general descriptions of links between types of extreme weather and climate change.</li> <li>- Communication materials that focus solely on meteorological aspects of climate change can prime individuals to focus only on climate mitigation and overlook solutions to address adaptation, vulnerability, and disaster risk reduction.</li> </ul>	<ul style="list-style-type: none"> <li>- Highlights strengths and limitations of using extreme weather events as opportunities for climate change communication in general and in relation to EEA specifically.</li> <li>- Captures dynamics of extreme weather/climate change group discussions.</li> <li>- Has implications for effective communication of extreme weather and climate change relationships.</li> </ul>
<p><b>Paper 2: Social media messaging by climate action NGOs: a case study of the 2019-2020 Australian Black Summer bushfires</b></p>	<ul style="list-style-type: none"> <li>- Climate action groups are using extreme weather events as climate change communication and mobilisation opportunities on social media.</li> <li>- Climate action group tweets exhibited limited engagement with and utilisation of climate science, although only 1% of tweets claimed (inaccurately) that climate change causes extreme weather.</li> <li>- Only 15% of climate action group tweets during the Black Summer mentioned how vulnerability and disaster risk reduction influence bushfire impacts.</li> </ul>	<ul style="list-style-type: none"> <li>- Captures advantages and challenges of communicating about extreme weather/climate change on social media platforms.</li> <li>- Provides an empirical and nuanced analysis on the ways in which climate action groups are engaging their audiences about climate change during extreme weather events.</li> </ul>
<p><b>Paper 3: Examining contrasting influences of extreme weather experiences on individual climate activism</b></p>	<ul style="list-style-type: none"> <li>- Dialogue with fire and climate experts (in part) informed subjective attribution of bushfires to climate change.</li> <li>- Bushfire experiences and associated trauma may lead some individuals to increase their climate activism, while leading others to decrease their activism and distance themselves from the issue.</li> <li>- Sharing extreme weather stories with others can support trauma coping and recovery.</li> </ul>	<ul style="list-style-type: none"> <li>- Shows how trauma affects individual climate action after extreme weather experiences.</li> <li>- Demonstrates how dialogue with experts and group participation supports climate learning and action after extreme weather events.</li> <li>- Captures the heterogeneity of different types of extreme weather experiences and individual responses to them.</li> </ul>
<p><b>Paper 4: Extreme weather events as teachable moments: catalyzing climate change learning and action through conversation</b></p>	<ul style="list-style-type: none"> <li>- This theoretical paper offers an empirical strategy that aims to support effective dialogue and individual behaviours to address climate change and extreme weather risks.</li> </ul>	<ul style="list-style-type: none"> <li>- Provides practical guidance that leverages the opportunities and challenges of climate change communication in the extreme weather context (inspired by healthcare literature, climate change communication literature, and prior studies from this thesis).</li> </ul>

The two commentary-style articles included in the appendix also connect with the research aims and questions. Reflecting on the COP26 climate conversations campaign I conducted with fellow graduate students offered useful lessons on barriers to climate dialogue and how to overcome them (appendix A). A special edition of the journal *Social Media & Society* provided an opportunity to reflect on my thesis research journey and why two-way dialogue is essential for climate action, especially in the extreme weather context (appendix B).

## **9.2 Opportunities and challenges for climate change communication (research question 1)**

This thesis reveals a variety of important opportunities and challenges of leveraging extreme weather events for climate change communication and encouraging climate action among members of the public. I have specifically focused on how climate change communicators (e.g., scientists or climate activists) can help encourage individual-level actions to address extreme weather and climate change risks at both individual and societal levels. This may include personal disaster risk reduction strategies; changing one's lifestyle behaviours to reduce one's greenhouse gas emissions; and advocating for policy-level adaptation and mitigation actions to address climate-related risks. I have intentionally left these actions relatively broad and flexible to cover the range of potentially applicable actions in different local contexts, and because diverse individuals may prefer to pursue different kinds of behaviours (see section 9.4).

### *Opportunity 1: interest in the extreme weather and climate change relationship*

As demonstrated by papers 1 and 3, non-climate scientists can be significantly interested in learning how climate change relates to extreme weather events. This interest is especially strong among individuals who have directly experienced an extreme weather event (who comprised most

of the participants of this thesis's studies). Growing media coverage on the relationship between extreme weather events and climate change may reflect a perception among news outlets that audiences are interested in this information (Hopke, 2018). As news media play an agenda-setting role that affects public opinion, this coverage can play a substantial role toward informing the public about the relationship between extreme weather events and climate change (Langer & Gruber, 2020; Maibach et al., 2022). Likewise, paper 3 shows that climate action groups are leveraging extreme weather events as opportunities to engage audiences on social media about climate action. Paper 2 also showed that climate groups played a substantial role in helping mobilise individuals affected by bushfires into climate activism.

*Opportunity 2: salience of extreme weather and reduced psychological distance of climate change*

While public attention and media coverage often results from the disruptive and harmful impacts of extreme weather events, it is also associated with general human interest in weather phenomena and its deep embeddedness in human culture (Endfield & Veale, 2020; Hulme, 2017). Weather is local, tangible, and something we experience daily. It contrasts significantly with climate change which can feel psychologically distant in time and space, along with uncertainties whether it is occurring and an unclear sense if it affects us personally (Keller et al., 2022). My findings suggest that extreme weather events open an opportunity window in which individuals may exhibit a heightened receptiveness to engaging with climate-related information. Paper 3 found that experiencing bushfires reduced psychological distance of climate change and heightened perceptions of vulnerability to climate impacts. As one participant stated: “*when it's in your own backyard, yeah, it's hard not to go . . . this is real, this is really happening.*” On the other hand,

the focus groups of paper 1 did not make statements to this effect (but they were nevertheless interested in how climate change related to the heatwaves).

An intriguing finding of paper 1 is that the impacts of climate change on a single extreme weather event can be more attention-grabbing than describing general relationships between types of weather and climate change. As described, researchers theorise that extreme weather events reduce the psychological distance of climate change. Focusing on a single specific weather event – especially one that an individual directly experienced and is therefore highly familiar and pertinent – can therefore act as a locus of attention to help non-climate scientists reflect on climate-related risks in a perceptually concrete context (in comparison to discussing the general links between a heatwave and climate change without reference to a specific event).

### *Opportunity 3: Extreme weather events as climate conversation starters*

As described in the literature review (chapter 2), prior studies have primarily assessed public opinion after extreme weather events rather than testing more proactive communication strategies and interventions. My initial research proposal focused largely on testing one-way communication of extreme event attribution from climate scientists to lay audiences. I ultimately reoriented my approach to focus primarily on two-way dialogue (appendix B). The findings suggest that extreme weather events can help generate climate change discussions among members of the public, which may help facilitate individual-level actions to address risks (see next section for further discussion of the kinds of actions that may result from these efforts). A variety of psychological barriers that can inhibit climate discussions, including the climate spiral of silence and pluralistic ignorance (Appendix A; Geiger & Swim, 2016; Maibach et al. 2016). The findings of papers 1 and 3 suggest

that extreme weather events could help overcome these barriers to climate dialogue, much in the same way that significant life experiences enable physicians to open health behaviour discussions with their patients (chapter 8). Directly experiencing weather events or reading about them on news media and social media can spark questions such as: “Is it climate change?”, “is climate change now affecting me directly?” and “What actions are needed and by whom?”.

*Opportunity 4: Extreme event attribution results can support public engagement efforts*

The increasing availability and turnaround time of EEA results can help inform these discussions with timely information (Clarke et al., 2023). As shown in paper 1 (chapter 5), participants engaged deeply with technical aspects of EEA studies around comparing counterfactual worlds (i.e., climate models with/without anthropogenic greenhouse gas emissions). This was somewhat surprising as I anticipated the participants to be more interested in the results than the scientific process. However, this finding aligns with prior psychological literature examining how counterfactual thinking forms a crucial aspect of human cognition (Kahneman & Tversky, 1982; Roese, 1997). Explaining the counterfactual methodological design of EEA studies led participants to imagine alternative pasts and potential futures for our planet and society. The finding that climate science can stimulate one’s imagination and spark counterfactual thinking is another novel contribution. It resonates with growing research on the role of imagination in how individuals contemplate climate change, potential future pathways for themselves, their communities, and society at large, and their role in helping shape different societal trajectories (Galafassi et al., 2018).

Scientific approaches for assessing how climate change affects specific extreme weather events are often discussed in terms of their potential utility for climate litigation and loss and damage

mechanisms (e.g., Stuart-Smith et al., 2021); public engagement should be more frequently included among its potential applications, such as being incorporated into climate action communication campaigns and as a discussion prompt for citizen assemblies on climate change, town halls, and other public fora. Thus, extreme weather events present another public engagement opportunity to help crystallise the impacts of climate change, reflect on how climate change is influencing our lives today, and imagine alternative futures.

*Opportunity 5: Processing extreme weather experiences, emotions, and trauma*

As examined in paper 3, psychological impacts of extreme weather events are another crucial consideration. Extreme weather events can be highly traumatic and cause harmful mental health impacts (Bryant et al., 2014). Prior research has shown the importance of meaning-making processes for building personal resilience after disasters by helping individuals find a sense of purpose amid suffering (Park, 2016). For some individuals, having a chance to discuss their experiences, share their stories, and act upon climate change confers psychological benefits by enabling individuals to process their experiences and associated emotional responses. Beneficial well-being effects of these activities also result from participating in a group with like-minded individuals, who provide a community of support (Muldoon et al., 2019). Bushfire Survivors for Climate Action – an NGO from whom I recruited several of my participants for paper 2 – is exactly the sort of a group striving to gather individuals with similar experiences to offer a sense of solidarity and fight for climate action.

There was also a strong desire among participants in papers 1 and 3 to make sense of their experiences and understand how climate change alters heatwaves and bushfires, respectively.

Participants in paper 3 described how discussions with climate and fire experts were helpful for affirming their understanding of the bushfire-climate change relationship. In paper 1, focus group participants also expressed substantial interest in how scientists assess the role of climate change in affecting extreme weather events, and how their findings align or clash with their own personal experiences and observations. Therefore, efforts to engage individuals affected by extreme weather events offers an opportunity for them to make sense of their emotions, experiences, and perceptions related to the event.

*Challenge 1: Subjective attribution and motivated reasoning*

This thesis's findings show that efforts to engage members of the public about climate change and encourage individual actions after extreme weather events face a variety of challenges. First, if individuals are to view such events as moments for reflection, and potentially individual action, on climate change, they must subjectively attribute these events to climate change (Sambrook et al., 2021). If one does not perceive a connection between climate change and an extreme weather event, it is unlikely that it will affect climate perceptions or behaviours (although it could still potentially affect perceptions around extreme weather risks more generally). Whether individuals perceive this link can be influenced by their prior attitudes and beliefs through a motivated reasoning process (Howe, 2021; Ogunbode et al., 2019). This was evident in papers 1 and 2 as participants readily perceived a relationship between the case study extreme weather events and climate change. Thus, the effectiveness of interventions seeking to engage the public after extreme weather events to encourage individual behaviours to reduce weather risks or to address climate change are likely to be modified by individual attitudes and beliefs.

*Challenge 2: Communicating nuances of the climate change and extreme weather relationship*

The links between climate change and extreme weather events are often nuanced. It is important to distinguish between the effects of climate change on the frequency, duration, and intensity of different types of extreme weather; it does not cause extreme weather events to occur; and it does not affect every type of weather event (National Academies, 2016; IPCC, 2021). Even in cases where climate change is linked to a weather event, it does not always have a substantial effect (e.g., Harrington et al., 2021). Furthermore, paper 1 captured some of the difficulties around communicating scientific uncertainties and statistical aspects of EEA studies. Despite testing a variety of ways of expressing scientific uncertainty, this information seemed to erode trust in the results among the participants. This finding aligns with Osaka and Bellamy (2019), who found that conflicting attribution results led individuals to doubt the robustness of the science. Uncertainty is an integral part of science, so determining ways to effectively share this information with non-expert audiences remains an ongoing challenge for climate change and science more generally. Building on prior literature (Hassol et al., 2016), the discussion section of paper 1 (chapter 6) offers some guidance for communicating uncertainty in the extreme weather context. Further research is needed to test how diverse audiences engage with scientific information about the links between climate change and specific types of extreme weather events, and to provide additional communication best practices. The findings of paper 2 (chapter 6) raise questions around the responsibilities of climate advocacy groups and other “alternative science communicators” in conveying these nuances.

### *Challenge 3: Communicating nuances of extreme weather risks*

Another challenge specifically relevant to the extreme weather context is that focusing solely on meteorological aspects of extreme weather events could detract from considerations of adaptation, disaster risk reduction measures, exposure, and vulnerability in shaping extreme weather risks. Scholars have previously raised this concern (Kelman et al., 2015; Lahsen & Ribot, 2021; Raju et al., 2022). However, paper 1 provided the first empirical evidence for this dynamic in a climate change communication context – learning about EEA primed focus group participants to only discuss mitigation actions when asked about solutions to reduce heatwave risks. Relatedly, paper 2 showed that only 15% of tweets by Australian climate action groups during the Black Summer bushfires mentioned non-climate change factors that influence bushfire risks (e.g., firefighting, emergency responses, community vulnerabilities, etc.). Ignoring these aspects leaves out crucial components of extreme weather risks and could lead to misguided responses that do not address key risk drivers. Therefore, those seeking to engage public audiences about these weather events face the challenge of communicating a holistic picture of risk dynamics.

### *Challenge 4: Divergent subjective responses to extreme weather events*

The concept of extreme weather experiences is often assumed as a binary in research studies – an individual was either in direct physical proximity to an event or not. This belies the fact that diverse people can have substantially different subjective experiences of extreme weather events, including positive reactions. For instance, many of the participants in paper 1 discussed how they enjoy heatwaves in the UK. Similarly, news media often use ‘fun in the sun’ visuals in their coverage of heatwaves, despite accompanying reporting discussing the health risks of heatwaves for vulnerable populations and other negative societal impacts (O’Neill et al., 2022). There is

nothing morally wrong with enjoying a heatwave, but these contrasting narratives illustrate how climate impacts can be unevenly distributed. If individuals view the increased frequency and intensity of heatwaves as beneficial, it could prove challenging for communicators to leverage their occurrence to communicate climate change risks and the need for action. This finding is, in part, why I added a second case study focused on Australian bushfires. Yet even in paper 2 – in which all participants felt bushfires caused negative impacts on their lives and communities – there were a variety of different experiences with different levels of personal impacts and divergent individual behavioural responses in terms of activism participation.

This thesis provides new evidence that when it comes to extreme weather events, extreme weather experiences, and subjective responses to these experiences, context matters (Zanocco et al., 2018). While extreme weather experiences may help galvanise further participation in various forms of climate activism for some individuals (e.g., protests, contacting elected officials), paper 2 showed that others may instead distance themselves because of feelings of eco-paralysis and/or climate-related anxiety. There can be an inclination to move on after these events, rather than dwell on them (Crow & Albright, 2021). These findings tie into existing mixed results on how extreme weather experiences affect climate attitudes, beliefs, and behaviours (Howe et al., 2019). This cautions against overstating of the potential for these events to help incentivise individual climate action.

#### *Challenge 5: Potential habituation to intensified extreme weather events*

Additionally, as climate change increasingly alters many kinds of extreme weather events, a shifting baseline effect could normalise more frequent/intensified climate extremes (Moore et al.,

2019). In other words, many types of extreme weather events could become less shocking as they happen more often and with greater intensity. Therefore, the opportunity to leverage these events to engage the public about climate change and encourage climate action may not remain consistent over time. News media coverage and societal attention to extreme weather events can also quickly dissipate. There are other important questions around the timing of public engagement efforts after extreme weather events (see section 9.3 below).

*Challenge 6: Contesting framings, blame games, and power dynamics of teachable moments*

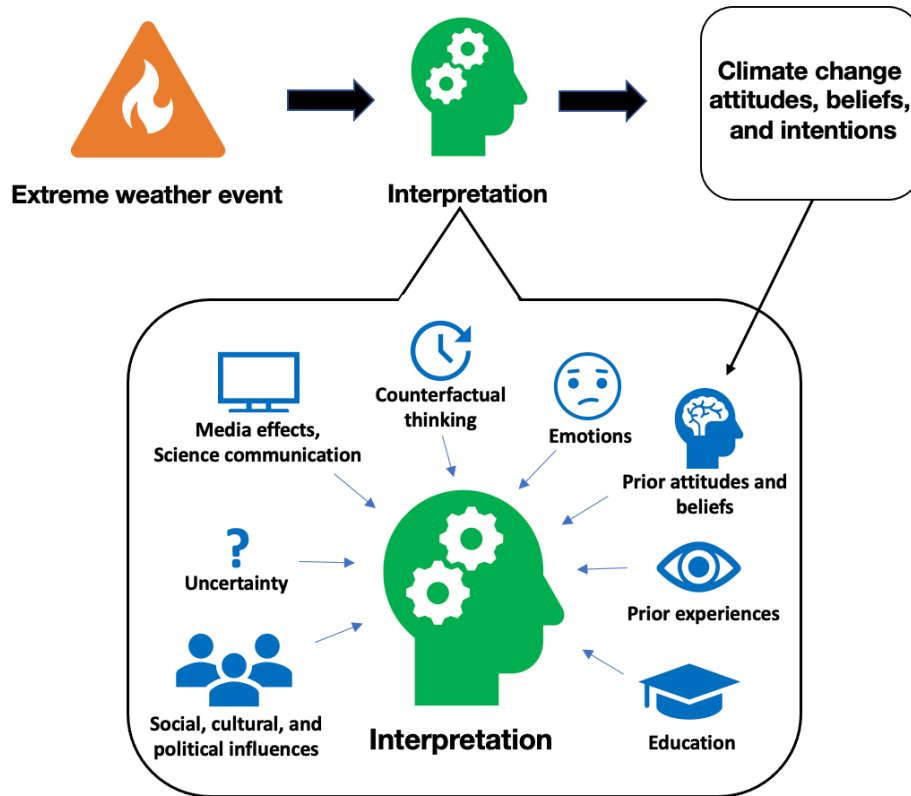
If extreme weather events are to become teachable moments, then what they teach, and to whom, are fundamentally important questions. These events can become matters of political contestation, framings battles, and blame games. For participants in paper 3, bushfires engendered a stronger perceived urgency to address climate change. As shown in paper 2, tweets from Australian climate groups during the Black Summer fires focused predominantly on climate change. In contrast, Scott Morrison, who was Prime Minister during the Black Summer bushfires, framed the fires as a natural disaster requiring greater hazard reduction and governmental emergency powers, with a substantially weaker focus on climate change (Chester, 2020). Similarly, when winter storms in Texas left millions of citizens without power in 2021, several Republican elected officials misleadingly blamed renewable energy technologies for the crisis – in fact, the main driver was likely the effects of the cold temperatures on natural gas production (Searcey, 2021). In other cases, politicians can be quick to blame climate change and neglect aspects of exposure and vulnerability. For example, policymakers in Brazil strategically framed floods as being caused by climate change rather than addressing local planning failures (Lahsen & Ribot, 2021).

Thus, not only does the concept of extreme weather experiences mask a wide range of potential experiences and perceptions – the vagueness of the term “teachable moment” can also encapsulate a wide range of potential lessons. This process is liable to substantial power dynamics, raising the question of who has the power to set the agenda of what steps are taken (or not) in the wake of extreme weather events. Powerful actors have been shown to take advantage of disasters to implement controversial policies while public attention is diverted (Klein, 2007). These socio-political dynamics underscore the importance of public engagement to empower citizens to participate in shaping responses to extreme weather events and climate change. The ability for diverse people to become civically engaged on climate-related issues cannot be separated from broader power dynamics at local, regional, and international levels. Citizens can play a substantial role in climate action; however, their ability to do so is contingent upon freedoms of assembly, speech, and other fundamental human rights.

### **9.3 Maximising public engagement opportunities and addressing challenges (research question 2)**

The second research question aimed to examine how to maximise opportunities and address challenges associated with climate change public engagement efforts after extreme weather events. First, communicating scientific findings about climate change and extreme weather events through one-way communication channels remains crucial. This information will continue to inform societal responses to climate-related risks. At the same time, the most important overarching finding of this thesis is that efforts to engage the public about climate change after extreme weather events should consider a variety of other socio-cultural and psychological dimensions beyond communicating climate science. Scientific information is only one potential factor that may

influence whether individuals perceive a link between an extreme weather event and climate change, and that this subjective attribution process can vary among audiences with different climate attitudes and political affiliations (e.g., Hai & Perlman, 2022). Synthesising a variety of prior literature described throughout this thesis and the findings from the papers, figure 9.1 shows the factors that may influence the subjective attribution process. The figure is intended to provide a helpful conceptual visualisation for climate communicators such as activists and scientists seeking to engage members of the public in local communities after the occurrence of extreme weather events (rather than proposing an empirical psychological model).



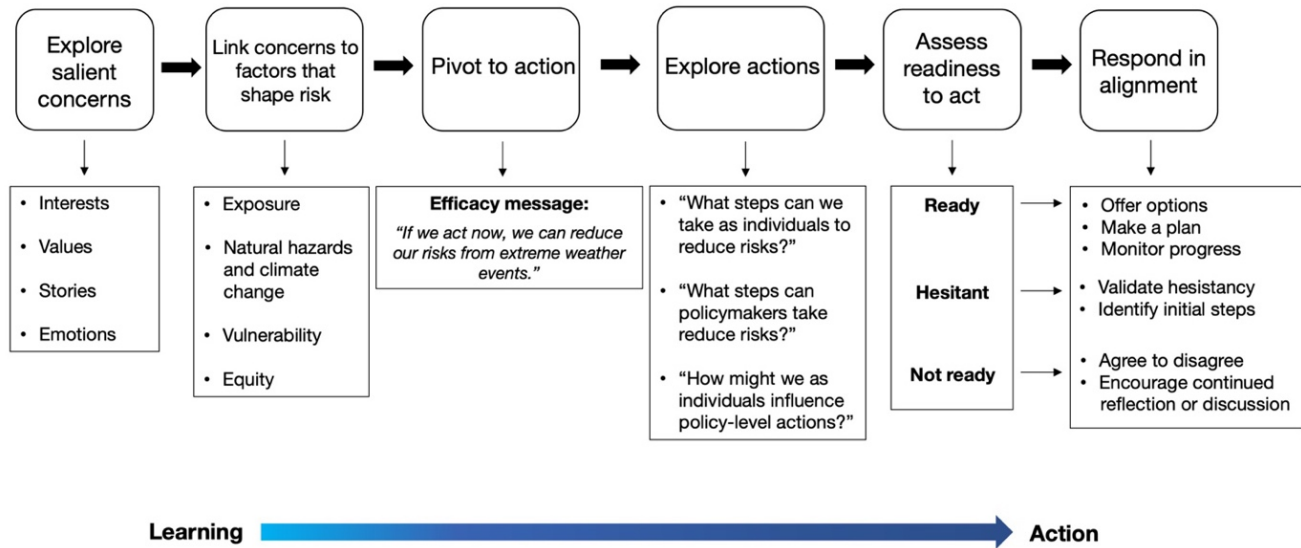
**Figure 9.1:** Conceptual visualisation of factors that can potentially influence individual subjective attribution of extreme weather to climate change.

As depicted in the figure, an individual directly experiences or observes the occurrence of an extreme weather event. A variety of factors can influence how the individual then interprets these

experiences and observations in terms of their potential relationship to climate change, including comparisons to one's prior experiences and observations; cultural, political, and social influences; educational background; potential influences of exposure to news media, social media, and climate science; uncertainties; counterfactual thinking (see paper 1); and motivated reasoning associated with one's pre-existing beliefs, ideologies, and values. This complex array of subjective factors can incorporate elements of both observation-driven "experiential processing" involving sensory inputs, intuition, and emotions, as well as logical assessment of information, i.e., "analytical processing" (Marx et al., 2007). This subjective attribution process might in turn alter or reaffirm individual environmental attitudes, beliefs, and behaviours, which can guide interpretations of future extreme weather events. Bearing these factors in mind can help climate communicators remember that science is a potentially relevant aspect of the subjective attribution process, but not the entire process – this is a key assumption of the public engagement with science model that also applies to many issues at the interface of science and society (see chapter 4).

This thesis has argued that dialogue-based approaches are a vital tool for engaging the public about climate change and encouraging individual climate action after extreme weather events. Dialogue can help leverage the opportunities and address the challenges described in the prior section. Conversations provide an opportunity to make sense of, reflect upon, and share experiences and/or observations of extreme weather events, as well as to deliberate on potential behavioural responses. The importance of dialogue on societal issues has long been emphasised but there is a need for more practical guidance (Weingart et al., 2021). That was the driving motivation of paper 4 (chapter 8), which offers a framework that climate communicators such as activists and scientists

can use to initiate and facilitate action-oriented conversations after extreme weather events (reproduced in figure 9.2 below).



**Figure 9.2:** Teachable moment communications process (TMCP) adapted for climate change and extreme weather events (from paper 4, chapter 8)

The framework offers a variety of strategies for engaging the public about climate change after extreme weather events that also help address the aforementioned challenges. First, as a dialogue-based framework, it offers flexibility for communicators to tailor conversations after extreme weather events to the experiences, interests, and values of conversation participants. Furthermore, throughout this thesis I have refrained from focusing on one specific type of climate action that individuals can pursue to act on climate change and extreme weather risks – a variety of interventions may be needed to address risks at both individual and systemic levels for different local circumstances. The framework approach therefore encourages communicators to collaboratively explore different potential individual actions relevant to the type of extreme weather event and local contextual considerations, and to gauge one’s willingness to pursue one

or more of these actions (which may focus on personal risks from extreme weather events, personal ways of reducing one's greenhouse gas footprint, or individual participation in climate activism). A participatory approach also helps avoid didacticism, in which experts are seen as only teaching non-experts. Instead, two-way dialogue can encourage mutual learning among all participants that incorporates, but is not entirely limited to, relevant climate science. The framework also helps capture nuances of extreme weather risks and their relationship with climate change. Climate-related discussions are a highly suitable format for exploring these dynamics – the strategic questions offered in paper 4 (chapter 8, box 1, p.199) can help prompt thinking around interconnected risk dimensions. This approach also leverages the findings from the papers on the importance of providing spaces for emotional processing and storytelling after extreme weather experiences.

What might public engagement interventions that could benefit from this framework look like in practice? Further research and testing are needed; however, it could prove useful in the following contexts:

- Town halls, citizen assemblies, and other venues in which climate experts have opportunities to engage in discussions with non-climate specialists
- When climate activists and members of climate action groups engage their colleagues, family members, and friends in conversations (see appendix A)
- Canvassing, i.e., “door to door” campaigns that engage individuals in conversations about socio-political issues, often during election cycles
- Social media exchanges among climate experts and non-experts (Hawkins et al., 2014)

- Conversations among health professionals with their patients about the health risks of climate change and extreme weather events (Campbell et al., 2023)

Again, the goal of these efforts should not only be to encourage others to pursue individual actions to address climate-related risks; these situations offer valuable opportunities for mutual learning and to facilitate more diverse ideas and perspectives for climate action.

It is important to note that those who seek to galvanise climate conversations after extreme weather events could be accused of exploiting suffering for political gain. However, it is arguably more of a disservice to those who suffer from the impacts of these hazards to not discuss the factors – including but not limited to climate change – that influence their impacts and will continue to affect more people in the future. Nevertheless, to avoid potentially exacerbating psychological distress among individuals directly affected by extreme weather events, communicators should first check that conversation participants are willing to discuss the topic and enable them to end the discussion at any time.

Although this thesis has focused on a dialogue-based approach, these strategies – capturing nuances of extreme weather events and their relationship with climate change, telling stories about personal experiences of these events, differentiating between individual actions that shape one's own personal risks (e.g., evacuation plans) versus activism targeted at policy-level actions – could also be implemented in one-way communication formats as well (such as in the communications of climate action groups and news media articles). While a greater emphasis on

encouraging climate conversations is needed, one-way forms of communication remain extremely important for shaping societal responses to climate change.

## **10. Conclusion**

Researchers have long hypothesised that extreme weather events could help mobilise diverse members of the public to act on climate change. However, studies examining how extreme weather events affect climate change beliefs, concerns, and behaviours offer mixed results (Howe et al., 2019). Further research is needed on proactive climate change communication strategies in the context of extreme weather. This thesis has sought to help fill this gap by examining to what extent extreme weather events provide valuable moments for climate communicators to engage members of the public about climate change. After conducting focus groups exploring how non-climate scientists engage with extreme event attribution findings; analysing tweets by Australian climate action groups during the Australian Black Summer bushfires; interviewing Australian bushfire survivors and climate activists; adapting a health behaviour communication framework for climate change communication; and drawing lessons from an international climate conversations campaign, the findings offer several important conclusions.

When extreme weather events occur, non-climate experts can be interested in learning about how climate change relates to extreme weather events. Extreme event attribution results demonstrating how extreme weather events are linked to (or not linked to) specific extreme weather events can also be attention-grabbing. Counterfactual aspects of climate science can stimulate one's imagination to envision alternative pasts and futures. Extreme weather experiences, socio-cultural attitudes and beliefs, emotional responses, trauma, and many other dynamics can together influence individual perceptual and behavioural responses to extreme weather events. A wide array of different potential actions to respond to climate change and extreme weather risks may be applicable in various local circumstances, and individuals may be inclined to pursue different kinds

of behaviours. Relevant actions can include personal adaptive behaviours to reduce weather-related risks, lifestyle decisions to reduce one's greenhouse gas emissions, and activism to advocate for climate adaptation and mitigation policies.

The most substantial challenges centre around communicating nuances, including the ways climate change affects specific types of extreme weather events (and that it does not necessarily affect every extreme weather event), and how complex interactions between hazards, exposure, vulnerability, and responses determine risks. These nuances can lead to alternative framings and blame games in which different actors strategically direct responsibility for the effects of extreme weather to specific factors. As stated earlier, if an extreme weather event can be a teachable moment, it raises questions of what exactly it teaches and to whom – the answers to these questions are open to debate. Although one-way communication channels remain important, I have argued that interpersonal conversations are a meaningful, productive, and underappreciated communication approach that can help climate communicators leverage these opportunities and address these challenges. Dialogue can be especially helpful for navigating complex risk dynamics and the different types of actions individuals might be inclined to pursue to address these risk factors in local contexts.

These findings offer promising directions for future research. The samples of papers 1 and 3 were not generalisable to the United Kingdom and Australian populations, respectively. Paper 2 was also not generalisable to other climate action groups. The findings can now inform more quantitative-oriented approaches (e.g., surveys) with larger sample sizes. Additionally, the participants in this thesis were already concerned or highly concerned about climate change. Future

research should explore dynamics of extreme weather perceptions and climate change communication among individuals indifferent to, or actively sceptical, of climate change and climate action, and among other distinct population segments. Future research could examine communication dynamics around specific types of climate science/extreme weather nuances (see challenge 3, p.221) and offer additional evidence-based guidance for effective communication.

The question of how different audiences engage with climate change is especially pertinent to paper 4, which proposes a step-by-step dialogue framework for climate communicators. Had time allowed, as part of this thesis I would have conducted a study testing the effectiveness of the framework among individuals with different climate attitudes and in contrasting settings. One method could be an experiment in which one group of climate advocates receives a training session on the framework, and the quantity, quality, and outcomes of their climate discussions over the subsequent months are compared to another group who does not receive the training. The framework could also prove useful for facilitating discussions about other types of environmental and social issues. Another relevant question is how the potential teachable moment qualities of extreme weather events for encouraging individual climate action compare to other societal phenomena that may affect climate attitudes. This might include slow-onset climate impacts such as sea-level rise, socio-political events such as elections and climate-related protests, and many other types of occurrences to which diverse audiences may respond differently.

There are also other important aspects of climate change communication that I did not empirically examine. For instance, I engaged minimally with literature on environmental education and behavioural science that could have yielded additional valuable insights. While paper 3 focused

specifically on individual climate activism participation, there is substantial research exploring barriers, drivers, and motivations around other specific climate-related behaviours. There is also substantial research examining audience responses to different kinds of climate messengers (e.g., Fielding et al., 2020). For example, paper 3 found that firefighters are using their firefighting experiences as the basis for personal climate communication efforts. Emergency first-responders have been found to be trusted climate change messengers, so this would be a promising research topic (Sleeth-Keppler et al., 2017). Future research could also build on my findings to dive deeper into dynamics of climate discussions among individuals with different kinds of relationships, e.g., co-workers, community members, constituents and elected officials, family and friends, etc.

The timing of the public engagement interventions after extreme weather events is another crucial consideration. It remains unclear when these efforts would be most effective and there is a risk that conversations could trigger harmful psychological emotions and stress for some individuals if conducted in the immediate aftermath of an event. The proposed dialogue framework accounts for this by encouraging communicators to check that conversation participants are comfortable and willing to discuss the topic before engaging in a climate-related discussion. Nonetheless, this thesis did not empirically examine temporal or longitudinal dimensions, which forms another fertile direction for research. This could entail multi-wave surveys and interviews assessing the impacts of public engagement campaigns conducted at different time periods after an extreme weather event.

A final implication of this thesis is the importance of knowledge exchange across groups with varied climate change experiences, expertise, and understandings, such as researchers working on

meteorological aspects and risk dimensions of extreme weather events, NGOs and climate activists, journalists, policymakers, and diverse members of the public more generally. Each of these actors can offer unique functions, insights, and perspectives that can help shape responses to extreme weather events and climate change more broadly. Further research is needed to explore strategies for effectively facilitating knowledge exchange among different actors.

In conclusion, we do not need to wait and see if extreme weather events help catalyse action on climate change. We, as individuals, can turn these events into moments for dialogue, learning, and action – and it all begins with speaking up.



*Illustration by Alice Chautard for the Talk Climate Change campaign (appendix A)*

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## **Appendix A: Breaking the climate spiral of silence: Lessons from a COP26 climate conversations campaign**

This commentary article is based on a campaign I co-founded with several other post-graduate students at the University of Oxford's School of Geography and the Environment. It was originally conducted as a climate change communication campaign for the 2021 United Nations COP26 climate meeting in Glasgow, Scotland. However, I soon after realised that the campaign offered highly valuable insights for research on the topic of climate conversations (and for this thesis as well). The piece is co-authored with the other students with whom I conducted the campaign.

**Breaking the climate spiral of silence: Lessons from a COP26 climate conversations  
campaign**

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Published 23 February 2023

Available from: <https://link.springer.com/article/10.1007/s10584-023-03493-5>

**Abstract**

Conversations about climate change are crucially important for mobilizing climate action, as well as for processing emotions and finding meaning in times of crisis. However, limited guidance exists on how to successfully facilitate these discussions, especially among individuals with a wide range of beliefs, knowledge levels, and opinions about climate change. Here, we describe the Talk Climate Change project — an Oxford University student-led climate conversation campaign associated with the 2021 United Nations COP26 meeting. Over 1000 individuals across 40 countries held climate-related discussions. They then described their discussions in submissions to an interactive conversation map ([www.talkclimatechange.org](http://www.talkclimatechange.org)), along with messages to COP26. We reflect on the campaign's outcomes and offer advice on overcoming barriers to effective climate dialogue; how to handle emotional responses; and other considerations for catalyzing meaningful and productive climate discussions. We call for a stronger focus on training conversational skills, providing context-specific discussion resources, and empowering diverse people to have conversations about climate change among their families, friends, coworkers, and communities.

## Introduction

*“How many of our friends and family members understand why COP26 is important or what it even is?”*

This is the question that we, a group of graduate students at the University of Oxford asked ourselves in January 2021. There was already much speculation about the potential outcomes of the 26th United Nations Climate Change Conference (COP26), to be held in November 2021 in Glasgow, Scotland. COP is the annual meeting of parties to the United Nations Framework Convention on Climate Change during which delegates assess and negotiate paths for mitigating and adapting to climate change (Evans et al. 2021). The outcomes of these negotiations affect all life on Earth. At the time, we were struck by the limited awareness of it beyond individuals directly involved in environmental work. When we mentioned COP26 to close contacts not engaged in the environmental movement in professional or personal contexts, the term was unfamiliar to most of them. Even among our fellow students, in the same country as the upcoming conference, awareness was surprisingly low. Public polling confirmed this perception. In September and October 2021, only 35% of people in Great Britain reported knowing of COP26 and understanding what it was about; this figure was even lower in the USA, where only 14% of Americans reported an awareness and understanding of it (Hudson et al. 2021).

Fortunately, awareness of COP26 increased during the conference, such as in the UK, where 60% of the public reported hearing a fair or significant amount about COP26 in November 2021 (Conner 2021). This was most likely associated with substantial media coverage of the conference (Boykoff et al. 2022). Nevertheless, that such a pivotal meeting could remain a matter relatively

confined to the environmental community is not only troubling — it is also risky. Public engagement is crucial for climate action, especially as many decarbonization and adaptation solutions require public participation to ensure their success (Hügel & Davies 2020). For example, transitioning energy systems away from fossil fuels, such as through the construction of renewable energy infrastructure, can encounter significant opposition without community buy-in and support (Perlaviciute et al. 2018). A report commissioned by the UK's Department for Business, Energy, and Industrial Strategy notes that effective public engagement is essential for successfully achieving net zero targets (Demski 2021). Likewise, public opinion and voting preferences can influence policy agendas (Brulle et al. 2012). A lack of awareness can also reduce the diversity of voices on the issue, allowing fossil fuel corporations and high polluting industries to dominate (Global Witness 2021), while excluding vulnerable and marginalized communities most susceptible to climate impacts (Sultana 2022).

We therefore decided to use COP26 as an opportunity to start a student-led conversation campaign to help broaden the range of individuals aware of and engaged in climate action. Our campaign ([www.talkclimatechange.org](http://www.talkclimatechange.org)) sought to inspire and track 26,000 climate conversations worldwide from June 2021 to November 2021. In this essay, we discuss our experiences designing the campaign and reflect on the lessons its outcomes hold for climate change communication.

### **Deficit versus dialogue**

At first, we contemplated creating an informational website to educate others about COP26 and climate change more generally. This is the most common mode of science communication — known as the deficit model, one provides information and presumably it fills gaps in another's understanding (Sturgis & Allum 2004). To be sure, it is vitally important that the scientific

community continue to inform the public about advances in research and understanding. Nevertheless, researchers have for decades pointed out limitations of the deficit model, as it implies that attitudes, beliefs, and behaviors are based solely on knowledge, rather than a complex array of personal, contextual, cultural, and value-driven factors (Simis et al. 2016). It also tends to treat the public as a single entity when it is in fact composed of diverse groups and individuals.

As we sought to not only inform people beyond the environmental community about the conference but also find a way to feed their views and perspectives back to COP, we required a different approach. We also wanted to empower a diverse range of individuals — both including and beyond scientists — to start conversations. We therefore decided to follow a public engagement approach, also known as the dialogue model (Suldovsky 2017). In contrast to the deficit model, the dialogue model does not view communication as a one-way transfer of knowledge from expert to lay person. Instead, it seeks to break down divisions between technical and public spheres to facilitate spaces for the exchange of ideas, opinions, and information; at a practical level, this may entail interpersonal discussions and other public engagement opportunities that incorporate two-way communications (Wibeck 2014; Patenaude & Bloomfield 2022).

Researchers are increasingly recognizing that dialogue-driven approaches are vital for climate action. Conversations about climate change provide opportunities for reflection on the issue's many different impacts, meanings, and emotional responses (Salamon & Gage 2020; Tait et al. 2022). For instance, studies have documented the effectiveness of climate community forums and citizen assemblies for public engagement (e.g., Devaney et al. 2020; Hanson 2018; Myers et al. 2017). During these sessions, citizens are typically exposed to climate science, but also offered the

opportunity to engage in discussions and deliberation about the material. Furthermore, conversations hold communicative power. Goldberg et al. (2019) found that discussions among family and friends helped improve understanding of the scientific consensus that climate change is occurring and driven by human activities. On social media, some scientists have found conversational approaches, rather than didactic teaching, to be a more rewarding form of engagement about climate change (Hawkins et al. 2014). Conversational approaches can also help reach individuals less exposed to climate information and media coverage, such as in rural communities with limited Internet access (Mycoo 2015).

Despite the importance and effectiveness of climate conversations, such discussions among the public do not often happen. In the USA, in contrast to growing alarm about climate change, about 2/3 of Americans say they rarely or never talk about climate change (Leiserowitz et al. 2021). Some researchers have called this the climate spiral of silence (Maibach et al. 2016). According to the spiral of silence theory, individuals are less willing to express opinions that they believe are not shared by others, which in turn influences public opinion (Noelle-Neumann 1993). A spiral is a fitting metaphor for this silencing effect, as the less people hear others speak about climate change, the less they feel it is a socially acceptable topic for discussion, creating a vicious cycle. Researchers have found that those who care about climate change underestimate how much others care about it, which leads to self-silencing on the issue (Geiger & Swim 2016). A misunderstanding of how others feel about an issue is known as pluralistic ignorance, which is a common phenomenon for climate change (Sparkman et al. 2022). The notion of individual silence associated with a lack of social support is pertinent to a variety of societal issues, such as in the context of sexual violence and the #MeToo movement (Zacharek et al. 2017). Discussing climate

change can also feel uncomfortable as it is a politically charged topic, which is, in part, a result of decades of campaigns by fossil fuel companies to sow doubt, division, and mistrust about the issue (Supran & Oreskes 2021).

Power dynamics are an additional consideration. As Bucchi and Trench (2021, p.7) note, conversations are “. . . not necessarily open and equitable. Many attributes can be a handicap to participation, including gender, educational level, ethnicity, and language. It takes conscious action to address these imbalances and exclusions.” This is particularly relevant to climate change as the environmental movement has been criticized for excluding women, people of color, Indigenous peoples, and poorer populations in the Global South who are not only the most vulnerable to climate change, but often least heard when it comes to climate decision-making (Okereke & Coventry 2016; Abimbola et al. 2021). Furthermore, climate change can be unpleasant, distressing, and awkward to discuss, especially amid significant political polarization and climate anxiety (Hickman et al. 2021). One may also feel unprepared to engage in climate change discussions due to a perceived lack of knowledge on the topic (Geiger et al. 2017). However, researchers have shown that climate change communication training can increase the frequency and quality of climate discussions (Swim et al. 2018).

Compared to the large number of studies incorporating a one-way climate communication model, there is limited evidence-based guidance on strategies for successfully encouraging climate conversations (Markowitz & Guckian 2018). There is growing empirical evidence that having climate conversation participants identify shared values (i.e., objects or ideals that individuals feel are worth protecting) can support positive conversational outcomes (Bloomfield et al. 2020). For

example, van Swol et al. (2022) found that facilitating group discussions based on shared values was more effective toward building group consensus on climate change beliefs than discussions based purely around a climate change article. Establishing shared values has also been found to increase support for climate policies (Geiger et al. 2022). Drawing on her personal experiences and empirical literature, climate scientist Dr. Katharine Hayhoe advises finding ways to connect climate change to specific interests and values among diverse communities, e.g., among faith groups, talking about religious values of protecting living beings; among wine connoisseurs, how climate change impacts vineyards; among scuba divers, the impacts of warming oceans; etc. (Hayhoe 2021).

An analysis of the 2019 Curious Climate Tasmania project, which sought to facilitate climate conversations between scientists and non-scientists, highlights the importance of establishing trust, agency to act, and a genuine back and forth exchange (Kelly et al. 2020). Likewise, the organization Climate Outreach advises establishing respect, asking questions, and practicing active listening to ensure a civil and effective discussion (Webster & Marshall 2019). Other organizations have trained youth to engage their parents about climate change, drawing upon motivational interviewing techniques, such as asking open-ended questions to encourage storytelling (ACE 2017). We incorporated these guidelines into our campaign strategy and build on them below.

### **The Talk Climate Change campaign**

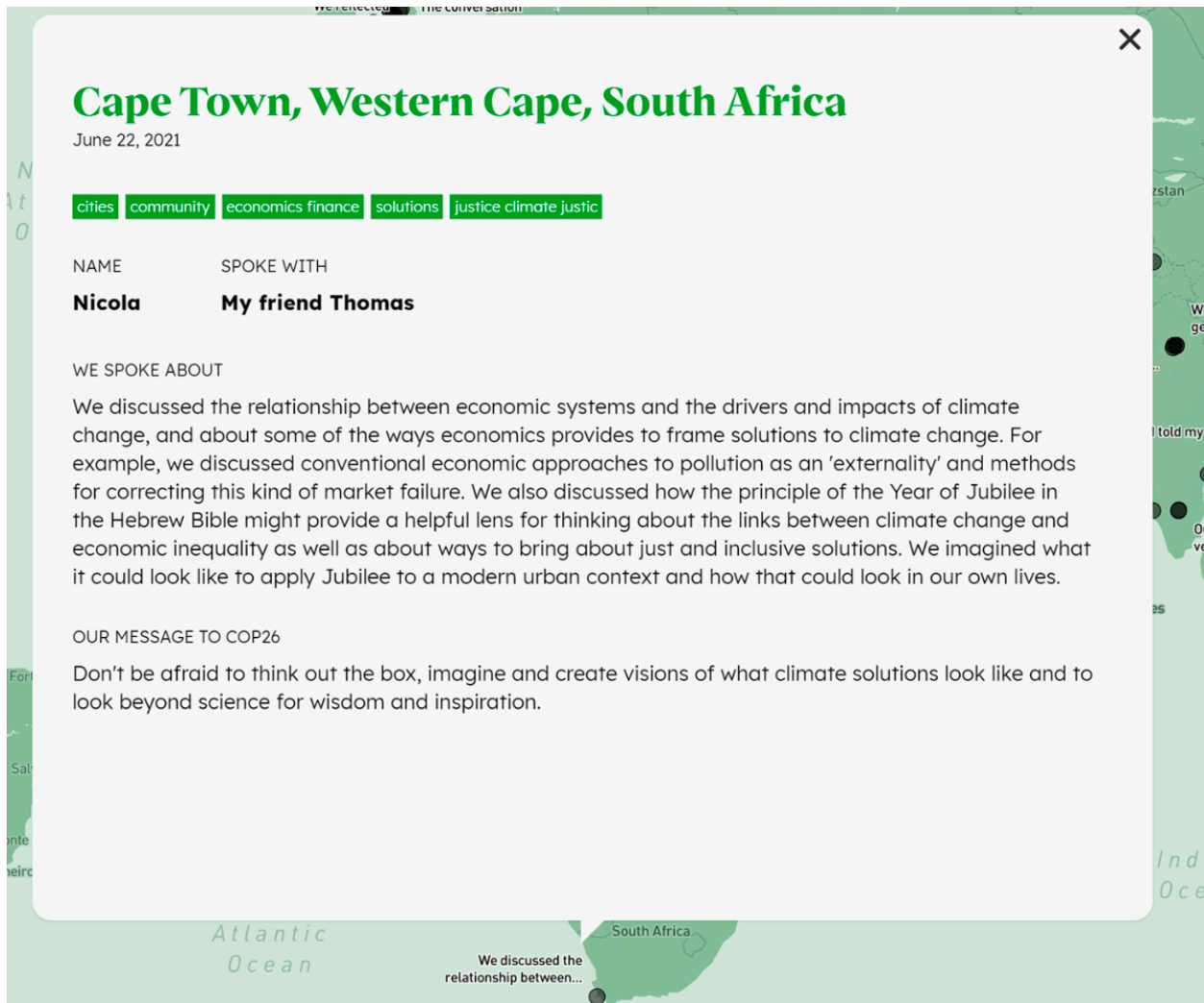
We launched the campaign in June 2021 and set a goal of encouraging and documenting 26,000 climate conversations by 1 November 2021 — the first day of COP26. The number 26,000 was a relatively arbitrary decision; we chose a number loosely related to COP26 that was ambitious and attention-grabbing, but not impossible to achieve. The conversations did not have to relate to

COP26, but we used the occasion of the conference as a call to action. Conversations could be held over any medium, in person or online, so long as there was a back-and-forth dialogue. We built an associated website to serve as the platform for our campaign. The core structure of the website included a form in which anyone could submit information about their climate conversations and an interactive map showcasing climate conversations submitted from around the world (see [www.talkclimatechange.org](http://www.talkclimatechange.org)). Although we expected our participants to consist mostly of environmentally concerned individuals, we encouraged them to have conversations with others beyond the environmental community to help break the spiral of silence. We hoped that this would initiate opportunities for diverse individuals who do not frequently speak about climate change to understand, reflect upon, and find ways to support climate action. Engaging in these discussions (as well as viewing the resulting conversation map) could help counter perceptions of pluralistic ignorance by showing that people care about — and are talking about — the issue more than often assumed (Geiger & Swim 2016).

When deciding what and how much information to collect via the form, we did not want to make the process of filling out the form too arduous. We also needed to balance considerations of privacy, cybersecurity, and anonymity. Accordingly, we required submissions to include the first name of the person submitting, the first name of their conversation partner, their relationship, the location where the conversation took place (no more specific than city/town), the conversation content, and up to five pre-populated thematic tags describing the discussion content (e.g., “food” and “transport”). We offered participants an open-ended space to describe their conversations and the meaning they derived from them, as well as the option to write a message to COP26 (which we later presented at the conference) and to upload an image associated with the conversation.

Initially, we allowed images of the participants or of objects or landscapes representative of the conversation topic; however, we ultimately deleted all images containing people from the dataset to provide full participant anonymity. For additional safety for minors, when submitters clicked a box that they were under 18 years old, the photo upload feature was disabled. As this article describes a non-identifiable dataset created prior to the conception of this publication, it was exempt from ethical approval in accordance with the University of Oxford's Central University Research Ethics Committee guidelines.

Figure A1 shows an example of a conversation submission. We also developed brief conversation prompts on a range of topics such as climate justice, nature-based solutions, and net zero, as well as a guide for educators to use in the classroom. The educator guide adapted general climate conversation guidance to the more structured environment of the classroom, including advice from a sustainability education expert, lesson plans, and a worksheet. Likewise, we collected brief conversation advice statements from 50 leading environmental scholars and activists from diverse backgrounds (e.g., age, expertise, gender, and race). These statements offer valuable expert perspectives on both the importance of climate conversations and practical strategies for facilitating effective discussions. We promoted the campaign on Facebook, Instagram, LinkedIn, and Twitter, as well as via relevant external email newsletters. We also created a 1-min promotional video which introduced the campaign and provided instructions on how to participate. The conversation map, expert advice statements, guides, promotional video, and other materials remain available at [www.talkclimatechange.org](http://www.talkclimatechange.org).



**Figure A1:** Example of a submission to the campaign’s interactive conversation map.

### Campaign outcomes

We received a total of about 500 climate conversation submissions, involving over 1,000 people, from 40 countries. The conversations took place among people with many kinds of relationships, including children, siblings, parents, grandparents, friends, co-workers, taxi drivers, nurses, strangers, and more. Conversations covered a wide range of topics (Table 1). We note that as self-reported data, the submissions represent how campaign participants perceived and reflected upon their discussions, rather than being necessarily complete, objective, or accurate accounts.

Conversation tag	Frequency
1. Education	90
2. Politics/policies	59
3. Activism	58
4. Community	57
5. Individual carbon footprint	55
6. Solutions	54
7. Energy	51
8. Recycling	50
9. Animals/biodiversity	46
10. Weather	40

**Table A1:** The top 10 (of 46 total) thematic tags campaign participants most frequently used to describe the content of their conversations. Participants could assign up to five tags to each submission.

Numerous conversation submissions indicated plans to pursue further individual climate actions post-discussion, such as reducing personal energy use, engaging in activism, and more regularly having discussions. For instance:

*My friend and I talked about how to support environmental and climate objectives through professional careers that are not specifically focused on these issues. We discussed the personal and ethical debates surrounding choice of profession/vocation and the trade-offs of working directly for a climate-focused org with those of working for a large company not focused on climate but with substantial potential to support climate goals. . . We didn't make any decisions related to our own careers, but we did decide to continue these important conversations in the months and years ahead.*

Messages to COP26 expressed a wide range of sentiments. The most common messages urged countries to increase the ambition of their emissions reduction targets, diversify climate leaders

and voices represented at the conference, and generally take the threat of climate change more seriously. For example:

*Our message to COP26 is that we want desperately to show world governments and industry leaders that the world can be saved and that it's not hopeless, but we have to act now. Individual change can only do so much because so much is based on a global industrial scale. I want my sister to grow up in a world where she can still thrive.*

Our website received over 15,000 visits from over 120 countries and a high level of engagement on social media (e.g., over 100,000 Twitter impressions on our campaign launch announcement alone and 25,000 views of our campaign video). This suggests that there was significant interest in learning more about our campaign, as well as in viewing conversations submitted by others (regardless of whether these visitors ultimately participated). The campaign was also featured in a WIRED Magazine article on ways to act on climate change (WIRED 2021). We made special efforts to elevate submissions from Global South countries by, for instance, highlighting them in our email newsletters and social media posts. We organized a range of climate conversation events, including running a climate conversation activity for children and their families during the London Science Museum's "Future Explorers" program, participating in the UK's "Great Big Green Week," and holding workshops among community and interfaith groups where we trained participants to have effective climate conversations. We also worked to engage students, faculty, and staff across our university. The project was presented at COP26 as part of a Paris Committee on Capacity Building panel and other outreach activities during the conference.

## **Lessons for climate change communication**

Based on our experiences conducting the campaign and upon subsequent reflection on its outcomes, we offer five lessons for effectively facilitating climate conversations among individuals with differing beliefs, opinions, and knowledge levels about climate change. These suggestions build on the prior literature described above and are intended for environmental communication practitioners seeking to increase both the quantity and quality of climate conversations in diverse settings.

### *1. Affirm the importance of climate conversations*

The submissions to our interactive map from 40 countries exhibit a remarkably meaningful and rich array of climate conversations, covering a diversity of topics discussed by people with varying relationships. Numerous submissions mentioned plans to build on initial discussions to incorporate other ways of taking action on climate change. Yet while the quality of participation was excellent, we fell far short of our goal of 26,000 submissions. As described, this stands in contrast to the significant online engagement we received both in visits to our website and engagement on social media from around the world. This disparity suggests that many people were interested in the campaign but ultimately did not participate. This is not entirely surprising; catalyzing climate conversations can be difficult, which is, after all, why we started the campaign in the first place. Research in the USA shows that even among those most alarmed about climate change, only about a third participate in climate activism (Goldberg et al. 2021). The total number of submissions may also reflect the limited resources of a student project conducted on a volunteer basis, as well as the short time window of the campaign.

Speaking up about a topic as unsettling as climate change is not easy — it takes courage. Therefore, encouraging climate conversations is, in part, a matter of incentives. Participants need to be reminded of the importance of these conversations for inspiring both individual behavior change and climate activism targeted at policymakers and other stakeholders, as well as for providing opportunities for dialogue on this enormous societal issue. Although a single discussion may not immediately lead to dramatic impacts, at scale thousands of discussions hold immense power. Furthermore, many individuals ultimately find these discussions rewarding, even if they can feel somewhat awkward to start. As one participant described:

*A number of practical actions emerged [from the conversation], which were previously unclear. I left the meeting feeling much more able to make a positive difference through my everyday words and actions.*

Likewise, in order to fight feelings of pluralistic ignorance and alienation (Geiger & Swim 2016), campaign organizers should make participants feel part of a larger conversation effort. Tracking conversations, as we did on our interactive map, is one way of achieving this; on the other hand, the time and effort required to submit a conversation summary adds an additional barrier to participation. This is likely another factor for why we did not receive as many submissions as hoped. Structured venues and events, such as Climate Cafés (Tait et al. 2022), can also help facilitate climate discussions.

## *2. Build conversational skills*

Based on anecdotal feedback, we realized that another barrier to participation was a feeling of discomfort and lack of preparation for engaging in climate conversations, reflecting the aforementioned empirical findings on climate discussions (e.g., Geiger et al. 2017). We therefore began conducting climate conversation workshops in which we explained barriers to effective environmental communication, explored potential conversation topics, described how to handle emotional responses, and practiced listening skills. This included an active listening exercise sometimes taught in mindfulness courses in which participants listen to someone else speak for several minutes and are not permitted to respond verbally (body language reactions are allowed). They then switch roles to experience what it feels like to truly be heard. As Oxford University economist Kate Raworth noted in her submission of conversation advice to our website:

*If you begin with curiosity, empathy and genuine listening, you'll find that a topic that once seemed so hard to crack open can suddenly turn into a lively discussion that flows towards action.*

These training sessions proved helpful as participants reported feeling more comfortable with the prospect of engaging in climate discussions.

Like any other communication technique, interpersonal dialogue is a skill that can always be improved. Further evidence-based guidance for having effective climate conversations and training associated skills would be beneficial. A foundational understanding of scientific, social,

and policy aspects of climate change can also build one's confidence to engage in discussions on the topic.

### *3. Tailor the conversation*

Among the skills we taught in our conversation workshops, a helpful technique is considering the background, beliefs, interests, and values of one's conversation partner and framing the discussion accordingly (Swim et al. 2018; Hayhoe 2021). In practice, this means asking pertinent questions to explore what others care about and seeking to link these interests to climate action. This approach helps facilitate more personally meaningful and relevant discussions. The most frequent thematic tags listed above (Table 1) reflect how campaign participants sought to make their discussions relevant to their conversation partners' lives by discussing their personal carbon footprints, social dimensions of climate change, and local weather. For instance, one participant tailored a discussion based on his conversation partner's political views:

*I talked to a conservative family member about their concerns about the Energy Innovation and Carbon Dividend Act and helped them feel better about measures being taken to preserve the US's economy while environmental regulations are put in place. I hope this opened the door for future conversations with my conservative family members about the climate.*

Others used extreme weather events as a basis for discussions: *After an unprecedented heatwave, it's easy to start this kind of conversation.*

Tailoring a conversation requires careful listening, authenticity, and trust. Tailoring can be conducted transparently, rather than in a manipulative manner; communicators can openly explain that they would like to explore how climate change is relevant to their conversation partner's interests, rather than attempting to do so covertly.

#### *4. Give space for diverse emotional responses*

Climate change can evoke a wide range of emotions with varying levels of intensity (Brosch 2021). For many, it may evoke strongly negative feelings such as anger, fear, guilt, and worry (Hickman et al. 2021), as well as feelings of uncertainty (Moser 2014). It is important to affirm the validity of different kinds of emotional responses to climate change and acknowledge that there is no single appropriate way to feel about the issue. Climate conversationalists should therefore provide a safe space for individuals to express how they truly feel without fear of judgment or retribution. As Dr. Britt Wray, Stanford University, explained in a contribution to our campaign:

*To meet this distress, we need to have socially supportive conversations with others who can legitimize these concerns, reckon with feelings rather than dismiss them, and provide the creative environment in which people can strategize about how they're going to show up in the world, as individuals and collectives, to meet the moment.*

Communicators should not view conversations as a debate to be won; rather, they should see them as an opportunity for mutual learning. On a more practical level, we also encouraged our campaign participants to check that their conversation partners were comfortable discussing the topic and explain that they could end the discussion at any time. Likewise, environmental communicators

are not obliged to remain in conversations with individuals who do not reciprocate kindness and respect.

##### *5. Provide resources for distinct conversational settings*

To successfully facilitate climate conversations, one must consider among whom discussions occur, in what venues they take place, and to what extent individuals feel empowered to participate. Different locales, such as businesses, classrooms, and community centers, can benefit from specially tailored conversation resources and training suited to their needs and context. As a teacher from Islamabad, Pakistan, described in her submission:

*As a class we talked about how climate change is the most pressing environmental issue we are faced with today . . . We hope to spread our knowledge about climate change with our school community soon and start a discussion on how we as a school community can help take action.*

Different resources are clearly needed to support a teacher engaging her class (e.g., by providing climate action activities relevant and accessible to students), compared to conversations among companies, governments, communities, and other contexts.

One of the most memorable experiences of our campaign was running a climate conversations activity booth at the London Science Museum for children and their families (figure A2). We prepared a set of conversation prompts about climate change designed for children, such as their feelings about being in nature, protecting animals, and sustainability in their schools. We guided

parents and guardians to have these conversations for about 10–15 min, with their children subsequently filling out a worksheet describing their discussion. It also proved a useful opportunity to educate families about COP26, and many wrote messages to the conference. We estimate that a total of about 450 children and their parents/guardians participated in climate conversations at the museum. We were surprised by the number of people who told us it was the first conversation they ever had with their children about climate change. Many of them found it to be an emotionally moving experience.

**CLIMATE CONVERSATIONS WORKSHEET**

Your first name: *Olle*

First name of person/people you spoke with: *Pat*

Your relationship with them (such as classmate, friend, parent):  
*Grandma*

What you spoke about:  
We spoke about... *What we could do to help the climate in schools. ~~and how to do~~*  
*We could plant trees and put solar pannels on the roofs of schools and farm buildings.*

What is your message to world leaders gathering at the United Nations climate conference in Glasgow, Scotland next week?  
*Stop burning fossil fuels and don't cut as many trees down.*

**Figure A2:** Example of a climate conversation submission from the London Science Museum family activity

## Conclusion

This article has described our experiences designing and conducting a climate conversations campaign in the lead-up to COP26. We hope our campaign’s successes and challenges serve as a useful model for environmental advocates pursuing similar dialogue-driven approaches for public engagement. In the near future, we plan to offer our conversational map as a free online tool for environmental groups to encourage discussions about climate change and related issues as part of their campaigning efforts. Like any communication technique, conversational skills can always be improved, especially when grappling with sensitive, emotionally charged issues. More resources and training opportunities should be made available to help environmental practitioners, researchers, and advocates facilitate effective interpersonal dialogue in diverse settings. Amid

significant political polarization, conversations about climate change can help break down barriers and echo chambers, opening new possibilities for cooperation and progress. Furthermore, climate conversations can also help elevate voices less often heard and offer new ideas and solutions. As Dr. Anthony Leiserowitz, Director of the Yale University Program on Climate Change Communication, explained in a contribution to our campaign:

*Climate change can seem overwhelming, but each of us has this superpower - of talking with and engaging the people we love, who talk to other people, who talk to other people, who talk to other people, until everyone is talking about it, which changes public and political will for climate action. And it all starts with a simple conversation!*

Our campaign was born out of the simple idea to use the power of dialogue to engage people about the complex and often emotionally charged issue of climate change. By encouraging participants to listen, learn, and approach climate conversations openly and empathetically, we successfully empowered diverse individuals to speak up about climate change in their local communities. This helps fight the climate spiral of silence. Ultimately, we hope this model can help support a ground-up increase in political and social action on climate change and other pressing societal challenges.

### **Acknowledgements**

We are grateful for the many people across our university and around the world who participated in our conversation campaign and supported us in other ways, including providing guidance and resources, testing the web platform, and promoting the project among personal networks and communities. We specifically thank Jory Fleming, Macarena Carmona Schwartzmann, Ben Harwood, Melissa Bradshaw, Jill Kubit, Deb Morrison, Gary Belkin, Alice Chautard, Erica

Nielsen, Oxford University Environmental Change and Management alumni, and the 50 climate experts who provided conversation advice statements for our website. Lastly, we express our thanks to three anonymous reviewers whose feedback significantly strengthened this paper.

### **Data availability**

Further details about the student initiative that forms the basis of this publication are available at [www.talkclimatechange.org](http://www.talkclimatechange.org).

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## **Appendix B: The science of climate conversations**

One of my supervisors, Dr James Painter, and I were invited to contribute to a special edition of *Social Media and Society* seeking contributions related to “rethinking climate change communication.” In the resulting article, I reflect with James on how my PhD research evolved to focus on dialogue-based communication approaches for climate change and offer some suggestions for future research on this topic.

## **The science of climate conversations**

Joshua Ettinger with James Painter

*Social Media and Society*

Published: 7 June 2023

Available from: <https://journals.sagepub.com/doi/10.1177/20563051231177930>

### **Abstract**

Dialogue-based approaches are crucially important for engaging the public about climate change. This entails going beyond a one-way information transfer to facilitating spaces in which diverse individuals can express their beliefs, emotions, opinions, and uncertainties about climate change in discussions with others. However, only a limited number of empirical studies have been published on best practices, dynamics, and effects of climate conversations. Although research on this topic is growing, information on this approach is still rare in comparison to studies that test audience responses to climate information or analyze climate-related discourses across different communication channels. In this article, the lead author reflects on how his PhD research evolved from testing climate change framing strategies to focusing on multi-directional discussions about climate change. We offer suggestions for advancing research on climate conversations across different communication channels and developing best practices for facilitating such discussions.

### **Introduction**

When I started my PhD in Geography and the Environment at the University of Oxford in 2019, I planned to research how scientists can most effectively communicate links between climate change and extreme weather events. Previously, for my master's research, I had conducted an experiment testing how Americans respond to fearful versus hopeful climate change frames in short online videos (Ettinger et al., 2021a). I assumed I would use a similar experimental design for my doctoral

research. Examining audience responses to information is, after all, one of the most common methodological approaches in applied communications research: craft a message, test how audiences respond, apply the feedback, repeat. Building on the research of my supervisors and other scholars, I wanted to explore communication aspects of extreme event attribution techniques, which assess how climate change alters the likelihood and/or intensity of specific weather events (Stott et al., 2016).

However, as I began my initial literature review, I came across a quote attributed to Oscar Wilde: “Conversation about the weather is the last refuge of the unimaginative.” In the United Kingdom especially, discussing the ever-changing weather is always a reliable conversation topic, even if Wilde considered such attempts rather uninspired. Yet talking about the weather, at least in the context of climate change, is hardly mundane. As described extensively in the 2021 Working Group I report by the Intergovernmental Panel on Climate Change (IPCC), climate change is altering the duration, frequency, and intensity of many types of extreme weather events around the world (IPCC, 2021). Climate change, combined with increased exposure and vulnerability to these events in many regions, is driving higher disaster-related costs (Ebi et al., 2021). Many researchers have argued that extreme weather experiences can increase climate change concerns among the public by making climate change more visible and tangible, although there are a variety of mixed results and nuances in relation to this hypothesis (Howe et al., 2019).

Reflecting on the concept of interpersonal conversations about the weather, I added some new terms to my literature searches: “dialogue”, “conversation”, “discussion”, etc. I was hoping to find empirical research on the role of back-and-forth discussions in shaping how people perceive

weather events and subjectively attribute them to climate change. At the time, I found surprisingly little empirical research examining discussions about weather, or about climate change in general. This contrasted with hundreds of studies that have tested audience responses to different framings of climate change information presented in text, images, video, or virtual reality (Badullovich et al., 2020); tracked and analyzed climate-related news media coverage (e.g., Chinn et al., 2020; O'Neill et al., 2022); explored the role of television weathercasters and other types of messengers as climate change communicators (e.g., Maibach et al., 2022); assessed communication strategies of various climate policy actors and fossil fuel companies (e.g., Yi et al., 2023), and other types of communication research. Researchers have also examined a variety of aspects of climate-related discourse on social media platforms (e.g., Fownes et al., 2018; Hautea et al., 2021; Pearce et al., 2015). Social media platforms enable back-and-forth exchange and analyses of posts can capture the prevalence of climate change discussions online. However, aggregating thousands or millions of posts, as typically done, may limit the ability to explore finer nuances of conversational exchanges and how these discussions evolve over a series of interactions among specific users.

These interdisciplinary studies have offered an array of valuable insights into communication aspects that influence climate change issue engagement among various actors. Nonetheless, literature in this area typically focuses on one-way communication of information, i.e., from researchers to participants, journalists to news consumers, and governments to citizens. I struggled to find research into best practices, dynamics, and effects of multi-directional dialogue about climate change (with some exceptions, described below). This clearly represented a significant gap in climate change communication literature. Fortunately, this is now beginning to change.

### **The importance of climate conversations**

As social animals, speaking with others is fundamental to our daily lives. Dialogue is also crucial in shaping how we grapple with societal issues. The importance of conversation is, in part, why the field of science communication has, over the past several decades, called for a shift away from the knowledge deficit model to a public engagement approach (Leshner, 2003). The deficit model assumes that non-experts have deficits in their understanding, experts can provide information to fill these gaps, and audiences will absorb the information and act accordingly (Simis et al., 2016). Yet we are more complex than information processing machines; subjective factors such as our existing attitudes, political views, and cultural backgrounds influence how we respond to information and engage with societal issues (Wibeck, 2014; Suldovsky, 2017).

The public engagement approach, also known as the dialogue model, acknowledges these complexities, seeking to break down divisions between the scientific community and the public at large. This model acknowledges that diverse audiences may engage with information in distinct ways. At a more practical level, public engagement can entail direct exchange between experts and non-experts, such as through science exhibitions and fairs, town halls, citizen science projects, and citizen assemblies (Akin & Schuefele, 2017). This approach also recognizes there is more to scientific issues than science alone, seeking to create spaces in which individuals can express a wide range of attitudes, beliefs, emotional responses, ethical perspectives, moral values, and prior experiences related to pressing societal challenges (Dietz, 2013). Public views can (and should) inform decision-making about issues at the interface of science, technology, and society (Weingart et al., 2021).

However, there are good reasons not to say goodbye to the deficit model entirely. Transferring knowledge remains fundamental to education, journalism, and evidence-based decision-making. Information (and misinformation) can still inform public opinion. Yet the notion of dialogue – and specifically interpersonal discussions – is extremely important for a variety of contemporary societal issues, and perhaps none more than climate change. The Yale Program on Climate Change Communication tracks a variety of aspects of American attitudes, beliefs, and behaviors related to climate change, including how often individuals report speaking about climate change with others. Despite rising levels of concern about climate change in recent years, only “24% of Americans say that they hear people they know talk about global warming at least once a month” (Leiserowitz et al., 2022, p.4). Like the agenda-setting effect of news media (Langer & Gruber, 2020), how often the public discusses a given issue can affect public opinion. Known as the spiral of silence, individuals are less likely to speak up about issues that they perceive others do not talk or care about, creating a vicious cycle (Maibach et al., 2016; Noelle-Neumann, 1993). This silence “is not in most cases a rejection of information per se, but the failure to integrate this knowledge into everyday life or to transform it into social action” (Norgaard, 2011, p.11). Put simply, how are we to address climate change if we do not even talk about it?

Researchers have, in recent years, begun to recognize the crucial importance of conversations for climate action and conduct empirical research on the topic. Emerging findings suggest that correcting pluralistic ignorance – the perception that others do not care about climate change as much as they actually do – can increase willingness to engage in climate discussions (Geiger & Swim, 2016). Likewise, building foundational knowledge about climate change can also raise individual comfort to participate in climate discussions (Geiger et al., 2017; Beery et al., 2019).

Climate activists often engage family members in climate conversations to galvanize others into climate activism, and children can foster stronger climate concerns among their parents through discussions (Lawson et al., 2019; Fine, 2022). Conversations can also help communicate the scientific consensus about human-driven climate change (Goldberg et al., 2019). Beyond persuasive aspects of discussions, climate cafés and discussion groups are growing in popularity as therapeutic resources for dealing with climate anxiety and other emotional challenges associated with climate change (Tait et al., 2022). Boudet et al. (2019) examined community-level discussions about climate change after extreme weather events, finding that the occurrence of these discussions was associated with attribution of the event to climate change, educational levels, and political opinions. Other researchers have offered evidence-based guidance for effective climate discussions, highlighting the importance of listening, finding common ground, and building trust, among other strategies (Webster & Marshall, 2019; Kelly et al., 2020).

Since starting my PhD, I have reoriented my approach to focus primarily on multi-directional communications in the context of extreme weather events and climate change. I facilitated focus groups to explore public perceptions of extreme event attribution and assess dynamics of extreme weather-related discussions (Ettinger et al., 2021b). In interviews with Australian adults who directly experienced bushfires, my coauthors and I found that conversations with fire experts helped affirm an understanding of how climate change exacerbates bushfires, and that climate activists find solidarity in sharing stories about their bushfire experiences (Ettinger et al., 2023a). Working with a healthcare researcher, we adapted the Teachable Moments Communication Process – a dialogue-based framework physicians use to promote healthy lifestyle behaviors among their patients (Flocke et al., 2012) – into a climate conversation guide (Ettinger et al.,

2023b). Looking to translate theory into practice, with several other graduate students I also co-founded a climate conversations initiative that tracked climate discussions among 1,000 people across 40 countries for the United Nations COP26 meeting (see [www.talkclimatechange.org](http://www.talkclimatechange.org)). We have published several best practice recommendations for facilitating climate conversations based on the outcomes of our campaign (Ettinger et al., 2023c).

### **Further developing research on climate conversations**

Research on climate conversations is only beginning. We still need to answer many questions: how do climate conversations differ across various settings, communication channels (in person, over private messages, on social media, etc.), for different purposes, and among people with distinct relationships (family members, friends, coworkers, etc.) and climate attitudes? How do dimensions of power and bias influence who participates in climate discussions? Can conversations draw in those who are not already interested in climate change? What are the range of outcomes of climate conversations and how can they be measured? What are the implications of artificial intelligence and large language models for climate-related discussions and for science communication more generally? (Schäfer, 2023).

There are also promising ways of building on existing climate communication research by incorporating conversational considerations. For example, beyond examining the prevalence and content of news articles about climate change, researchers could explore how climate news media consumers share and discuss articles they read with others. Social media analyses could further incorporate indicators of conversational quality and dynamics of online exchanges about climate change (e.g., Bortree & Seltzer, 2009; Foderaro & Lorentzen, 2022). Concepts from the field of linguistics could be applied to examine more subtle conversational cues such as delays between

statements; how often interlocuters interrupt one another; and the tendency for individuals to unconsciously engage in similar mannerisms and speaking styles as discussion partners (a.k.a., ‘the chameleon effect’), all of which have been shown to affect conversational experiences and outcomes (Chartrand & Bragh, 1999; Levitan et al., 2012). There is a need to further explore longitudinal effects of repeated climate conversations among the same people. Existing Conversational Analysis methods might also be useful for the climate context (Paulus et al., 2016).

To be sure, there are methodological challenges to navigate. Capturing *in situ* ‘real-world’ conversations poses some limitations. To obtain data on climate discussions, researchers must rely on self-reports, record them, or directly observe them. The presence of a researcher or awareness that a conversation is being recorded may affect participant interactions. Analyzing social media discussions can bypass some of these issues; however, individuals may feel inhibited to fully express themselves in the public domain. Further research is needed to address these challenges and questions, which are equally applicable to conversations about other pressing societal issues, such as artificial intelligence, genetic engineering, and public health behaviors. At a practical level, academic institutions offer communications training sessions that focus predominantly on giving presentations and media interviews – conversational skills such as active listening could also be added into these programs (Abrahams & Groysberg, 2021).

As people around the world face increasingly devastating climate impacts, finding ways to facilitate effective climate conversations will only grow in importance. Implementing conversational best practices could boost the effectiveness and outcomes of citizen assemblies on climate change and other deliberative bodies (Myers et al., 2017; Capstick et al., 2021). Likewise,

governments and a wide range of organizations are currently engaging in internal discussions on whether and how they can commit to net zero emissions (Fankhauser et al., 2022) – training effective dialogue skills among climate advocates within organizations could aid these efforts.

We still need one-way communication of the best available evidence to inform societal responses to climate change. However, my PhD journey has convinced me of the merits of multi-directional climate conversations: they pave the way to climate action, provide spaces for grappling with climate-related emotions, and help ensure more diverse voices are heard on arguably the greatest challenge humanity has ever faced.

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## **Appendix C: Extreme weather events are exactly the time to talk about climate change – here’s why**

The following article was published in *The Conversation* – in it, I describe some of the key findings of this thesis and connect them to the extreme weather events that happened in many regions around the world during summer 2023.

## Extreme weather events are exactly the time to talk about climate change – here’s why

Joshua Ettinger

*The Conversation*

Published 27 July 2023

Available from: <https://theconversation.com/extreme-weather-events-are-exactly-the-time-to-talk-about-climate-change-heres-why-210412>

Record-breaking heatwaves are [sweeping across the northern hemisphere](#), affecting large parts of southern Europe, the US and China. On July 24, Sicily recorded blistering temperatures [of more than 47.5°C](#) and wildfires are currently [tearing through Greece](#). The heatwaves come as [record numbers of fires continue to burn](#) across Canada.

A [study by the World Weather Attribution group](#) found that these heatwaves would have been “virtually impossible” without climate change. In fact, the heatwave that is affecting parts of China was made 50 times more likely by global warming. This is exactly what climate scientists have been warning us about for decades – climate change makes many types of extreme weather event [more likely, more intense and longer lasting](#).

As a PhD researcher examining extreme weather events and climate change communication, I have spent the past four years exploring how extreme weather events may affect the way the public feels, thinks and acts on climate change.

One area of interest to researchers is how extreme weather events might reduce the [“psychological distance”](#) associated with climate change. While climate change can feel abstract and vague, extreme weather is something people can experience firsthand.

But [research offers contrasting results](#). Some studies have found that extreme weather events lead to an [increased belief](#) that human-driven climate change is occurring and [greater support for climate action](#). Others [find no effects](#) or suggest that these effects are [only temporary](#).

However, [we often underestimate](#) how much the public already cares about climate change. In Britain, [just 4% of the public](#) say they are not at all concerned about climate change, while only [11% of Americans](#) dismiss the issue.

Given that [most people](#) are already concerned about climate change, an important question now is how to shift these existing concerns into action.

[Talking about climate change](#) is a powerful way of mobilising climate action, and extreme weather events provide helpful climate conversation starters. We can use these moments as opportunities to [engage our families, friends and communities](#) in discussions about how climate change may relate to these events and [what we can do about it](#).

So, if you decide to engage people you know in discussions about extreme weather and climate change, here are a few thoughts and guidelines to keep in mind.

## **1. Listen and share perspectives**

[Extreme weather events can be traumatic](#) and climate change can evoke a wide range of emotional responses. If the person you are talking to is comfortable discussing the topic, ask them about their experiences and observations.

Encourage them to tell stories and affirm the validity of their emotional response – whether they are afraid, angry, hopeful or worried. There is no one right way to feel about climate change, so listen to what they have to say and then share your own perspective too.

## **2. Talk about planning and preparation**

When discussing extreme weather events, some people may link their experiences to climate change, while others focus on various local factors that contribute to extreme weather risks.

The risks associated with extreme weather arise from a [combination](#) of factors. These include the weather itself, which can be influenced by climate change, the level of exposure of people and places to extreme weather and the vulnerability of those to harm.

Climate change, for instance, can affect the frequency, intensity and duration of wildfires. But emergency responses, evacuation procedures, firefighting and healthcare systems are crucially important to reduce risks. There are also significant equity and justice implications of extreme weather as different populations are [affected disproportionately](#).

It's also important to bear in mind that while climate change affects many extreme weather events, it [does not necessarily affect every instance](#). Weather systems are complex and there are [meteorological processes](#) that scientists are still trying to understand.

We also need to make sure the roles of local planning and preparation in minimising the impact of these events are not overlooked.

### **3. Challenge arguments about politicising the weather**

In May 2023, Republican governor of Florida, Ron DeSantis, dismissed concerns about global warming by claiming that he rejects the [“politicisation of the weather”](#). Ontario premier, Doug Ford, recently [made a similar argument](#) about Canada's wildfires.

In conversations, it's possible that someone might accuse you too of “politicising” the weather. You can (respectfully) push back against this claim.

This argument is a [discourse of climate delay](#). Rather than denying the existence of human-driven climate change, climate delay discourses try to shut down climate discussions and cast doubt on the need to act very quickly. These arguments disingenuously assert that acting on climate is too expensive, too late or that someone else should take care of it – and they are [becoming increasingly common](#).

If we shouldn't discuss climate change when extreme weather occurs, then when is the right time? If we want to protect lives, we need to talk about – and act upon – the risks associated with extreme weather events and the disasters they can cause.

If talking about climate change politicises the weather, so be it. The politics of climate denial and delay affected this summer's weather, and our current decisions will shape our planet for thousands of years.

The science is clear. Act now or face increasingly dire consequences.

## **Appendix D: Co-authorship information**

This thesis contains a total of six publications. Each of the publications and the contributions of co-authors are described below.

### **What's Up with the Weather: Public Engagement with Extreme Event Attribution in the United Kingdom**

Joshua Ettinger, Peter Walton, James Painter, Shannon Osaka, Friederike E.L. Otto  
*Weather, Climate and Society*

JE: conceptualisation, methodology, analysis, writing – original draft

PW: supervision, conceptualisation, methodology, funding acquisition, writing – editing

JP: supervision, conceptualisation, methodology, writing – editing

SO: methodology, writing – editing

FO: supervision, project administration, funding acquisition, writing – editing

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

Joshua Ettinger, Mary Sanford, Peter Walton, David Holmes, James Painter  
*Oxford Open Climate Change*

JE: conceptualisation, methodology, analysis, writing – original draft

MS: methodology, analysis, writing – editing

PW: supervision, methodology, writing – editing

DH: methodology, writing – editing

JP: supervision, methodology, writing – editing

### **Examining contrasting influences of extreme weather experiences on individual climate activism**

Joshua Ettinger, Peter Walton, James Painter, Kelly Fielding, Robyn Gulliver, Friederike E.L. Otto  
*Global Environmental Psychology*

JE: conceptualisation, methodology, analysis, writing – original draft

PW: supervision, methodology, funding acquisition, writing – editing

JP: supervision, methodology, writing – editing

KF: methodology, writing – editing

RG: methodology, writing – editing

FO: supervision, project administration, funding acquisition, writing – editing

### **Extreme weather events as teachable moments: catalyzing climate change learning and action through conversation**

Joshua Ettinger, Peter Walton, James Painter, Susan Flocke, Friederike E.L. Otto  
*Environmental Communication*

JE: conceptualisation, writing – original draft

PW: supervision, writing – editing

JP: supervision, writing – editing  
SF: conceptualisation, writing – editing  
FO: supervision, writing – editing

**Breaking the climate spiral of silence: Lessons from a COP26 climate conversations campaign**

Joshua Ettinger, Alexis McGivern, Marcus Spiegel, Brittany King, Zoha Shawoo, William Finnegan  
*Climatic Change*

JE: conceptualisation, project administration, writing – original draft and editing  
AM: conceptualisation, writing – reviewing and editing, project administration  
MPS: conceptualisation, data curation, funding acquisition, writing – editing, project administration  
BK, ZS, WF: project support, writing – editing  
AC: campaign website design and technical support

**The science of climate conversations**

Joshua Ettinger and James Painter  
*Social Media and Society*

JE: conceptualisation, writing – original draft and editing  
JP: supervision, writing – editing