Critical Climate Geographies

Climate change has become a major topic for human geographers for decades. Yet in recent years, the terms of engagement have begun to evolve. The relationship between the discipline of human geography and the topic of climate change is rapidly broadening and deepening, creating new fields with their roots outside of climate science. In this regard, an especially vibrant area of scholarship is the consolidating field of 'critical climate geographies': an area of work that not only examines the spatial and temporal dimensions of climate change, but also interrogates the social, political, economic, and cultural structures that underpin climate change and its governance (Bulkeley, 2019; Castree, 2015; Mahony & Hulme, 2018). Drawing from critical theory, political economy, post-structuralism, and decolonial perspectives, critical climate geographies challenge dominant paradigms, expose power relations, and seek to address inequalities and injustices associated with climate change (Sultana, 2022; Yusoff, 2018; Swyngedouw, 2010; Nightingale, 2017).

Critical climate scholars emphasise the co-production of climate knowledge, recognising the interplay between environmental processes and societal dynamics (Lemos & Morehouse, 2005; Whatmore, 2013; Lave et al., 2014). As such, critical climate geographies focus on the entanglements of social science perspectives embedded within climate geographies. This contrasts with traditional or "uncritical" climate geography, which may focus primarily on physical aspects of climate systems or spatial patterns without engaging deeply with these underlying socio-political issues and their meanings (Aspinall, 2010; Bulkeley, 2019). In order to make sense of how evolving climate change research intersects with the work of human geographers, this paper considers the present and future role of critical climate change research in geography, both within the discipline and within climate scholarship more broadly. After this introductory overview, the paper proceeds in three sections: first, it will delineate the landscape of current work in critical climate geography, before secondly exploring where critical climate geography is developing most promisingly. Finally, the paper will conclude by asking where next for critical climate geography?

1. Critical Climate Geographies: An Absent Presence

Our interjection into the 'critical climate geographies' narrative begins at the 2018 Royal Geographical Society (RGS) conference in Cardiff, where the organisers convened a meeting to discuss the revitalisation of the RGS-IBG Climate Change Research Group (CCRG). This effort was made to restore a scholarly collective that was on the verge of being disbanded, broken up, and absorbed into related groups, barely ten years after its founding. At the time, the call came as a surprise to many of those who attended. The apparent demise of a dedicated climate research group within a disciplinary space whose history has often centred on the mapping of climates stood in stark contrast to the wider context of climate events and politics that year. In 2018, the Intergovernmental Panel on Climate Change (IPCC) released its influential special report on 1.5˚C warming. Extinction Rebellion (XR) began its first wave of protests, occupying five bridges in London on November 17th 2018. Greta Thunberg's speech at Davos a few months later would catapult her to global fame and galvanise the *Fridays For Future* movement into a worldwide force. Despite geographers living, writing, and thinking amongst these unfolding events, contributing to the IPCC's reporting, providing critical viewpoints on socio-political causes and implications of events, and engaging in the civil society that shaped that year and those before it, there did not seem to be a cohesive sense of doing 'climate geography' together, nor indeed of being *climate geographers* at all.

Yet the CCRG's near demise points to a wider issue. The sense that the wider social sciences, including geography, have had a one-way, 'science-first' relationship with studying climate

change was articulated by John Urry, a sociologist who as recently as 2010 argued - perhaps controversially - that 'the social sciences have been nowhere, barely even Johnny-come-latelies' (Szerszynski and Urry, 2010: 3) in climate change research. Indeed, As Harriet Bulkeley (2019) later argued, there has long been an uncomfortable engagement between human geography and climate change, where the epistemological divide between human and physical geography has at times entrenched assumptions of a socio-natural divide. As a result of this discomfort, there is "a curiously ambiguous position within our discipline of both an explicit presence and an underlying absence" for climate change (ibid: 3).

Despite concerns in 2018, the CCRG was ultimately not disbanded. On the contrary, climate change has become a topic of such importance that *Climate Changed Geographies* was named as the chair's theme of the 2023 RGS conference, Yet the awkward ambiguity of climate within the discipline remains cloyingly persistent. More recently still, the contradictory presence-yet-absence in the discipline of geography was demonstrated in an emerging debate in Ireland about the introduction of a school qualification on 'Climate Action and Sustainable Development', highlighting a desire for a new discipline to address social and political responses to climate change specifically. As Möller (2024) writes, geographers have taught these issues for years, yet the need for a debate highlights a disconnect between what geographers do and what the discipline of climate geography is perceived as doing, perhaps linked to the lack of a cohesive scholarly articulation of what *climate geographies are or might be,* and what *climate geographers do*.

There is a need, in other words, to turn the lens back on climate geography and it is here that 'critical climate geographies' have a crucial role to play. Yet what makes this such a challenge is the vast scale and sprawling diffusion of Geographic engagement with the climate. Geography is already a discipline that spans from natural scientific perspectives such as glaciology and climatology to post-structural social scientific perspectives that explore the discursive and emotional geographies of climate change. As a result, this expanding landscape of climate geography remains unmapped, even in outline. Climate change is everywhere within geographical scholarship. Yet, it is not *equally* everywhere. Which themes, fields, sub-fields and innovations have proliferated the fastest within the discipline? Which appear most promising as catalysts for future work? And what remains to be done despite these efforts? With these questions in mind, this paper aims to sketch the most active and promising contours of critical climate Geography, past, present, and future.

It does so by drawing on the expertise of a group of scholars convened towards this purpose by the RGS' reinvigorated Climate Change Research Group [CCRG] in November 2022. In an event entitled *Mapping the Landscape of Climate Geography*, which brought together leading UK geographers from a diverse range of fields to sketch the contours of the discipline's engagement with the climate, 23 UK and international scholars discussed their views on the primary engagement sites by climate geography and, subsequently, the fields within those sites. Whilst the workshop primarily consisted of UK geographers, we are aware that much of the critical climate geographical scholarship is produced elsewhere globally, and that many of the geographers present in the workshop actively researched geographies outside of the Anglo-perspective. In this sense, our positionality is that we are not UK geographers (and this paper is not about the shape of UK geography in relation to climate scholarship), but merely that we are all global geographers who work in UK institutions who identify with being a 'climate geographer' in the broad sense of the term. Our discussions enabled examination of the perceived contributions made by human geographers to the field of critical climate geographies, the distillation of key avenues in which human geographers are currently advancing the field, and future possibilities. This has framed the structure of our review through the sections 'Where we are now', 'Where we are going', and 'Where next' - the landscapes within each are presented in the following three sections.

This paper draws together the diverse human geography perspectives from the workshop to outline pathways for critical geographical engagement with the climate, building upon and extending previous insights of the field of critical climate geographies to identify the distinctive perspectives that critical geographical scholarship brings. While no such task can hope or aim to be a fully comprehensive and systematic 'mapping' of climate geographies, we intend to add new insights of what it means to be a critical climate geographer based on previous and extant scholarly geographical interactions with climate change. Aiming to highlight the conceptual and practical commonalities that critical climate geographers share in their approaches, we outline the emerging landscape of critical climate geographies to foster a shared understanding of the field. Throughout this paper, we use 'discipline' to refer to Geography as an institutionalised academic domain; 'subdiscipline' to describe more established thematic areas within it, such as political or urban geography; and 'field' to describe more fluid or emergent areas of scholarship, such as climate geographies. 'Critical climate geographies' is thus treated as an interdisciplinary field - variegated, plural, not yet fully formalised within disciplinary boundaries, yet nonetheless a site of growing cohesion, self-awareness, and importance to the future of the discipline.

2. Where are we now?

Recent work on the epistemology of climate change has helped to situate critical climate geographies within the wider landscape of climate geography. For example, Aspinall (2010) identified two spheres of geography's contribution to climate knowledge, highlighting, on the one hand, engagement with the physical aspects of understanding the climate: notably the domains of climatology, historical climate change, numerical modelling, and geomorphology. On the other hand, he foregrounded geographic contributions to the spatial mapping of climate impacts, including, in particular, biogeographic responses, vulnerability and inequality, but also - in a reflexive sense - human geographers' critical contributions to science-policy debates and the social and political construction of climate change (ibid).

However, while Aspinall (2010) identified the physical and spatial mapping aspects of climate geography, our definition of critical geography extends further to interrogate the socio-political structures underlying these phenomena. Critical climate geographies challenge dominant paradigms and expose power relations, seeking to address inequalities and injustices associated with climate change (Swyngedouw 2010). Geographers such as Brace an Geohegan (2011), Edensor et al (2019), and Garrard (2020), have critically engaged with the temporal politics of climate change, highlighting not only the ways in which environmental time is perceived by the public, how climate timeframes are communicated and intersect with these lived experiences, and who benefits from these framings. The resulting politics of climate time is shown to underpin competing discourses and political projects, emerging as a key critical lens on these frameworks.

Work of this sort has invigorated a critical nexus at the science-policy interface, in which communication and framing is shown to be an actor in the landscape of climate vulnerability. For example, Bulkeley (2019) has argued how climate impacts might reshape forms of vulnerability and the possibilities for resilience and adaptation. Yet the science-policy interface, including research on the factors that influence individual attitudes and behaviours, and the politics of governance systems continue to focus on individual responsibility. For example, in the realms of critical and political geography, she has emphasised the contribution of geopolitics and security studies as well as rising attention to carbon markets, climate-induced migration, cities and climate change, alternative economies, climate and development, climate finance, corporate social responsibility, and carbon sequestration. In other words, the framing of these problems shapes their manifestation.

Picking up this point, Bulkeley thus reframes the question *Where does human geography fit into the study of climate change?* in its entirety. Arguing that the role of geography is not in

responding to the social lacunae left by the gaps in physical data, nor even in deciding what societal responses to these findings should be, but rather ontological, she situates the role of the discipline in asking how climate change is "made, remade, held together, contested, is always in a state of unbecoming" (2019:11). For climate geographers, this represents a fundamental shift in mindset: from being 'climate geographers' in a descriptive sense, to being 'critical climate geographers' with the power to initiate societal change. As such, whilst for Aspinall, the diverse scope of geography as a discipline is important in advancing its contribution, for Bulkeley, this integrative middle ground between human and physical geography underpins climate change's ambivalent, dialectical and contradictory presence-yet-absence in geography. Rather than viewing climate change as an objective problem to which a societal response is required, climate change emerges through an antagonistic framing as a condition actively shaping new forms of politics.

This is a crucial standpoint, yet it presents a definitional challenge. In the early decades of the 2000s, for example, many human geographers were concerned, alongside political scientists, with climate governance and its diverse scales and multilevel aspects. This included urban/local scales and Bulkeley's focus on cities and urban governance of climate change (Bulkeley and Betsill 2005, 2007, Bulkeley et al. 2009, Granberger and Elander 2007) and urban experimentation (Bulkeley and Castan Broto 2013, Bulkeley et al. 2019). Yet it has also extended to the transnational (Andonova et al. 2009), highlighting both multi-level (Betsill and Bulkeley 2006; Gustavsson et al. 2009) and polycentric (Jordan et al. 2015) governance interactions, as well as profiling the re-emergence of national territoriality and sovereignty governance (Kythreotis 2012) and more recently, missing interconnections of multi-scalar climate governance (Kythreotis et al., 2023). Notably, it also attended to how discourses of climate change are embroiled with those of securitisation globally, and within the United Kingdom's security policy specifically (Peters, 2018; Methmann and Oels 2015; Gemenne et al. 2014), green authoritarianism and a post-politics of scale (Kythreotis, 2023) and attended to blindspots over the interaction and amplification of climate risks across scales (Challinor et al. 2017).

More recently, human geographers have been especially prominent in developing historical accounts of the development of discursive and material economies – such as developing social histories of climate politics (Jager and O'Riordan 2019), contextualising the emergence of key policy hooks such as the 2-degree target (Randalls 2010) or how economic theories of cost-benefit analysis have shaped ideas of optimal climate change (Randalls 2011) and the uncomfortable epistemic politics of climate and colonialism (Mahony and Hulme 2018, Mahony and Endfield 2018). In doing so, human geographers have demonstrated that climate is not only a physical phenomenon but also a social one (Offen 2013), shaping specific cultural and material economies (c.f. Capriotti 2011). These economies, including carbon economies, have been the subject of critique by geographers who seek to understand and address their impact on society (Bridge 2010; Jordus Lier et al. 2021; Bridge et al. 2019; Lovell and Ghaleigh 2013; Blakey 2021).

This spirit of reflexive self-awareness has seen geographers play an enthusiastic role in attending to the knowledge politics of climate change. Indeed, for many, this has been their critical meat and drink. Following early work in geography that emphasised the social dimensions of climate science (Demeritt 2001) and in political science, where Foucauldian approaches were employed to highlight how viewing the earth from space via remote sensing has produced new ways of understanding environmental governance that privilege the planetary scale and calculative practices (Lovbrand et al., 2009; Lovbrand and Stripple 2011) human geographers have been active alongside Science, Technology and Society [STS] scholars in highlighting the politics of making climate policy knowledge. Notably, work in this area has critiqued the making of global knowledge (Hulme and Mahony, 2010; Mahony and Hulme 2016), contested objectivity of knowledge (Mahony 2015, Grindsted 2014) and

emphasised the importance of moving beyond modelling as a singular source of information (Demeritt and Wainwright, 2005, Hulme, 2011).

This critical position emerges in part from the experience of participation. Human geographers have been at the forefront of research on climate change impacts, adaptation, and vulnerability (for example, see work by Barnett, 2003; Adger, 2006; Liverman, 2004; O'Brien, 2012). In addition to their contributions to climate change assessments, such as the Intergovernmental Panel on Climate Change, human geographers have developed a political attention to knowledge-shaping processes through ethnographic work with advisory bodies (Owens 2000, 2005, 2006, 2010; Turnpenny et al. 2013; Dudley et al. 2022) and the study of specific knowledge processes, such as knowledge translation (Machen 2018). They have highlighted the contributions to climate science and policy of lay knowledge (Brace and Geoghegan 2010) and indigenous knowledge (Chanza and DeWit 2016) and contested the epistemological makeup of scholarly communities that have gathered around climate change or the Anthropocene (Hulme 2007, Castree 2015) arguing that geography as a discipline is particularly well suited to addressing the conceptual challenges that the Anthropocene presents (Johnson et al. 2014).

Within this, a key theme has been the nexus of climate and conflict: a recurrent concern of human geographers (Adger et al. 2013, Mach et al. 2020) that has been extended through critical engagements with climate migration (Parsons 2019, Adger and de Campos 2020), and the imbrications of climate migration and race and racism (Baldwin 2016, 2022) as well as differential geographies of health (Curtis and Oven 2011). This is, however, a vibrantly contested area of work. Indeed, this is part of the point. As Watson, Lenton and de Campos (2023) argue, for example, to better understand the implications of climate change on global society and security from a geographical perspective, it is essential to develop a more holistic understanding of the interplay among climate, conflict and migration. So to this end, climate geographers have engaged productively with the ways in which the historical and present political economy shapes the landscape of climate change and its policy responses. Work by Farhana Sultana (2023; 2022) and Kathryn Yusoff (2018) among others, highlights how the legacy of colonialism – and its undergirding racial logic – underpins the epistemology of climate science. By asking “whose growth in whose planetary boundaries?” (Sultana, 2023: 1), for example, this burgeoning body of work returns the weight of politics to ‘the uneven anthropogenic use and abuse of the planet's biosphere and common pool resources’. The result is a reflexive lens on the questions we ask, who gets to speak, and the imbricated consequences for society, environment and the humans embedded within them.

Indeed, this nexus of the climatic, the epistemic, and the political has increasingly underpinned attention to the emerging digital landscape of climate geographies. For example, Nost (2015) has highlighted that governing ecosystems via software creates social relations that legitimise the neoliberalization and financialisation of nature. At the same time, several scholars have explored the role of social media platforms in the circulation and understanding of climate knowledge (Pearce et al. 2019; Tuitjer and Dirksmejer 2021). Machen and Nost (2021) then further explore the epistemic commitments that thinking about climate through algorithmic devices entails and how these epistemic commitments intersect with operations of hegemonic power. In a different vein, recent geographic scholarship has also attempted to counter and subvert these top-down hegemonic narratives, for example, by proposing speculative-feminist propositions for planetary images in an era of the climate crisis, in which ‘earth images may transcend their dominant roles as scientific tools and cultural allegories and become tactical devices for imagining and acting otherwise’ (Englemann et al., 2022: 237).

Complementing their engagement with the technical dimensions of climate sensing, critical climate geographers have engaged enthusiastically with the embodied and the human. Notably, research in this area has explored the personal and emotional impacts of climate grief (Head 2016; Moser 2021) and the gradual damage caused by the slow violence of

environmental degradation (O'Lear 2016). Additionally, they have investigated the role of emotions in politics, such as how enjoyment can influence political action (Pohl and Swyngedouw, 2023) and how emotions can drive transformative change (Ryan 2016). Geographical studies now emphasise the importance of starting with a ground-level understanding of climate, including its emotional and affective dimensions, to comprehend mobility and change (Parsons, 2019). Seeking always to interpret the transformative potential of these frames, much attention has focused also on how these emotional, embodied and discursive frames contribute to political subjectivities (Dowling 2009, Bond et al. 2020) and public participation in decision-making (Pallett and Chilvers 2019, Chilvers et al. 2022).

A plethora of perspectives have emerged to underscore this importance in recent years, highlighting how climate viewpoints are shaped by socioeconomic status (Weckroth and Ala-Mantila, 2022), place (Howarth and Parsons, 2022; Brown et al., 2019), power and politics (Nightingale, 2017), governance (Adger et al., 2009), psychology (Clayton et al., 2015); vulnerability (O'Brien and Wolf, 2010) and geographical scale (Kythreotis et al., 2021). Indeed, this impetus towards change is one of the most consistent dimensions of the field. Despite their consistent foregrounding of intractability, the contested geographies of climate change have tended to retain a common interest in the generative politics of policy (Head and Gibson 2012). This means not only how policy might be improved but also possibilities for more fundamental transformation (O'Brien 2011, Chatterton 2016) and a more radical sense still of how climate imaginaries and technologies shape futures to be acted upon (Braun 2015, Mahony and Randalls 2020, Machen et al. 2022, Anderson 2010). And as ever, reflexivity has been key, with scholarship on climate justice (Henrique and Tschakert 2020, Barett 2012) complemented by concerns for equity both in climate policy (Liverman 2009, Klinsy et al. 2017) and in institutional spaces of decision-making (Gay-Antaki and Liverman 2018).

Whilst typological generalisation of what is already a huge and rapidly growing field of work is challenging, two broad, cross-cutting themes may be identified, that both connect the varied approaches and underpin geography's general disciplinary contribution to the study of climate change. Specifically, the focus on *climate epistemologies* and *climate values*, which underpin the fundamental lenses through which geographers have faced the climate crisis. Here, *Climate epistemologies* references the persistent goal of deconstructing the work that produces the climate as an object of global governance, examining the implications of different epistemic commitments and forms of climate governance, and exploring possibilities for contesting/resisting/reappropriating new ways of seeing via technology (Bakker and Ritts 2018; Goldstein and Nost 2022) . As Jasanoff (2017) argues, these different ways of seeing and understanding climate matter because they generate standpoints with both an epistemic and a political difference, from which to address "the often-messy processes of linking scientific knowledge to decision-making within different policies" (Mahoney and Hulme, 2018: 395).

Just as epistemic framings shape not only what we know about the climate but also what we see of it, such framings also produce and are produced by our *climate values*, necessitating practical attention to the politics underpinning climate knowledge, its frames, its assumptions and its effects (Kythreotis et al., 2019). Returning attention and scrutiny to these values has had a mixed response in contemporary climate geographies. On the one hand, recent geographical climate change literature has witnessed a growing attention to values, considered significant factors in public engagement with climate science (Corner et al. 2014), climate scepticism (Poortinga et al 2011, McCright and Dunlap 2011), disagreement (Hulme 2009) pro-environmental behaviour (Lorenzoni et al., 2007), risk perception (Leisserowitz 2006) and in the assessment of climate impacts (Wolf et al., 2013), as well as future policy acceptance (Nilsson et al 2004; Demski et al., 2015).

Yet at the same time, the concept of values itself has been problematised for its implicit essentialism (Hajer 1995), fragmented theoretical legacy (Corner et al. 2014), malleability

(Hulme, 2009) and the problematic relationship between values and behaviour that creates a 'value-action gap' in which pro-environmental behaviours are seen as only loosely correlated with pro-environmental action (Poortinga et al 2004, Pepper et al. 2009). As a result, perhaps ironically, many of the most prominent engagements with values and climate change have taken place outside of geography (c.f. Moellendorf 2014; Morrow 2020). Nevertheless, the notion of climate values now offers an increasingly definitional point in critical climate geographies, drawing together what seemed two decades previously as irreconcilable strands of climate governance: environmental data generation/knowledge epistemologies and the cultural politics of the environment.

3. Where are we going?

As interventions such as these demonstrate, critical climate geographers have found, after several decades of concerted contribution to climate discourse and policy, a common and distinctive voice. What began as a limited, even somewhat bearish, engagement with a topic viewed as important but inescapably connected to natural science has permeated every corner of the discipline, in order to produce something both fundamentally Geographic, and also novel in its relationship to the environment. Having previously sought to protect the 'fragile consensus' around global climate action (Broadbent et al., 2016), recent years have seen critical scholars develop the confidence to challenge and re-politicise climate change by approaching it on novel terms. Only now are the diverse hybrids of climate scholarship that have emerged from this engagement beginning to reconnect and coalesce, laying the ground for a novel geographical body of scholarship on the changing climate.

Critical climate geographers today share a largely consensual viewpoint on climate as a "multiple and dynamic condition" shaped by political, socio-economic, and cultural forces: a perspective conditioned by the discipline. After all, Geography is, at its core, an (inter)disciplinary subject (Baerwald, 2010). The cleft nature of the geographic discipline necessitates an awareness of the possibilities of 'an interdisciplinary discipline' almost by default (Goudie, 2016; Baerwaldt, 2010). And this interdisciplinary viewpoint has presented a unique set of epistemological and ontological challenges (Suy & DeLyser, 2011), to which critical climate geographers have dedicated substantial efforts in recent years. In particular, we identify four areas where critical climate geographers engage with particular vigour. Linked in their pursuit of cross- and interdisciplinary reflexivity, each field reflects a deep engagement with the history of the discipline of Geography, and a clear sense of where this inheritance can lead climate scholarship. Rather than simply problems to be solved, these areas of contested engagement constitute, we argue, a self-aware consolidation of the field, not just as geographers engaging with climate questions, but also of harnessing a shared sense of historical reflexivity to bear on critical present-day questions.

3.1 Linking the social and natural scientific dimensions of Climate Geographies

As the influence of the social sciences has grown in climate scholarship, concerns over the best ways to bridge competing epistemologies have become increasingly important. Well-documented epistemological disjunctures have become practical problems to resolve, particularly concerning the impact of climate change on humans, where a troubling gap persists between statistical climate models and their impact on people and livelihoods. Indeed, this is a position that geographers have taken up with increasing self-awareness in the wake of Castree's (2015) call to situate geography in opposition to the 'ontological monism' characteristic of many forms of inquiry in global change science, which he argues have limited understanding of complex interactions between humans and the environment. Towards this end, authors such as Popke (2016) and Colven et al. (2019) have posited Geography as an inter-epistemological dialogue capable of coping with the hybrid nature of climate change in that multiple knowledges and understandings need to be considered. And within this wider disciplinary imperative, critical climate geographers provide a key nexus, opening up the

potential benefits of a collaborative approach to climate modelling, actively advocating for a leading role in interdisciplinary climate change research (c.f. Lane et al. 2011), exploring the political promise of considering the posthuman (Whatmore 2013; Wilson 2025), as well as generating robust analysis of embedded relations between physical geographic knowledge, gender, and power (Carey et al. 2016).

Practical examples of such approaches have emerged in the interim, with Rickles et al. (2017), for example, highlighting the capacity of GIS mapping to bridge existing silos, ranging from content knowledge, technological knowledge, and pedagogical knowledge, to incorporate the versatility of GIS and its potential for interdisciplinary research. Yet, far wider potential exists to bring scholars together across a "cultural" divide that has proved challenging to transgress, often privileging physical sciences and scholarship at the expense of social scientific work. As a discipline that 'uniquely straddles physical/environmental and human/social scholarships', 'Geography should be centre stage for understanding today's climate emergency' argue Taylor and O'Keefe (2021: 394). And on this stage, critical climate geographers play a vital connecting role.

3.2 Reconciling knowledge from above and below

In addition to the ability of a geographical lens to bridge and transcend horizontal epistemological silos, climate geographers are equally adapt at confronting the vertical challenges arising from top-down and bottom-up approaches. Specifically, the now central but intractable problem of how to meaningfully reconcile climate change as a statistical process with its impacts on a human scale remains a pressing question for contemporary scholarship. For critical climate geographers, it is a question to which a deep engagement with lay knowledge, as a site of valuable data, participation, and engagement in scholarship, has increasingly provided answers.

Engagements in this area have been fruitful. Brace and Geoghagen (2011), for example, convincingly made the case that a more nuanced understanding of the issue can be gained by considering different landscapes and temporalities of climate change, whilst Devine-Wright (2013; 2009) highlights the importance of place attachment, at various scales, for understanding human responses to climate change. Burnham et al. (2016: 18) similarly highlight how the 'dissonance' between data sets produced using different approaches and methods 'arises because each method produces knowledge that is partial and situated'. From an adaptation standpoint, Conway et al. (2019) make a similar case, arguing that integrating the results of bottom-up and top-down approaches is a crucial step towards developing relevant information to inform immediate adaptation decisions.

Taking this perspective a step further, critical climate geographers have sought to understand not only top-down and bottom-up accounts of the climate but also the insights of multiple intersecting scales (Bruno Soares et al. 2012; Kythreotis et al. 2023; Lehman and Kinchy 2021). For example, Wurzel et al. (2020) critically analyse how multilevel and polycentric climate governance structures enable and/or constrain climate pioneers, leaders and followers, highlighting how structural position shapes both actions and knowledge. Yet, as Swyngedouw (2010) has cautioned, a focus on consensus within climate governance works towards a post-political condition, which itself is antithetical to and exerts violence against the political dissensus that constitutes the 'bottom-up' condition of the political (Swyngedouw 2010).

Applying a policy lens to this perspective, Howarth et al. (2021: 1) similarly argue that the 'dynamism of local scales are a powerful resource': a position taken up with particular enthusiasm by urban geographers (e.g., Broto et al., 2021; Wolfram et al., 2019; Connolly and Kythreotis, 2025), whose efforts to rethink and reorient urban life in response to climatic change have necessarily involved 'actors at multiple levels and scales' (Wolfram et al., 2019)

and new configurations of infrastructural, data and ecological flows (Luque Ayala and Rutherford 2023). Foregrounding accounts from different locations and epistemological traditions, these accounts have begun to coalesce into a critical research agenda to 'drive systematic analysis of innovative urban governance, its heterogeneous formation, politics and possibilities' (McGuirk et al., 2022: 1). Geographers are thus increasingly placing their faith in the local as a solution to the inertia and unwieldiness of the global scale.

3.3. Decolonising Climate Knowledge

Valuing and accounting for knowledge circulating at very different scales is a challenge central to critical climate geography. Recent years have seen the proliferation of critical lenses seeking to foreground the value and power of local, indigenous, and non-Western knowledge. This point is compellingly made by Mahoney and Hulme (2018) in their intervention on the epistemic geographies of climate change. As they argue, by considering different epistemologies, the role of space, and the political context, a more comprehensive understanding of climate change can be obtained, informing more effective approaches to addressing the issue.

Yet, as recent work has argued, there is more to this than merely a question of accuracy, but also of fully engaging with analytical positionality. Building upon the huge impact of Sarah Radcliffe's call to decolonise the discipline (2017; 2022), critical climate geographers have been increasingly concerned to decolonise their systems of environmental thinking: a burgeoning area of scholarship within Geography. Led by key scholars such as Kyle Whyte (2017), Kathyrn Yusoff (2018) and Farhana Sultana (2023; 2022), (see also Simpson et al., 2024; Gay-Antaki, 2022) this area of climate geographical thinking is not only growing but consolidating as a rejoinder to the dominance of natural scientific thinking on the environment.

Emerging as a proliferating field in its own right, decolonial climate geography has also become a counterpoint to the concept of the Anthropocene, a hugely influential environmental lens with a strong rooting in the discipline (e.g., Lewis and Maslin, 2015; Castree, 2014a, 2014b, 2014c; Whitehead, 2014, Sandover 2020). Indeed, a growing group of authors argues that the Anthropocene is a concept redolent with racialised assumptions and strongly rooted in colonial logic (Yusoff, 2018). Arguing against the 'depoliticized instrumental co-production of knowledge that underlies dominant understandings of climate change' (Goldman et al., 2014: 526), scholars such as Sultana (2022) in particular, have drawn focus away from top-down modelling towards highlighting the inequitable impacts of climate change through an understanding of climate coloniality and the lived experiences of people and communities on the ground. Contending, from this standpoint, that 'many approaches to doing climate research reinforce the political economy of colonial knowledge' (Goldman et al., 2014: 526), these approaches have aimed contested values such as neoliberal paradigms, mainstream climate discourses and practices that conform with current Global North epistemological framings (Parsons, 2023).

3.4 Co-production and Creativity

In seeking to re-politicise the frames, methods, and approaches that underpin geographical scholarship on climate change, critical climate geographers have also sought, with equal enthusiasm, to develop new ways of speaking and writing with those at the geographic margins (Sultana, 2007). In particular, this body of work has emphasised the value of co-production in shaping climate policy, with numerous authors (e.g., Sartorius et al., 2024; Howarth et al., 2022; Howarth, 2018; Jack et al., 2020; Jagannathan et al., 2020; Bremer and Meisch, 2017) outlining the potentialities and pitfalls of the approach for climate geography. These and other authors have explored, in particular, how to best unite the contrasting epistemological traditions and norms associated with different stakeholders regarding co-production, describing and exploring how various types of uncertainty can be represented,

how narratives can be co-produced, and the value they bring to the integration and interrogation of relevant knowledge.

In this regard, critical climate geographers are far from alone in their interest in co-production, a perspective that has been explored across the social sciences. They do, however, add something particular to their interpretation. Among geographers, co-production is more than merely a research tool, being instead 'reconceptualized as a prism, where each aspect allows different but complementary insights on the relationship between science, society, and nature' (Bremer and Meisch, 2017). Yet it is no less practical for this. On the contrary, understanding and reconciling the transformative potential of science-practice collaborations is viewed as a means to 'unite scientific and practice-based knowledges' (Howarth et al., 2022) to 'catalyze a more integrated and actionable scholarship and practice' (Jagannathan et al., 2020).

Doing so means finding new ways to approach the impacts of climate change on the terms in which they are perceived, a task to which critical climate geographers have devoted much energy. For example, Yusoff and Gabrys (2011) have explored the role of imagination in shaping understandings of climate change, arguing that creative research practices such as storytelling and art can harness imagination to generate new knowledge and understanding of climate change. Along similar lines, Ryan (2016: 5) has argued that traditional climate change research methods have tended to neglect the emotional and subjective experiences of individuals and communities affected by climate change, necessitating 'emotive-physical storytelling' to generate greater engagement and impact. Taking this position further, Bentz et al. (2021: 687) make the case for fusing arts and science 'to create forms of knowledge that include embodiment as a way of knowing'. By actively pursuing new ways of conceptualising the climate through alternative lenses, geographers are solving the problems they raise, showing and telling the climate through the eyes of those who live it.

4. Where next?

In highlighting the contributions that critical geographers have made to climate change, Bulkeley (2019) suggests that questioning the a priori divisions between the social and the natural is particularly important. This ontological positioning enables critical geographers to move beyond interventions that position social science as responses to an objective (bio-physically defined) problem and instead see climate as a condition in which the problem framing matters as much as the response. Her core message is that rather than being carved off as an environmental concern or a bridging device between the findings of science and the implications for society, recognising "climate-as-condition creates new progressive possibilities for politics and action" (2019:16). Critical climate geographers must thus ensure that the values and epistemologies of the field remain as inclusive as possible to enable these progressive possibilities for politics and action to emerge.

For geographers, the emergence of climate change as a social scientific agenda is rooted, as ever, in Geography's particular histories and architectures. This has always been a discipline with a split personality; its physical and human dimensions exist in a sometimes uneasy yet durable relationship. In fact, one of the strengths of Geography as a discipline is that it draws its analytical innovativeness from many other cognate social science disciplines. Our world, Geographers recognise, can only be interpreted fully when informed by epistemological self-awareness. And it is this awareness of climate change as a confluence of inter-epistemological dialogue, that is, if not unique to Geography, then at least particularly well suited to it. Inheriting an uneasy legacy brings purpose: both a vital critical asset and a critically important one. Since geographers have always engaged with the interplay between environmental and social dimensions, they are especially well placed to assess how the prevailing power and politics of the day shape the frames employed to interpret them.

Crucially, this reflexive, historically situated perspective offers not only an awareness of the deep imbrication of power within the scholarship and policy of environmental management but also the means and obligation to unpack how 'knowledge has been shaped by Anglo-Western experiences and epistemologies' (Collins, 2022: 1243). Critical climate geographers, in other words, bear a legacy that presents a critical path forward: the opportunity to trace the complex landscape of power that underpins environmental analysis, asking who stands to benefit from each frame and who to lose. By situating climate policy within this broader landscape of power, this novel realm of geographical thinking can push back against the technocratic tendencies of adaptation, sustainable development, and green growth, highlighting the conflicts, contestations and consolidations that drive them. In embracing critical climate geographies, the field is uniquely positioned to challenge dominant paradigms and address the complex socio-political dimensions of climate change. Critical climate geographies, viewed in this way, may become less an "underlying absence" (Bulkeley, 2019: 3) than a convergent centrepoint and critical mirror to climate scholarship more broadly: a field of meeting and reflection on the spatialities of climates, and the hybrid climate-societies.

References

Adger, N., Barnett, J., & Dabelko, G. (2013). Climate and war: A call for more research. *Nature*, *498*(7453), 171-171.

Adger, W. N., & de Campos, R. S. (2020). Climate-change disruptions to migration systems. In *Routledge Handbook of Migration and Development* (382-395). Routledge.

Adger, W. N., Lorenzoni, I., & O'Brien, K. L. (Eds.). (2009). Adapting to climate change: Thresholds, values, governance. Cambridge: Cambridge University Press.

Anderson, B. (2010). Preemption, precaution, preparedness: Anticipatory action and future geographies. *Progress in Human Geography*, *34*(6), 777–798. https://doi.org/10.1177/0309132510362600

Andonova, L. B., Betsill, M. M., & Bulkeley, H. (2009). Transnational climate governance. *Global Environmental Politics*, *9*(2), 52-73.

Aspinall, R. (2010). Introduction: Geographical Perspectives on Climate Change. *Annals of the Association of American Geographers*, *100*(4), 715–718. http://www.jstor.org/stable/40863596

Baerwald, T., (2010) Prospects for Geography as an Interdisciplinary Discipline, *Annals of the Association of American Geographers*, *100*(3), 493-501. https://doi.org/10.1080/00045608.2010.485443 [6]

Bakker, K., & Ritts, M. (2018). Smart Earth: A meta-review and implications for environmental governance. Global environmental change, 52, 201-211.

Baldwin, A. (2016), Premediation and white affect: climate change and migration in critical perspective. *Transaction of the Institute of British Geographers*. *41*, 78-90. https://doi.org/10.1111/tran.12106

Baldwin, W. Andrew (2022). *The Other of Climate Change: Racial Futurism, Migration, Humanism.* Maryland: Rowman and Littlefield.

Bentz, J., do Carmo, L., Schafenacker, N., Schirok, J. & Corso, S.D. (2021). Creative, embodied practices, and the potentialities for sustainability transformations. *Sustainability Science*, *17*, 687-699.

Betsill, M. M. & Bulkeley, H. (2006). Cities and the multilevel governance of global climate change. *Global Governance*, *12*(2) 141-159.

Betsill, M. M. & Bulkeley, H. (2007). Looking back and thinking ahead: a decade of cities and climate change research. *Local Environment 12*(5), 447-456.

Blakey, J. (2021). Accounting for elephants: The (post) politics of carbon omissions. *Geoforum*, *121*, 1-11.

Bond, S., Thomas, A. & Diprose, G. (2020). Making and unmaking political subjectivities: Climate justice, activism, and care. *Transactions of the Institute of British Geographers*, *45*, 750– 762. https://doi.org/10.1111/tran.12382

Brace, C. & Geoghagen, H. (2011). Human geographies of climate change: Landscape, temporality, and lay knowledges. *Progress in Human Geography, 35*(3), 284–302.

Braun, B. (2015). Futures: Imagining socioecological transformation—An introduction. *Annals of the Association of American Geographers*, *105*(2), 239-243.

Bridge, G. (2011). Resource geographies 1: Making carbon economies, old and new. *Progress in Human Geography*, *35*(6), 820–834. https://doi.org/10.1177/0309132510385524

Bridge, G., Bulkeley, H., Langley, P. & van Veelen, B. (2020). Pluralizing and problematizing carbon finance. *Progress in Human Geography*, *44*(4), 724–742. https://doi.org/10.1177/0309132519856260

Broadbent, J., Sonnett, J., Botetzagias, I., Carson, M., Carvalho, A., Chien, Y. J., ... & Zhengyi, S. (2016). Conflicting climate change frames in a global field of media discourse. *Socius*, 2, 1-17.

Broto, V. C., & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92-102.

Brown, K., Adger, W. N., Devine-Wright, P., Anderies, J. M., Barr, S., Bousquet, F., ... & Quinn, T. (2019). Empathy, place and identity interactions for sustainability. *Global Environmental Change*, *56*, 11-17.

Bruno Soares M., Gagnon, A.S., Doherty, R. (2012) Conceptual elements of climate change vulnerability assessments: a review. *International Journal of Climate Change Strategies and Management,* 4(1): 6-35.

Bulkeley, H. (2019). Navigating climate's human geographies: Exploring the whereabouts of climate politics. *Dialogues in Human Geography*, *9*(1), 3-17.

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361-375.

Bulkeley, H., Marvin, S., Palgan, Y. V., McCormick, K., Breitfuss-Loidl, M., Mai, L., ... & Frantzeskaki, N. (2019). Urban living laboratories: Conducting the experimental city?. *European urban and regional studies*, *26*(4), 317-335.

Bulkeley, H., Schroeder, H., Janda, K., Zhao, J., Armstrong, A., Chu, S. Y., & Ghosh, S. (2009). Cities and climate change: the role of institutions, governance and urban planning. *Change*, *28*, 30.

Bulkeley, H. & Betsill, M. M. (2005). *Cities and climate change: urban sustainability and global environmental governance*. Vol. 4. Psychology Press.

Burnham, M., Ma, Z. & Zhang, B. (2016). Making sense of climate change: hybrid epistemologies, socio-natural assemblages and smallholder knowledge. *Area*, *48*(1), 18-26.

Caprotti, F. (2012). The cultural economy of cleantech: environmental discourse and the emergence of a new technology sector. *Transactions of the Institute of British Geographers*, *37*, 370-385. https://doi.org/10.1111/j.1475-5661.2011.00485.x

Carey, M., Jackson, M., Antonello, A., & Rushing, J. (2016). Glaciers, gender, and science: A feminist glaciology framework for global environmental change research. *Progress in Human Geography*, *40*(6), 770–793. https://doi.org/10.1177/0309132515623368

Castree, N. (2015). Geography and global change science: Relationships necessary, absent, and possible. *Geographical Research*, *53*(1), 1-15.

Castree, N., Adams, W. M., Barry, J., Brockington, D., Büscher, B., Corbera, E., ... & Wynne, B. (2014). Changing the intellectual climate. *Nature Climate Change*, *4*(9), 763-768.

Castree, N. (2015). Changing the Anthropo (s) cene: Geographers, global environmental change and the politics of knowledge. *Dialogues in Human Geography, 5*(3), 301-316.

Challinor, A. J., Adger, W. N., & Benton, T. G. (2017). Climate risks across borders and scales. *Nature Climate Change*, *7*(9), 621-623.

Chanza, N. & De Wit, A. (2016). Enhancing climate governance through indigenous knowledge: Case in sustainability science. *South African Journal of Science, 112*(3-4), 1-7.

Chatterton, P. (2016), Building transitions to post-capitalist urban commons. *Transactions of the Institute of British Geographers, 41*, 403-415. https://doi.org/10.1111/tran.12139

Chilvers, J., Pallett, H., Hargreaves, T., Stephanides, P., & Waller, L. (2022). *An Observatory for Public Engagement with Energy and Climate Change: A briefing note introducing the UKERC Public Engagement Observatory.*

Clayton, S., Devine-Wright, P., Stern, P. C., Whitmarsh, L., Carrico, A., Steg, L., & Bonnes, M. (2015). Psychological research and global climate change. *Nature Climate Change*, *5*(7), 640-646.

Colven, E. & Thomson, M.J. (2019). Bridging the divide between human and physical geography: Potential avenues for collaborative research on climate modelling. *Geography Compass*, *13*(2), e12418.

Connolly, C. and Kythreotis, A.P. (2025). Building back better through urban blue and green space? A critical review of post-pandemic urban planning and climate governance. *Urban Studies.* https://doi.org/10.1177/00420980251332518

Conway, D., Nicholls, R.J., Brown, S., Tebboth, M.G., Adger, W.N., Ahmad, B., Biemans, H., Crick, F., Lutz, A.F., De Campos, R.S. & Said, M. (2019). The need for bottom-up

assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change*, *9*(7), 503-511.

Corner, A.J., Markowitz, E. and Pidgeon, N.F. (2014). Public engagement with climate change: the role of human values. *Wiley Interdisciplinary Reviews:. Climate Change*, *5*, 411-422.

Curtis, S. E., & Oven, K. J. (2012). Geographies of health and climate change. *Progress in Human Geography*, *36*(5), 654-666.

Day T. (2017). The Contribution of Physical Geographers to Sustainability Research. *Sustainability*, *9*(10), 1851. https://doi.org/10.3390/su9101851[7]

Demeritt, D., & Wainwright, J. (2005). *Models, modelling, and geography.* Questioning Geography. Oxford: Blackwell, 206-25.

Demski, C., Butler, C., Parkhill, K.A., Spence, A., & Pidgeon, N. F. (2015). Public values for energy system change. *Global Environmental Change*, *34*, 59-69.

Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of community & applied social psychology*, *19*(6), 426-441.

Devine-Wright, P. (2013). Think global, act local? The relevance of place attachments and place identities in a climate changed world. *Global Environmental Change*, *23*(1), 61-69.

Dudley, H., Jordan, A., & Lorenzoni, I. (2022). Advising national climate policy makers: A longitudinal analysis of the UK Climate Change Committee. *Global Environmental Change*, *76*, 102589.

Edensor, T., Head, L., & Kothari, U. (2019). Time, temporality and environmental change. *Geoforum*, *108*, 255-258.

Edwards, P. (2010). *A Vast Machine.* Cambridge, MA: MIT Press.

Engelmann, S., Dyer, S., Malcolm, L. & Powers, D. (2022). Open-weather: Speculative-feminist propositions for planetary images in an era of climate crisis, *Geoforum*, *137*, 237-247.

Fisher, D. (2004). *National governance and the global climate change regime.* Rowman & Littlefield.

Garrard, G. (2020). Never too soon, always too late: Reflections on climate temporality. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(1), e605.

Gay-Antaki, M. (2022). Border crossers: Feminist decolonial geography and climate change. *Progress in environmental geography* , *1* (1-4), 115-136.

Gay-Antaki, M., & Liverman, D. (2018). Climate for women in climate science: Women scientists and the Intergovernmental Panel on Climate Change. *Proceedings of the National Academy of Sciences*, *115*(9), 2060-2065.

Gemenne, F., Barnett, J., Adger, W. N., & Dabelko, G. D. (2014). Climate and security: evidence, emerging risks, and a new agenda. *Climatic Change*, *123*, 1-9.

Goldman, M.J., Turner, M.D. and Daly, M., 2018. A critical political ecology of human dimensions of climate change: Epistemology, ontology, and ethics. *Wiley Interdisciplinary Reviews: Climate Change*, *9*(4), e526.

Goldstein, J., & Nost, E. (Eds.). (2022). The nature of data: Infrastructures, environments, politics. University of Nebraska Press.

Goudie, A., (2016). The integration of Human and Physical Geography revisited. *The Canadian Geographer, 61*(1). https://doi.org/10.1111/cag.12315[8]

Granberg, Mikael. & Elander, Ingemar. (2007) Local Governance and Climate Change: Reflections on the Swedish Experience, *Local Environment*, 12:5, 537-548, DOI: 10.1080/13549830701656911

Grindsted, T.S. (2014). What Can Human Geography Offer Climate Change Modelling?. In: Singh, M., Singh, R., Hassan, M. (eds) *Climate Change and Biodiversity. Advances in Geographical and Environmental Sciences*. Springer, Tokyo. https://doi.org/10.1007/978-4-431-54838-6_18

Gustavsson, E., Elander, I., & Lundmark, M. (2009). Multilevel governance, networking cities, and the geography of climate-change mitigation: two Swedish examples. *Environment and Planning C: Government and Policy*, *27*(1), 59-74.

Hajer, M. A. (1995) *The politics of environmental discourse: Ecological modernization and the policy process*. Clarendon Press.

Head, L. (2016). *Hope and grief in the Anthropocene: Re-conceptualising human–nature relations*. Routledge.

Howarth, C., & Parsons, L. (2021). Assembling a coalition of climate change narratives on UK climate action: a focus on the city, countryside, community and home. *Climatic Change*, *164*(1-2), 8.

Howarth, C., Lane, M., Morse-Jones, S., Brooks, K., & Viner, D. (2022). The 'co'in co-production of climate action: challenging boundaries within and between science, policy and practice. *Global Environmental Change*, *72*, 102445.

Hulme, M. (2008). Geographical work at the boundaries of climate change. *Transactions of the Institute of British Geographers*, *33*(1), 5-11.

Hulme, M. (2009) *Why we disagree about climate change.* CUP. Cambridge

Hulme, M. (2011). Reducing the future to climate: a story of climate determinism and reductionism. *Osiris*, *26*(1), 245-266.

Jäger, J., & O'Riordan, T. (2019). The history of climate change science and politics. In *Politics of Climate Ch*ange (1-31). Routledge.

Jasanoff, S. (2017). Virtual, visible, and actionable: Data assemblages and the sightlines of justice. *Big Data & Society*, *4*(2), 2053951717724477.

Johnson, E., Morehouse, H., Dalby, S., Lehman, J., Nelson, S., Rowan, R., Wakefield, S., & Yusoff, K. (2014). After the Anthropocene: Politics and geographic inquiry for a new epoch. *Progress in Human Geography*, *38*(3), 439–456. https://doi.org/10.1177/0309132513517065

Jordan, A. J., Huitema, D., Hildén, M., Van Asselt, H., Rayner, T. J., Schoenefeld, J. J., ... & Boasson, E. L. (2015). Emergence of polycentric climate governance and its future prospects. *Nature Climate Change*, *5*(11), 977-982.

Jordhus-Lier, D., Houeland, C., & Ellingvåg, T. H. (2022). Alienating assemblages: Working the carbonscape in times of transformation. *Progress in Human Geography*, *46*(2), 319–338. https://doi.org/10.1177/03091325211018730

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., ... & Bauer, S. (2017). Why equity is fundamental in climate change policy research. *Global Environmental Change*, *44*, 170-173.

Kythreotis, A. P. (2012). Progress in global climate change politics? Reasserting national state territoriality in a 'post-political' world. *Progress in Human Geography, 36*(4), 457-474.

Kythreotis, A. P. (2023). The paradoxical (post-)politics of scale: Exploring authoritarian state environmental policymaking in Brunei. *Territory, Politics, Governance,* 1-21, https://doi.org/10.1080/21622671.2023.2262508

Kythreotis, A. P., Howarth, C., Mercer, T. G., Awcock, H. & Jonas, A. E. G. (2021) Re-evaluating the changing geographies of climate activism and the state in the post-climate emergency era in the build up to COP 26. *Journal of the British Academy, 9*(5), 71-95.

Kythreotis, A. P., Mantyka-Pringle, C. S., Mercer, T. G., Whitmarsh, L., Paavola, J., Corner, A., Chambers, C. D, Miller, B. A. & Castree, N. (2019). Citizen *Social* Science for more integrative and effective climate action: a science-policy perspective. *Frontiers in Environmental Science, 7*, 10. https://doi.org/10.3389/fenvs.2019.00010

Kythreotis, A. P., Mercer, T. G., Jonas, A. E. G. & Marsden, T. K. (2023). Rethinking urban adaptation as a scalar geopolitics of climate governance: climate policy in the devolved territories of the United Kingdom. *Territory, Politics and Governance, 11*(1), 39-59.

Lane, S. N., Odoni, N., Landström, C., Whatmore, S. J., Ward, N., & Bradley, S. (2011). Doing flood risk science differently: an experiment in radical scientific method. *Transactions of the Institute of British Geographers*, *36*(1), 15-36.

Lave, R., Wilson, M. W., Barron, E. S., Biermann, C., Carey, M. A., Duvall, C. S., … & Van Dyke, C. (2014). Intervention: Critical physical geography. *The Canadian Geographer/ Le Geographe Canadien, 58*, 1-10.

Lehman, J., & Kinchy, A. (2021). Bringing Climate Politics Home: Lived Experiences of Flooding and Housing Insecurity in a Natural Gas Boomtown. Geoforum, 121, 152-161. https://doi.org/10.1016/j.geoforum.2021.02.022

Leiserowitz, A. (2006) Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. *Climatic Change. 77*, 45–72. https://doi.org/10.1007/s10584-006-9059-9

Lemos, M. C., & Morehouse, B.J. (2005). The co-production of science and policy in integrated climate assessments. *Global Environmental Change. 15,* 57-68.

Lin, S., Sidaway, D., Meeteren, M., Boyle, M. & Hall, T., (2022). Trajectories of geography and public policy., *Space and Polity*, 26(2), 77-87. https://doi.org/10.1080/13562576.2022.2149958 [9]

Liverman, D. M. (2009). Conventions of climate change: constructions of danger and the dispossession of the atmosphere. *Journal of Historical Geography*, *35*(2), 279-296.

Lövbrand, E. & Stripple, J. (2011). Making climate change governable: accounting for carbon as sinks, credits and personal budgets. *Critical Policy Studies*, *5*(2), 187-200.

Lövbrand, E., Stripple, J. & Wiman, B. (2009). Earth System governmentality: Reflections on science in the Anthropocene. *Global Environmental Change*, *19*(1), 7-13.

Lovell, H. & Ghaleigh, N.S. (2013). Climate change and the professions: the unexpected places and spaces of carbon markets. *Transactions of the Institute of British Geographers*, *38*(3), 512-516.

Luque-Ayala, A., & Rutherford, J. (2023). Emerging Techno-ecologies of Energy: Examining Digital Interventions and Engagements with Urban Infrastructure. Infrastructuring Urban Futures: The Politics of Remaking Cities, 67.

Mach, K. J., Adger, W. N., Buhaug, H., Burke, M., Fearon, J. D., Field, C. B., et al. (2020). Directions for research on climate and conflict. *Earth's Future*, *8*, e2020EF001532. https://doi.org/ 10.1029/2020EF001532

Machen, R. & Nost, E. (2021). Thinking algorithmically: The making of hegemonic knowledge in climate governance. *Transactions of the Institute of British Geographers*; *46,* 555– 569.

Machen, R., (2018). Towards a critical politics of translation:(Re) Producing hegemonic climate governance. *Environment and Planning E: Nature and Space*, *1*(4), 494-515.

Machin, A., (2013) *Negotiating climate change: Radical democracy and the illusion of consensus.* Bloomsbury Publishing.

Mahony, M. (2015). Climate change and the geographies of objectivity: the case of the IPCC's burning embers diagram. *Transactions of the Institute of British Geographers*, *40,* 153-167. https://doi.org/10.1111/tran.12064

Mahony, M., & Endfield, G. (2018). Climate and colonialism. *Wiley Interdisciplinary Reviews: Climate Change*, *9*(2), e510.

Mahony, M., & Hulme, M. (2018). Epistemic geographies of climate change: Science, space and politics. *Progress in Human Geography*, *42*(3), 395–424. https://doi-org.libproxy.ncl.ac.uk/10.1177/0309132516681485

Mahony, M., & Randalls, S. (Eds.). (2020). *Weather, climate, and the geographical imagination: Placing atmospheric knowledges*. University of Pittsburgh Press.

McCright, A. & Dunlap, R. (2011). Cool dudes: the denial of climate change among conservative white males in the United States. *Global Environmental Change*, *21*, 1163–1172.

Methmann, C., & Oels, A. (2015). From 'fearing' to 'empowering' climate refugees: Governing climate-induced migration in the name of resilience. *Security Dialogue*, *46*(1), 51–68. https://doi.org/10.1177/0967010614552548

Moellendorf, D. (2014). *The moral challenge of dangerous climate change: Values, poverty, and policy.* Cambridge University Press.

Möller, I. (2024). *Why introduce a new Leaving Cert subject on climate action? Geographers have been teaching these issues for years.* Irish Times. Available online: https://www.irishtimes.com/ireland/education/2024/04/11/why-introduce-a-new-leaving-cert-subject-on-climate-action-geographers-have-been-teaching-these-issues-for-years/ Retrieved: 8th May 2024.

Morrow, David. (2020). *Values in Climate Policy.* Rowman and Littlefield. London.

Moser, S. C. (2021). Waves of grief and anger: Communicating through the "end of the world" as we knew it. In *Global Views on Climate Relocation and Social Justice* (273-288). Routledge.

Nightingale, A. J. (2017). Power and politics in climate change adaptation efforts: Struggles over authority and recognition in the context of political instability. *Geoforum*, *84*, 11-20.

Nilsson A, von Borgstede C, Biel A. (2004). Willingness to accept climate change strategies: the effect of values and norms. *J Environ Psychology*, *24*, 269–277.

Nost, E. (2015). Performing nature's value: software and the making of Oregon's ecosystem services markets. *Environment and Planning A: Economy and Space*, *47*(12), 2573–2590.

O'Brien, K. & Wolf, J. (2010) A values-based approach to vulnerability and adaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 232-242.

O'Neill, John; Holland, A., & Light, A. (2008). *Environmental Values.* Routledge. London.

O'Lear, S. (2016). Climate science and slow violence: A view from political geography and STS on mobilizing technoscientific ontologies of climate change. *Political Geography*, *52*, 4-13.

Owens, S. (2000). 'Engaging the public': information and deliberation in environmental policy. Environm*ent and Planning A*, *32*(7), 1141-1148.

Owens, S. (2010). Learning across levels of governance: Expert advice and the adoption of carbon dioxide emissions reduction targets in the UK. *Global Environmental Change*, *20*(3), 394-401.

Owens, S., Petts, J., & Bulkeley, H. (2006). Boundary work: knowledge, policy, and the urban environment. *Environment and Planning C: Government and Policy*, *24*(5), 633-643.

Pallett, H., Chilvers, J., & Hargreaves, T. (2019). Mapping participation: a systematic analysis of diverse public participation in the UK energy system. *Environment and Planning E: Nature and Space*, *2*(3), 590-616.

Parsons, L. (2019). Structuring the emotional landscape of climate change migration: Towards climate mobilities in geography. *Progress in Human Geography*, 43(4), 670-690.

Parsons, L. (2023). *Carbon colonialism: How rich countries export climate breakdown*. Manchester: Manchester University Press.

Pearce, W., Niederer, S., Özkula, S.M. and Sánchez Querubín, N., 2019. The social media life of climate change: Platforms, publics, and future imaginaries. *Wiley interdisciplinary reviews: Climate change*, 10(2), e569.

Pepper M, Jackson T, Uzzell D. (2009) An examination of the values that motivate socially conscious and frugal consumer behaviours. *International Journal of Consumer Studies*, *33*(2), 126–136.

Pohl, L. & Swyngedouw, E. (2023). Enjoying climate change: Jouissance as a political factor. *Political Geography*, *101*, 102820. https://doi.org/10.1016/j.polgeo.2022.

Poortinga, W, Spence, A, Whitmarsh, L, Capstick, S. & Pidgeon N. (2011). Uncertain climate: an investigation into public scepticism about anthropogenic climate change. *Global Environmental Change*, *21*, 1015–1024.

Poortinga, W., Steg, L., & Vlek, C. (2004). Values, Environmental Concern, and Environmental Behavior: A Study into Household Energy Use. *Environment and Behavior*, 36(1), 70–93. https://doi.org/10.1177/0013916503251466

Popke, J. (2016). Researching the hybrid geographies of climate change: reflections from the field. *Area*, 48(1), 2-6.

Randalls, S. (2010). History of the 2 C climate target. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(4), 598-605.

Randalls, S. (2011). Optimal climate change: Economics and climate science policy histories (from heuristic to normative). *Osiris*, *26*(1), 224-242.

Randalls, S., (2017), Contributions and perspectives from geography to the study of climate. *Wiley interdisciplinary reviews: Climate changeWIREs Clim Change*, *8*, e466. https://doi.org/10.1002/wcc.466[10]

Rickles, P., Ellul, C. and Haklay, M. (2017). A suggested framework and guidelines for learning GIS in interdisciplinary research. *Geo: Geography and Environment*, 4(2), e00046.

Ryan, K., (2016). Incorporating emotional geography into climate change research: A case study in Londonderry, Vermont, USA. *Emotion, Space and Society*, 19, 5-12.

Sartorius J., Geddes A., Gagnon A.S., and K. Burnett. (2024). Participation and co-production in climate adaptation: scope and limits identified from a meta-method review of research with European coastal communities. *Wiley Interdisciplinary Reviews: Climate Change*, e880.

Simpson, M., & Pizarro Choy, A. (2024). Building decolonial climate justice movements: Four tensions. *Dialogues in Human Geography*, *14*(2), 269-272.

Sultana, F. (2022). The unbearable heaviness of climate coloniality. *Political Geography*, 99, 102638

Swyngedouw, E. (2010). Apocalypse forever?. *Theory, culture & society*, *27*(2-3), 213-232.

Taylor, P.J. & O'Keefe, P. (2021). In praise of Geography as a field of study for the climate emergency. *The Geographical Journal*, *187*(4), 394-401.

Thornes, J. E., & Randalls, S. (2014). Applied meteorology and climatology. *Progress in Physical Geography: Earth and Environment*, *38*(4), 389-391. https://doi.org/10.1177/0309133314539234 [11]

Tuitjer, L. & Dirksmeier, P. (2021). Social media and perceived climate change efficacy: A European comparison. *Digital Geography and Society*, *2*, 100018.

Turnpenny, J., Russel, D. & Rayner, T. (2013). The complexity of evidence for sustainable development policy: analysing the boundary work of the UK Parliamentary Environmental Audit Committee. *Transactions of the Institute of British Geographers*, 38, 586-598. https://doi.org/10.1111/j.1475-5661.2012.00549.x

Vincent, K., Daly, M., Scannell, C. & Leathes, B. (2018). What can climate services learn from theory and practice of co-production? *Climate Services*, *12*, 48-58.

Weckroth, M., & Ala-Mantila, S. (2022). Socioeconomic geography of climate change views in Europe. *Global Environmental Change*, *72*, 102453.

Whatmore, S. J. (2009). Mapping knowledge controversies: science, democracy and the redistribution of expertise. *Progress in Human Geography*, 33(5), 587–598. https://doi.org/10.1177/0309132509339841

Williams, C., Fenton, A. and Huq, S., 2015. Knowledge and adaptive capacity. *Nature Climate Change*, *5*(2), 82-83.

Wilson, H. (online). Urban maintenance as compromise: Coming to terms with the multispecies city. Environment and Planning E: Nature and Space, 8(1), 232-250. https://doi.org/10.1177/25148486241280354

Yusoff, K. and Gabrys, J., 2011. Climate change and the imagination. *Wiley Interdisciplinary Reviews: Climate Change*, 2(4), 516-534.