Distinktion: Scandinavian Journal of Social Theory

ISSN: 1600-910X (Print) 2159-9149 (Online) Journal homepage: http://www.tandfonline.com/loi/rdis20

Thinking like a climate

Hannah Knox

To cite this article: Hannah Knox (2015) Thinking like a climate, Distinktion: Scandinavian Journal of Social Theory, 16:1, 91-109, DOI: 10.1080/1600910X.2015.1022565

To link to this article: http://dx.doi.org/10.1080/1600910X.2015.1022565

Distinktion: Scandinavian Journal of Social Theory, 2015
Vol. 16, No. 1, 91–109, http://dx.doi.org/10.1080/1600910X.2015.1022565

RESEARCH ARTICLE

Thinking like a climate

Hannah Knox*

Department of Anthropology, University College London, London, UK

This paper explores the ontological implications of global climate change as climate science becomes grounds for politics. Prompted by parallels between what I call 'climate thinking' and recent philosophical work on the materiality of scientific practice, the paper draws on the work of Karen Barad to explore the ontological contours of scientific descriptions of anthropogenic climate change and the implications of this ontology as it gets taken up in politics. The paper explores how consensus around the reality of climate change has begun to shift the focus of climate politics away from the issue of uncertainty towards the question of the appropriate sites and agents of political action. Focusing on the relationship between the materiality of climate change enacted by scientific descriptions of a changing climate and the political responses these descriptions have provoked, the paper argues that approaching climate as a political material is far from a retreat from a more humanist version of politics. Rather, an attention to climate ontology in fact leads to the observation that climate change is reintroducing political questions of agency, ethics, and responsibility into domains where these questions have been until now bracketed out as issues of social and not scientific concern.

Keywords: climate; objectivity; ontology; politics; responsibility; science; uncertainty

> 'Climate change' means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (United National Framework Convention on Climate Change, Article 1)

In 2014, the International Panel on Climate Change (IPCC) released its report on *Impacts, Adaptation and Vulnerability*. On page 17 of the report, a remarkable claim was made: The report stated, for the first time in an IPCC document, 'human interference with the climate *is* occurring' (IPCC 2014, 17; emphasis added). The certainty of this statement recalled for me a conversation that I had had three years earlier during ethnographic research on climate action and carbon reduction in Manchester. I had been discussing my academic interest in the cultural politics of climate change with Richard Sharland, the then head of Manchester City Council's Environmental Strategy Team, and had suggested that the politics of climate change hinged on the issue of uncertainty. Sharland had disagreed. Citing Al Gore's film, *An Inconvenient Truth*, he stressed that the big political challenge for those attempting to tackle climate change was not uncertainty but the inconvenience of the

*Email: h.knox@ucl.ac.uk

implications of scientific data that were 'producing messages that we don't want to hear'. For Sharland, uncertainty was a distraction from the more important barriers to action on climate change: a get-out, or excuse for inaction.

In 2011, Richard Sharland's insight seemed to go against the grain of much that had been written on the place of uncertainty in the political challenges of climate change (Shackley and Wynne 1996; Saloranta 2001; O'Reilly et al. 2011; Yearly 1992). However, since 2011 the politics of climate change has seen a continued shift from discussions of uncertainty to the establishment of an ever more robust consensus on the facticity of human-induced global warming (Edwards 2010). In 2001 the Third IPCC Working Group I Assessment Report on climate change stated that the panel was only 66% certain that climate change was induced by human activity. By 2013 and the publication of the Fifth IPCC Working Group I Assessment Report, the level of certainty quoted in the report had risen to 95%, provoking the subtle shift from a language of probability to a language of fact.

Whilst the IPCC report alone is of course insufficient to quieten the most vociferous of climate sceptics, its conventionally conservative approach to assessing the findings of climate science suggests that the move to re-articulate the role of humans in climate change as fact rather than probability is indicative of a more pervasive acceptance that human-induced climate change is 'real' (Brysse et al. 2013). Indeed during my own field-work amongst councillors and officers working in the areas of health, waste, community support, economic regeneration, and environment in a local authority in the North of England, I spoke to no one who doubted the reality of climate change and its potential harmful effects. As with the latest IPCC report, the matter of whether climate change was happening, or not, was not the issue. In this shifting discourse, discussions about what to do about climate change were no longer dominated by worries about the truth status of scientific models, but had begun to focus instead on the implications of climate as a new geo-social leviathan.

Although the transformation from probability to fact might appear trivial, I suggest that it indicates an important moment in the way in which the relationship between the action of humans and the action of their environments is being approached in governmental circles. Taking human-induced climate change to have been endorsed as a scientific fact allows us provisionally to set aside uncertainty as the focus of political wrangling, and to open up our analysis of climate politics to consider the way in which climate-change-as-fact reframes questions about the appropriateness of different kinds of action against climate change and the sites where this action should take place. Until very recently, the ambiguous facticity of climate change remained a driving consideration in discussions of how governments and individuals should respond to the threat of global warming (Schneider and Kuntz-Duriseti 2002; Webster 2002; Hulme 2009). Deciding who should be responsible for doing something about a problem whose causes were still unverified and whose reality was thus in doubt was frequently deferred by appeals to science to provide the evidence that current practices were harmful, and that counteraction would be effective in mitigating the worst-case scenarios that some climate models were predicting. However, if the latest IPCC report is to be taken as an indicator of a more general acceptance of the reality of climate change in governmental discourse, our analytical attentions must also move from the issue of how truths become established and/or contested, to the implications of the ontology of the version of climate change we find in governmental practice.

Focusing on climate-change-as-fact prompts an analytical move for those scholars interested in the political implications of climate change away from questions of epistemology and struggles over the establishment of truth claims. It shifts the discussion away from

questions regarding the verifiability of data and the appropriateness of particular methodological techniques for predicting the future, to consider how climate 'itself' is being activated as what we might call a 'political material'. Specifically, it raises the question of how an ontology of climate, as it becomes revealed through both predictive climate models and the reformulation of social life through the lens of carbon emissions, is itself working to frame debates about political action.

In what follows I draw both on my own field-work with local government actors who are attempting to create forms of social intervention that respond to the findings of climate scientists, and on public discussions among climate scientists about their political responsibilities as climate scientists to do something about climate change. Focusing on the way in which a science-defined version of climate change is being appealed to as a prompt for political action, and on the ambivalences that this appeal is throwing up in these two spheres, I interrogate how a changing climate is figuring as what we might call a political material. In order to shed light on how a scientific definition of climate change is unsettling some of the boundaries between science and politics, I turn my attention to understanding the relational ontology of climate change as it is described by policy-facing climate scientists. This leads to the observation that the relational ontology of climate change bears some resemblance to the ontological propositions of much post-constructivist philosophy of science, and in particular Karen Barad's science-derived philosophy of 'agentive realism' which emerges out of the challenges that quantum physics posed to the foundations of objective science (Barad 2007). Building on and extending Barad's philosophy to demarcate the relational ontological commitments of policy-oriented climate science, I explore how these relational principles have come to inflect the forms of political intervention that are emerging as a direct response to climate science. In this way I extrapolate some of the ways in which climate change might be figuring as a political material.

A politics of climate change

The empirical inspiration for this paper derives from an ethnographic study that I conducted between 2011 and 2013 with a network of people in Manchester, UK, who were attempting to develop institutional and governmental responses to the threat of global climate change. The study involved my participation in and observation of a range of governmental and quasi-governmental initiatives oriented towards an overall reduction of carbon emissions for the city of Manchester. These included institution-specific projects to reduce the carbon emissions of particular organizations, city-wide projects to insulate houses and transform people's energy use, and a multi-lateral project that aimed to transfer expertise on carbon reduction between Manchester and other European cities.

One thing that was shared by the participants in all of these initiatives was the idea that carbon reduction was a direct and logical response to the kind of climate science summarized in the IPCC document above. None of the policy documents circulating in the city at the time of my field-work entered into any kind of discussion about the validity of climate science, but took the status of scientific knowledge on climate change as established and uncontroversial. The beginning of Manchester's Climate Change Action plan, for example, stated:

> CO2 is a gas: the invisible image of expended carbon, and a spent natural resource.
> CO2 currently consists of more than 380 parts per million of the earth's atmosphere, and it is rising. 350 parts per million is the optimum level for life as we know it, probably the best level for people and all of nature to prosper.

> It is the responsibility of all of us to reduce CO2 emissions and spend our carbon more carefully. This document outlines the actions we need to take. (MACF 2009, 3)

One of the initiatives that was developed and launched during the time of my field-work was a programme of 'carbon literacy'. Developed by a community interest company in close collaboration with the local council, the Manchester carbon literacy programme was designed as a method through which Manchester's citizens could be inducted into the science and governance of climate change and, accordingly, encouraged to change their behaviour in a way that would begin to impact on global climate change.

The training in Carbon Literacy was offered initially to the employees of a number of organizations, including officers and councillors working within the city council itself. The principle of the programme, as with other activities oriented to bringing about social and behavioural change to reduce carbon emissions, was that people would be trained up to become carbon literate and would then be able to impart their learning to colleagues through a model of peer-to-peer learning. The Carbon Literacy programme proceeded through a two-stage process, starting with a half-day online learning session, followed by a face-to-face training session that was meant to reinforce the lessons learnt through the online learning.

The content for the online learning section of the site had been developed in consultation with climate scientists working at a local university who had provided information on topics including: 'how climate here and elsewhere is likely to change', 'what greenhouse gases are and their relationship to weather and climate', and 'how our actions impact on climate change'. Learners were taken through these topics and provided with graphics such as a visual representation of what a tonne of carbon might look like, before being encouraged to estimate their carbon footprint and to work out ways of reducing their carbon impact in future.

During the face-to-face training sessions emphasis was placed on reinforcing the message that people needed to begin to feel responsible for their own carbon emissions. Although the idea was that those trained up in carbon literacy would go on to train other people, the expectation was not that they would become experts in climate science but rather that they would promote a particular understanding of how people should conceive of their place within a global climate system. The sessions opened for example with a round of 'green bingo'. Designed as an ice-breaker, each person in the room was given a card which had a bingo grid filled in with a set of environmentally friendly behaviours including: 'cycles to work', 'is vegetarian', 'recycles', 'always turns off computer screen'. People then had to circulate around the room, finding someone who did one of the activities on the grid, gradually filling up the grid until one person won the game. In order to reinforce the idea that carbon reduction was a necessary practice, various epistemological devices were used, including the graphic representation of a tonne of carbon dioxide, the calculation of how many worlds would be needed to sustain each person's consumption activities, and the ecological footprint for each participant which was compared with similar footprints for those living in other parts of the world. The workshop was oriented to ensuring that people understood precisely how the relationship between their daily practices and climate change should be conceived, and how this conceptualization might provide the basis for making practical choices about how and what they should consume.

Inculcating a sense of responsibility in citizens in both this project and others thus involved attuning people to the basic science of climate change and as well as providing them with ideas for how they might respond to a transformed interpretation of their own place within a global climate system. The political work of reducing carbon emissions

within these local authority initiatives rarely revolved around convincing hardened climate sceptics that climate change was real. The struggle was rather one of how to encourage people to recognize themselves as a constituent part of a global climate system, and to alter their actions accordingly.

The local politics of climate change revolved then around instilling a particular sense of human-environmental relationality amongst the general public. The aim of the carbon literacy programme was ambitious – every Manchester citizen was to be offered carbon literacy training by 2020. No longer was it to be acceptable for people to imagine themselves to be divorced from broader systems dynamics that crossed not only communities and national borders, but also a line between nature and society. The role of government in this setting was to find ways of transforming people's understanding of their place in a global environmental system by encouraging them to think of themselves not just as isolated individuals with personal needs and wants, but rather to conceive of themselves as constituent parts of the climate system described by climate scientists.

The means by which this was to be achieved was, as we have seen, in the first instance by providing people with basic scientific facts. Resting very much within the logic of a modernist form of scientific objectivity (Daston and Galison 1992), graphical depictions of climate science used in these training sessions and in other public engagement events offered a singularized picture of past global warming and future warming effects. The analytical gaps between objective scientific images that projected a changing climate, and the personal transformations that would be required by people to prevent this future scenario from materializing were bridged by descriptions of how global climatic changes were predicted to affect Manchester itself. Graphs showed gradually climbing carbon emissions and projections of future temperature rises differentially distributed across the globe. Again supported by evidence provided by research conducted in local universities, Manchester residents were informed that they could expect climate change to manifest in the future in the form of increased flooding, 'extreme weather events', rising insurance costs, droughts affecting agriculture and infrastructure, and the knock-on socio-economic effects of even more extreme climatic conditions in the tropics. At the same time, those involved in instilling a mode of relationality that required publics to begin to 'think like a climate' were concerned that the bridging of this epistemological gap between the climate as object and climate as an aspect of people's subjectivity was not currently effective. The on-going challenge was how to encourage people to internalize objective accounts of climate in order that they could see themselves as part of the very dynamic that visualizations of predictive climate models were describing.

Given that the reality claims of climate science were so central to this political intervention, it is perhaps unsurprising that an important means of legitimizing the redistributions of responsibility required by climate change was through the direct involvement of spokespeople for climate science in political processes. In January 2013, Manchester climate scientist Kevin Anderson was invited to a packed council chamber at Manchester City Council to give a presentation to the elected councillors, officers, and members of the public on the latest predictions of climate science. Richard Leese, the leader of the council, had previously heard Anderson give a passionate presentation about the alarming picture that was resolving out of climate scientists' analyses of a changing global climate system and, in what some saw as a brave move, had invited the scientist to address the council directly. As with the carbon literacy programme's use of climate science, Leese hoped that Anderson's presentation would both help educate councillors and officers about the dire implications of carbon emissions, and prompt discussion and ideas about how to respond to these scientific findings.

Anderson already had his own ideas about what should be done to reduce emissions and who should be doing something about them. In a striking move that I had been pre-attuned for by others who had already seen Anderson speak, he began his treatise on what to do about climate change by turning the spotlight from the audience, onto himself, and then back again casting everyone in the room as prime examples of the 1%–5% of the global population responsible for 40%–50% of global carbon emissions. Asking the audience to consider who is in the 1%–5% he flashed up a PowerPoint slide that enacted his reflexive engagement with the problem. The slide pointed to 'climate scientists, climate journalists & pontificators, OECD (& other) academics, anyone who gets on a plane, and for the UK anyone earning over £30k?' as those whom we might hold responsible for climate change.

In recent years Kevin Anderson and his colleague Alice Bows-Larkin have gained something of a name for themselves both as climate scientists and as proponents of a form of climate action that has emerged as a direct response to their scientific findings. Their most idiosyncratic political act has perhaps been the decision to refuse to fly on the basis of their analysis of the contribution of aviation emissions to global warming. As academics accustomed to being active on an international conference circuit, this decision not to fly has been publicly noted. During the UN Climate summit in Warsaw, Poland, in 2013 Anderson and Bows-Larkin were interviewed by the independent news channel Democracy Now! and were questioned about this decision not to fly to the conference but to arrive there by train. In response Anderson explained,

> I haven't flown for eight years and Alice for something similar I think, because of the carbon dioxide emissions from flying, it is sort of emblematic of modern life for the wealthy few of us that it symbolizes what we do day-in, day-out, that we don't think twice about burning more and more carbon. So it is important for us to make what is a symbolic gesture and hopefully that catalyses action with other people to also say, we too can make those sorts of changes.

Anderson's personal response to climate change is an example of a kind of activism that has come about through an acknowledgement that the climate as object of scientific enquiry is complexly entangled with the actions of human beings, including climate scientists themselves. Although public understandings of climate change are only now coming to some kind of agreement that human-induced climate change might be happening, this consensus has been well established among climate scientists for some time (Oreskes 2004; Cook et al. 2013). As a result, among climate scientists the implications of their findings about human-induced climate change have for several years been provoking controversial discussions about just what role climate scientists themselves should play as political advocates for climate change action. For some particularly vocal climate scientists, climate change has come to reframe the role of scientists in society, propelling them as 'unlikely activists' (McKibben 2013), with a pressing responsibility for engaging the public in a fight against climate change. In trying to understand the ontological implications of the scientific descriptions of climate change that appear in policy work, in what follows I focus specifically on how the ontology of climate has been central to the forms of political intervention developed and proposed by these 'unlikely' activist scientists.

The activist scientist

Anderson is just one of several scientists who have stood up as public advocates for revolutionary political action on climate change. In a recent article in the *New Statesman* by the political commentator Naomi Klein, provocatively entitled 'How Science Is Telling Us All

to Revolt', Klein reviews this phenomenon of environmental scientists finding themselves drawn into political action on the basis of their research results (Klein 2013). Anderson's political advocacy for action on global climate change is cited at length alongside others including the well-known climate scientist/activist James Hansen, and the geophysicist Brad Werner who similarly argues for political revolution as a likely and necessary response to the speedy and progressive depletion of the earth's resources that his models have revealed.

For each of these science-activists, the way in which they articulate their political activism is less through a commitment to particular ideological or political principles than via the self-evidence of the data that they have been intimately involved with in the course of their professional work. Moreover, what is particularly striking is the reflexive acknowledgement that as people who inhabit the same social world as those who have produced the data on global environmental change they are also directly implicated in the phenomena that they are describing. Whilst scientists have long entered into political campaigning on the basis of the findings of the research that they have conducted, their entanglement in the worlds that they are describing and their responsibility to respond to this entanglement through transformations in both their personal and political lives has not been the key issue. For those scientists campaigning on issues such as the effects of nuclear weapons, or tobacco, or acid rain, science has provided evidence that has shown the potentially harmful effects of physical phenomena on human beings. However, the divide between natural processes and social effects in these cases is not breached. In contrast, in climate science, society itself is visible in climate data. The acknowledgement by climate scientists of their own entanglement in the data that they have produced points to an interesting destabilization in the kind of objectivity that climate science can claim for itself. In the case of climate change, it has been in part the capacity to read the practices of climate science itself (as one facet of the practices of the rich and privileged of the world) into the alarming models that climate scientists have produced, that made it possible for climate data itself to be a prompt for a form of political action aiming to re-engineer scientists' own participation in social processes in the hope that they might be able to stabilize the numbers in their models and calm the climate system in the future. Activist scientists like Anderson and Bows-Larkin have found themselves having to reconceive political responsibility through their attunement to a kind of systems (or climate) thinking that disavows a clear separation between the observer and that which is being observed.

Perhaps unsurprisingly the call by some climate scientists to become politically active has not been universally well received. In a discussion in *The New York Times* on the role of climate scientists in climate activism for example, Susan Solomon, one of the scientists involved in compiling the Fourth IPCC Report on Climate Change, argued against the idea that climate scientists should be expected to dictate environmental policy: 'I believe that is a societal choice. I believe science is one input to that choice, and I also believe that science can best serve society by refraining from going beyond its expertise. In my view, that's what the I.P.C.C. also is all about, namely not trying to make policy-prescriptive statements, but policy-relevant statements' (Revkin 2007). This kind of position that reinforces the distinction between science and society is well documented within studies of the relationship between science and policy-making (Jasanoff 1990, 1996). Research in the social studies of science has demonstrated the important role that such 'boundary work' plays in maintaining the legitimacy of science by enacting its separation from non- or pseudo-science on the one hand, and society on the other (Shackley and Wynne 1996; Guston 2001). It is perhaps unsurprising, then, that most climate scientists seem to concur with Solomon that the best means by which they can make a difference to

policy is by remaining within the boundaries of legitimated scientific knowledge production.

However, the particular form of climate activism taken by political spokespersons for science such as Anderson and Bows-Larkin still bears thinking about if we are to understand better the relationship between a consensus view of climate change and the ground for contemporary forms of political action. As we have seen, for activist scientists this centres on a form of personal and professional responsibility that emerges out of a scientific understanding of the relationship between people and climate. The notion that climate scientists should be at the vanguard of climate change politics because of their simultaneous proximity to the science and their status as citizens of a global-environmental system offers a powerful counter-argument to a position that works to reinforce the sanctity of the scientist as standing outside society. In contrast to those who enact the boundary work which holds up the neutrality of science, some policy-facing climate scientists and climate observers have begun to argue that such boundaries are fallacious and that a neutral position is no longer possible. The financier Jeremy Grantham, for example, recently argued in the journal *Nature* that 'Overstatement may generally be dangerous in science (it certainly is for careers) but for climate change, uniquely, understatement is even riskier and therefore, arguably, unethical' (Gratham 2012, 303). Kevin Anderson has proposed a similar argument, positioning himself against the kind of argument proposed by Susan Solomon. Far from seeing his own work as singularly political, Anderson argues that all climate science is necessarily political. For Anderson, the act of staying silent is just as – if not more – political than speaking up. With this in mind, he has described his own experience of the lack of engagement by most climate scientists as a case of being 'deafened by the political roar of most scientists who work on climate change'. He goes on:

> So we may think we're doing this neutrally, but we're not at all. That silence is an advocacy for the status quo. So there are no such things as scientists that are not political. Scientists by their nature are being political, whether they engage or do not engage in the wider debates. And I would argue that the ones are who are the least political are the ones who engage in it. (Manchester Climate Monthly 2013)

So what exactly is the nature of this political entanglement?

To return to Anderson's reflexive observation that climate scientists are themselves not only responsible for publicizing their findings but are also partly responsible for climate change itself, the question of action as it relates to climate science appears to be tied not only to questions of advocacy but also to a broader question of personal responsibility that is raised by the reconceptualization of climate as a natural/social system. At the crux of this debate about whether climate scientists should or should not be political is the question of the relationship between scientific practice, data, and political action, and the personal responsibility of scientists to act on findings that reflect back on them as social actors. Ambivalence about doing politics on the basis of data retains the objectivity of scientists as actors who are situated outside the system that their models and experiments describe. But, for those scientists who are advocating action on climate change, the key issue is an acknowledgement that science is already entangled in the systems which are producing the effects being studied and that even inaction is already action of a kind.

From where, then, do they see this sense of political responsibility to derive? As with the carbon literacy example with which I started, the claim appears to be that it comes directly from an engagement with climate models, whereby scientists and others who are shown these models are invited to see their own activities and choices captured in the

curves of rising temperatures and the maps of climate hotspots. In a manner not dissimilar to the social affordances of rivers and forests described in Alberto Kohn's recent book *How Forests Think*, human-induced climate change manifests itself in graphical depictions which structure the possibilities of a political response (Kohn 2013). Kohn describes how the formal qualities of rivers and forests in the area of the Amazon where he does field-work have an important and often overlooked capacity to provide the conditions of possibility for particular forms of life, meaning, and action to occur. For Kohn the ontology or particular *form* of the forest must be recognized as a key factor in the formation of both indigenous and post-colonial practices of relationality in this space. Similarly, we might argue that a scientific rendering of climate and the incorporation of this rendering into policy also has a powerful organizing effect. If the climate is *objectively* spiralling out of control, and we are *factually* facets of that spiralling process, then surely it is we who should try to change our way of acting in order to bring it back under control. It is to index the experience of a relationship between ontology and action that I have titled this paper 'Thinking Like a Climate'.

The trigger for political advocacy amongst climate scientists, then, is not political philosophy, but rather a particular understanding of the relational dynamics of the human-natural climate system. As Klein puts it, changing the political system is 'no longer a matter of mere ideological preference but rather one of species-wide existential necessity' (Klein 2013). In this respect climate change action seems a clear example of what Swyngedouw has termed a 'post-political' form of contemporary action, where politics is based not on a social vision of an idealized future, but on apocalyptic eco-imaginaries that promise to be resolved via 'complex managerial and institutional configurations' (Swyngedouw 2010, 222). As Swyngedouw points out, 'in the climate change debate, the political nature of matters of concern is disavowed to the extent that the facts in themselves are elevated, through a short-circuiting procedure, on to the terrain of the political, where climate change is framed as a global humanitarian cause' (Swyngedouw 2010, 217). Nonetheless, the facts of a policy-oriented climate science are no longer the sacrosanct facts of a version of science that is able to keep nature separate from society. Here political action is framed by a certain understanding of material relationships of which human actions become enfolded as an important constituent part. Climate change thus offers, I suggest, an example of what Marisol de la Cadena (2010) and Mario Blaser (2010) have called 'ontological politics'. However, it is an ontological politics in which the ontology at its centre is not the relational vibrancy of earth beings or the relational emergence of indigenous pluriverses but the circulating qualities of a complex and dynamic climate system. It is to the ontological politics of a version of 'the climate' that is being responded to in policy circles that I now turn.

An ontology of climate

It is striking that in philosopher of science Karen Barad's recent book, *Meeting the Universe Halfway*, Barad begins her discussion of the ontological commitments of quantum physics with an account of the anxiety surrounding the extent to which the work of physicists Niels Bohr and Werner Heisenberg may have been implicated in the development of nuclear weapons during the second world war. *Meeting the Universe Halfway* turns out, however, to be less of a discussion of the ethics of scientific knowledge production and its impact on global politics, than a philosophical discussion of the opportunities that an analysis of quantum physics might hold for a reinvigorated philosophy of science that

acknowledges the relationship between multiple forms of human and non-human agency as a basic ontological commitment.

Barad is particularly concerned with the way in which quantum physics posed a challenge to Newtonian science, leading physicist Niels Bohr to develop a theory that was able to acknowledge what Barad calls the 'intra-action' of observer and observed. The emergence of quantum mechanics was a fascinating moment for science, for it disrupted the basis upon which scientists had been able to claim objectivity in their work by proposing that the properties of the natural world being measured were destabilized or 'diffracted' by the very act of measurement.[1] Perhaps interestingly for our analysis here, Barad's analysis hinges on a differentiation between Heisenberg's *uncertainty* principle, that focused on the undecidability of two variables (e.g. position and momentum), and Bohr's concern with complementarity. If Heisenberg was preoccupied with the inherent *unknowability* of both the position and the momentum of a particle at any moment in time, Bohr argued that it was impossible for a particle to have both position and momentum at the same time, and that it was the presence or absence of particular measurement equipment that determined whether the particle would manifest in terms of either momentum or position (i.e. the variables of momentum and position were *complementary* to one another) (Barad 2007, 22). If Heisenberg and Bohr differed in their interpretation of the paradoxical observations that led to quantum theories, the effect of the paradox that observation seemed to change what was being observed was that, for both, the experiment could no longer be claimed to exist apart from the experimental subject. Now, in quantum physics, the presence of the experimental apparatus and the scientific subject had to be incorporated as an active component of the dynamic system that the scientist was aiming to observe.

With her attention to the ways in which quantum physics found itself needing to dismantle the separation between observer and observed, Barad derives a theoretical perspective that I suggest is helpful for assessing the epistemological and political implications of climate change. Barad's theory of intra-activity, which she derives from her analysis of quantum physics, allows us to explore whether, in the cases I have described, a similar recursive relationship between the models and the realities which they attempt to model is also at play, and if so what the particular relational commitments, and thus politics, of this recursivity might be.

The incorporation of the effects of almost all human practices into that which is being measured by climate science comes only after years of analysis in which the science of climate change proceeded for the main part within the confines of 'normal' science (Funtowicz and Ravetz 1993). The emergence of climate science is a dual story whereby the analysis of the circulating systems of weather has sat alongside a parallel and at times intersecting analysis of the effects of the radiative properties of carbon dioxide as a determinant of climatic variation. Science-inspired suggestions of local anthropogenic climate change go back to the eighteenth and nineteenth century, but it was at the turn of the twentieth century that a potential link was first established between the levels of carbon dioxide in the atmosphere and global climate change. In the early nineteenth century Joseph Fourier identified the warming effect of the earth's atmosphere, arguing that the atmosphere absorbs radiant heat (Edwards 2010; Weart 2008) and terming this for the first time a 'serre' or 'greenhouse' effect. In the 1850s, this suggestion was explored in more detail by chemist John Tyndall who analysed the different radiative potentials of various gases found in the atmosphere in order better to understand how this greenhouse effect worked. But it was Svante Arrhenius, a Swedish scientist, who identified an interaction between the heat-retaining effects of CO2 and water vapour and first made the tentative suggestion that the human extraction of fossil fuels might one day contribute to global

warming. In an 1896 academic paper, Arrhenius calculated 'that doubling the amount of CO2 in the atmosphere would raise the global average temperature by 5–6 degrees' (Edwards 2010, 73). Arrhenius thought that the potential existed for humans to exacerbate this process by burning fossil fuels, but predicted it would be several thousand years before human activities would be able actually to affect global temperatures.

The idea that carbon dioxide could be a key factor in determining global temperature changes was initially contested and, despite initial interest in the work of Arrhenius and the US climate scientist Thomas Chamberlain who further demonstrated Arrhenius's theory, the theory that CO2 could be held responsible for either global warming or cooling was broadly discredited. It was not until the 1930s that the British steam engineer Guy Stewart Callendar revived the theory and with it reiterated the possibility that human activity itself might be capable of effecting global changes in temperature.

Although the idea that human activities might conceivably have been responsible for the changes in CO2 levels that were being detected, the scientific method through which this information was discerned was working very much within the kind of modernist objectivist scientific paradigm that has been written about extensively by scholars of the history of science (Daston and Galison 2010; Shapin and Shaffer 1985). This was only to shift as the method for analysing climate moved gradually from the collation of information across different disciplinary subfields, to the incorporation of different kinds of data into complex climate models which were able not only to describe the climate system in terms of a dynamic interaction of physical properties, but could begin to provide both retro-analysis of an earlier science of climate and predictions of future trajectories under different scenarios.

In his 2010 book, *A Vast Machine*, Paul Edwards recounts how the establishment of a scientific consensus around the link between these climate and carbon phenomena emerged under great scepticism and only it became possible to demonstrate this link effectively with the invention of computer modelling which was for the first time able to analyse the feedback loops of heat radiation in complex circulations of air in the global atmospheric system. Edwards also suggests that an increased attention to the measurement of carbon was prompted by analyses of levels of the radioactive isotope carbon-14 as a method of measuring the effects of the fall-out of nuclear testing in the mid-twentieth century, a project which led to the establishment of stations to measure atmospheric levels of carbon at Mauna Loa in Hawaii and also in Antarctica (Edwards 2010; Lövbrand and Stripple 2011; Weart 2008). Research on the decay of carbon-14 also opened the way for analyses of the different kinds of carbon that were to be found in the atmosphere, allowing scientists to determine by the 1960s that a significant proportion of atmospheric carbon dioxide was derived directly from the burning of fossil fuels (Weart 2008). It was the emergent effect of these coincidental scientific advances taking place in often otherwise unconnected fields – oceanography, meteorology, engineering, and computer science – that provided the grounds upon which an increasingly robust argument that human activities were indeed changing the global climate could begin to be established.

As the 1980s saw the establishment of an ever more robust consensus among climate scientists, one effect of this consensus was to open up to climate science the possibility of its possible complicity, as part of the activity of modern industrialized economies, in the production of the system that it was detecting and the future direction of the system that its models predicted. Whilst this remains admittedly a marginal concern within mainstream climate science, the tension between the climate as an objective entity and the climate as dynamically constituted by human environmental interactions is a problematic which proliferates within attempts to use climate science as justification for policies for

social and environmental change. Two further examples from my own field-work illustrate the issue whereby the social practices through which objective description and forms of intervention are developed, becoming recognized as part of the problem that they are trying to describe. The first was a repeated observation that was made in a project that was hoping to develop a technological answer to climate change through the promotion of digital technologies that would reduce travel and provide information to help people make more ecologically friendly decisions. Here discussions frequently revolved around the question of whether digital technologies might actually be a major cause of climate change with a correlation between increases in IT use since the 1980s and global increases in carbon emissions perhaps pointing to a more fundamental inseparability of problem and solution. Similarly, conversations about how to produce future low-carbon cities often circled around a tension between proposals to increase the density of cities in order to reduce transport costs and thus reduce carbon emissions in order to mitigate climate change, and questions over whether the building work itself would end up producing more carbon emissions than would be offset by a projected reduction in car journeys. In each of these cases where climate science was used as justification for social intervention, the objectivity of the science was tripped up by the realization that any potential solution would have to be analytically reincorporated as part of the object that it was meant to resolve. Whilst Bohr was shocked to find, in his experiments with light particles, traces of the presence of the scientific observer, those using science as the grounds for policy were frequently unsettled by a realization of the entanglement of the means of tackling of climate change and the nature of the object which this analytical or practical was working to transform.

To return to Barad's discussion of quantum physics, Barad builds on Bohr's recognition of the role of the experimental apparatus and scientific observer in changing the nature of the reality being measured, in order to propose an ontological philosophy which she terms 'agential realism'. From her analysis of Bohr's quantum physics, Barad aims to develop a new ontological foundation for the philosophy of science. In many ways the description that Barad arrives at is consistent with other work in Science and Technology Studies that has focused on the materiality of scientific practice and the entanglement of the human and the non-human in the production of scientific knowledge (Latour and Woolgar 1979; Mol 2003; Stengers 2010). However, her commitment to the development of a philosophy derived from quantum physics itself leads her to place a greater emphasis on what she calls the *intra-agentive* properties of humans and non-humans within experimental systems and the development of a more singular and realist description of the world than other studies in the social construction of science have produced. For Barad, agential realism is a philosophical approach that not only tries to describe the role of non-humans in social processes, but also aims to account for the realization that 'we are part of the nature we seek to understand' (Barad 2007, 26).

In drawing attention to an ontological understanding that allows for the entanglement of humans and non-humans in the production of science, Barad's work provides us with some helpful resources with which to understand the ontological contradictions that contemporary climate science appears to have brought to the fore in policy work, though it does so more as a sympathetic or parallel description to that which I am providing here, rather than a theory to be applied to explain the relationship between science and politics.

The understanding of the global climate that has emerged out of the analytical work conducted by the history of climate science described above, and which is now institutionalized in climate models, hinges on a recognition that the object of analysis is in a process of constant mutation and change and, significantly, that the actions that are contributing to

these changes are distributed and multi-faceted. One challenge in climate modelling is how to gather sufficient and appropriate data so that climate models accurately mirror the complex dynamic system which they themselves have revealed the climate to be. If Barad claims for agential realism that 'matter is a dynamic and shifting entanglement of relations, rather than a property of things' (Barad 2007, 35), the version of climate science which has appeared in policy circles has also emphasized the relational and systemic nature of the global climate in a way that pushes modellers to account not only for geophysical processes but also their link with geopolitical and economic formations. As demonstrated by the quote from the IPCC with which this article opens, the climate is conceived by climate science as a dynamic system. The climate is not primarily a thing but a set of relationships. In anthropogenic climate change humans have been incorporated into this relational scheme, becoming reconceived not as outside but as part of the nature that climate science seems to describe, raising the issue for those who use science as the basis of political activism of how to address their own latent presence within the models that they are working upon. Whilst not identical, I suggest this problem is not dissimilar to Bohr's need to account for the role of context in the production of different experimental realities. As Barad puts it, 'Agential realism is not about representations of an independent reality but about the real consequences, interventions, creative possibilities and responsibilities of intra-acting within and as part of the world' (Barad 2007, 37).

Because of her avid commitment to the rigours of Bohr's scientific method and the ontological conundrums that this method has provoked, Barad's work provides a language that helps to shed light on the systemic, dynamic, and intra-active characteristics of the ontological relationships put on the table when climate science becomes oriented to political ends. Her commitment to taking seriously the findings of a quantum physics that shares with a science-inspired ontology of climate an opening up to new dimensions of relationality, which both extends and disrupts this science, leads her philosophy to mirror the requirement for climate scientists, policy activists, and climate publics to acknowledge their 'intra-activity' with the world they are simultaneously observing. Moreover, the desire that Barad exhibits to develop an explicitly political philosophy on the basis of her understanding of quantum physics also suggests some parallels with the ambitions of those who are attempting to intervene in the governance of climate change that we are concerned with here. Like Barad, those who are negotiating the relationship between science and political action are concerned with the question of how to mobilize an understanding of human beings' intra-active participation in natural processes to bring about forms of social change. Nonetheless, reading climate governance through Barad's agential realism only gets us so far. Further attention to the specific worries of those who are trying to tackle science-defined climate change suggests some key differences between Barad's agential realism and the ontology of climate within which these governmental actors and subjects are working.

Agents, systems, and momentum

In coining the neologism 'intra-action', Barad makes a move against the idea of 'interaction' which would point to the interplay between two well-defined entities. In contrast, intra-action points to the way in which the relation itself is constitutive of those things being related. As we have seen, this approach allows us to appreciate that phenomena are not 'merely the result of laboratory experiments engineered by human subjects' (Barad 2003, 816). Rather phenomena are the co-becoming of human and non-human actions, including matter, apparatuses, and practices, in which distinctions like those

between human and non-human themselves emerge. Recasting phenomena in this way, Barad makes a move to reconceive the world as 'agential intra-activity in its becoming' (Barad 2003, 816). For Barad an important effect of an attention to intra-activity is that it acknowledges the indeterminacy of the world. The consequence of this approach is that Barad places great emphasis on the capacity of intra-agentivity to produce radically open futures. She argues: 'The future is not what will come to be in an unfolding of the present moment; rather the past and the future are enfolded participants in matter's iterative becoming' (2003, 816). It is here that I suggest her philosophy begins to deviate from the particular ontology of a governable climate with which we are concerned here.

If the climate is conceived by those attempting to create political solutions to climate change as an intra-active system, it is certainly not understood as a system in which 'the future is radically open at every turn' (Barad 2003, 826). In fact, the requirement that activist climate scientists and the technicians of carbon mitigation feel to enact their own agentive interventions into the climate system is derived not from a sense of the openness of the system, but with a dread that the future is worryingly over-determined, and a fear that human action risks being ineffective in a system which is already exhibiting a powerful momentum in an apocalyptic direction.

One of the central tenets of Kevin Anderson's analysis of climate mitigation possibilities, for example, is the notion of the 'carbon budget'. This is the idea that the global climate system is affected not by daily, monthly, or yearly emissions rates but by the cumulative amount of carbon in the atmosphere. 'For long-lived gases such as CO2 and many other greenhouse gases, cumulative emissions, the stock that builds up in the atmosphere, is the quantity that matters. Every day we turn the lights on, every time we drive a car we add to the accumulating stock of atmospheric CO2. Our cumulative emissions – and our carbon budget – are pivotal to understanding temperature and climate change' (Anderson 2012, 21).

Manchester's carbon literacy project also builds explicitly on this idea of the carbon budget in order to try to stress to people the urgency of the need to act. For Anderson and other technicians of carbon mitigation, the fear is that this carbon budget is rapidly being used up. Although still tentatively optimistic about the capacity of humans to curb a trajectory towards disaster, the longer that the reduction of carbon emissions is delayed, the more dire the predictions become, and the less capacity humans will have to intervene in a climate system out of (human) control. The ontological implication of attending to cumulative emissions rather than emission rates is an acknowledgment that although the climate is produced through intra-actions, its effects are systemic and identifiable, allowing it to operate as a kind of hyper-object (Morton 2013) with a superagency all of its own. If a science-inspired ontology of climate change puts new forms of relationality in play, it does so by simultaneously reinscribing the singularity of the system. Society bleeds into nature, but it does so in such a way as to produce a new nature/culture whose singularity is key to the framing of political interventions as a matter of changing behaviours and/or introducing technological solutions. Climate models which predict the future direction of climatic variations under different cumulative emission scenarios have produced alarming results which have been variously described in terms of runaway climate change, of tipping points, and of points of no return (Pearce 2007; Stern 2008, 6). As James Hansen explains in an interview in *The New York Times*, 'if we burn even a substantial fraction of the fossil fuels, we guarantee there's going to be unstoppable changes. We're going to leave a situation for young people and future generations that they may have no way to deal with' (Gillis 2013).

For policy-oriented climate science then, the systemic interactions that climate science has come to model have a temporal element that demonstrates not just that climates are produced out of a process of systemic intra-action, but that the space and time within which humans will be able to retain a particular, desired intra-active role in the climatological process is closing down. The idea of *momentum* captured in the concept of 'runaway climate change' points to a scenario that could have been otherwise but is increasingly likely to come to be. Whilst Barad thus holds agency up as central to a new ontological model, in *thinking like a climate* we find not just that phenomena have the capacity to differentiate objects in the process of their becoming but that they also work to differentiate the form that agency itself might take. If the particular climate ontology that we are concerned with here shares with Barad an acknowledgement of intra-active becoming, this same climate thinking also complicates the philosophy of agential realism by putting into question the very nature of agency itself. Where Barad claims that 'particular possibilities for acting exist at every moment, and these changing possibilities entail a responsibility to intervene in the world's becoming, to contest and rework what matters and what is excluded from mattering' (Barad 2003, 827), climate scientists like James Hansen remind us that 'the important point is that we have started a process that is out of humanity's control',[2] while Kevin Anderson concludes in an attempt to hold on to agency: 'there is real hope, but that hope reduces significantly each day' (Anderson 2012, 39). Thinking-like-a-climate requires an acknowledgement not only of the intra-agentive effects of subjects and objects, then, but of the overarching agency of the system-as-a-whole.

The ambivalence towards the capacity of individual human agency to respond to an anthropogenically driven climate system that is overwhelming in its own momentum has important implications for how we might think about the politics of climate change and its relationship to climate science. As discussed in the introduction to this special issue, attention to materiality as a site of politics can at times seem to displace or de-centre human agency in favour of an attention to the affordances and structuring effects of materials themselves. However, a focus on the ontology of climate change seems to demonstrate that climate change is not so much a set of material relations which have political effects by reorganizing people and things in dynamic reconfigurations. Rather, the version of climate change that we find invoked in the mundane technopolitics of carbon reduction provokes a realm of political action which re-poses the question of the relationship between the objectivity of science and the subjectivity of politics.

Far from an attention to the ontology of climate science having the effect of displacing the agency of humans by attending instead to the political agency of things, in the attempts at climate change mitigation that we have considered here it is precisely the particular ontology of climate as systemic interconnection that establishes an imperative that climate scientists and other citizens alike must acknowledge their agency, albeit at the moment at which the possibility of that agency making a political difference seems about to disappear. If the 'science wars' were concerned with the risk that an attention to sociality might pollute the objectivity of science, it is now, ironically, the materiality of climate reconceived as an anthropogenic problem, and its particular ontological characteristics seemingly revealed by contemporary climate science, that is bringing the makers of objectivist science back into the picture as newly reconceived 'political' actors whose political responsibility is defined not by ideology but by a privileged understanding of their (and thus of all of our) participation in reproducing a system of global environmental change.

Although the reduction of responsibility from the collective to the personal register is often seen as an anti-political move, as we have seen here there is an intimate and important relationship between the claims to need to take personal responsibility for climate change

and the exhortation that society must act collectively to mitigate this transformation. Here the attempts by activists to lead by example by changing their own practices is meant as a performance of their commitment to a form of political intervention that takes its lead from scientific data on material processes. As the scientific evidence has become more robust, the calls of scientists like James Hansen and Kevin Anderson have at the same time become ever more radical and vociferous. Hansen, who retired in 2013 eventually finding his position as climate activist untenable within the institutional structures of NASA, now dedicates himself full time to the cause of environmental activism.[3] Meanwhile, Kevin Anderson's calls for social and political transformation have also become increasingly revolutionary. Recently feted by anti-globalization activist Naomi Klein (Klein 2013), Anderson couples his academic work with speeches to political bodies about the necessity for deep and sweeping social and political change to tame and slow the ravages of a changing climate.

Perhaps then, the politics provoked by large-scale environmental processes is not as 'post-political' as Swyngedouw suggests (Swyngedouw 2010). If the distracting issue of whether anthropogenic climate change is real is gradually being displaced by a consensus that human-induced climate change is happening, then we are entering a moment in which the ontology of climate as established in the interstices of science and policy might become a prompt for a reinvigorated set of arguments about who or what might be the appropriate sites, agents, and custodians of politics. This is not to say that the ontology of climate described here is politically deterministic or indeed emancipatory. But it is to recognize that the politics of climate change is one where questions of responsibility, ethics, and political action can no longer be simply bracketed out as a domain separate from the production of scientific fact (Latour 2004). If we are to critique the politics, we must attend simultaneously to the ontological commitments of climate science out of which particular political possibilities resolve. What the effects of this ontologization of politics will be for emergent forms of political intervention itself remains to be seen.

Conclusion

This paper has attempted to explore the ontological status of climate as it becomes conceived as an object of climate change governance and the implications of this practical ontology for our understanding of a contemporary relationship between science and politics. In paying attention to the principles of climate as promoted by those who use climate science as the grounds for political intervention, I have proposed an explanation for the emergence of a particular kind of ontological politics which is reorganizing the conceptual parameters of the roles and responsibilities of objectivist scientists, political activists, and climate publics. Ontological politics in this register is a politics where climate change, revealed through predictive climate models that incorporate historical data from different disciplinary sources, provides the grounds for particular kinds of political action. Karen Barad's work has been particularly helpful for investigating this ontology of climate and its implications for a contemporary politics of climate mitigation.

By paying attention to the specific understandings of climate change that cast it as an extended material process that, whilst incorporating new realms of activity, re-establishes itself as a model of a singular reality (Law, this issue), I have demonstrated how this particular ontology of climate has had the effect of opening science up to politics in new ways. Far from displacing the role of the person in the production of the climate as an object of intervention, an attention to the political exhortations that arise from conceiving of climate as a systemic material process is shown to have begun to return science to

politics, albeit at a moment when the possibilities of mobilizing human agencies against previously unforeseen environmental effects appear to be receding.

Latour and Woolgar's original ground-breaking analysis of scientific practice aimed to elucidate the production of scientific facts in a manner that mirrored scientific practice in its requirement to bracket out a classically sociological version of the human scientist from its description of processes of scientific knowledge production (Latour and Woolgar 1979). At pains to show that science was best explained not through recourse to descriptions of cultural beliefs or value systems, but through a minute attention to the relational enactments that scientists participated in as they mobilized scientific apparatus, experimental equipment, and rules and modes of communication, Latour and Woolgar made a choice not to dwell on the usual sociological categories of personality, biography, and identity in their description of scientific knowledge production. And yet now, even Latour himself has acknowledged the effects of climate change on the status of the scientist as agent: 'While the older problem of science studies was to understand the active role of scientists in the construction of facts, a new problem arises: how to understand the active role of human agency not only in the construction of facts, but also in the very existence of the phenomena those facts are trying to document?' (Latour 2014, 2).

With climate science, we find that the stability of scientific representation, whose construction Latour himself revealed so carefully, is being challenged through a material politics in which the agency, morality, and effects of the scientist and his or her society must be read into the scientific models themselves and responded to accordingly. I have argued that it is helpful to conceive of climate as a political material not because it replaces human politics with a politics of matter (Bennett 2010; Braun and Whatmore 2010) but because of the way in which it no longer allows for materiality to stand apart from sociality and, in doing so, opens the door once again for politics to re-enter the domain of objective description where it has, for most of modernity, been bracketed out.

Acknowledgements

I would like to thank my colleagues at CRESC for many inspirational conversations and the anonymous reviewers of this paper for their insightful comments. I would also like to thank all of those people who helped me during my research to understand the on-going challenges that they are facing as they try to bring climate change into politics.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This research was funded by the Economic and Social Research Council (ESRC) Centre for Research on Socio-Cultural Change (CRESC) [RES-577-28-0001].

Notes

1. For histories of scientific objectivity see Daston and Galison (1992; 2010) and Shapin and Schaffer (1985).
2. Quote from James Hansens TED (Techology, Entertainment, Design) talk "Why I must speak out about Climate Change". Feb 2012, available at: http://www.ted.com/talks/james_hansen_why_i_must_speak_out_about_climate_change?language=en. Last Accessed 19.3.2015.

3. As reported in *The New York Times* and *The Guardian* newspapers: http://www.theguardian.com/science/political-science/2013/apr/02/james-hansen-retires-science-politics, http://www.nytimes.com/2013/04/02/science/james-e-hansen-retiring-from-nasa-to-fight-global-warming.html?_r=0.

Notes on contributor

Hannah Knox is a Lecturer in Digital Anthropology and Material Culture at University College London. Her research is concerned with the relationship between technological systems and social change, and she has conducted field-work in the UK and Latin America. Her publications include *Objects and Materials: A Routledge Companion* and *Roads: An Anthropology of Infrastructure and Expertise*.

ORCID

Hannah Knox http://orcid.org/0000-0003-2294-0258

References

Anderson, K. 2012. Climate change going beyond dangerous – brutal numbers and tenuous hope. *Development Dialogue* 61: 16–40.

Barad, K. 2003. Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society* 28, no. 3: 802–31.

Barad, K.M. 2007. *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham, NC: Duke University Press.

Bennett, J. 2010. *Vibrant matter: A political ecology of things*. Durham, NC: Duke University Press.

Blaser, M. 2010. *Storytelling globalization from the Chaco and beyond*. Durham, NC: Duke University Press.

Braun, B, and S. Whatmore. 2010. *Political matter: Technoscience, democracy, and public life*. Minneapolis: University of Minnesota Press.

Brysse, K., N. Oreskes, J. O'Reilly, and M. Oppenheimer. 2013. Climate change prediction: Erring on the side of least drama? *Global Environmental Change* 23, no. 1: 327–37.

Cook, J., D. Nuccitelli, S.A. Green, M. Richardson, B. Winkler, R. Painting, R. Way, P. Jacobs, and A. Skuce. 2013. Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters* 8, no. 2: 024024.

Daston, L., and P. Galison. 1992. The image of objectivity. *Representations (Special Issue: Seeing Science)* 40: 81–128.

Daston, L., and P. Galison. 2010. *Objectivity*. Cambridge, MA: MIT Press.

de la Cadena, M. 2010. Indigenous cosmopolitics: Conceptual reflections beyond 'politics'. *Cultural Anthropology* 25, no. 2: 334–70.

Edwards, P.N. 2010. *A vast machine: Computer models, climate data, and the politics of global warming*. Cambridge, MA: MIT Press.

Funtowicz, S., and J.R. Ravetz. 1993. Science for the post-normal age. *Futures* 25: 735–55.

Grantham, J. 2012. Be persuasive, be brave, be arrested if necessary. *Nature: International Weekly Journal of Science* 491, no. 7424: 303.

Gillis, F. 2013. Climate Scientist to Retire from Nasa. New York Times, Science Section, 1st April 2013 url: http://www.nytimes.com/2013/04/02/science/james-e-hansen-retiring-from-nasa-to-fight-global-warming.html?pagewanted=all&_r=0 last accessed 19.3.2015

Guston, D.H. 2001. Boundary organizations in environmental policy and science. *Science, Technology and Human Values* 26, no. 4: 399–408.

Hulme, M. 2009. *Why we disagree about climate change. Understanding controversy, inaction and opportunity*. Cambridge: Cambridge University Press.

IPCC. 2014. Summary for policymakers. In *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. C.B. Field, V.R.

Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, et al., 1–32. Cambridge: Cambridge University Press.
Jasanoff, S. 1990. *The fifth branch: Science advisers as policy makers*. Cambridge, MA: Harvard University Press.
Jasanoff, S. 1996. Beyond epistemology: Relativism and engagement in the politics of science. *Social Studies of Science* 26: 393–418.
Klein, N. 2013. How science is telling us all to revolt. *New Statesman Online*, October 29. http://www.newstatesman.com/2013/10/science-says-revolt.
Kohn, E. 2013. *How forests think: Toward an anthropology beyond the human*. Berkeley: University of California Press.
Latour, B. 2004. Has critique run out of steam? From matters of fact to matters of concern. *Critical Inquiry* 30: 225–48.
Latour, B. 2014. Agency in the time of the Anthropocene. *New Literary History* 45, no. 1: 1–18.
Latour, B., and S. Woolgar. 1979. *Laboratory life: The social construction of scientific facts*. Princeton: Princeton University Press.
Lövbrand, E., and J. Stripple. 2011. Making climate change governable: accounting for carbon as sinks, credits and personal budgets. *Critical Policy Studies* 5, no. 2.
Manchester City Council (2009). Manchester: A Certain Future. Manchester: Manchester City Council.
Manchester Climate Monthly. 2013. Professor Kevin Anderson on science, silence and 'neutrality' #Manchester #climate. *Manchester Climate Monthly*, December 12. http://manchesterclimatemonthly.net/2013/12/23/professor-kevin-anderson-on-science-silence-and-neutrality-manchester-climate/.
McKibben, B. 2013. *Oil and honey: The education of an unlikely activist*. New York: Times Books.
Mol, A. 2003. *The body multiple: Ontology in medical practice*. Durham, NC: Duke University Press.
Morton, T. 2013. *Hyperobjects: Philosophy and ecology after the end of the world.* Minneapolis, MN: Minnesota University Press.
O'Reilly, J., K. Brysse, M. Oppenheimer, and N. Oreskes. 2011. Characterising uncertainty in expert assessments: Ozone depletion and the West Antarctic ice sheet. *Wiley Interdisciplinary Reviews: Climate Change* 2: 728–43.
Oreskes, N. 2004. Beyond the ivory tower. The scientific consensus on climate change. *Science* 306, no. 5702: 1686.
Pearce, F. 2007. *With speed and violence. Why scientists fear tipping points in climate change*. Boston: Beacon Press.
Revkin, A.C. 2007. Scientist at work Susan Solomon: Melding science and diplomacy to run a global climate review. *The New York Times*, February 6. http://www.nytimes.com/2007/02/06/science/earth/06profile.html?_r=0.
Saloranta, T.M. 2001. Post-normal science and the global climate change issue. *Climatic Change* 50, no. 4: 395–404.
Schneider, S.H., and K. Kuntz-Duriseti. 2002. Uncertainty and climate change policy. In *Climate change policy: A survey*, ed. S.H. Schneider, A. Rosencrantz, and J.O. Niles, 53–87. Washington DC: Island Press.
Shackley, S., and B. Wynne. 1996. Representing uncertainty in global climate change science and policy: Boundary-ordering devices and authority. *Science Technology and Human Values* 21, no. 3: 275–302.
Shapin, S., and S. Schaffer. 1985. *Leviathan and the air-pump: Hobbes, Boyle, and the experimental life.* Princeton, NJ: Princeton University Press.
Stengers, I. 2010. *Cosmopolitics I*. Trans. R. Bononno. Minneapolis, MN: University of Minnesota Press.
Stern, N. 2008. The economics of climate change. *The American Economic Review* 98, no. 2: 1–37.
Swyngedouw, E. 2010. Apocalypse forever? *Theory, Culture & Society* 27, no. 2–3: 213–32.
Weart, S.R. 2008. *The discovery of global warming*. Cambridge, MA: Harvard University Press.
Webster, M. 2002. Communicating climate change uncertainty to policy-makers and the public. *Climatic Change* 61, no. 1–2: 1–8.
Yearly, S. 1992. Green ambivalence about science: Legal-rational authority and the scientific legitimation of a social movement. *The British Journal of Sociology* 43, no. 4: 511–32.