Climate change and the imagination

Kathryn Yusoff and Jennifer Gabrys (2011)

Published in *WIRES Climate Change*, 2

The Possible's slow fuse is lit By the Imagination.

- Emily Dickinson

Imagination is the key to pre-experiencing alternative futures.

- Gyorgy Kepes

Introduction

This paper explores the complex terrain of the imagination [1] as a way of understanding and exploring the manifestations of climate change in culture and society. Imagination here is understood as a way of seeing, sensing, thinking, and dreaming the formation of knowledge, which creates the conditions for material interventions in and political sensibilities of the world (Box 1). The genealogy of the 'imagination' as a historical and cultural form is vast and inseparable from the ontological formation of the human, constituted in relation to the environment or material world. Thus, how we imagine the world constitutes our genesis of being, as Samuel Beckett's coda 'Imagination Dead Imagine'[2] makes explicit. In the history of thought, Descartes' binary of an inside and outside of perception constructed an internal imagination in contrast to the material world outside [3]. In his study, The Weather in the Imagination (2005), Lucian Bola offers a similar positivist view of climate as something 'out there' mediated by the imagination. An alternative approach might consider how imagination is actively produced through iterative processes and practices that establish dominant framings of the imagination.

There are two distinct schools of thought here. (1) Imagination as a relational space that is informed by the objects and subjects with which it is entangled. (2) Imagination as a mediator between the positivist world and the human mind. This way of describing the world as divided between an internal perceptual faculty (the imagination) and an external material reality (the world) has been thoroughly contested in a range of different disciplines, such as sociology,[4] geography,[5] art theory,[6] postcolonial studies, literature,[7] philosophy,[8] feminist theory,[9] and more recently in the post-humanities and social theory. Kearney suggests that while there is a plurality of terms for the imagination, they all adhere to a basic trait of capturing 'the human power to connote absence into presence, actuality into possibility, what is into something—other-than-it-is. In short, they all designate our ability to transform the time and space of our environment into a specifically human mode of existence (Dasein).'[10] What we can say now of the imagination is that rather than being the site of division it is a site of interplay between material and perceptual worlds, where concepts cohere, forces pull and attract, and things, discourses, subjects, and objects are framed, contested, and brought into being.

It is now well understood that anthropogenic climate change is as much a political, social, and cultural event, as it is a scientific one. New scientific knowledge of climate often has to contend with existing knowledge structures and imaginations of environmental processes, as well as

challenge dominant framings and trajectories of societal development (such as unlimited growth and technological mastery).[11,12] While a majority of work on the social life of climate change has been marked by a distinct concentration on scientific,[13] technological and economic [14] approaches to climate, parallel work in the disciplines of geography,[15] political science,[16] environmental history,[17] anthropology,[18] creative practice,[19] and science studies [20,21] has begun to pay attention to climate as a dynamic cultural and societal force capable of reshaping societies and environments.[22] Further to this reimagining of climate as a social as much as a scientific event, there have been a growing number of voices that have contested the 'deculturing' of climate change [23] and challenged the role of climate science as a basis for effective decision making under conditions of uncertainty.[24] What was once termed 'Human Factors' [25] or 'Human Dimensions' [26] in scientific models of climate change and conceptualized as an arena for the dissemination of scientific knowledge and the programming of behavioral change has been reimagined as a far more potent space in which new knowledge and understandings of climate change are made and enacted that move beyond climate science into new interdisciplinary spaces within and beyond the academy. Climate change, in short, is being reimagined as an ethical, societal, and cultural problem that poses new questions and reconfigures the geographic imaginaries of the world.

These new cultures of climate change can be characterized by three distinct temporal and spatial imaginative framings of climate change:

First, there has been a concentration on the futurity of climate change, including the arts and techniques of imagination that are bound up with making scenarios, narratives, and contingency plans that project toward or back from uncertain futures. An engagement with the arts of futurity can be seen in the workings of the Intergovernmental Panel on Climate Change (IPCC); the practices of scenario modeling; back-casting and forward-looks that characterize much of the science–policy interface of climate science; and the economics of futures markets (Chicago Climate Futures Exchange), weather derivatives and climate risk insurance. However, climate futures have probably had their most imaginative expression in the catastrophic renderings of abrupt climate change. Often drawing on the same array of popular environmental concerns that date to the 1960s (resource shortages, population explosions, peak oil, environmental collapse, technoscientific disasters), climate-change catastrophism reproduces familiar concerns with social destabilization caused by finite resources and environments gone awry as a consequence of human hubris. In the imagining of the unimaginable, these extreme scenarios often seek to redefine or challenge the acceptable limits of the discourse of climate change through speculative science fiction or an engagement with what Susan Sontag called the 'aesthetics of disaster'.[27] This speculative turn in climate futures is instigated by the uncertainties inherent in climate impacts and predictions. These uncertainties open a generative space of unknowing that has been populated by various 'visions' of the future. The arts of this futurity are anticipatory, preemptive, and promiscuous.

Second, there has been (post-Copenhagen) a tacit acceptance of the need for adaptive strategies that can be embedded in everyday practices. This entails an imaginative recasting of climate change as something that is not 'out there' (located in a global imaginary or in distant places such as the Arctic or Sub-Saharan Africa), but as something that has relevance for all cultures across all scales, and thus is something 'in here', entangled in contemporary practices and future possibilities. This process of re-public-ing [28] and re-locate-ing [29] climate change has motivated a number of projects that rework the representational practices of climate into the intimate and social sphere.[30] These practices are in distinct contrast to the causal models of climate-change science that imagine humans as either drivers of climate change or recipients of

its effects, rather than as a heterogeneous and differentiated social body with distinct desires, constraints, and imaginations.

Third, this 'cultural turn' in climate change has seen a critical engagement with the practices of climate science. Multiple creative practitioners and researchers are now seeking to expand modes of climate science production to reconsider the social spaces of climate interaction at the science-policy-public interface, and to promote new forms of the coproduction knowledge between different communities of practice (such as science–art or art–public collaborations). This latter work, which seeks to redefine the boundaries of climate beyond science, has been led by both academics interested in the social and historical study of science [31–35] and creative practitioners interested in engaging in what this scientific knowledge does in the world, as both creative practice [36–38] and public engagement.[39] These responses to the dominance of science-led investigations into climate change have sought to find ways in which to democratize climate science by reorientating the models of practice and politics of expertise, as well as reimagining the experience of environmental data and the possibilities of its use with diverse publics.

Futures: Hopeful and Catastrophic Imaginations

Climate change is a social, environmental, and scientific phenomenon that is characterized by its relationship to futures. Scientists predict levels of carbon concentration and future states of the planet through climate models, while politicians appeal for collective participation in shaping futures through anticipatory logics.[40] At the same time, industries attempt to manage and speculate on the risk of future climates, and creative practitioners imagine possible future worlds. 'Futures' as an area of study has received increasing attention, particularly in relation to risk management, [41,42] disaster management, [43] and scenario building.[44] Yet within this work, there has been scant attention as to how futures could be deployed as a cultural and creative method of environmental imagining and how the arts and humanities could contribute to future narratives. The arts and humanities play an important role in thinking through our representations of environmental change and give tangible form to the imagination of different worlds outside of the constraints of the given present. The uncertain futures of climate-change impacts have had profound effect on the public imagination of and engagement with climate change.[45]

In this respect, climate science arguably requires even more sophisticated integration with complex cultural and political systems not just to anticipate and mitigate future impacts, but also to reconsider the political and temporal logics that underpin current scenario trajectories, and examine the descriptive crafts that produce them as spaces for the imagination. As Barbara Adam comments:

> The scientific production of the future, in the form of technological innovations, it seems, stands in an inverse relation to the capacity to know the scientific creations with all their potential consequences. That is to say, the techno-scientific ability to produce futures is not matched by scientific knowledge of futures thus created. This gap between science-based action and scientific knowledge of impacts raises the specter of structural irresponsibility at the very core of science: for the translation of scientific knowledge into products and for the scientific guidance that underpins inter/national regulation and politics.[46]

Adam suggests that the casual logic that underpins scientific reasoning and its evidential base is unhelpful when there is no past precedent from which the future can be extrapolated with any degree of certainty.

While it is clear that imagining is as ground-breaking a process in the sciences as it is in the arts and humanities, the work of the imagination in science remains buried in practices and intuitive forms of testing that are not properly acknowledged in the descriptive arts of climate future scenarios and the metrics of baselines. While scenarios may be acknowledged as learning or mediating tools to communicate vulnerabilities, perceptions of risk or possible consequences, they often inadvertently become taken as statements of the future, thereby acquiring a solidity and authority that is unmerited (because we have no precedent for climate change under current social conditions). Arts and humanities scholars and practitioners in collaboration with scientists can reconsider how climate futures are imagined, who is involved, and how these practices constitute future worlds. This process of imagining and enacting future worlds encompasses the metaphorical, ethical, material, and imaginative registers through which environmental understanding emerges. Furthermore, these predictive methodologies of climate science policy, which differ markedly from materialist forms of knowledge on which empirical science is based, challenge us to recognize the changed conditions of knowledge production in the climate sciences. This is much more akin to the descriptive arts of the humanities, in the production of probable, preferred, or hoped for futures.

Climate futures arguably require approaches that are not only characterized by calculability and risk, but also mobilize imaginative acts that open new spaces and practices for dealing with the effects of living with uncertain futures. There is much work to be done in the 'cultural' sphere of how we respond to climate change, and how we might realign the practices and contexts of science production. Rather than define 'arts' and 'sciences' as separate disciplines in need of intersection,[47] however, many new creative and scientifically informed practices are emerging that focus especially on new opportunities for political participation and public engagement with climate change.[48] Creative practices may open up new scales of sensation, new forms of representation, both aesthetic and political, and expanded publics for engaging with this critical issue.[49] However, the most radical potential of the arts and humanities is the ability to constitute alternative possibilities to neoliberal approaches to environments,[50] which actively attempt to disable the imagination of alternatives, outside of economic systems of environmental governance and the valuation of natures that capital can 'see'.[51] In this sense, arts and humanities do not just or necessarily 'mediate' science, but rather the intersection of these fields realigns these disciplines and the terms of their encounter, providing not just practical adaptation, but also cultural resilience in the production of alternatives.[48]

Representing climate change is an imaginative and creative act that joins the sciences, social sciences and humanities, although the historical forms that constitute these representational troupes differ markedly. Imagining futures is also a political act that configures present actions, behaviors and decision making or future presents. In risk theory, determining what counts as significant risk configures the sphere of the actionable, and thus the sphere of mitigation. The sociologist Ulrich Beck suggests that the politics of climate change is productive of a world at risk, so that we now operate at the level of the world object.[52] While the imagination of the world at risk produces a dispersed and politically diffuse set of relations that makes attribution difficult, Beck argues in his Cosmopolitan Manifesto that new communities and forms of solidarity might arise from these shared imaginations of risk. While risk theory [53,54] and scenario building have led the examination of climate futures, an interdisciplinary approach to developing climate futures provides a more robust understanding of the social and cultural dimensions of futures, and the descriptive and persuasive arts that have been employed in creating those futures as spaces in which new concepts can take hold. The arts and humanities have long been involved in the creation of future environments, whether through science-fiction imaginings of possible catastrophes; designs for new environments; or through speculative proposals for environmental

practices. Understanding future representations as a practice that describes environments in the present and their imaginative possibilities to become otherwise is part of how we might understand how possible futures are set in motion.

The classic texts of postwar environmental literature, including Rachel Carson's Silent Spring (1962), Donella Meadows' Limits to Growth (1972), and James Lovelock's Gaia Theory (1965), have all been reissued or revisited [55–57] in the context of climate change. This thematically situates climate change within a modernist trajectory and its attendant cultures of catastrophe that signal the limits of science, in which science sows the seeds of destruction through the creation of new risks. In the 1950s and 1960s, it was atomic bombs that put the world at risk (powerfully imagined in films such as Barry Hinds' and Mick Jacksons' Threads (1984), Jimmy Murakami's When the Wind Blows (1986) Nicholas Meyer's The Day After (1983), Peter Watkins' War Game (1965), and in B-movie classics such as Gordon Douglas' Them! (1954); in the 1960s and 1970s, the gigantic irradiated ants of Them! came back as oversized amphibians in Frogs (1972), a consequence of the chemical revolution and its threatened mass mutations; while exploding populations and resource shortages were also a major concern for science fiction (the most notable being Richard Fleischer's Soylent Green (1973) (Figure 1) based on Harry Harrison's novel, Make Room, Make Room (1966)) and the attendant ecological destruction of overexpansion (see Douglas Trumbull's Silent Running (1972)). The science fiction that emerged from modernity and its cultures of catastrophism displayed a distinct fascination with disaster at moments in history when it became easier to imagine the end of the world than alternative futures.[58,59] While these filmic futures may seem fantastical, we can also view them as the imagination of environmental returns, figured through the specter of wastes and mutations, which motivate a consideration of what is hidden from our current perceptive and temporal frame. The dispersal of form that these environmental returns took—Them, The Thing, The Bomb— Sontag suggests was 'the contemporary negative imagination about the impersonal' [27] that informed perceptions of environmental risk. In climate change, we can see a similar negative imagination of the impersonal when climate is constructed as exterior to society (as an environmental problem not a social problem), which will return (in both the material and Freudian sense) to haunt postindustrial society.

Figure 1. *Soylent Green* film poster, dir. Richard Fleischer (1973).

Lawrence Buell illustrates the various imaginations (pastoral, moral, liberal—and their failure) articulated by American writers and demonstrates how such imaginations created, mediated, and concretized the productive relations between landscape and desire in American culture. He suggests:

> Apocalypse is the single most powerful master metaphor that the contemporary environmental imagination has at its disposal. Of no other dimension of contemporary environmentalism, furthermore, can it be so unequivocally said that the role of the imagination is central to the project; for the rhetoric of apocalypticism implies that the fate of the world hinges on the arousal of the imagination to a sense of crisis.[60]

Buell suggests that this framing reveals that the greatest threat is perceived not as the threats themselves, but our perception of them. Research into public perceptions of climate change has revealed confused [61] and often contradictory understandings of climate change,[62] which can hinder the ability to identify effective strategies to address it.[63–65] This perceptual confusion often becomes manifest over time in shifting opinions about the risk of climate change and its veracity, and is highly dependent on the preoccupations of media coverage.[66] Buell also suggests that there is a perception that environmental concern will only be activated by a great ecological disaster: a 'Great Ecological Spasm', as he calls it.[60] But this, he says is 'only a permutation of the first: in both cases, the imagination is being used to anticipate and, if possible, forestall actual apocalypse'.[60] What becomes clear is that the imagination not only shapes the perception of the climate change but co-fabricates it in ways that effect the possibilities to act on it. In this sense, imagination is not external to the object of study (climate change), but actively produces it as an event in differentiated ways: rational, apocalyptic, modernist, scientific, utopic (heralding the end of capitalism), and ontological.

Much has been said against the 'doom-laden' narratives of climate change as being unhelpful, [67] a distraction, or simply as the source of misinformation, and research that has examined the shifting tides of media attention that are given to climate change has borne out this critique. But to frame all such attempts to engage with disastrous or catastrophic renderings of climate change as negative misses the point of the creative role of fiction and the cautionary offerings of the disaster. [68,69] A story at its best, asks us to imagine alongside the protagonist of a story the full range of emotional challenges and difficult choices that have to be made once all the usual landscape markers and reference points have shifted or disappeared. While films like The Day after Tomorrow focus on the catastrophic event of climate change and revel in its spectacular destruction,[70] Cormac McCarthy's The Road (2006) and J G Ballard's The Drowned World (1999) push us toward imagining what it will be like to live on through the disaster, in a post-apocalyptic world of everyday survival. Novels such as The Road and Margret Atwood's Year of the Flood [71] provoke us to think about what it might be like to endure and survive, both emotionally and practically, within changed environments. Distinct climate-change works to emerge in recent years include Ian McEwans' Solar (2010) about a washed-up academic on the international climate-change circuit; Doris Lessing's Mara and Dann (1999) set in a new Ice Age in Africa; and Kim Stanley Robinson's trilogy, Forty Signs of Rain (2004), Fifty Degrees Below (2005), and Sixty Days and Counting (2007), which deals with ecological and sociological themes of climate change through the lens of the National Science Foundation, while exploring themes of alternative utopianism.[72] Frederic Jameson writes about Stanley Robinsons' Science Fiction (SF): 'Utopia as a form is not the representation of radical alternatives: it is simply the imperative to imagine them'.[73] Frederic Jameson sees SF as a crucial intervention in social thought, a cognitive space of critical imagining that offers a 'representational mediation on radical difference'.[73] The utopian potential of SF is its ability as a narrative form to imagine an outside to scientific knowledge, while maintaining a dialectic relation to it, thus making us aware of our epistemic limitations.[74] As James Kneale and Rob Kitchin argue, SF can be seen more as 'a gap: between science and fiction', an 'interest in the fragile fabrication of mimesis' that offers 'a privileged site for critical thought'.[75] What writers like Stanley Robinson make clear is that science fiction takes the most speculative dimensions of science and imagines what these speculations might look like if they were to become manifest in the world.[76] In this sense, speculative science fiction is a cultural meditation on risk.

Imaginings of devastated social and environmental landscapes are often absent from political and scientific understandings of climate change, which take epistemological or rational approaches, often eschewing speculative or polemical descriptions of future scenarios. Yet, fiction can allow us to trace the contours of a changed world and to experience its dislocation across social, cultural, and emotional registers. Many environmental disaster novels are then landscape novels in which the protagonists must cultivate a relation to the destroyed and changed landscape in order to survive, as Ballard describes:

> This growing isolation and self-containment, exhibited by the other members of the unit... reminded Kerans of the slackening metabolism and biological withdrawal of all animal forms about to undergo a major metamorphosis. Sometimes he wondered what zone of transit he himself was entering, sure that his own withdrawal was symptomatic not of a dormant schizophrenia, but of a careful preparation for a radically new environment, with its own internal landscape and logic, where old categories of thought would merely be an encumbrance [77].

This fictional journey then becomes both a form of emotional and social adaptation for the protagonists and the reader, a means to rethink a radically new environment. Held as we are through emotional bonds formed with the protagonists, the passage through altered landscapes may be crucial to how we culturally adapt to the new landscapes of climate change. Fear and hope

about climate change may or may not drive action, but they are a part of how we register and understand environmental change, and in this sense they are instructive to understanding the imaginings not just of futures, but also of modes of adaptation. In this sense, the imagination of climate change landscapes is an entry point for examining environmental relations to identity, place, practices,[78] and nonhumans,[79] what can be referred to as the environ-mental imagination.

Imaginations of the far-flung future/past and stories of scientists as time travelers are not only found in fiction, but also often pervade popular science accounts of climate change,[80] particularly those that deal with the artifacts of ice cores and the discourses of abrupt climate change.[81] For example, Gale Christianson starts his account of the 200-year story of global warming, Greenhouse (1999) with this epigram from H G Wells:

> The past is but the beginning of a beginning, and all that is and has been is but the twilight of the dawn [82]

It is likely that Richard Alley had in mind Wells' time traveler when he suggests that ice cores afford the possibility of traveling in time, and thus by extension, the ice core scientist must be imagined as the modern-day time traveler. In another story of ice cores, The Ice Chronicles, the biologist Lynn Margulis imaginatively frames ice cores as both a new historic rule and an heroic witness to time's arrow, a 'rocky biopsy of the Earth's skin'[83] or 'missives from the past' in which 'the real hero is a long skinny chunk of icy layered sediment that faithfully record 40,000 human lifetimes of weather change'.[84] Similarly, Alley suggests,

> To read the record of past climate shifts, we have to find the right history book. Humans hadn't yet mastered writing the last time the climate jumped, so we can't look up the answer in the library. Fortunately, there is a sort of ''library'' in ice sheets... [85].

The iconic and alluring nature of the ice core as a modern day witness to history of weather has not escaped the attention of artists or iconoclasts. An ice core forms the basis of the Science Museum, London exhibition of Atmospheres: Exploring Climate Science (2010), and it is a key iconic object that shifts the temporal horizon of climate pasts and futures in narratives of climate change [86–89].

Iconic objects and images have been crucial to the narrative of climate change in the popular imagination, and icons such as the polar bear have had a marked impact across the affective and sensuous registers of climate-change politics.[90] While polar bears may now seem a somewhat cliched rendering of climate change, it is useful to explore how icons and iconic places in the narrative of climate change such as polar bears,[91] the Arctic,[92] and sea ice,[93] mediate climate change for audiences, functioning as boundary objects,[29] examples of contested cross-cultural objects,[94] and narratives that circulate in much different ways in Western and indigenous cultures.[95] Establishing effective cross-cultural dialogues around climate change involves taking account of differing and often contested geographical imaginaries of places, people, and things, as well as establishing common matches and meeting places in climate knowledges.[96] As such, an attention to the imaginative constructions of climate change suggests a need to pay attention to multiple positions in the dialogs between different cultural perspectives.

In our imaginations of climate futures (and climate pasts), whether in computer models, carbon sinks,[97] or experimental architectures, we are always rendering an ordering of time that denotes a relation between the past, present, and future. For science and fiction alike, the imagination of

futures requires a careful critique of the ideologies of time—particularly in relation to present action—that are being produced. The most common of these are:

1. The present as a sum composed of past and future (time imagined as a package).

2. The future as a telos of the past (time as linear, continuous, if not progressive).

3. The future as a sphere of action based on enframings of the past and future in the present (time as a space of action, an emancipatory possibility of the present).

4. The future as the possibility of becoming otherwise (time as dislocation).

Commenting on the future in a way that is deeply instructive for our present relation to time, philosopher Elizabeth Grosz notes,

> It is not... the reconstruction of the past that helps explain our present, but an understanding of our present, and its dislocations, that helps bring about unknowable futures [98].

In the dislocations of the present, the imagination of the future is a catalyst for thinking about how we might be in the world in other, hitherto unthought ways. Future imaginings can thus be thought of as a process for developing adaptive capacities and emotional resilience within changed environments.

Adaptation: Imagination by Degree

Adaptation often appears to be the less dramatic imaginative counterpart to the catastrophic future scenarios of abrupt climate change. In this respect, adaptation practices may be presented as viable and pragmatic alternatives for configuring attainable climate futures, typically through iterative and local every-day practices. Within this conceptual framing, climate change is not imagined as something that will either teach us a catastrophic lesson or rescue us from our current neoliberal culture by forcing the development of new economies and values. Instead, climate change is located 'in here', within our cultural practices and our everyday lives, rather than 'out there' as a remote and global force of alterity. Climate change in this framing is understood as something in which we participate, and that is embedded in our lives. This imagining of a more local scale of climate change securely locates it in the realm of personal and social action.

At the same time, however, adaptation presents issues related to the politics of liveable futures: who decides the modes of adaptation or toward what conditions is adaptation directed; what and whom does adaptation involve; at what scale are these scenarios envisioned, and how are they carried out? The imagining of adaptation scenarios may at times simply sidestep these issues and present scenes of relative self-sufficiency or autonomy or, alternatively, these scenarios might involve actors of socioeconomic privilege, while neglecting those persons or locations where resource limitations may raise entirely different issues about what constitutes viable modes of adaptation.[99] Moreover, 'preparedness', as Andrew Lakoff points out, while signaling toward 'a way of understanding and intervening in an uncertain, potentially catastrophic future',[100] has as much to do with addressing political inequalities within present practices as it does with a state of readiness for catastrophic future scenarios.

These complexities of adaptation are often taken up in creative practice projects that present alternative living scenarios for environmentally precarious futures that are at turns oriented toward imagining and critiquing survival practices and technologies. Practitioners and researchers within art, design, architecture, and engineering have focused especially on the city, the community, and the scaled-down unit of the home, as key sites of adaptation and intervention

that span from the practical to idealistic and the ironic. While the home is often imagined as a key space in which to manage and regulate individual consumption,[101] it also functions as a space of imagined self-sufficiency for weathering eco-catastrophe. Historian of science and design, Peder Anker suggests that a number of 'ecological architecture' projects from the 1960s onward have often put forward proposals for sustainable living that are based on a relatively questionable parallel to autonomous or 'spaceship' technologies.[102] Many of the imaginaries and proposals for adaptation within climate-change imaginaries draw on the 1960s and 1970s living experiments, including Buckminster Fuller's geodesic domes,[103] Jack and Nancy Todds' systems for 'living machines' that encompass food, energy, and shelter,[104] and Ken Yeang's green skyscrapers.[105]

These approaches to imagining sustainable architecture in many ways continue to inform contemporary creative practice projects addressing similar concerns. The artist Mary Mattingly has developed multiple projects, including a self-sustaining barge, Waterpod (2009, with Ian Daniel), and Flock House (2010, with ecoarttech et al.), a living experiment that imagines 'how communities deal with disaster followed by a steadily encroaching sea', that bring forward such strategies for addressing climate change. The Flock House (Figures 2–4) addresses the question of climate-change survival by proposing a structure for continual movement, since 'survival is keeping your community on the move':

> The Flock House finds your community living behind a protective tsunami shield, collecting diminishing rainwater, and growing food in hanging gardens with reclaimed wastewater. Conventional wastewater treatment plants are too big, too energy intensive, too chemically dependent and, perhaps most importantly, too stationary. The Flock House natural water treatment system allows your community to quickly establish new systems in each successive move. Treatment ponds and wetlands are left behind and on-board nurseries provide quick replacement. Aquatic plants and microorganisms leverage natural processes to supply your community with consistent, coveted water [106].

This structure, which has been implemented as an actual 'living prototype', is imagined to be mobile in all modalities: airborne, seaworthy, and automotive, a 'capsule' that may adapt to rising sea levels by remaining mobile. While the Flock House perhaps embodies many of the adaptive technologies that are characteristic of attempts to deal with resource shortages and infrastructure collapse, at the same time these technologies are packaged in a self-contained mobile architecture that lacks context. Anker suggests that such approaches to self-sufficiency, or developing architectures that are 'closed loops', where the domicile floats free of worldly constraints and concerns may limit our ability to consider how living consists more of joined up cultural, political, and even aesthetic matters.[102]
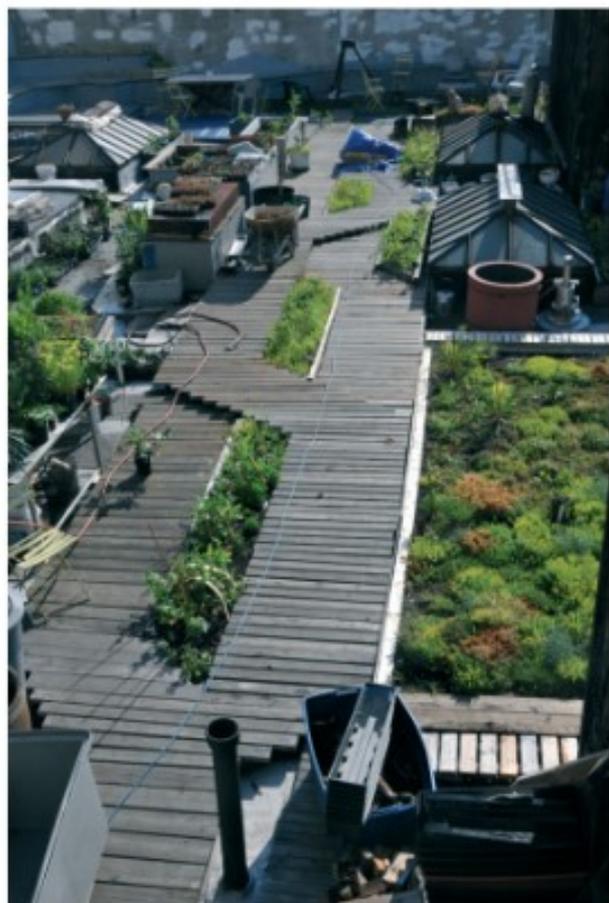
Figure 2, 3, 4. *Flock House*, Mary Mattingly et al., 2010.

By imagining autonomy to a point of excess, however, it may be possible to engage in the practice of 'ironic ecologies', which Bronislaw Szerszynski suggests may be effective in moving away from a strictly solutions-based approach to environmental change, to consider how a 'crisis in political meaning' may be one of the key areas to address when considering environmental adaptation. An approach that encompasses irony allows a greater investigation into our inability to adapt or to address the 'gap between 'is' and 'ought' within environmental practices.[107] The Yes Men's Survivaball (2006), an autonomous living pod originally presented as a spoof Halliburton product, is at once a critique and parody of a highly individuated if technologically advanced attempt to survive catastrophe, particularly since that catastrophe may be seen to be inflicted by the neoliberal corporate culture that peddles such merchandize, thereby making a profit from the very disasters to which it has contributed (Figure 5). Numerous creative practice projects then take up the issue of individual survival, from Stefan Szczelkun's Survival Scrapbooks, do-it-yourself (DIY) manuals for self-sufficient living dating to the 1970s and featured during the Foundation for Art and Creative Technology (FACT) Liverpool exhibition, Climate for Change (2009),[108] to the Museum of Modern Art (MoMA), New York exhibition, Safe: Design Takes on Risk (2005), which features a number of projects that propose home survival kits and security devices for life in a state of lockdown. Imaginings of catastrophic futures inform these projects, revealing how different future imaginings motivate different practices of adaptation.

Such adaptation strategies and proposals raise questions about the necessary connections and relations that might actually facilitate 'survival'. Environmental imaginaries of survival and adaptation may have the tendency to pare down the basic unit of living to the bunker or the self-sufficient barge. At the same time, these projects beg the question of what other systems cannot be eliminated from spaces and practices of 'survival'. Resilience and preparedness, as discussed above, may not be best realized—or imagined—through depoliticized capsules for survival, but rather through more thorough-going encounters with the social and political connections that make survival and adaptation possible—and ethical. [109,110] Such encounters inevitably raise questions about the scale at which we imagine adaptation to be viable. Is a living pod, reminiscent of the Biosphere 2 experiment; an ecological community with an 'energy descent plan',[111] as the Transition Town experiments that have now proliferated from the United Kingdom to become a worldwide phenomenon; a sustainable city; bioregion; or nation the most 'sustainable' scale at which to imagine adaptation and response to changing climates? Or, are these categories not necessarily mutually exclusive, and do practices of adaptation necessarily need to account for connections made across these scales and situated modes of experimentality?

Figure 5. *Survivaball*, Yes Men et al., 2006.

Cities are larger-scale sites of both utopic and dystopic imagining in relation to climate change - many of the images of climate-change catastrophe feature flooded and ruined urban centers, whether of New York, London, or Shanghai. Cities are then sites for renewed interest in adaption planning and creative interventions for new forms of urban living. Changes to building practices and infrastructure are areas where many efforts are focused within urban adaptation proposals. Adaptation to climate change is influencing urban planning initiatives worldwide, including new approaches to building on coastal land in Singapore, and prototypes for floating homes in the Netherlands.[112] The built environment, land use, urban agriculture, and infrastructure, are sites for adaptation proposals and projects, not just at the level of planning and engineering, but also through creative practice and climate-change imaginaries.

In the proposal Thurrock 2015, commissioned through the Visionary Thurrock planning project developed by the urbanism practice General Public Agency, artist Nils Norman presents 'some solutions to the ecological and social impact of global warming on Thurrock, Essex, UK'.[113] These solutions are generated and gathered through a mobile research vehicle powered by hydrogen fuel-cell technology, which he used to conduct fieldwork and engage Thurrock publics in conversations on adaptation to climate change. The project was conducted through a collaborative team of creative practitioners proposing 'design solutions' for climate change in Thurrock. As Norman outlines in his Thurrock 2015 pamphlet (2004), the 'emergency problem solving workshops' cover everything from 'sea defence' to 'gardening actions'. The climate-change adaptation proposals range from the practical to the romantic and idealistic, including 'utopia study'. At first glance, these participative adaptation strategies might appear to be a fantastic laundry list of save-the-world proposals. Yet these multiple strategies assembled together instead create a dialog among these different adaptation practices: utopia study may in fact be as important a site of investigation as sea defence, since our future imaginings of ideal relationships with environments informs what counts as practical—or possible—in the realm of climate change. By activating a space for public dialogue about adaptation, Norman potentially enlarges the scope for considering how adaptation is imagined, and who is involved in resourcing and implementing those imagined adaptations.

Urban infrastructure projects are key areas where many of these questions about adaptation are materialized. Climate-change adaptation in many ways is generating a new wave of proposals for reimagining urban processes, from green infrastructure projects that propose new connecting networks of green space to improve the ecological processes of cities,[114] to new ways of imaging water infrastructure not as centralized use and disposal but rather as decentralized systems of reuse and recycling,[115,116] or transport proposals that implement new forms of urban movement or dialog about circulation in the city.[117] Urban imaginaries are well-known sites of grand visions that often collide with political complexities and local conditions, and proposals for climate-change oriented urban infrastructure projects raise similar questions about the methods of participation and implementation. At the same time, projects such as Thurrock 2015 and Actions: What You Can Do with the City (2008–2009), a composite of DIY urban interventions curated through the Canadian Centre for Architecture, suggest there are many ways in which urban publics may become engaged in thinking through and implementing adaptation not just at a master-planning level, but also at the level of everyday practices and community organizations.

A focus on urban actions at the level of do-it-yourself urban interventions suggests that not just spatial scale, but also the scale of practices are key ways in which adaptation scenarios are imagined. A number of creative practice projects engage with community as the scale at which environmental intervention and adaptation is imagined or proposed. More contemporary imaginings of alternative modes of living propose adaptation through a 'graceful' retreat from rising sea levels, as with the Helen and Newton Harrisons' Greenhouse Britain (2007) project that addresses how to relocate communities in the United Kingdom away from coastal areas subject to sea-level rise. Transition Towns are, in a much different way, a community of practice that attempts to realize new strategies for living beyond Peak Oil, and without an excessive reliance on fossil fuels and distributed trade networks. The proposals that emerge from new forms of transport to community-based energy generation and alternative currencies recur in many creative practice projects that attempt to intervene in the space of everyday life, and thereby reveal just how interconnected economic exchange or energy generation are with extended cultural networks.[118] Interventions into the home may take place at the level of reimagining the home as self-sustaining system, as discussed above, or at the level of recasting everyday consumption or energy practices, including energy monitoring technologies such as Ben Engebreth's Personal Kyoto (2006),[119] or the Interactive Institute's power-monitoring cord, STATIC! (2004). As these multiple projects indicate, adaptation is ultimately more than a technical matter, and public and community participation in developing climate-change adaptation suggests that cultural and political aspects of adaptation are just as critical to the imagining of climate change as technical innovations. Such participation, which is not always straightforward or easily called upon,[120] extends not just to imagining collective futures and implementing adaptive responses at multiple scales, but also to developing new forms of public engagement with climate science and climate politics.

Climate Practices

Engaging with climate change in multiple ways (beyond science) then asks questions of sites, networks, knowledges, and practices of constructing, producing, or invoking climate. A common route into climate for art-public collaborations has been to talk about the weather. While climate is the sum of the more than day-to-day weather events that take place, many of our on-the-ground experiences of earth systems and climate filter through a more erratic if intimate engagement with weather. Weather phenomena, from raging storms to atmospheric effects, have formed the focus for many artists' projects. Olafur Eliasson has demonstrated the local effects of weather through his sun, mist, and mirrors installation, Weather Project (2003–2004), in the Tate Modern's Turbine Hall. His The Glacierhouse Effect versus the Greenhouse Effect (2005) uses ostensibly climatic

terms to reveal the more local experiment of sun and ice, melting and freezing in turns on architectural scaffolding. While the weather suggests a more intimate point of access to these phenomena [121] in many ways artists working with climatic data have appropriated both the data and the modes of visualization and rendering to recontextualize how these data appear and circulate. Using radar echo to 'sound' through the ice, Chris Drury develops visualizations, Under the Ice (2008), that reveal sound-generated patterns in ice, which literally put our ear to the ice. Artists Thomson and Craighead gather and reposition the stores of local weather data, accumulating this information for locations around the world and presenting digital numbers in a real-time update of green data scrolling across black backgrounds. Their project, Weather Gauge (2003), oscillates between the local and abstract systems that weather and climate, data and place, continually rearrange. Gathering and rendering weather data take place in artists' projects that range from visualizations and algorithms, including Ramon Guardans, Adolph Mathias, Mathias Gommel, Algorithmic Echolocation (2003), which analyses 420,000 years of atmospheric chemistry contained in the Vostok, Antarctic ice core through image and sound; John Klima's weather financial visualizations in 'Ecosystm' (2001); and Inigo Manglano-Ovalle's scanned iceberg sculpture, 'Iceberg (r11i01)' (2005), which uses the measurements of an iceberg in the Labrador Sea to recreate and present this form at full size in the space of the gallery. Other projects in this vein include Gavin Baily and Tom Corby's Cyclone.soc (2005), which brings together weather data of severe storms with online debates and develops data visualizations through this meeting.

Weather stories can be used to document, [122] as Jari Silomaki's My Weather Diary (2001–2007) (Figure 6), which takes the daily record of photograph and fact to suggest states of weather that are once personal and global, where a view of a frozen lake at Christmas time in Finland intersects with the Tsunami in Southeast Asia, 2004. Similarly, Fred Ivar Utsi Klemetsen's on-going documentation, The Lives and Culture of the Sami Reindeer People, captures a way of life that is vanishing both due to modernization and to shifting climatic influences. Highlighting the dual influences of climate and oil development in the Arctic, Subhankar Banerjee's photographs, taken over the course of 7 years of fieldwork (2000–2007), document caribou migrations and the lives of Inuit people who depend on these animals for their subsistence (Figure 7). It was the presentation of his Arctic images at the Smithsonian, together with the use of these in the US Senate, which also captured an effective argument against drilling in the Arctic National Wildlife Refuge.[123] Banerjee's images do not begin as a polemic, but rather through documenting Inuit and Arctic landscapes in a changing climate under political and resource pressure, his work circulates in such a way that local stories can begin to carry as much weight as global decisions about the extraction and allocation of resources, and to reconfigure what constitutes a politics of climate change (Figures 8 and 9).

The night between Christmas day and Boxing Day in Kuivasjarvi. At the same time a tsunami is travelling towards the beaches in Southeast Asia.

Figure 6. The night between Christmas Day and Boxing Day in Kuivasjarvi. *My Weather Diary*, Jari Silosmaki 2001–2007.

These practices of documentation and narration also suggest that stories can be a place of intervention, interruption, and reimagining. Pierre Huyghe indicates ways of rerouting the usual narratives in his project, A Journey that Wasn't (2005). Beginning with Edgar Allan Poe's tales of the Antarctic, Huyghe works through the imaginative registers and colonial exploration that have taken place in relation to the Polar Regions. His imagined Antarctic voyage is dramatized within Central Park in New York, further revealing that many of our narratives about environments and remote regions are played out not through actual experience, but through imaginative geographies that reveal as much about the politics of imagining as what may exist in those regions.

In this respect, Huyghe's fictional journey raises questions about actual journeys now conducted under the banner of climate change, most notably the Cape Farewell expeditions (2001–2008). These journeys, which gather together well-known artists, writers, filmmakers, and other celebrities, intend to sail to the Arctic in order to allow creative practitioners to make work about climate change. While the celebritization of climate change is hotly debated, it is important to remember that imaginations have histories. The Cape Farewell journeys have in many ways transported a certain amount of metropolitan baggage and expeditional hubris to what many participants on this voyage have seen as an 'unpeopled' icescape and seascape.

Ian McEwan, one of the participants on Cape Farewell, describes the paradox of the hubris that underscores attempts to 'save the world', which collides with the simple problems of how to sort out the boot room collectively shared by expedition participants. With this insight, however, he

misses the complex internal–external politics of the traveling ship in its newfound landscape. In his article, A Boot Room in the Frozen North (2005), McEwan writes,

> The whole world's population is to the south of us, and up here we are our species' representatives, making in the wilderness, a temporary society, a social microcosm in the vastness of the Arctic.

Not only does this emptying of the North reproduce the colonial imaginations of a vast empty space ripe for exploration/exploitation, it prioritizes a western framing of the environment over the inhabitants of the North and their voices, not to mention overwriting the infrastructures of science that produce these spaces within the context of climate change. Another such art project, David Buckland's projection of words onto ice ('Burning Ice', 'Sadness Melts') enacts this very framing of the ice as a blank canvas for Western discourses of climate change. How, we might ask, would these words and forms of projection be changed by an engagement with the inhabitants of the northern ice and seascapes? The metaphorically blank canvas, as Gilles Deleuze suggests, is never blank but is already densely populated with virtual cliches (or historic geographic imaginaries). The work of the artist is not to cover a blank canvas with new images, but to rid it of all the cliches that already occupy it. [124] Another way to think about cliches is as habits of sight and thought, or a priori imaginative framings, that prevent the imaginative openings and dislocations that might direct thought and practice in new ways.

Figure 7. *Caribou Migration I, Oil and The Caribou*, Subhanker Banerjee, 2002. The coastal plain of the Arctic National Wildlife Refuge is the core calving area of the Porcupine River caribou herd. It is also the most debated public land in the US history—whether to open up this land to oil and gas development or to preserve it has been raging in the halls of the US Congress for over 30 years. This caribou herd has symbolized the Arctic Refuge—both for its ecological and cultural significance. Individual caribou from this herd may travel more than 3000 miles during their yearly movements, making it one of the longest terrestrial migrations of any land animal on the planet. Numerous indigenous communities living within the range of the herd have depended on the caribou for subsistence food. The Gwich'in are caribou people. To open up the caribou calving ground to oil and gas development is a human-rights issue for the Gwich'in Nation. In addition to the perceived threat of oil development in their calving ground, this caribou herd has been severely impacted by climate change in recent years.

Figure 8. *Nikolai Shalugin, Yukaghir and The Climate*, Subhanker Banerjee, 2007. The Yukaghir people of Nelemnoye in the Verkne Kolymsk region (upper Kolyma River) primarily depend on subsistence hunting and fishing. Climate change

as predicted by the scientific community may have severe impact on the local fish and thereby on the Yukaghir culture. Decreased abundance and local and global extinctions of arctic-adapted fish species are projected for this century. Southernmost species are projected to shift northward, competing with northern species for resources. Yukaghir culture is the oldest and most endangered indigenous community in Siberia.

Figure 9. *At the Corral-Ilya Golikov, Nikolayev Matvey and Osennia Dariya Mikhailevna, Even and The Climate*, Subhanker Banerjee, 2007. Caribou (North American forms of Rangifer tarandus) and reindeer (Eurasian forms of the same species) are of primary importance to people throughout the Arctic for food, shelter, fuel, tools, and other cultural items. Caribou and reindeer herds depend on the availability of abundant tundra vegetation and good foraging conditions, especially during the calving season. Climate-induced changes to arctic tundra are projected to cause vegetation zones to shift significantly northward, reducing the area of tundra and the traditional forage for these herds. Freeze-thaw cycles and freezing rain are also projected to increase. Future climate change could thus mean a potential decline in caribou and reindeer populations, threatening human nutrition for many indigenous households and a whole way of life for some arctic communities (Text credit: Banerjee 2002–2007).

These aforementioned artists' projects rework the scale and site of data and data generation, from the remote to the intimate. The visualization and sonification of climate data may be seen as a way to allow other extra-scientific points of entry and connection within and through this data. Yet in many ways Isabelle Stengers' description of the way in which processes of inquiry and observation inform our capacity to feel and make worlds is even more relevant.[48] Listening—and sensing—suggests more than passive reception, but rather a commitment to constituting the world through perception. What we might here term the affective spaces of climate change are at the same time effective in reconstituting the registers and knowledge networks of climate change through their material-sensible [48] arrangements. If, as Stengers suggests, a critical part of inquiry and observation is the capacity to feel and be aware of worlds in the making, then these multiple forms of authorship are important not just as forms of data input, but also as ways of being in and being engaged with the world. The artist Amy Balkin queries the complicated fact of this global atmospheric citizenship through her project Public Smog (2007),[127] which is the result of her simultaneous attempt to register the entire atmosphere as a World Heritage Site worthy of protection and to appropriate the market-led approach to atmospheres, where limited rights to pollute the atmosphere are allocated to and traded among companies (Figures 10 and 11). Given the impossibility of any one individual being able to register the atmosphere as a heritage site, since heritage designation must occur through nations, and given the scope of the atmosphere, since a consortium of all the worlds' nations would have to agree to this designation, Balkin instead reconstitutes the atmosphere into a more democratic space by using the only available tool for treating the atmosphere as a commons by buying back enough emission credits in order not to pollute. Taking her cue from the unitization of the atmosphere for the purposes of emissions trading schemes (ETS), Balkin asks how we might reshape our atmosphere if we were able to buy back the rights to pollute on the open market, and, in doing so, she questions the very

citizens and commons that is constituted through the carbon market. Given the ways in which we are collectively reshaping our environments, it is timely to develop projects that imagine how we might also reshape the political tools and practices of citizenship that allow us to engage with climate change.

Figure 10. 'Public Smog is a Scheme' Public Smog, Flash loop documentation still, Amy Balkin, 2006–2011.

Figure 11. 'Public Smog is no Substitute' Public Smog billboards, Bonamoussadi, Douala, Cameroon, Amy Balkin, 2009 (Image Credit: Benoît Mangin).

Conclusion

The Anthropocene

Alongside these aforementioned attempts to situate climate change and democratize the practices of climate science and decision making discussed in the previous sections, there is a concurrent geographic imaginary that gestures toward the universal and epic, that of the Anthropocene: The Geological Age of Humans. The framing of human activity as a geomorphologic force summons up to the imagination what might be termed, after the French philosopher Michel Serres, 'the plates of humanity'.[128] The destructive nature of these 'plates of humanity' to other life forms raises questions about how we imagine and understand the collective human condition, the longevity and sustainability of Homo sapiens, [129] and the impact of humans on nonhuman and inhuman worlds. In short, the Anthropocene provokes us to imagine ourselves as a population acting collectively, reorganizing the conditions of life in terrestrial, atmospheric, and oceanic spaces; passing out of the territories of man and into the territory of earth as the organizing

condition of earth systems. The age of the anthropocene then invokes an imaginary that is also a cosmology, as it repositions humans as the driving force of change on earth, just at the point where philosophers were predicting the death of humanism and the relic of 'the human'. However, there are dangers to both over and under stating the reach of the human into earthly life.

The work of the imagination is a will to become; in many different ways the imagination extends, pushes, challenges, and confides to us what the human is. But, perhaps the greatest work of the imagination is its counterweight to the actuality of the world, to imagine how we might be otherwise. As Nigel Clark comments,

> In this way the 'human' always embodies something of the other-than-human: traces of storms that have been weathered, stirrings of the earth that have been ridden out, poisons and infections that have been stomached. And the echo of events in the solar system and the wider cosmos [130]

Given the challenges that climate change presents to us, which are political, social, cultural, moral, ethical, spiritual,[131] physical, and emotional, our ability to imagine other possibilities, to embrace decidedly different futures with creativity and resolve, to learn to let go of the sense of permanence we may have felt about certain landscapes that have seemed to be always so, and to embrace change, is paramount to building resilience and adaptive capacity.

Imagination can be thought of as a way of seeing,[132] or rather a constellation of a way of thinking and sensing that becomes typified or consolidated in images and social actions, what might be thought of as a collective social mapping. Imagination may also be seen as key to the culture and science relation,[133] where science is often positioned as a discipline that is lacking in the cultural reflexivity to examine its own imaginaries, particularly those related to the globalities of whole earth computer modeling,[134] the framing of human subjects, units of measurements and the continuance of status quo models of the economy. To challenge and critique the practices of climate sciences is an attempt to uncover and understand the collective imaginative geographies that shape understandings of climate change, rather than the calculated imaginary of doubt that is orchestrated by climate skeptics.

We might also understand dominant imaginative framings of knowledge as paradigms, [135] but that would be to reduce the imaginative capacity to a causal operative in the methodological search for scientific truths, rather than to see the pioneering work of the imagination as experimental and challenging to understandings of science.[136] Loraine Daston has argued that the concept of the imagination has played a central role in antiscientific attitudes since the Romantic period, while scientists have frequently been hostile to claims of the imagination.[136] However, while this Newtonian framing of a materialist science does not acknowledge the heterogeneity of the sciences, and most notably the 'new' sciences of climate change, it does offer a cautionary tale to forms of knowledge production that attempt to exclude the work of the imagination and thus elide the locus of responsibility that is configured in relation to the future through these imaginative acts. A relational approach to climate change might stress how relations come before things and indeed are part of their construction, and thus any attempt to understand what kind of a thing climate change is would require an investigation in the relational and historic geographies of climate in the imagination; such as those between weather and climate; between modernity and environmental perception; between catastrophe and climate; and between science and risk. This approach would not put imagination inside matter or imagination as a control of matter, but see continuance and shifts, thresholds and various open-ended forms of becoming that are enabled and perceived through an imaginative reckoning with the world of climate.

Box 1: Graphical Imaginations

Geographical imaginations [137] is a term that is used by geographers to describe the role of the imagination in shaping geographic thought, perception, and models of the world. More than a set of images in the mind or an imagination of the world created through images, geo-graphical imagination is a term deployed to seek to understand how unifying or dominant views shared by communities, nations, or distinct groups of people are negotiated, consolidated, and reproduced through images (such as maps, diagrams, icons, and descriptive imagery). In anthropology these imaginaries might be referred to as World Views or Cosmologies and often suggest a symbolic ordering of the world as much as a physical description of it, denoting power structures or the arrangement of human-environment interactions. More recent impetus to consider the geographical imagination has come from post-colonialist [138] and feminist scholars,[139] who seek to go beyond contesting dominant geographic imaginaries by rethinking the outside, repressed and excluded dimensions of those dominant images and discourses. In his survey of culture and imperialism, Edward Said writes,

> *just as none of us is outside or beyond geography, none of us is completely free from the struggle over geography. That struggle is complex and interesting because it is not only about soldiers and cannons but also about ideas, about forms, about images and imaginings [140].*

In the geographical imagination of climate change we might explore how the imagery of climate change mobilizes and extends familiar geographical imaginations of Africa,[141] Indigenous peoples, [142] refugees, globality and models of the world,[143] while it challenges other imaginaries about unlimited growth, the role of science, the commons, our responsibilities across temporal and geographic scales, and the ethics of the 'good life'.

References

1. Kearney R. The Wake of Imagination: Ideas of Creativity in Western Culture. London: Hutchinson; 1988.

2. Beckett S. Imagination Dead Imagine. London: Calder Publications Ltd; 1966.

3. Warnock M. Imagination. Berkeley, CA: University of California Press; 1979.

4. Fuller S. The New Sociological Imagination. Thousand Oaks: Sage; 2006.

5. Gregory D. Geographical Imaginations. Oxford: Blackwell; 1994.

6. Jay M. The Dialectic Imagination. Berkeley, CA: University of California Press; 1996.

7. Bakhtin M. The Dialogic Imagination. Austin, TX: University of Texas Press; 1981.

8. Irwin R, ed. Climate Change and Philosophy. London: Continuum; 2010.

9. Bell V. Feminist Imagination: Genealogies in Feminist Theory. Thousand Oaks: Sage; 1999.

10. Kearney R. Poetics of Imagining: Modern to Postmodern. London: HarperCollins Academic; 1991.

11. Luke TW. The politics of true convenience or inconvenient truth: struggles over how to sustain capitalism, democracy, and ecology in the 21st century. Environ Plann A 2008, 40:1811–1824.

12. Stoekl A. Bataille's Peak: Energy, Religion and Post- sustainability. Minneapolis: University of Minnesota Press; 2007.

13. Intergovernmental Panel on Climate Change (IPCC) Climate Change 2007. The Physical Science Basis. Cambridge: Cambridge University Press; 2007.

14. Stern N. The Economics of Climate Change: The Stern Review. Cambridge: Cambridge University Press; 2007.

15. Demeritt D. Science studies, climate change and the prospects for constructivist critique. Econ Soc 2006, 35:453–479.

16. Hulme M. Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity. Cambridge: Cambridge University Press; 2009.

17. Daniels S, Endfield G. Narratives of climate change: introduction. J Hist Geogr 2009, 35:215–222.

18. Crate S, Nuttall M. Anthropology and Climate Change: From Encounter to Actions. California: Left Coast Press; 2009.

19. Miles M. Representing nature: art and climate change. Cult Geographies 2010, 17:19–35.

20. Adger N. Social capital, collective action, and adaptation to climate change. Econ Geogr 2003, 79:387–404.

21. Adger N. Social and ecological resilience: Are they related? Prog Hum Geogr 2000, 24:347–364.

22. Szerszynski B, Urry J. Special issue changing climates: introduction. Theory Cult Soc 2010, 27:1–8.

23. Hulme M. Cosmopolitan climates: hybridity, foresight and meaning. Theory Cult Soc 2010, 27:267–276.

24. Dessai S, Hulme M, Lempert R Jr, Pielke R. Climate prediction: a limit to adaptation? In: Adger N, Lorenzoni I, O'Brien K, eds. Adapting to Climate Change: Thresholds, Values, Governance. Cambridge: Cambridge University Press; 2009, 64–78.

25. Proctor J. The meaning of global environmental change—retheorizing culture in human dimensions research. Glob Environ Change 1998, 8:227–248.

26. Pendergraft C. Human dimensions of climate change: cultural theory and collective action. Clim Change 1998, 39:643–666.

27. Sontag S. The imagination of disaster. In: Denby D, ed. Awake in the Dark: An Anthology of American Film Criticism, 1915-Present. New York: Vintage, Random House; 1977, 263–278.

28. Latour B, Weibel P. Making Things Public: Atmospheres of Democracy. Cambridge, MA/ Karlsruhe, Germany: MIT Press/ZKM; 2005.

29. Slocum R. Polar bears and energy-efficient lightbulbs: strategies to bring climate change home. Environ Plann D 2004, 22:413–438.

30. Benigno A. ''Sustainable development'' as collective surge. Soc Sci Q 2002, 83:101–118.

31. Szersynski B. Reading and writing the weather: climate technics and the moment of responsibility. Theory Cult Soc 2010, 27:9–30.

32. Miller CA, Edwards PN, eds. Changing the Atmosphere: Expert Knowledge and Environmental Governance. Cambridge, MA: MIT Press; 2001.

33. Golinski J. British Weather and the Climate of Enlightenment. Chicago: Chicago University Press; 2007.

34. Jankovic V. Reading the Skies: A Cultural History of English Weather. Manchester: Manchester University Press; 2000, 1650–1820.

35. Miller CA, Edwards PN, eds. Changing the Atmosphere: Expert Knowledge and Environmental Governance. Cambridge, MA: MIT Press; 2001.

36. British Council. Long Horizons: An Exploration of Climate Change, curated by Julie's Bicycle; 2010. Available at: http://www.britishcouncil.org/climatechange-longhorizons. (Accessed December 31, 2010).

37. Lippard L, ed. Weather Report: Art and Climate Change. Boulder: Boulder Museum of Contemporary Art; 2007.

38. Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008.

39. Slocum R. Consumer citizens and the cities for climate protection campaign. Environ Plann A 2004, 36:763–782.

40. Anderson B. Preemption, precaution and preparedness: anticipatory action and future geographies. Prog Hum Geogr 2010, 34:777–798.

41. Adam B. Towards a New Sociology of the Future. Available at: http://www.cf.ac.uk/socsi/futures/. (Accessed February 1, 2010).

42. Adam B, Groves C. Future Matters: Action, Knowledge, Ethics. Leiden: Brill; 2007.

43. O'Brien G, O'Keefe P, Rose J, Wisner B. Climate change and disaster management. Disasters 2006, 30:64–80.

44. Nordlund G. Futures research and the IPCC assessment study on the effects of climate change. Futures 2008, 40:873–876.

45. Pielke RA Jr. Misdefining ''climate change'': consequences for science and action. Environ Sci Policy 2005, 8:548–561.

46. Adam B. Minding Futures: An Exploration of Responsibility for Long Term Futures. ESRC PF Paper—Minding Futures—140704. Available at: http://www.cf.ac.uk/socsi/futures/.

47. Snow CP. The Two Cultures and the Scientific Revolution. Cambridge: Cambridge University Press; 1959.

48. Gabrys J, Yusoff K. Arts, sciences and climate change: practices and politics at the threshold. Science as Culture, 2011. doi:10.1080/09505431.2010.550139.

49. da Costa B, Philip K, eds. Tactical BioPolitics: Art, Activism and Technoscience. Cambridge: MA: MIT Press; 2008.

50. Castree N. Neoliberalism and the biophysical environment 1: what 'neoliberalism' is, and what difference nature makes to it. Geogr Compass 2010, 4:1725–1733.

51. Robertson MM. The nature that capital can see: science, state, and market in the commodification of ecosystem services. Environ Plann D 2006, 24:367–387.

52. Beck U. The World at Risk. London: Polity; 2009.

53. Stern N. The Economics of Climate Change: The Stern Review. Cambridge: Cambridge University Press; 2007.

54. Beck U. The World at Risk. London: Polity Press; 2008.

55. Carson R, Christie R, Lear L, Wilson EO. Silent Spring. 40th Anniversary Edition. New York: Mariner Books; 2002.

56. Meadows D. Randers J, Meadows D. Limits to Growth: The 30 Year Update. Oxford: Earthscan.

57. Lovelock J. Revenge of Gaia: Why the Earth is Fighting Back and How We Can Still Save Humanity London: Allen Lane; 2006.

58. Yusoff K. Visualizing Antarctica as a place in time: from the geological sublime to 'real time'. Space Cult 2005, 8:381–398.

59. Yusoff K. Excess, catastrophe, and climate change. Environ Plann D 2009, 27:1010–1029.

60. Buell L. The Environmental Imagination: Thoreau, nature writing, and the formation of American Culture. Cambridge, MA: Harvard University Press; 1995, 285.

61. Lorenzoni I, Pidgeon NF. Public views on climate change: European and USA perspectives. Clim Change 2006, 77:73–95.

62. Ungar S. 'Knowledge, ignorance and the popular culture: climate change versus the ozone hole. Public Underst Sci 2000, 9:297–312.

63. Bostrom A, Morgan GM, Fischhoff B, Read D. What do people know about global climate change? 1. Mental models. Risk Anal 1994, 14:959–970.

64. Carvalho A. Ideological cultures and media discourses on scientific knowledge: re-reading news on climate change. Public Underst Sci 2007, 16:223–243.

65. Zehr SC. Public representations of scientific uncertainty about global climate change. Public Underst Sci 2000, 9:85–103.

66. McComas K, Shanahan J. Telling stories about global climate change: measuring the impact of narratives on issue cycles. Commun Res 1999, 26:30–57.

67. Hulme M. The conquering of climate: discourses of fear and their dissolution. Geogr J 2008, 174:5–16.

68. Apocalypse Space Cult, Special Issue 1997, 1.

69. Disaster Space Cult, Special Issue 2006, 9.

70. Lowe T, Brown K, Dessai S, de Franca Doria M, Haynes K, Vincent K. Does tomorrow ever come? Disaster narrative and public perceptions of climate change. Public Underst Sci 2006, 15:435–457.

71. Atwood M. The Year of The Flood. London: Bloomsbury Publishing PLC; 2009.

72. Stanley Robinson K. Future Primitive: The New Ecotopias. London: Tor Books; 1994.

73. Jameson F. Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions. New York: Verso; 2005, xii.

74. Yusoff K. Climates of sight: mistaken visibilities, mirages and 'seeing beyond' in Antarctica. In: Cosgrove D, Dora VD, eds. High Places: Cultural Geographies of Mountains and Ice. London: I B Tauris; 2008, 48–63.

75. Kneale J, Kitchin R, eds. Lost in Space: Geographies of Science Fiction. London: Continuum; 2002, 3–4.

76. Stanley Robinson K. Imagining Abrupt Climate Change: Terraforming Earth. Seattle: Amazon Shorts; 2007.

77. Ballard JG. The Drowned World. London: Gollancz; 1999, 14.

78. Heisse U. Sense of Place and Sense of Planet: the Environmental Imagination of the Global. Oxford: Oxford University Press; 2008.

79. ESF-COST. Landscape in a Changing World Bridging Divides, Integrating Disciplines. Serving Society Science Policy Briefing; Paris and Brussels: ESF-COST; 2010.

80. Lynas M. Six Degrees: Our Future on a Hotter Planet. London: Fourth Estate; 2007.

81. Alley RB. The Two-Mile Time Machine: Ice Cores, Abrupt Climate Change, and Our Future. Princeton, NJ: Princeton University Press; 2002.

82. Wells HG. The Discovery of the Future 1913. Quoted in Christianson G E Greenhouse: The 200-year Story of Global Warming. London: Constable; 1999, 1.

83. Margulis L. In: Mayewski PA, White F, eds. The Ice Chronicles: The Quest to Understand Global Climate Change. Hanover: University Press of New England; 2002, xviii.

84. Margulis L. Mayewski PA, White F, eds. The Ice Chronicles: The Quest to Understand Global Climate Change. Hanover: University Press of New England; 2002, xvii.

85. Alley RB. The Two-Mile Time Machine: Ice Cores, Abrupt Climate Change, and Our Future. Princeton, NJ: Princeton University Press; 2002, 11.

86. Wolff E. Ice cores. In: Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008, 38–39.

87. Yusoff K. Core histories. In: Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008, 32–37.

88. Frazar H. Icy demands: coring, curating and research the GISP2 ice core. In: Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008, 40–41.

89. Clark N. Life on a spike 42–43. In: Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008.

90. Yusoff K, Gabrys J. Bear life. Focus forum on contemporary art and society. In: Davis L, ed. Regional Animalities, vol 6. Singapore: National University of Singapore Press and the Documenta 12 Magazines Project; 2007, 66–83.

91. Yusoff K. Biopolitical economies and the political aesthetics of climate change. Theory Cult Soc 2010, 27:73–99.

92. Lynge A. Rights and responsibilities: how should we respond to climate change in the arctic. In: Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008, 100–104.

93. Bravo M. Voices from the sea ice and the reception of climate impact narratives. J Hist Geogr 2009, 35:256–278.

94. Broadbent ND, Lantto P. Terms of engagement: an Arctic perspective on the narratives and politics of global climate change. In: Crate S, Nuttall M, eds. Anthropology and Climate Change: From Encounter to Actions. California: Left Coast Press; 2009, 341–355.

95. Henshaw A. Sea ice: the sociocultural dimensions of a melting environment in the Arctic. In: Crate S, Nuttall M, eds. Anthropology and Climate Change: From Encounter to Actions. California: Left Coast Press; 2009, 153–165.

96. Luduc TB. Sila dialogues on climate change: Inuit wisdom for a crosscultural interdisciplinarity. Clim Change 2007, 85:237–250.

97. Gabrys J. Sink: the dirt of systems. Environ Plann D 2009, 27:666–681.

98. Grosz E. In the Nick of Time: Politics, Evolution and the Untimely. Durham: Duke University Press; 2004, 108.

99. Adger N. Social capital, collective action, and adaptation to climate change. Econ Geogr 2003, 79:387–404

100. Lakoff A. Preparing for the next emergency. Public Cult 2007, 19:247–271.

101. Hinchliffe S. Helping the earth begins at home. Glob Environ Change 1997, 1:53–62.

102. Anker P. The closed world of ecological architecture. J Arch 2005, 10:527–552.

103. Fuller RB. Operating Manual for Spaceship Earth. Baden: Lars Muller Publishers, 2008.

104. Todd N, Todd J. From Eco-Cities to Living Machines: Principles of Ecological Design. Berkeley: North Atlantic Books; 1994.

105. Yeang K. Ecodesign: A Manual for Ecological Design. New York: Academy Press; 2006.

106. Mattingly M, et al. Flock House. Available at: http://www.flockhouse.tumblr.com. (Accessed October 31, 2010).

107. Szerszynski B. The post-ecologist condition: irony as symptom and cure. Env Polit 2007, 16:337–355.

108. Yuill S. Survival scrapbooks Mute Magazine. Available at: http://www.metamute.org/en/Survival-Scrapbooks. (Accessed December 31, 2010).

109. Abel es M. The Politics of Survival. Durham: Duke University Press; 2010.

110. de Goede M, Randalls S. Precaution, pre-emption: arts and technologies of the actionable future. Environ Plann D 2009, 27:859–878.

111. Hopkins R. The Transition Handbook: From Oil Dependency to Local Resilience. Totnes: Green Books.

112. Perkins B, Ojima D, Corell R. A Survey of Climate Change Adaptation Planning. Washington, DC: H. John Heinz III Center for Science, Economics and the Environment; 2007.

113. Norman N. Thurrock 2015. Available at: http://www.visionarythurrock.org.uk/docs/artists/nilsnorman/index.htm. (Accessed December 31, 2010).

114. Mostafavi M, Doherty G, eds. Ecological Urbanism. Baden: Lars Muller Publishers; 2010.

115. Bell S, Teh TH. People, pipes and places. In: Networks of Design. Boca Raton: Universal Publishers; 2009, 19–23.

116. Emerging Sustainability. Collaborative Portal. Available at: http://emergingsustainability.org/index. (Accessed December 31, 2010).

117. Metro Cable in San Agustín, Caracas (Urban Think Tank) and Manguinhos Complex in Rio de Janeiro (Jorge Mario Jauregui) in the MoMA New York exhibition Small Scale, Big Change: New Architectures of Social Engagement, 2010–2011.

118. Bridge G. Resource geographies I: making carbon economies, old and new. Prog Hum Geogr, published online 5 November 2010, 1–15. doi:10.1177/0309132510385524.

119. Engebreth B. Personal Kyoto 2005–2006. Available at: http://www.personal-kyoto.org/. (Accessed December31, 2010).

120. Barnett C. Convening publics: the parasitical spaces of public action. In: Cox KR, Low M, Robinson J, eds. The SAGE Handbook of Political Geography. London: Sage Publications; 2007, 403–417.

121. Fleming JR, Jankovic J, Coen D. Intimate Universality: Local and Global Themes in the History of Weather and Climate. Sagamore Beach, MA: Science Publications USA; 2006.

122. Thornes J. Cultural climatology and the representation of sky, atmosphere, weather and climate in selected art works of Constable, Monet and Eliasson. Geoforum 2006, 39:570–580.

123. Banerjee S. Subhankar Banerjee: Resource Wars. New York: Sundaram Tagore Gallery; 2008.

124. Deleuze G. Francis Bacon: The Logic of Sensation (trans. Daniel W. Smith). London: Continuum; 2003.

125. Nancy JL. Listening Trans (trans. Mandell C). New York: Fordham University Press; 2007, 5.

126. Nancy JL. Listening Trans (trans. Mandell C). New York: Fordham University Press; 2007, 7.

127. Balkin A. Public Smog. 2007. Available at: http://www.publicsmog.org. (Accessed December 31, 2010).

128. Serres M. The Natural Contract. Anne Arbour: University of Michigan Press; 1995, 16.

129. Weisman A. The World Without Us. London: Virgin; 2007.

130. Clark N. Exorbitant globality. Theory Cult Soc 2005, 22:165–185.

131. Orr M. Environmental decline and the rise of religion. Zygon 2003, 38:895–910.

132. Yusoff K, ed. BiPolar. London: The Arts Catalyst/Arts Council England; 2008, 7.

133. Prigogine I, Stengers I. Order out of Chaos. London: Flamingo; 1985.

134. Edwards PNA. Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming. Cambridge, MA: MIT Press; 2010.

135. Kuhn S. The Structure of Scientific Revolutions. 2nd ed. Chicago: University of Chicago Press; 1970.

136. Daston L. Fear and loathing of the imagination in science. Dædalus 1998, 127:73–95.

137. Gregory D. Geographical Imaginations. Oxford: Blackwell; 1994.

138. Spivak G. Who Sings the Nation-State? Language, Politics, Belonging. Chicago: Chicago University Press; 2007.

139. Butler J. The Psychic Life of Power: Theories in Subjection. Stanford: Stanford University Press; 1997.

140. Said E. Culture and Imperialism. London: Chatto and Windus; 1993, 6.

141. Manzo K. Imagining vulnerability: the iconography of climate change. Area 2010, 42:96–101.

142. Martello ML. Arctic indigenous peoples as representations and representatives of climate change. Soc Stud Sci 2008, 38:351–376.

143. Jasanoff S. Image and imagination: the formation of global environmental consciousness. In: Miller C, Edwards P. Changing the Atmosphere. Cambridge, MA: MIT Press; 2001, 309–337.