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# Climate change communication beyond the digital divide: Exploring cartography's role and privilege in climate action

## ABSTRACT

*Despite widespread acceptance amongst researchers, climate change and responses to it remain a socially and politically debated topic. Within cartography and cognate disciplines, this has often been construed as an issue of communication: maps are tools for communication and better maps will lead to greater understanding of and responses to climate change. While existing research has shown some support for the efficacy of such approaches, this article calls into question the underlying assumptions of access and equity that pervade such communicative approaches to mapmaking and data visualization. Two new case studies from the authors' research group highlight the importance of greater consideration of*

## KEYWORDS

critical cartography  
augmented and virtual  
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narrative maps  
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emotions  
map communication  
model  
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risk communication

*equity and access for climate change communication cartography (CCCC): first, an experiment on the use of storytelling and narrative in maps of climate impacts and, second, an augmented reality tool that presented users with storm surge information for their region. These two cases lead us to an interrogation of the assumptions that undergird claims for the rhetorical power of using cartographic stories and augmented reality. It is, we argue, somewhat of a luxury to experience climate change through stories, not lived experiences or through augmented reality, as opposed to forced displacement. We conclude by reinterrogating the map communication model in light of understandings of maps as constantly made and remade by both map author and map user. By calling into question the ontogenetic security of maps, CCCC can better understand both the impacts and equities of its maps.*

## **INTRODUCTION: CLIMATE CHANGE, COMMUNICATION, CARTOGRAPHY**

A 2021 study drawing from a dataset of 88,125 climate-related research journal articles concluded with ‘high statistical confidence’ that more than 99 per cent of peer-reviewed scientific literature agrees that humans are the dominant force behind climate change (Lynas et al. 2021). This update from Cook et al.’s (2013) study (which found 97 per cent consensus) occurs even as upwards of 30 US Senators refuse to acknowledge any scientific evidence supporting anthropogenically driven climate change (Drennen and Hardin 2021). Beyond elected officials, poll after poll in the United States, as well as other nations, reveal deep political and cultural splits with respect to understandings of and support for responses to climate change (Leiserowitz et al. 2021). Within this context, maps have been framed as powerful media objects capable of shaping public understandings of climate change (McKendry and Machlis 2009; Kostelnick et al. 2013; Retchless 2014; Johannsen et al. 2018; Fish 2020a). Following this argument, it is possible that better maps will lead to better outcomes. And indeed, within the United States, major media outlets such as the *New York Times* (Bhatia and Popovich 2021) and *The Washington Post* (Mufson et al. 2019) have placed maps at the centre of stories about climate change and its impacts.

In light of the prominent role that maps have come to play in efforts to communicate climate change and its impacts to the broader public, this article calls into question underlying assumptions around access and equity that pervade communicative approaches to mapmaking and data visualization. In such approaches, the goal of the cartographic product is to communicate the author’s intent as powerfully and persuasively as possible; as such, in climate change communication cartography (CCCC), a given visualization’s explicit goal is to communicate as effectively and persuasively as possible the author(s)’ intended information about climate change. While research has demonstrated the efficacy of CCCC approaches (Fish 2020c; Sermet and Demir 2020), this article demonstrates a series of inequitable assumptions and sketches an intersectional, relational approach to addressing CCCC approaches moving forward.

To do so, this article first traces the roots of CCCC through the highly influential map communication model (MCM) of cartography that presented maps as finished, static and authoritative means of presenting objective information (Robinson et al. 1995). Drawing from the tradition of critical cartography and

its emphasis on the tensions and elisions hidden within mapping discourses (Crampton 2001) helps to resituate maps and data visualization efforts as processes that are constantly reshaped – both by their ostensible authors and those interpreting them – and opens for consideration questions of inclusion and exclusion within CCCC. Reflecting on two new case studies both concretizes and opens these concepts for further consideration. Drawn from our research groups' recent work, the two case studies highlight the importance of greater considerations for equity and access in CCCC: first, an experiment on the use of storytelling as a means of climate change communication – specifically contrasting the presentation of information using either a human interest story or detailed scientific language when presenting long-term impacts on oceans; second, a study testing how an augmented reality (AR)-based presentation of local storm surge flooding may enhance user engagement as compared to a traditional cartographic representation. Each case highlights the effects of presentation format on what sorts of users are able to engage with the topic and in what kinds of depths. These two cases allow an interrogation of the assumptions that undergird claims for the rhetorical power of CCCC, providing glimpses into a new form of the digital divide – one not necessarily of raw access to technology, but instead shaped by time, space and positionality within larger sociocultural systems (Kelley 2018).

In the conclusion, we argue that it is somewhat of a luxury to experience climate change through cutting-edge, interactive visualizations and not immediate, material outcomes, such as forced displacement. We return to the presumed ontogenetic security of maps as objects in positivist MCMs; in so doing, we open the door for a nuanced, co-constructive understanding of CCCC that sees maps as tools to immerse their readers through narrative transportation, but ones wherein the final destination is in dialog with the everyday lives of a broader audience. This approach views CCCC as relational and therefore simultaneously engages with the cultural and historical rhetorical power of maps, the communicative quality of maps, the efficacy of maps in promoting climate action and the asymmetries in access to climate maps and visualizations. A critical engagement with CCCC is necessarily ambitious. This article only begins the process of tracing the web of relations that structures the kinds of communication that are possible within CCCC, focusing on the weak points and oft-unconsidered tensions within said web. In this light, we end by suggesting a series of alternative approaches for data visualization of climate risk that foreground empathetic engagement while supporting diverse users, not only in overcoming the traditional barriers to technological access but also in establishing and maintaining engagement with climate change in a way that meshes with these users' often more pressing everyday concerns.

## **CARTOGRAPHY, THE MCM AND ITS DISCONTENTS**

Cartography is often described as the art and science of mapmaking (Krygier 1995). The current discipline encompasses both (1) practising cartographers who create maps in both the print and digital domains (the art) and (2) research cartographers who have historically focused on use the scientific method as a way to justify, typify and describe the artistic decisions that are made by practising cartographers (the science). In the second half of the twentieth century, research cartography primarily relied on highly controlled experimental methodologies drawn from psychology and advertising research to test the effectiveness of individual aspects of a map design (Montello 2002).

This research was in response to Robinson's call in 'The look of maps' (1952) for an empiricist, cognitive cartography. This early research was described through what became known in academic cartography as the MCM, which illustrated a connection between the 'communicator' (map designer) and the 'receiver' (map reader) via the conduit of the map (Figure 1; see also Montello 2009). The first formal MCM was published in Board (1967) as a chapter within Chorley and Haggett's *Models in Geography*, a title which reflected the larger turn of academic geography towards an emphasis on formal models and laws at the time. The MCM integrated ideas from information theory (Shannon 1948; Weaver 1953) and semiotics (Bertin 1983) and by the 1970s, it had become the dominant paradigm for cartographic research (Freitag 1971; Hake 1973; Ratajski 1977). The goal of the map within the context of this model was to transfer geographic information as viewed by the cartographer to the map reader. The research at this time thus focused on ascertaining and measuring the effectiveness of the map in communicating to the map reader the information which the cartographer aimed to impart. Crampton outlines the major principles of the MCM:

First, there is a clear separation between the cartographer and the user. Secondly, the map is an intermediary between the cartographer and the user. Thirdly, the map communicates information to the user from the cartographer. And fourthly, it is necessary to know the cognitive and psychophysical parameters of the map user's abilities to comprehend, learn and remember information communicated by the map.

(2001: 237)

By the 1980s mainstream academic cartographers had recognized that cartographic communication is significantly more nuanced than the MCM conveyed (Montello 2002). Research increasingly focused on how prior knowledge, spatial abilities, understanding of the symbols used in the map, attitudes and interpretation of reality by the map reader among others, also influence how the map reader interprets the content of the map (e.g. Fabrikant and Skupin 2005; MacEachren 1995).

The end of the twentieth century saw the development of two distinct communities within the discipline. The first built upon the Robinsonian tradition and focused on expanding cartographic theory into the digital and interactive domains (DiBiase 1990). The second became what is presently known as 'critical cartography' and focused on critiquing the development of maps, data and their design with a particular eye towards power and structural relations. Much work in this area followed J. B. Harley's foundational text,

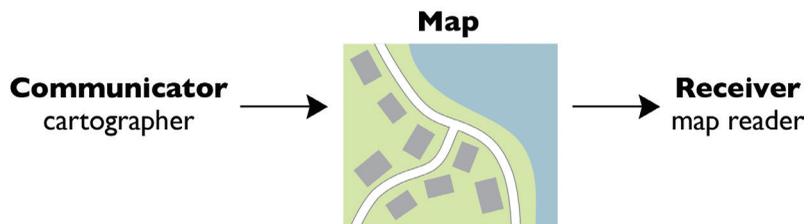


Figure 1: The MCM.

'Deconstructing the map' (1989), a piece which continues to influence the discipline (see Rose-Redwood 2015).

In each case, the map remains a powerful, static tool for communication. MacEachren recognizes that they must be constructed with care and in consideration of both the data the map will show and the reader the map will have; however, maps are still constructed by a cartographer to be presented to a reader/interpreter. As MacEachren states the goal of representation in a map is to convince the map reader of a geographic finding:

Once you are convinced of a location [...], an attribute at a location [...], or a relationship [...] and you want to convince someone else of your assessment, a map is an ideal presentation device. A well designed map is convincing because it implies authenticity. *People believe maps*. It is this general acceptance of maps (in contrast to the suspicion of statistical analysis) that makes maps a powerful presentation device, but one that must be constructed with use and care.

(1994: 9, emphasis added)

Dennis Wood notes that Harley's 'critical' approach continued to view maps as tools for communication:

The problem for Harley remained the bad things people *did* with maps, and ultimately that left the maps themselves out of the picture. [...] Harley was never able to conceive of the map as other than a representation of reality; was never able to grasp the map as discourse function; was never able to understand that the heart of the problem wasn't the way the map was *wielded*, but the map function itself.

(1993: 50, original emphasis)

See also Pickles 2004 for a wider discussion of MacEachren, Harley and their limits. In each case, MacEachren and Harley, the map remains a tool to be put to use for communication, for better or ill, but ultimately an object, secure in its function within society.

It was the early 2000s that saw two important theoretical moves away from this conceptualization of static maps, in part driven by the growing number of interactive spatial visualizations found on the internet. First, ontogenetic approaches to cartographic research emphasized that 'maps are never ontologically secure, stable objects, but are rather constantly coming into being as they are created and recreated by multiple actors', including both the map creator(s) and any potential map readers (Thatcher 2018: n.pag.). Such approaches called for a rethinking of maps alongside a greater consideration of the technologies through which maps are both created and experienced (Kitchin and Dodge 2007; Dodge et al. 2009). Second, alongside this increased emphasis on the ontogenetic aspects of modern maps, cartographers also began to broaden their studies of map communication to consider map users' affective as well as cognitive responses to map content in the early twenty-first century (Fish 2020b; cf. Tyner 1982 as an example of earlier work that explored related ideas). We characterize this shift in emphasis as an empathic turn, with empathy defined as the act of 'feeling into' an aesthetic object ('Einführung', as first defined by philosopher Robert Vischer in 1873), a deep emotional and embodied engagement that transports and transforms the viewer, often engendered through richness of narrative or

sense of spatial presence (for a history of the development of 'Einführung', see Koss 2006). Some exemplars of this empathic turn stemmed directly from calls to ontogenetically rethink maps as culturally contingent, embodied engagements with cartographic objects as well as practices (Dodge et al. 2011); however, a more positivist tradition remains within academic cartography that sought to extend traditional cartographic communication models by drawing on approaches from psychology to explore affective as well as cognitive responses (Caquard and Dormann 2008; Fabrikant et al. 2012; Griffin and McQuoid 2012; Caquard and Cartwright 2014; Caquard and Griffin 2018). While different with respect to the fundamental ontological status of maps, both approaches to understanding the role of emotion in cartography share two assumptions: (1) maps may be emotionally charged and are not simply a vehicle for communicating spatial information and (2) map users are embodied actors who do not simply understand maps but also engage with them emotionally.

CCCC has developed within these broader contexts of ongoing debates between and amidst professional, academic, critical and otherwise cartographers; however, as the name suggests, it has largely remained rooted within the framework that sees maps as powerful tools of communication, and further within the a tradition of scholarship which seeks to quantify and measure the success of emotional responses to said maps. In the next section, we first trace the paths that CCCC has followed as it draws from specifically positivist, psychological approaches before then detailing two CCCC projects that operated in this vein. By situating CCCC within larger conversations around the power, limits and purpose of cartography, we are able to open for debate alternative visions of CCCC that call into question both the ontological security of the map as object as well as, and perhaps more importantly, the elision of concerns over equity and access that occurs with a focus on quantitative measurements of communicative success. In doing so, we begin to highlight the weak points and areas of tension in the web of relations that structure CCCC, pointing the way towards approaches that may better meet the needs of both climate communicators and map users.

## **CARTOGRAPHIC CLIMATE CHANGE COMMUNICATION**

Recent developments in climatic change communication and science communication more generally have broadly paralleled this empathic turn in map communication. Over the last half century, science communication has moved from an information deficit model (Miller 1983; Simis et al. 2016) to an emphasis on how emotions (Loewenstein et al. 2001; Terpstra 2011), political commitments (Kahan et al. 2011) and heuristics and biases (Keller et al. 2006) inform understanding, engagement and behavioural responses to scientific information. In climate change communication, research over the last several decades has similarly emphasized building engagement (defined by Lorenzoni et al. as 'a personal state of connection' with the hazard, including cognitive, affective and behavioural aspects [2007: 446]), managing emotional responses (Leiserowitz 2006; Moser 2007; O'Neill and Nicholson-Cole 2009; Smith and Leiserowitz 2014; Morris et al. 2019) and reducing psychological distancing (as described in Hatfield and Job [2001] and Spence et al. [2012]), this coping mechanism involves focusing on risks to future generations and distant communities while downplaying risks to nearby and familiar people and places).

In line with recent trends in CCCC, and models of map communication more generally, cartographers have increasingly focused on developing tools that not only inform but also emotionally engage users. Here, we consider two such CCCC efforts: cartographic storytelling and geolocated AR. By employing storytelling and design techniques intended to foster narrative transport and sense of presence, these recent developments in CCCC signal a shift towards designing tools to increase empathic connection and reduce emotional distance. As such, story maps and geolocated AR tools can be seen as an attempt to overcome perceived limitation of maps as cold, technocratic products that hold their subject at a distance, engaging in what Haraway (1988) described as the disembodied ‘god trick’ of objectivity. In contrast, CCCC story map and AR tools *claim* to invite the user into an embodied, grounded perspective on climate change, either by encouraging identification with a narrator (story map) or by placing the user’s avatar on a real-world landscape as seen through a cell phone screen (AR). While these attempts at empathic design may succeed in increasing certain forms of engagement, we call into question the equitability of access to such experiences and, more fundamentally, the potential discordance between the depth and breadth of engagement touted by CCCC visualizations and those actually, materially experienced by users. Specifically, we argue that story maps and AR tools frequently provide somewhat shallow and thin expressions of empathy and engagement and that each risks flattening the experience of climate change hazards both in terms of who may experience them and how.

### ***Storytelling, maps and climate change***

Communicating climate change is difficult for many reasons, one of which is the psychological distance individuals tend to place between themselves and the causes and effects of a changing climate. Trope and Liberman (2010) describe this psychological distance through ‘construal level theory’ which describes how objects or events that are removed from our direct experience also become seen as more abstract – and vice versa. Accordingly, narrative stories suggest one potential way in which to make climate change and its effects less abstract and spatially and psychologically distant (Van Boven et al. 2010). In this framing, stories are inherently relatable, highlight human experience (not simply abstract effects) and can evoke emotions which are seen as important for getting people engaged with climate change (empathy).

Stories, in this frame, are engaging in ways that information presented in a scientific way are not. One reason for this may be tied to ‘narrative transportation’, or the process of being lost in a story. More precisely, Morris et al. define narrative transport as the ‘degree to which a plot activates the story receiver’s imagination through an *empathetic* connection with the characters’ (2019: 21, emphasis added). Green and Brock (2000) theorize that narrative transportation may thereby reduce psychological distance, as the reader (of maps or novels) feels closer to the places and/or characters presented in the narrative. With narrative transportation, a reader is more likely to connect emotionally with the media and, hence, less likely to ‘boomerang’ – a process of ‘counter-arguing’ whereby prior beliefs become strengthened against the new information being presented (Hart and Nisbet 2011; Morris et al. 2019).

Following that work, it has been suggested that stories be used to communicate climate change (Dahlstrom 2014; Bloomfield and Manktelow 2021), and indeed, they have been shown to be effective in certain ways (Rickard

et al. 2021). Morris et al. (2019) found that those who read a story vs. those who read scientific information were more likely to be transported and were thus more likely to engage in pro-environmental behaviours following the study. Similarly, Gustafson et al. (2020) found that personal stories were an effective means of persuasion about the effects of climate change. Their study also provided evidence of the key role of emotions in explaining why stories are so effective as a means of persuasion about climate change. Within geography and cartography, there has been a growing interest in incorporating stories with maps (Pearce 2008; Caquard 2011; Mocnik and Fairbairn 2018; Fish 2020c). This has been in part driven by the growing field of data journalism which often combines data visualizations, spatial and otherwise, with personal stories (Cairo 2016), but also by technological advancements which range from open-sourced tools to ESRI's proprietary StoryMaps which offer user-friendly ways for creators to present personal stories combined with maps, graphics, media and text.

Despite both the potential for stories to communicate climate change and the potential of stories for making maps more engaging, little research has been published at this intersection of CCCC. In her currently unpublished master's thesis, Garrison (2021) examined narrative story maps as a means of communicating climate change impacts. Garrison's study measured the differences in level of narrative transportation (as measured via the narrative transportation scale, Appel et al. 2015) and emotional responses associated with stimuli describing the effects of climate change on hypoxia along the Oregon coast. In Oregon, hypoxia is one of the most dire impacts of climate change on livelihoods; however, it is invisible to those who do not rely on the ocean for their food and livelihoods. In her study, Garrison focused on assessing how different narrative designs affected how 171 residents of the Willamette Valley feel about ocean hypoxia, and climate change generally. The residents of the Willamette Valley are those who often visit the Oregon coast, enjoy the seafood that is fished there, but are not entrenched with the impacts of ocean hypoxia. In her study, Garrison tested four stimuli which varied across two dimensions: narrative structure (low or high) and format (map or text-only) (Table 1). High narrative structure describes written content that is more story-like, while low narrative describes content that is less story-like. In Garrison's case, the low narrative structure described a very scientific recounting of the issue of hypoxia. In the case of how she augmented the format, her text-only stimuli was a simple webpage, while the map stimuli included a map which drew readers into a particular estuary where hypoxia is having severe impacts on fishing.

Of the four stimuli, story maps (i.e. high narrative structure and map format) *did* result in greater individual-level interest and care in local climate change impacts, but *did not* leave study participants more transported or more emotionally affected. Garrison (2021) considers whether this result should call into question the suitability of the narrative transportation scale for story maps or other cartographic products, as prior to her study this scale

*Table 1: Stimuli design in Garrison's (2021) study.*

<b>Narrative structure</b>		
Text-only	High narrative (written story)	Low narrative (scientific writing)
Map	High narrative story map	Low narrative with a map

had generally been applied to only text or video-based stimuli. Unlike maps, she argues, these stimuli have well-established and understood connections with mental imagery formation, which is an essential component of narrative transportation.

While more research is needed, Garrison's study demonstrates that the connection between narrative transportation and successful CCCC is still poorly understood and, at this time, may be overstated – especially as it remains unclear how (or whether) cartographic products can engender the rich mental imagery needed to support narrative transportation.

### ***AR and climate change***

Similar to the putative benefits of narrative transport in climate change communication maps, several authors (e.g. Klopfer and Sheldon 2010; Smørndal et al. 2016) have suggested that AR-based visualizations may help build audience engagement with local climate change impacts. Unlike story maps, AR-based tools are often thin on narrative or worldbuilding, relying instead on rich, evocative imagery of climate change impacts, grounded in real-world settings, to drive engagement. Increased engagement through presence, immediacy and immersion has long been claimed as one of the most significant advantages of AR-based presentations. Both Wu et al. (2013) and Chang et al. (2013) have echoed Bronack (2011) in arguing for the potential of AR tools to improve the presence, immediacy and immersion of learning experiences. Presence includes both the ability to place oneself in an authentic physical environment (afforded by the live video feed which serves as the background 'reality' for the location-based augmentations, this dimension is closely related to immersion) and the ability to personally identify with the self that has been so placed as an authentic or genuine avatar (afforded by the ability to customize augmentations to match one's personal characteristics, this dimension is closely related to immediacy) (Lee 2004; Bronack 2011). Immediacy is based on creating 'a sense of proximity or psychological closeness' (Bronack 2011: 115). Immersion is characterized by the level of realism and tendency to suspend disbelief (Bronack 2011) and may be used to heighten engagement and emotional response (Dede 2009).

AR has been suggested to be particularly useful for present, immediate and immersive communication of information about phenomena – such as climate change and related hazards – that are generally not directly observable (Wu et al. 2013; Dunleavy et al. 2009). For climate-change-enhanced natural hazards (e.g. flooding), direct experience of a significant loss has been shown to trigger experiential learning and is one of the strongest predictors of risk perceptions and preparedness (Grothmann and Reusswig 2006; Siegrist and Gutscher 2008; Wachinger et al. 2013). The argument follows that if AR tools succeed in fostering an immersive hazard experience, then they should greatly increase cognitive, affective and behavioural engagement with the hazard. Moreover, to the extent that AR tools foster personal presence and immediacy, they may also help combat the tendency of those most threatened by hazards to use techniques such as psychological distancing or boomeranging to avoid engaging with new, difficult ideas.

Attempts to realize these potential advantages of AR for climate change communication have thus far largely focused on educational applications. For K-12 students, observational studies suggest that geolocated AR may facilitate place-based learning for climate impacts (Klopfer and Sheldon 2010) and

foster situated knowledge building and engagement for local sea level rise scenarios (Smørdal et al. 2016). Additional studies have explored AR applications' effectiveness in engaging users with climate-change-enhanced natural hazards, especially flooding. In these studies, geolocated, mobile AR applications for flood visualization were perceived as useful for flood risk management and outreach by emergency services workers (Haynes and Lange 2016; Haynes et al. 2018) and showed potential to promote situational awareness in emergency management and response (Mirauda et al. 2018).

However, none of these studies on AR for climate change and flood hazard communication included comparisons with a control group, limiting the ability to assess whether any effects on learning or engagement can be attributed to aspects of the AR experience not available through other technologies. In an attempt to address calls for 'controlled and comprehensive evaluation studies' of AR tool use and learning (Wu et al. 2013, 47) that go beyond AR-tool usability to consider affective variables (Cheng and Tsai 2013), Retchless (2019) used a study design with random assignment for treatment and control groups to examine the efficacy of AR in communicating storm surge flooding impacts to undergraduate students in Galveston, Texas. This study (previously only presented at conferences, e.g. Retchless 2018, 2019) concluded that a geolocated, mobile AR application for storm surge flooding was not associated with higher risk perceptions or sense of presence when compared with map or text-based controls (Figure 2). Because Retchless (2019) is one of the few studies designed to isolate the effects of AR format on learning and engagement for a climate-related hazard, we consider it here as a case study for illuminating likely challenges associated with leveraging AR for present, immediate and immersive CCCC.

Retchless (2019) surveyed 77 undergraduate students using a Qualtrics survey administered via Apple iPads. Participants were shown markers for storm surge flood depth at four buildings surrounding the quad of a Galveston-area campus in one of three randomly assigned formats: text (HTML-formatted table), map (Google Maps Javascript API) or AR (Wikitude platform). All three formats used the same marker-based depiction of flood depth, which was shown relative to users' recorded heights and varied only in perspective (egocentric in AR, allocentric for map and absent from text format) and geospatial context (absent for text format, present for map and

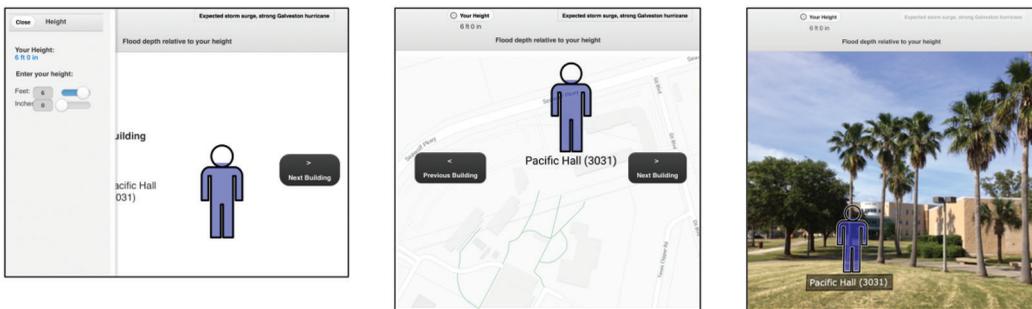


Figure 2: From left to right: text, map and AR-based presentations of storm surge flood depth for a building in Galveston, Texas (Retchless 2019). The text-based presentation also shows an interface for customizing the avatar's height so flood depths are user-height relative.

AR). To control for the added interactivity inherent in using the AR view to pan across the building flood markers, some versions of the map and text formats also added arrows that the user needed to click to scroll through the markers. Using a simple, consistent, marker-based stimulus across formats allowed the effect of the format to be evaluated separately from the effect of marker design. After viewing the flood markers, participants completed recall tasks for marker flood depths, a posttest measure of their storm surge risk perceptions, a sense of presence scale, additional Likert-scale questions about storm surge experience and risk beliefs and questions about individual differences in spatial and computer skills and demographics. The pre–post measure of risk perceptions was a 0–100 scale response to ‘[i]f you were standing at your current location during a strong hurricane, how much risk or danger do you feel you would be at from storm surge flooding?’. Sense of presence was measured via the Slater, Usoh and Steed questionnaire (Usoh et al. 2000).

Linear regression modelling showed that, when controlling for pre-test risk perceptions, posttest risk perceptions were significantly lower ( $p < 0.05$ ) for respondents in AR as compared to other formats (map and text). Risk perceptions did not vary significantly ( $p \geq 0.05$ ) with interactivity, user height, accuracy on recall tasks for building flood depths, total score on the sense of presence scale or spatial context (i.e. when considered together, AR and map formats did not differ from the text-based control) (Table 2). Sense of presence was higher for participants who began the study with higher risk perceptions, but was not associated with AR format, spatial context or other study variables (Table 2).

The results suggest that simply switching from map-based to AR-based presentations of the same content may not be sufficient to realize the claimed benefits of AR for present, immediate and immersive climate change communication – and may instead result in lower risk perceptions for climate-related hazards. This is in line with results from Simpson et al. (2022), which found that a similarly immersive technology – virtual reality (VR) – was also associated with lower personal risk perceptions for hurricane storm surge. By

*Table 2: Linear regression results for effects of marker format and other study variables on posttest risk perceptions and sense of presence.*

	<b>Posttest risk perceptions</b>	<b>Sense of presence</b>
(Intercept)	58.87 (45.94)	23.32 (13.61)
Pre-test risk perceptions	0.41 (0.13)**	0.09 (0.04)*
Interactive	11.80 (7.20)	-0.38 (2.18)
Spatial	-2.96 (6.61)	-0.66 (2.00)
AR	-16.22 (8.10)*	0.66 (2.45)
Height	-1.45 (7.65)	-1.11 (2.31)
Per cent correct	-0.24 (0.14)	0.04 (0.04)
Sense of presence	0.35 (0.40)	–
$R^2$	0.28	0.10
Adj. $R^2$	0.20	0.02
Num. obs.	76	76

\*\* $p < 0.01$ ; \* $p < 0.05$ .

considering how the water depth at which participants would evacuate varied between participants shown a presentation of storm surge flooding on a VR headset and participants shown the same presentation on a large desktop computer monitor, that study found that VR participants would evacuate at higher water levels than participants shown the desktop-based control. Simpson et al. (2022) suggest that this result may be explained by the lack of personal bodily harm or discomfort associated with the damage observed in the immersive VR flood experience, noting that the VR experience may have thereby created a sense of invulnerability in the subject, desensitizing them to the potential personal risks through a psychological process known as ‘extinction’. A similar extinction process – driven by repeated harmless exposure to a depiction of deadly storm surge in a real-world environment – may explain the lower risk perceptions observed for AR formats in the Retchless (2019) case study.

These two cases, Garrison (2021a) and Retchless (2019), suggest underexplored limits to how we understand and enact CCCC through varying technologies. Where, on the one hand, Garrison (2021a) calls into question the means by which increased empathy and narrative transportation occur in maps, Retchless (2019) suggests it may not occur at all in at least some AR environments – and that some aspects of immersive AR environments may instead actively discourage bodily engagement. In the concluding section, we suggest these limits may, in fact, occur due to an over-privileging of the first-world, highly educated experience in CCCC that elides the great effort required – on behalf of both designers and users – to establish and maintain empathic engagement with climate change narratives. Recognizing the necessarily co-productive work performed as ‘designers’ and ‘users’ meet in these virtual spaces to playfully create and recreate cartographic imaginaries for future climates, we call for studies to more deeply engage with ontogenetic understandings of maps that push beyond the MCM, destabilizing the designer-user dyad.

## **EQUITY, ACCESS AND THE LIMITS OF CCCC**

Like the written and spoken word, like photographs and cartoons, the map has become a psychological weapon in a warring world where the souls of men are as strongly attacked as their lives.

(Weigert 1941: 528)

Whether engagement is to be engendered through narrative transportation, immersive mixed reality tools or other techniques, we argue that designers of CCCC tools should be aware of the significant demands that such empathic engagement with climate change places on their users. This is a long-standing problem, inherent to the process of empathic engagement as understood and applied in the arts and architecture over the past century (Koss 2006). In the CCCC context, such empathic engagement or ‘feeling into’ the map similarly requires an often uncomfortable destabilization of the self, a giving over to the pull of the immersive narrative experience; such a state of wilful immersion may be challenging to maintain even from a position of relative safety and privilege, much less from a place of economic or social insecurity. Some barriers to engagement may be problems of design that can be addressed in a traditional MCM framework, such as adjustments to cartographic perspectives

or symbolologies that subtly tug users away from a more fully immersive experience. But other challenges in maintaining engagement require a deeper understanding of the positionality of designers and users, including how they meet and mix via the medium of the map. It is this second set of challenges that we explore in this final section.

Beyond the question of how well geospatial storytelling and AR tools actually promote climate change engagement as quantitatively measured in the above examples, there is also reason to question whether such engagement can be pursued equitably and without undesirable, unintended consequences. Concerns about the limits and dangers of highly 'engaging' communication products are not new in climate change communication. For example, studies of climate change communication have found that while fear-inducing imagery often captures attention, persistent or intense fear appeals can leave message recipients feeling overwhelmed, disempowered and more likely to consider climate change as a danger to a distant 'other' than to themselves (i.e. to deploy psychological distancing as a coping mechanism in the face of an overwhelming and uncontrollable threat) (see Leiserowitz 2005; O'Neill and Nicholson-Cole 2009; Spence and Pidgeon 2010). Moreover, drawing on the psychological theory of 'finite pool of worry' (the contention that individuals have a limited capacity for worry that they allocate among risks; Linville and Fischer 1991; Weber 1997) climate change communicators have also suggested that fear appeals may be especially likely to overwhelm message recipients who already face other pressing financial or health concerns, increasing the likelihood that they will ignore, downplay or otherwise disengage with climate change messaging (O'Neill and Nicholson-Cole 2009; Whitmarsh 2011). However, these authors have not yet explored how the goal of empathic engagement may itself be problematic, especially with regard to the privileged position that empathic engagement with CCCC demands of users of narrative and AR-based geospatial tools.

While recent work has engaged with the ethics of visual storytelling through maps (Roth 2021) and suggested inclusive paths forward, in this conclusion, we return to our earlier discussion of the MCM vis-a-vis approaches that highlight the contingent, always interpellated aspects of cartography. If critical cartography first deconstructed the map and called into question the power hidden by the mapmaker, more recent work has suggested that maps should not be viewed as secure objects of communication from map designer to map reader (Dodge et al. 2009). Following this line of thinking suggests that one path forward may lie in an intentional use of the flattening and unfolding experiences of CCCC described above, one which uses interactive changes in perspective and scale to play with and against dominant narrative structures regarding climate change and expectations of what constitutes a map. Carrying users on (short) trips to different landscapes, perspectives and experiences can inform and engage, but equally important is designing geospatial tools that effectively return users from the experience in a way that meshes with their lived realities and landscapes. The work of Bergmann and Lally suggests a path forward in this vein, noting that we 'need not settle for GIS [Geographic Information Systems], nor their geographic information, nor their limited cartographic repertoire' and instead suggest 'a flowering of more-than-Newtonian approaches to geographic inquiry in speculative digital realms' (2021: 26, 32). This stands in contrast to the assumptive experiences promised by maps as static means of communication which eschew imaginative and speculative possibilities in favour of 'aspirationally

precise' measurements of both climate change and the effectiveness of maps in communicating its impacts (2021).

Matthew Edney (2019) argues that the modern cartographic ideal is exemplified by the faith placed into the scale bar of modern maps – accurate at only certain, individual points on the map, but presented as definitive, it reflects the aspirationally precise illusion of authority cartographic representations seek. As the examples in the previous section suggest, CCCC has largely viewed maps in such a light. Even when engaging with empathy and narrative, the goal has been to measure accuracy, to weigh the impact the map *author's* creation has had upon the map *reader*: the map is accurate and contains information, the goal is to maintain its accuracy while increasing engagement with its information (as quantitatively measured). Through this derived disjuncture of map author and map reader, coupled with an emphasis on quantitatively measuring engagement, a quiet elision occurs. Namely, even if quantitative measures eventually identify cartographic techniques that overcome the challenges to empathic engagement described in our case studies and succeed in transporting most users – making them feel present in a landscape of climate catastrophe and engendering active and sustained engagement with climate change impacts – these benefits will almost certainly not accrue equally to all and may be least accessible to those who are most vulnerable to climate change. *Too much* narrative transportation, *too great* communication of climate change impacts can overwhelm viewers who already face other stressors and pressures – particularly if support is not offered to return users from the narrative feeling empowered rather than distressed. In the United States, climate change impacts have been unequivocally shown to be greater for poor people and people of colour (Frosch et al. 2018), and yet these are the same groups that due to other factors in their lives may be excluded from the benefits of engaging presentations of potentially overwhelming climate impacts.

This is not to suggest a patronizing, othering frame in which information is obfuscated to further increase quantitatively measured engagement for participants prejudged as unable to process more intense forms of communication. Rather, it is a call for practitioners of CCCC to reject the frame in which maps function as unidirectional tools for communication. *Sense of presence is not sense of place and narrative transport cannot be the final destination.* Effective, equitable CCCC demands an understanding of the map reader as a co-constitutive participant in the experience of the map (Wilmott et al. 2016), one that's integral in taking the information intended to be communicated out from the visual experience and into their own lives. For some, truly immersive AR experiences may be exactly the correct amount of narrative transportation; for others, it might be overwhelming. CCCC practitioners must embrace the co-constitutive nature of mapping and eschew measurements which place the effectiveness of communication as a linear measurement where more is always better. 'Know your audience' may seem neither a particularly new nor radical suggestion; however, within the framework of CCCC it is too often ignored in favour of quantitative measures of unidirectional communication. While significant research will be necessary to achieve these understandings, and historically the links between more critical cartography and more positivist branches have been fraught (Schuurman 2000), the stakes of climate change and the importance of equity in any response thereto require such work. To begin such work, we call for CCCC to:

- First, begin by acknowledging that the empathic engagement that CCCC tools are designed to encourage is a privileged experience. Even if the technology is accessible, it requires a strong emotional investment that may not be possible for all participants at all times.
- CCCC practitioners must further recognize that acknowledgement is not enough and practise mapping that accounts for the role of the map reader as co-constitutive of geospatial tools. Here, empty spaces and intentional ambiguities open spaces for the reader to project and include their own experiences, opening potential for readers/users from diverse backgrounds and perspectives to more fully engage with the cartographic imaginaries and narratives of CCCC. Here, particularly, CCCC practitioners should move past settler cartographies and consider alternative practices to mapping including, but not limited to, Indigenous mapping, counter-mapping and performance cartographies (Kahele and Louis 2017; Fujikane 2021; Collective et al. 2012).
- Explore playful, complementary combinations of new and existing techniques that work with – rather than against – the grain of intended narrative. For example, the cartographic components of story maps often hold their subjects at a distance, potentially pulling the user out of the narrative. AR promises a more grounded perspective, but often lacks narrative depth and emotional connection. Combining the two could artfully unfold and deepen the representation of cartographic content in a way that echoes the emotional beats of the narrative. Following Bergmann and Lally, we once more call for CCCC practitioners to pursue ‘a flowering of more-than-Newtonian approaches to geographic inquiry in speculative digital realms’ (2021: 32).
- Finally, significant work must be done on how to guide diverse users in their re-entry from engaging cartographic narratives or experiences. How can a story map or AR experience be designed to more clearly connect to users’ daily routines, and how can these connections ultimately drive lasting attitudinal and behavioural change? How might these re-entry paths differ based on users’ positionality/intersectionality?

These last questions form the core of the praxis of an inclusive and equitable CCCC, one that moves beyond a presumptive knowing of one’s audience to a co-constitutive knowing with. They require a step beyond an assumption of a positivist answer and a step into a reflexive practice of mapping informed by a theory that eschews the designer-user dyad.

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