COMMUNICATING THE CLIMATE

From Knowing Change to Changing Knowledge

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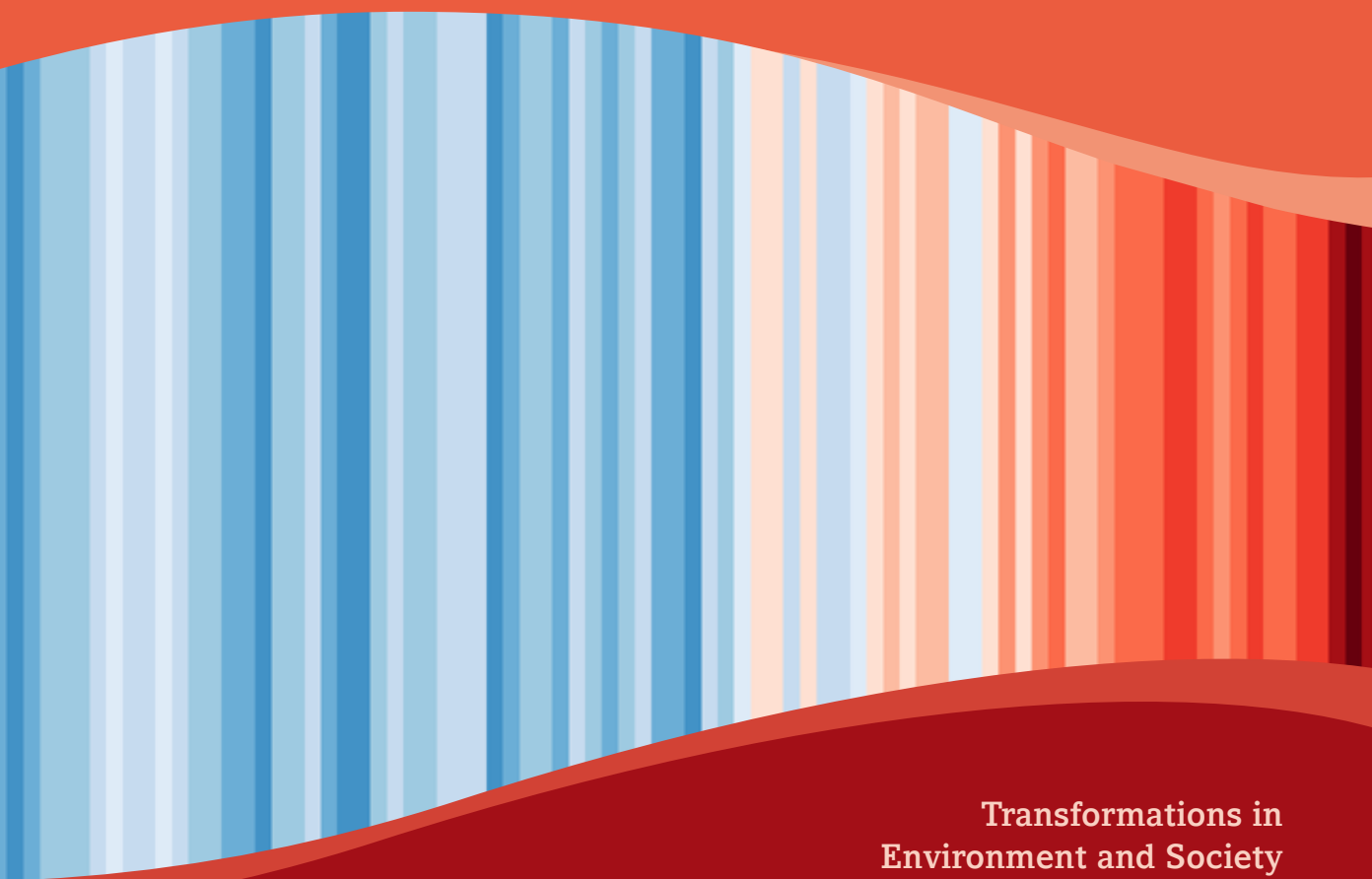

Transformations in Environment and Society

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Communicating the Climate

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Edited by

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Preface

After decades of climate change debate, what should have been obvious from the beginning has become increasingly difficult to ignore, and increasingly urgent: tackling anthropogenic climate change was never going to be straightforward, and it was never purely a scientific, political, or economic question. Instead, something as seemingly abstract and all-encompassing as "climate change" is, and always will be, an existential question, produced by an intimate collaboration between the life worlds and convictions of many different stakeholders. If we expect people to grapple effectively with what climate change means, interdisciplinary academic collaboration—combining the data-driven knowledge of the Earth's complex systems with an understanding that is more sensitive to the unpredictable and diverse world of humans—has to be part and parcel of how experts shape their messages and share them with the public. Climate change cannot be solved by dumping facts into the public sphere. Because of the scale of sociotechnical transformations that tackling climate change necessitates—changes to the energy system, changes to the agricultural system, changes to the way cities are built, changes to mobility, to name a few—it really is a deeply uncomfortable truth. For many, adapting to climate change means a complete redefinition of their lives. Unsurprisingly, many receive this message, and climate change as its carrier, with skepticism.

So, efforts to communicate the daunting complexity of climate change, and the scale of the change needed to prevent or mitigate it, have to account both for how people make sense of these facts and how this knowledge (along with its consequences and distribution) affects them. Yet so far, while there have been attempts to forge the interdisciplinary connections that are key to communicating issues relating to climate change, truly interdisciplinary collaborations have been few and far between.

As concerned human beings and as environmental scholars living in a world that is already experiencing the effects of a changing climate, we consider anthropogenic climate change to be the most pressing matter of our time—followed by overall environmental degradation and species extinction. The people we encounter in our work and our scholarly environment usually tend to agree. Yet public discussion of climate change is still too often dominated by the question of whether or not it is real. In interrogating

why this could be the case, we kept returning to the importance of science communication—typically understood as the communication of complex scientific issues to nonexperts, although in this volume we use it to also include communication between the natural sciences and the humanities, between scientists and the public, and between different stakeholders, as well as locals and activists. Not always, it seems, does more information about climate change lead to the desirable outcome—i.e., more action to mitigate the consequences of climate change or to tackle its causes.[1] This paradox intrigued us, prompting us to look more deeply into science communication.

The notion of stories and the act of storytelling are as fundamental in science communication as in any other form of communication. And as technology now enables us to be more interconnected with other parts of the world in real time than ever before, ever more connections will influence the development of our stories. Along with increased access to education, the technology available to us has enabled people to be more aware of what is happening around the planet, potentially increasing shared concerns of humanity. Satellites and computers, for example, allow us to create and disseminate visualizations of the planet, making it possible to imagine a truly *global* climate. This global perspective is visible in, for example, the graphics produced by the Intergovernmental Panel on Climate Change (IPCC), which outline several different future warming scenarios. Yet no one knows exactly how any of these scenarios would play out in the real world, what the particular negative consequences will be, and how and where they will occur. These stories are still unfolding.

As an early modern historian, one of the two editors of this volume, Katrin, usually knows how a story ends when she starts writing it—although the people living through the stories of the past did not. They still lived in the realm of sideshadowing, where multiple futures were still possible. As scholars, it is important to read the texts they left behind with an open mind, to see how they perceived their own situation and the world they lived in—and it can be difficult not to foreshadow too much while writing. The other editor, Jeroen, has no idea how the stories he deals with will end. As a sociologist of science, he thinks about issues of the present and the future, caught up in contemplating issues outside the normal temporal range of human planning. Often, his research topic,

1 Dan M. Kahan, Ellen Peters, Erica Dawson, and Paul Slovic, "Motivated Numeracy and Enlightened Self-Government," *Behavioural Public Policy* 1 (2013): 54–86.

climate engineering, leads him to think about developments five, thirty, a hundred years into the future, captured in the uncertainty of prediction and foreshadowing. For both of us, it is quite exciting to write about the present. We do not know how this story will end, but we do know that we want to influence it.

As both actors and subjects in the story of climate change, we are obviously invested in its outcome, for better or for worse. With our dual role as citizens and "experts," we, along with many others, share a responsibility to communicate the uncertainties, the complexity, and the implications of different climate futures, while still mobilizing as many people as possible to take action, whether individually or collectively. It may be an idle hope to think that we can change everyone's behavior, but we should at least try to do our part in the communication of climatic futures. The communication of the insights and results of climate science to the general public in the recent past has created awareness but has, as of yet, not been sufficient to foster sustained political pressure at a level that will definitely limit climate change. Neither scaremongering nor cold, hard facts have convinced people to change their attitudes and lifestyles[2]—and that is if something called "cold, hard facts" can even be said to exist. Hope, too, seems only to work to a limited extent. Time is of the essence when tackling climate change, but the timing cannot be "too late"—otherwise demoralization could lead to even fewer efforts.

So, in the case of anthropogenic climate change, as in almost all other parts of life, the way the message is conveyed is as important as the message itself. Simply assuming that people will accept facts imposed on them by the authority of climate scientists in a laboratory far away[3] is not only naïve, it also degrades the agency and independence of people. Science has provided us with a clear, albeit particular, understanding of climate change. Still, it has not been enough to foster sustained change. Studying the theory and practice of climate-change communication, with a reflexive focus on how it can be improved, is therefore essential to our own scholarly endeavors. What can we do to mobilize more climate outrage, more climate hope? Who should be the most important actors in the climate-change debate? Should the scientist and the science even be at the center of the debate, or are there other aspects that need more attention? These are questions we will tackle in this *Perspectives* issue.

2 See Elin Kelsey's 2014 *RCC Perspectives* issue "Beyond Doom and Gloom: An Exploration through Letters" (https://doi.org/10.5282/rcc/6804) and her multimedia Virtual Exhibition on the Environment and Society Portal (http://www.environmentandsociety.org/exhibitions/beyond-doom-and-gloom).

3 These labs can of course be "far away" geographically, spatially, or practically, but also culturally, hierarchically, or psychologically.

Questions of interdisciplinarity and engaging with different forms of knowledge were already familiar to us from our doctoral projects, and it was these questions that initially brought us together. As members of the structured Doctoral Program Environment and Society at the Rachel Carson Center, we interact with scholars from many different disciplines and many different countries on a daily basis. We both deal with climate change—be it as a consequence of a volcanic eruption during the Little Ice Age or as climate engineering as a proposed additional measure to tackle climate change today. Before collaborating on this volume, both of us were grappling with the enormity of climate change; both of us were grappling with the passivity of human responses to what the science is saying—both our own and that of others. Both of us were interested in the question: How can we integrate findings from the climate sciences into a doctoral project that is at home in the humanities and the social sciences rather than the natural sciences?

Our concerns coalesced into a central question that ultimately became an interdisciplinary workshop, "Communicating the Climate: How to Communicate Scholarly Findings on Climate and Weather in a Controversial Time," which we organized at the Rachel Carson Center in August 2017. The workshop's overarching questions were how to effectively communicate scholarly findings on climate and weather between different disciplines and to the public, as well as how to make sure our work has an actual impact. Four experts from different academic fields reflected on these topics, initiating lively discussions among the workshop participants and the Carson fellows, visiting scholars, and doctoral students who also attended. Dania Achermann spoke about some of the everyday challenges that humanities scholars and natural scientists face when working together on climate-related issues. Christoph Baumberger discussed the vocabulary used in IPCC reports (which are the result of international and interdisciplinary collaborations), the strengths and weaknesses of the reports, and how to read them. Grit Martinez addressed the roles of policies, governance, and civic activism in how different countries tackle climate change today. Helmuth Trischler reminded us of the different forms of (climate) knowledge production that play their part in questions around responsibility and climate justice in climate change. It was Helmuth's input during the workshop that provided the initial ideas that inspired this *Perspectives* issue.

But it is not enough to discuss these issues among ourselves as scholars; engagement with other groups, such as policy makers, citizen scientists, and local and indigenous activists

and residents, is crucial. Another important issue in this debate is whether our various identities are mutually exclusive—i.e., can a scientist also be an activist? What is the role of expertise in the communication of climate change? How central should its authority be?

The different essays in this issue discuss the role of the scientist in producing knowledge about climate change, and whether science should be decentered to make space for local, indigenous, or citizen-science approaches. This discourse about the role of the scientist takes us on a journey through time as well as around the globe to study several examples involving different actors. Together, the contributions to this issue tell a story of how we can know the climate, who can know it, and what knowledge is relevant and accepted (and by whom). Simultaneously, it asks the question of how knowing can change people, and perhaps inspire changes in their opinions and behaviors.

Once all the drafts for this issue came in, it was clear that almost every author felt the explicit need to address and defend the established scientific consensus behind anthropogenic climate change. As editors, we have decided to cut those parts to avoid repetition. But we would like to underline that all authors in this issue, whatever else their differences of opinion, are convinced that we live in a unique time in which the global temperature is rising due to emissions of greenhouse gases into the atmosphere as a result of human activity, and these emissions cause changes in local and global weather patterns. We also all agree that there is a dangerous lack of climate-change mitigation. Many of us, however, disagree about *how* to overcome this action deficit in climate change and in science communication. The papers collected in this issue represent our responses to the discussions in the workshop; they are diverse and explorative in the range of their topics. As such, they are pieces to think with rather than comprehensive discussions of communication theory and the history of science, which can be found elsewhere. This *Perspectives* issue provides different arguments and reflections about where to go from here. The human actors depicted in the different articles experience and embody these different visions, either directly or through stories.

The volume begins with an essay by Lynda Walsh, who—just as she did during our workshop—introduces the idea that the established authority of Western science may at times hamper rather than help meaningful action. We should therefore, she argues, seriously consider weaning science from its central role as the core provider of knowledge and authority. According to Jeroen Oomen, our second author, this endeavor could

prove dangerous and problematic because, despite its limitations, science does provide some neutral ground and established ways of knowing. These two pieces serve as the foundation on which the other essays build their arguments.

The first section, "Knowing Weather and Climate," explores the question of how climate and weather can be known, and what it means to know. We start by looking back in time with Katrin Kleemann's piece on an eighteenth-century volcanic eruption in Iceland that shows how knowledge influences the understanding of the world around us. Linden Ashcroft builds on this question with her story about the rescue of old weather data by citizen scientists.

The second section, "Negotiating Knowledge," addresses how different forms of knowledge, constructed by different groups and interests, are negotiated and contested around the globe. Emma Shortis's portrayal of the World Park campaign in Antarctica shows how scientific knowledge can be mobilized and how it can be used to further activist goals (as well as industrial interests). A similar argument is made by Saskia Brill, whose story about First Nations in Canada shows that science can not only be used as a political *tool*, but it can also be a meeting place for different interests. Next, Emilie Schur Petri analyzes a transnational example of building climate resilience, in which community health workers help shape knowledge about climate change and pollution, in order to foster resilience in their communities. Finally, Dorothea Born problematizes the role of science, warning that "Science" as it is commonly understood is also a construction that has often been used to justify and legitimize the barbarism of colonialism, exploitation, and racism. Science is not only knowledge—it is also a tool for power and domination.

The three papers that comprise the final section, "From Knowing to Action," raise the question of how knowing can be translated into action. Vera Karina Gebhardt Fearns illustrates the importance of the immersive arts for climate-science communication, while Eline Tabak looks at the potential of climate-change novels for the same purpose. Grit Martinez concludes this section with her comparison of the cultural settings of the climate change debate in the United States and Germany, making clear that most action is still local and regional, and it has to be taken by those who inhabit and govern their immediate environments.

Over the course of the coming decades or centuries, climate change will increasingly manifest in unexpected and volatile ways. On a global level, climate change will translate into rising sea levels as rising temperatures continue to cause the polar and glacial ice caps to melt and the warmer oceans to expand. On a regional level a changing climate might translate into desertification, loss of arable land, loss of crop yields, and water shortages in dry regions; in coastal regions it will translate into intensified storm frequency and flooding. In some regions, such as North America, climate change can (and already does) translate into a shift in the jet stream, which can cause colder and harsher winters. No single piece of writing will change these facts. No cumulative body of scientific research has proved powerful enough to avert these developments. In recent years, many authors have reflected on this apparent failure. Many of these reflections will be referenced, tackled, and discussed in this volume. Because the cumulative knowledge provided by science has not proved effective at galvanizing action, and the knowledge construct of science is highly problematic in its own right, more and more people have started to question what science can provide, what it can do.

In this issue, many people from a variety of disciplines have spoken to this question. The answers provided are not uniform. They are not necessarily profound. And they will likely not significantly alter the climate-change debate. But cumulatively, they offer a reflection on how science communication is a multifaceted beast, a daunting and challenging endeavor that is unavoidably important. *Communicating the Climate* thus contributes to the maturing conversation about climate change and about science—about what science does, what scientists do, and what science should do in the face of the environmental crisis we are facing. This conversation is a vital part of how to understand climate change.

We would like to thank everybody who participated in our workshop in August 2017. We also wish to express our gratitude to the Marie Curie Environmental Humanities Innovative Training Network (ENHANCE ITN), facilitated by the European Union and the European Commission, for funding for this workshop, and to the Rachel Carson Center for hosting our workshop and all the staff members who helped us make it happen. Particularly, we would like to thank Hannah Roberson for her invaluable assistance editing this *Perspectives* volume.

Lynda Walsh

Decentering Science in Climate Communication

Today, most climate communicators pride themselves on having moved past "deficit" models for communicating climate change—which cast nonexpert communities as ignorant vessels waiting to be filled with an understanding of their climate by experts—and on to various "coproduction" models.[1] These new models present climate knowledge as jointly constructed by expert and nonexpert communities. But they rest on neoliberal logics that privilege technoscientific authority by virtue of its imbrication with global economic development. I will argue in this essay that if we as climate communicators (and scholars of climate communication) truly believe in the "coproduction" of climate-change knowledge, we must question the centrality we have afforded climate science in our models.[2] We must find alternative models that do not position climate science and scientists as the final authority.

To understand my argument, a very brief history of models for producing and communicating climate knowledge is in order. I will treat the "Modes of Knowledge Production" model as an exemplar, but all major historical schemes exhibit roughly the same logic.[3] The Modes model identifies three historical epochs. In Mode 1, knowledge was produced according to an Enlightenment model by academic experts and disseminated through other sectors of society in a roughly linear fashion; this was the dominant mode through the first half of the twentieth century in the Western world, and the one that gave rise to the "deficit model" of science communication.

1 Massimiano Bucchi, "Of Deficits, Deviations and Dialogues: Theories of Public Communication of Science," in *Handbook of Public Communication of Science and Technology*, ed. Massimiano Bucchi and Brian Trench (New York: Taylor and Francis, 2008), 57–76.

2 By "climate science" in this essay I am referring collectively to the disciplines represented by Working Group II reports of the United Nations Intergovernmental Panel on Climate Change, namely the atmospheric scientists, paleontologists, dendrochronologists, and other scientists whose data is inputted to our primary technical models and visualizations of climate change.

3 On the "Modes of Knowledge Production" model, see Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott, and Martin Trow, *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* (London: Sage, 1994). Cf. Elias G. Carayannis and David F. J. Campbell, "'Mode 3'and 'Quadruple Helix': Toward a 21st Century Fractal Innovation Ecosystem," *International Journal of Technology Management* 46, no. 3–4 (2009): 201–34; and Harry M. Collins and Robert Evans, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science* 32, no. 2 (2003): 235–96.

The primary catalyst for the shift from Mode 1 to Mode 2 of knowledge production was the rise of neoliberalism. Neoliberalism emerged as a response to the state-sponsored reconstruction of European economies after World War II. Its logics aimed to downsize state governments and shift many of their responsibilities—e.g., social services, regulation of industry, environmental protection, education—to private companies who competed in a minimally regulated marketplace. This economic shift, which finally took hold throughout Europe and the Western hemisphere in the 1980s, catalyzed important changes to the relationship between technoscience and society. The resulting "Mode 2" model of knowledge production involved industry in (a) setting goals for basic STEM research—i.e., defining the economic and political problems whose solutions required the manufacture of technoscientific knowledge and/or technologies—and (b) funding this research. Various metaphors have been invoked to describe this entanglement of state, industrial, and academic actors in Mode 2 knowledge production; the dominant one is the "Triple Helix." In terms of the academic actors, it is primarily STEM academics who serve as gatekeepers of climate knowledge, but humanist academics play this role as well when they receive government or industry funding to work on climate change (e.g., in interdisciplinary institutes or in projects to promote the "science of science communication"). However, the humanities' greater historical distance from the Triple Helix, and their traditional alignment with civil society, create tensions for humanities scholars working on climate change, as indicated below by the differential respect accorded to STEM and humanities colleagues in interdisciplinary projects.

Recently, Carayannis and Campbell have proposed that we are entering a new mode of knowledge production, which adds the strand of "civil society" to create a "Quadruple Helix" of interactivity.[4] Citizen science is one example of Mode 3 knowledge production, but so are European research "clusters" that recruit humanist experts to help solve "wicked" problems, and decision-making models that weigh the needs, values, and emotions of stakeholders alongside quantitative criteria.[5]

4 Carayannis and Campbell, "'Mode 3' and 'Quadruple Helix,'" 201–34.

5 "Wicked" problems are problems whose complexity exceeds traditional causal models and which thus resist solutions. The term comes from social planning but has been adapted widely to multi-input, multi-effect problems such as climate change; see Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," Policy Sciences 4 (1973): 155–69. On Mode 3 knowledge production, see Mary G. Schoonmaker and Elias G. Carayannis, "Mode 3: A Proposed Classification Scheme for the Knowledge Economy and Society," *Journal of the Knowledge Economy* 4, no. 4 (2013): 556–77, https://doi.org/10.1007/s13132-012-0097-4. Terry Shinn, "The Triple Helix and New Production of Knowledge: Prepackaged Thinking on Science and Technology," *Social Studies of Science* 32, no. 4 (2002): 599–614.

So far, so good for communicators seeking the "coproduction" of climate knowledge. However, on closer inspection, the philosophy underpinning the dominant Mode 2 and Mode 3 theories is still essentially neoliberal: namely, "civil society" is defined in Mode-3 models not as a democratic source of potential resistance to state and industrial interests, but rather as a crowd-sourced pool of "creativity" and free labor that produces "innovation" as a form of capital.[6] Further, in Mode 3 models, "knowledge ecology"—implying the sustainable exchange of knowledge among equal agents—and "knowledge economy"—implying that knowledge is capital to be traded—are conflated to the point where any rationale for climate research must be justified almost entirely in terms of economic growth.[7] The resistant potentials of "civil society" or "ecology" to capitalist ventures are thus neatly erased.

There are already troubling signs of the effects of Mode 3 logics. Within the interdisciplinary research "clusters" set up at European institutions to tackle climate change, anecdotal reports from liberal-arts scholars suggest that the dominance of STEM (science, technology, engineering, and math) disciplines under Mode 1 and Mode 2 paradigms persists, meaning "civil" humanist epistemologies are often marginalized in research, or instrumentalized as mere tools to market STEM research. Empirical research into Mode 3 knowledge production in incubators and "science parks" has corroborated these reports, finding that among the four actors in the "Quadruple Helix" (government, industry, academics, and civil society), industrial and entrepreneurial actors have the greatest capacity to act on a global scale.[8] Neoliberal policies have encouraged these global actors to distribute their operations across the globe while still designing and managing projects from a Western corporate center.[9] In terms of climate politics, this is vividly illustrated by the recent "Great Garuda" seawall project in Jakarta, whose construction was contracted to a consortium of Dutch engineering firms for $40 billion and has already displaced thousands of indigenous fishers at locations along the coast.[10]

6 Schoonmaker and Carayannis, "Mode 3," 556–77.
7 Elias G. Carayannis, David F. J. Campbell, and Scheherazade S. Rehman, "Mode 3 Knowledge Production: Systems and Systems Theory, Clusters and Networks," *Journal of Innovation and Entrepreneurship* 5, no. 1 (2016): 17, https://doi.org/10.1186/s13731-016-0045-9.
8 Schoonmaker and Carayannis, "Mode 3," 556–77.
9 Andrew Herod and Melissa W. Wright, eds., *Geographies of Power: Placing Scale*, (Oxford: Blackwell, 2002).
10 Philip Sherwell, "$40bn to Save Jakarta: The Story of the Great Garuda," *The Guardian*, 22 November 2016, https://www.theguardian.com/cities/2016/nov/22/jakarta-great-garuda-seawall-sinking.

In short, Mode 3 models—in spite of their lip service to the coproduction of technoscientific knowledge by experts and nonexperts—double down on the neoliberal, "neocorporatist" logics of Mode 2.[11] By these logics, the Triple Helix of state, industrial, and academic actors continues to form a nexus through which all knowledge production on climate must be validated. If this is true, it doesn't matter how many strands get added—whether "civil society" in the Quadruple Helix model or even "the environment" itself in the Quintuple Helix model—the neoliberal Triple Helix will still act as gatekeeper on climate knowledge and communication. This result is surely of grave concern to scholars who wish to advocate for greater responsibility toward vulnerable communities—human and non—suffering both from neoliberal globalization and its climatic effects.

If Mode 3 generates troubling answers to our questions about the role of climate science in responsible climate communication, then what are the alternatives? Looking at recent cases, at least four emerge:

1. Climate scientists and climate-science research groups choose to resist the neoliberal paradigm and serve as advocates for vulnerable communities rather than their state and industrial partners;
2. Civil society and environmental actors resist the neoliberal paradigm and demand a different mode of climate knowledge production that does not exclude their voices when they are heard as resistant or contradictory to technoscientific accounts of climate;
3. Civil society and environmental actors effectively join the Triple Helix by contributing climate knowledge in a format validated by that nexus;
4. Civil society and environmental actors exploit the "multi-level," "multi-modal" nature of Mode 3 knowledge production[12] to communicate crucial climate knowledge around, rather than through, the "Triple Helix" nexus.

All four of these alternatives are already being enacted with varying degrees of success. In terms of Option 1, we have seen climate scientists such as James Hansen buck state and industrial norms to advocate directly with citizen groups for climate action. Note, however, that Hansen eventually had to relinquish his position at NASA to engage in this resistant behavior. So, while the occasional opposition figure may emerge, climate

11 Shinn, "The Triple Helix and New Production of Knowledge," 599–614.
12 Schoonmaker and Carayannis, "Mode 3," 556–77.

science as an enterprise is so entangled in the support system of the Triple Helix that significant resistance by individual scientists or research groups is unlikely.

In terms of Option 2, the examples of resistant civil-society groups are too many to enumerate—from Sea Shepherd and Greenpeace to climate skeptics and "Contrails" protesters outside meetings of the American Association for the Advancement of Science (AAAS). While these efforts may not have a direct effect on the production of climate knowledge, they do shape climate scientists' communication strategies and habits, and even to some extent the targets of climate research—as evidenced by the decade-long defense of the "hockey stick" graphic that has yielded graphs with ever-longer handles (now dating back 15 million years or so). Instances of resistance by nonhuman environmental actors to the neoliberal paradigm are even more dramatic and provocative—violent hurricanes, algae blooms, droughts, and mud crabs working with Vietnamese shrimp farmers to undermine sea walls. Unfortunately, these resistant acts, instead of generating a revolution of the neoliberal paradigm, have to date resulted in ever more extreme technocratic mitigation and adaptation measures—such as the Jakarta seawall, or Harvard researchers' proposal to shoot two million tonnes of calcite into the atmosphere.[13]

In terms of Option 3, multiple citizen-science projects have found a way to fit civic and environmental concerns into the logic of the Triple Helix in order to produce climate action: for example, Fukushima radiation monitoring, noise pollution in London, or the GIS-TEMP monitoring project in the US.[14] These projects have varied in their effects on climate justice: a few have produced action on behalf of suffering populations; others have merely provided the Triple Helix with free labor and reinforced its authority to determine what counts as climate knowledge.

Finally, in terms of Option 4, civil-society and environmental actors have found ways to advocate for justice by doing an end-run around the Triple Helix. Ceccarelli documented the efforts of Brazilian activists to block a consortium of scientists and pharmaceutical

13 David W. Keith, Debra K. Weisenstein, John A. Dykema, and Frank N. Keutsch, "Stratospheric Solar Geoengineering without Ozone Loss," *Proceedings of the National Academy of Sciences* 113, no. 52 (2016): 14910–14, https://doi.org/10.1073/pnas.1615572113.

14 See Ashley R. Kelly and Carolyn R. Miller, "Intersections: Scientific and Parascientific Communication on the Internet," in *Science and the Internet: Communicating Knowledge in a Digital Age*, ed. Alan G. Gross and Jonathan Buehl (New York: Routledge, 2016), 221–45; and James Wynn, *Citizen Science in the Digital Age: Rhetoric, Science, and Public Engagement* (Tuscaloosa: University of Alabama Press, 2017).

companies from "bioprospecting" in the Amazonian rainforest by launching a "biopiracy" protest campaign that persuaded national lawmakers to deny research permits to members of the consortium.[15] Similarly, numerous towns, cities, and even states in the USA, having observed negative climate effects in their communities with their own eyes, have taken action without waiting for federal support or approval. None of these efforts causes direct or substantial changes to the structure of the Triple Helix; but they do decenter it from its privileged position as the sole authority on climate knowledge and communication.

These climate-communication alternatives all have their strengths and weaknesses, and their success will always be situational. But each alternative effectively destabilizes or decenters the authority of "climate science": in Option 1, a rogue or resistant scientist fights the Triple Helix; in Option 2, "climate science" is an opponent that helps clarify convictions and strengthen solidarity; in Option 3, it is recruited by a community, almost as a subcontractor; in Option 4, it is a gatekeeper to be dodged. All of these alternatives constitute a significant role change for "climate science" in comparison to Mode 3 paradigms, which make it the centerpiece of a powerful knowledge-production regime driven by neoliberal economic logics. If we are truly interested in the coproduction of climate knowledge and communication, I would argue, we must wean ourselves off our dependence on this regime and find alternatives to use when talking about climate with vulnerable communities.

I spoke very recently with some climate scientists who were exasperated by failed efforts to communicate with a particular vulnerable community that distrusted scientists. "If they don't believe me," said one, throwing his hands up in the air, "what more can I do? I'm a scientist; science is what I do." I didn't understand him to be advocating the abandonment of the community to its climatic fate; rather, I took him to be insightfully limning his limits as an agent of the Triple Helix. For too long, we have depended on experts like this scientist to tell us what to think and say about climate change. They have done their part and more. Continuing to cede all responsibility for climate communication to the Triple Helix will result in technocratic "solutions" and communications delivered by the only actors with the reach and resources to act on a global scale—transnational corporations. If this is not the climate future we want, it's time for us to listen to

15 Leah Ceccarelli, *On the Frontier of Science: An American Rhetoric of Exploration and Exploitation* (East Lansing: Michigan State University Press, 2013).

vulnerable communities express their own climate knowledge and needs, and to put our considerable resources toward advocating for those needs in the best way we know how with the most powerful agents we can find—with or without the aid of climate scientists.

Suggested Further Reading

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Jeroen Oomen

A Level Playing Field, or the Hope for Science as a Common Ground

In spite of more than half a century of comprehensive research, and more than two decades of overwhelming scientific consensus, anthropogenic climate change as a scientific fact—as well as the corresponding policy prescriptions—is still cause for heated debate. Despite the fact that tremendous damage to ecosystems and the destruction of many millions, even billions, of lives is projected if no comprehensive effort is made to mitigate our carbon emissions, large parts of most societies still hesitate to accept anthropogenic climate change as "truth." Mitigation—and to what extent—is even more controversial. Evidently, there is a plethora of different reasons for this disagreement. Climate change fundamentally challenges our preferred lifestyles; its long-term effects and its delayed urgency challenge our psychosocial capacity to perceive the urgency accurately, and there has been significant effort invested in discrediting the findings of climate scientists.[1] I think, however, that part of the reason for our collective denial of anthropogenic climate change lies deeper, and is embedded in the way science (and technology) have become an almost sacrosanct pillar of our social hierarchies.

Various trends suggest that some of the authority over facts and truth that science formerly enjoyed is crumbling—although public trust in the scientific expert has remained rather stable. Conspiracy theories—such as doubts about the safety and effectiveness of vaccines, or belief in chemtrails and, most recently, a flat earth—seem to have taken flight in recent years, at least in political prominence. Various political actors, of all political colors, have consistently attacked the reliability of scientific findings. Questions of particular relevance include what guidance science, that crumbling vestige of epistemic authority, can still provide in dealing with environmental issues, such as climate change, and how to communicate scientific findings effectively—while remaining cognizant of their uncertainty and the limits to scientific knowledge.

1 On how climate change challenges our lifestyles, see Kari Norgaard, *Living in Denial: Climate Change, Emotions, and Everyday Life* (Cambridge, MA: MIT Press, 2011), and Amitav Ghosh, *The Great Derangement: Climate Change and the Unthinkable* (Chicago, IL: Chicago University Press, 2016). On the psychosocial capacity to perceive its urgency, see George Marshall, *Don't Even Think About it: Why Our Brains Are Wired to Ignore Climate Change* (London: Bloomsbury Publishing, 2014), and Timothy Morton, *Hyperobjects: Philosophy and Ecology at the End of the World* (Minneapolis: University of Minnesota Press, 2013). On efforts to discredit climate science, see Naomi Oreskes and Eric M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury Press, 2010).

Would Decentering Science Help?

In this issue of the Rachel Carson Center's Perspectives series, Lynda Walsh argues that Science,[2] the systematic project of knowledge production within and beyond academia, as it has come to be understood in the Western world—and because of the West's cultural hegemony, far beyond—should actively be decentered from its role as the sole provider of knowledge. She argues that models of science communication, in its various modes, and the recent turn to a more participatory citizen science—which hopes to capture the knowledge of citizens and laypeople—"rest on neoliberal logics that privilege technoscientific authority by virtue of its imbrication with global economic development" (this issue, p. 15). As a result, a neoliberal "Triple Helix of state, industrial, and academic actors continues to form a nexus through which all knowledge production on climate must be validated" (p. 18). This means, for Walsh, that "for too long we have depended on experts . . . to tell us what to think and say" (p. 20). Instead, she argues, we should award the scientist only a limited epistemic authority and should actively question and resist the scientist's connection to the Triple Helix. In short, we should decenter science and scientists from their perceived role as the final authority on knowledge.

What Does It Mean to Decenter Science?

In principle, Walsh's suggestion sounds helpful and desirable. It is difficult to disagree with her statement that "it's time for us to listen to vulnerable communities express their own climate knowledge and needs, and to put our considerable resources toward advocating for those needs in the best way we know how with the most powerful agents we can find—with or without the aid of climate scientists" (pp. 20–21). Yet underneath Walsh's suggestion of decentering science, further bringing into question the normative authority of the academic system, hides a balancing trick that is far more difficult than it seems at first glance.

For, what does it mean to "decenter science"? What is included in science? What does it mean to decenter the Western academic structure as the core provider of "truth"? What are the alternatives we can envision? While there are compelling reasons to distrust our scientific construct and many of its findings, decentering science, in the way that knowl-

2 As Saskia Brill outlines in her article in this volume, an important distinction to make is between Science as an overarching fact-finding enterprise and ideology, and science as a practice. See her piece for more details on this distinction introduced by Bruno Latour.

edge societies culturally understand it as a fact-finding enterprise (and a legitimization of power and policy), could lead to a general relativism and skepticism that would likely make it difficult to decide between different conceptions and opinions about reality. Evidently, science and scholarship has by and large been in the service of power,[3] not immune from using political games to create epistemic authority. It has also been an intricate part of capitalist and communist extractive hubris. But would disregarding science not lead to more power for the powerful rather than more of a voice for the marginalized?

Walking the Tightrope

As Yuval Harari points out, Western science started out from the admitting of ignorance.[4] Instead of seeing the world as either unknowable (mystical) or known (to the relevant extent), natural philosophers came to see the world as "knowable but not yet known." From this conception grew a systematic desire to understand and know the world, and eventually a codified method for doing so. In itself, this method was intimately bound up with the drive for domination of nature (already appearing clearly in the works of Francis Bacon), with the legitimization of colonialism, and with political power. Over the following centuries, the European scientific method developed into a cursed blessing or a blessed curse, depending on your outlook. It lifted more people out of poverty than was ever conceivable before, enabled (and limited) large-scale democracies, lengthened lifespans, increased health, and allowed tremendous improvements in living conditions for a large part of the world population.[5] At the same time, the scientific method was brought about at least in part by colonialism,[6] which it in turn enabled. It made possible the systematic subjugation and exploitation of people on an unprecedented scale, and was unimaginable without this entanglement. In doing so, it led to our current environmental predicament. It was co-opted to legitimize the world order on a "factual basis," led to incomparable horrors, and structured entire societies according to a promethean estate of science and evidence practices.[7] This tension is still present. The structures of

3 Christophe Bonneuil and Jean-Baptiste Fressoz, *The Shock of the Anthropocene: The Earth, History and Us,* trans. David Fernbach (London: Verso Books, 2016).
4 Yuval N. Harari, *Sapiens: A Brief History of Humankind* (New York: Harper, 2015).
5 On how science lifted people out of poverty, see Harari, Sapiens. On large-scale democracies, see Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (London: Verso Books, 2011).
6 Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton, NJ: Princeton University Press, 2000).
7 Zygmunt Bauman, *Modernity and the Holocaust* (Cambridge: Polity Press, 1989); Yaron Ezrahi, *The Descent of Icarus: Science and the Transformation of Contemporary Democracy* (Cambridge, MA: Harvard University Press, 1990).

academia, as well as the mindset of many of its researchers, still exhibit colonial tendencies, legitimizing the voice of the strong over those of the weak. At the same time, science has not yet lost its capacity to shock and disappoint, to lead to unexpected results that question dominant structures and narratives.

Although reasons of space do not permit an extensive treatment of what science is and what parts of the academic project are included in this discussion, the science spoken about here predominantly refers to the natural sciences. Where the humanities and the social sciences act in conjunction with the facts-provision of the natural sciences, within similar academic structures, their expertise faces similar questions of decentering.[8] When talking about the decentering of (Western) science, there are two important aspects of that "Western" science that should be retained. For one, there is a moderated form of positivist realism, meant here as a commonly accepted way of finding knowledge and a social acceptance of the resulting "truth." Knowledge is made, mediated, constructed, and coproduced through social and psychological processes, and is never an accurate description of an outside reality. Truth may well be unattainable, and the social and natural order are themselves also coproduced.[9] But the advances made in medicine, technology, and our understanding of the climate system (to name a few) show clearly that there is *some* access to external reality which, when findings are distributed fairly and equitably, has the potential to improve the lives of many. More importantly, science can represent and provide a widely shared and accepted vision of the world. While all science necessarily operates within the categories, distinctions, and visions given to the epistemological cultures of particular societies and places, the successes of science and technology, even in their political (and military) applications, have a widespread appeal—an appeal that is not neutral, but that could be utilized for better rather than for worse.

Second, in this realism there is the potential for an honest broker, weighing options and developments in a systematic manner.[10] Again, the concept of an honest broker requires much more qualification than can be given here—because how honest and objective can

8 Often, however, the humanities especially complicate visions of facts and futures rather than provide facts and knowledge. Here, questions of decentering would take another shape, to be discussed in other ways.

9 David Bloor, *Knowledge and Social Imagery* (Chicago, IL: Chicago University Press, 1976); Ian Hacking, *The Social Construction of What?* (Cambridge, MA: Harvard University Press, 1999); Sheila Jasanoff, *States of Knowledge: The Co-Production of Science and Social Order* (London: Routledge, 2004).

10 Roger A. Pielke Jr., *The Honest Broker: Making Sense of Science in Policy and Politics* (Cambridge: Cambridge University Press, 2007).

an honest broker and the connected knowledge even be?—but the possible common ground on which political adversaries could meet needs to be retained, in a sense that holds a strong commitment to a mutually agreed-upon truth.

When we talk about decentering Western science, about questioning scientific authority, we should not *just* ask ourselves what is gained. Importantly, we should also ask, what is lost? In an era that is often feared to be moving towards factual relativity (post-truthism) and manufactured distrust in science,[11] this common ground—on which, in principle, everyone could meet—is more direly needed than ever. If we decenter science, will this mean that we will also lose, to the extent that we haven't already, the ideal of an impartial, non-partisan truth? In short, the decentering of science, in climate communication as in all other controversial topics, should only be undertaken if there is a valid, workable replacement. In this issue of *Perspectives*, we will see instances in which the epistemic authority of science is used precisely *for* this honest brokering, enabling marginalized communities to have a voice in the climate change debate that they would otherwise not have had. We also see instances in which it is precisely science and the way it is centralized that perpetuate exclusion and extractivism. Where does decentering science lead?

The Crisis in Science

This skepticism about decentering Western science, for a lack of better alternatives, should not be misinterpreted as resignation to and acceptance of the status quo. Science, of course, faces its own problems and these should be critically examined. Under the weight of neoliberalism and other economic pressures, academia cannot really act except in conjunction with the demands of the state and industry. It is clear that the required common ground, which in principle should be accessible to all, is in practice far more accessible for, and receptive to, the needs of the powerful. Obfuscation of what has often been called lay knowledge (and, correspondingly, indigenous knowledge) has been, and to a large degree still is, inherent to common scientific practice.[12] Scientific knowledge has typically been regarded as the objective standard of truth, trumping the experience of communities with intimate knowledge of their environments.

11 See Oreskes and Conway, *Merchants of Doubt*.

12 See, for example, Brian Wynne, "May the Sheep Safely Graze: A Reflexive View of the Expert/Lay Knowledge Divide," in *Risk, Environment and Modernity: Towards a New Ecology*, ed. Scott Lash, Bronislaw Szerszynski, and Brian Wynne (London: Sage Publications, 1996), and "Patronising Joe Public," *Times Higher Education Supplement*, 12 April 1996, https://www.timeshighereducation.com/news/patronising-joe-public/93081.article.

Furthermore, according to Andrea Saltelli and Jerome Ravetz, science is in crisis.[13] This crisis is multifaceted. Science, while portraying a potential for firm and reproducible knowledge, faces many distinct and interrelated crises. It has a crisis of reproducibility, as the core tenet of science—that results must hold when experiments are reproduced by others—is often not met. It has a crisis of governance, because the way in which science both exerts influence on governance and is governed itself is opaque and controversial. It has a crisis regarding the use of science for policy, as its hypothetical predictions are unquestioningly used as reliable projections of the future.

This is not just a problem because scientific facts become uncertain, and the associated high stakes aren't met with a solid basis of facts. It is an issue because science isn't simply a fact-oriented search for knowledge. As Lynda Walsh also points out, science is intimately connected to power structures, with policy prescriptions, and with particular (narrow) visions of the future. As such, the promise of scientific and technological advances should never displace normative and political questions about how to organize the society and future that people collaboratively want to construct.

Many scientists, however, even now, still believe in a morally neutral, non-prescriptive science. This is naïve. Science is treated as policy prescriptive, and it is often also produced in order to influence policy. In the realm of climate change, for example, climate findings clearly *are* prescriptive (which is one of the reasons they attract so much controversy). At a talk I attended recently, Sheila Jasanoff pointed out that the IPCC explicitly states that its findings are merely an assessment, not policy prescriptive. As she rightly argued, the IPCC's findings are in fact policy prescriptive. They may not tell the political world how to reach the aim of climate mitigation, but the political and moral overtone is glaring: mitigate your carbon emissions now, or suffer the consequences!

These multiple crises, combined with the embedded authority of the scientific structures, has left science vulnerable to appropriation for a cause, regardless of what the results may be. This is a risk both for a centered and for a decentered science. Truth becomes even more bendable than it already is, only existing to serve a particular purpose. Doubt about science is peddled as a product for major industries to buy.[14] As Alice

13 As quoted in Alice Benessia, Silvio Funtowicz, Mario Giampietro, Ângela Guimarães Pereira, Jerome R. Ravetz, Andrea Saltelli, Roger Strand, and Jeroen P. van der Sluijs, *The Rightful Place of Science: Science on the Verge* (Tempe: Consortium for Science, Policy & Outcomes at Arizona State University, 2016).
14 Oreskes and Conway, *Merchants of Doubt.*

Dreger shows, the "activist left" too has appropriated science, adopting and accepting only those outcomes that fit within the liberal worldview.[15] Another peculiar form of scientific appropriation, this time in the form of decentering, also takes place in the rise of conspiracy theories. In this narrative, reality may still be knowable, yet scientists are certainly not providing "the rest of us" with access to this knowledge. The meteoric rise of anti-vaccination campaigns, belief that climate change is a hoax, belief in chemtrails, and belief that the Earth is flat bodes ill for a future that does not have a common narrative of truth. Would decentering science make it (and "truth") less or more vulnerable to such appropriation?

Conclusion

One of the main powers of "Western" science is that it can lead to inconvenient, unexpected, or even shattering truths. While cognitive capture is a reality—and the questions asked and solutions sought by scientists are definitely shaped and limited by their experiences, their funders, and their preconceived, often narrow, assumptions and epistemes—science has not yet lost its capacity to surprise, challenge, and reform. In this, a systematic search for a "truth" may be misguided in the sense that truth is in fact unattainable, but it is hard to deny that the Western scientific project has provided a very real (albeit particular) understanding of our world, and that no other knowledge system has seen such systematic accumulation of technological successes. Of course, the authority of science is, more often than not, a means of control and domination, shaping the way people can imagine their futures. But, at the same time, it can, ever so clearly, be a tool for empowerment instead.

The answer is not simple but, at least to me, it should not simply entail the decentering of science, in the sense of doing away with experts who can tell us what to think about certain issues. Rather, we should re-center other forms of knowledge production, and make science receptive to these and to the different voices that may enrich it. The belief in a single, knowable reality is naïve, colored as it will always be by the limits of human cognition and human culture. Still, operating under the assumption that there is a coherent reality out there, that it is, in principle, accessible through our mediated filters, that some truth may be attainable through systematic inquiry, provides indispensable

15 Alice D. Dreger, *Galileo's Middle Finger: Heretics, Activists, and the Search for Justice in Science* (New York: Penguin, 2015).

authority for a common discourse. Every society needs a principle of ordering, a common ground upon which to meet.

I think it is fair to state that part of the crisis of climate communication has been caused by the rigidity and normativity of the academic project, most notably the natural sciences, perhaps leading to a general skepticism of scientific findings (especially if they are uncomfortable!). At the same time, science, as an endeavor aimed at systematic knowledge production, has not yet completely lost its capacity to shock and disappoint while still being accepted. It should go without saying that we should appreciate and acknowledge the insight and experience of laypeople, communities affected by climate change, and different knowledge systems. But not at any cost. Rather than questioning the normative authority of scientific findings, then, decentering the implied neutrality of these facts should be the main aim. It is not the question of whether expertise should play a central role that is crucial; it is the question of whether or not expertise, and its associated technology, can help to build a desirable future. It is fine, and can even be societally productive and equitable, to decenter, to a certain extent, the scientist and the knowledge construct of this figure who is all too often still Western, white, and male. However, this must not regress to straightforward relativism. "Well, that is *your* truth," should never be the principal consequence of a decentered science.

Suggested Further Reading

Ghosh, Amitav. *The Great Derangement: Climate Change and the Unthinkable*. Chicago, IL: Chicago University Press, 2016.

Marshall, George. *Don't Even Think About it: Why Our Brains Are Wired to Ignore Climate Change*. London: Bloomsbury Publishing, 2014.

Morton, Timothy. *Hyperobjects: Philosophy and Ecology at the End of the World*. Minneapolis: University of Minnesota Press, 2013.

Norgaard, Kari. *Living in Denial: Climate Change, Emotions, and Everyday Life*. Cambridge, MA: MIT Press, 2011.

Oreskes, Naomi, and Eric M. Conway. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York: Bloomsbury Press, 2010.

Knowing Weather and Climate

Katrin Kleemann

Telling Stories of a Changed Climate: The Laki Fissure Eruption and the Interdisciplinarity of Climate History

Stories can be very powerful tools to illustrate complex connections that determine the world around us. History and science are not as different as they are often portrayed as being. Both tell stories. Historians work with historical documents. In the context of climate history, these are often referred to as archives of society and can take the form of diaries, newspapers, flood markers, or paintings, to name a few. Climate scientists work with so-called archives of nature, which can be corals, stalagmites, or tree rings, for instance. There is an abundance of written historical sources for the early modern and modern periods, and a smaller number for antiquity and medieval times, which together result in history being primarily the history of human cultures, with little recourse to "deep time." Historians tend to study decades or centuries, whereas geologists and other natural scientists often study periods spanning millions or even billions of years—for example, climate scientists can reconstruct the climate going back hundreds of thousands of years with the help of ice cores. But just as with historical sources, some records give a clearer, more detailed image than others. Once historians and scientists have reviewed their records, they write up the most probable story that combines the available sources and explains why something occurred the way that it did. In the words of Australian historian Tom Griffiths, hypothesis is just another word for story. Scientists test a hypothesis with experiments to see whether it abides by the laws of the real world. Often it does not, and they then have to come up with a different story—and ideally, one of them will turn out to be provable.[1]

The history of a volcanic eruption, located on the fringe of the then known world, will illustrate the need for stories and science in the past and the present. In this essay, I'll show what this need can tell us about knowledge production, the limits of science, and the limits of narratives, and about how knowledge travels.

1 Tom Griffiths, *Slicing the Silence: Voyaging to Antarctica* (Cambridge, MA: Harvard University Press, 2007), 324.

The Laki Fissure Eruption

On 8 June 1783 it began. Just a few kilometers southwest of Vatnajökull, Iceland's largest glacier, the earth opened up and disgorged the largest amount of lava produced by any eruption in the last millennium. The lava did not come from a stereotypical cone-shaped volcano, but from a 27-kilometer-long fissure consisting of around 140 vents and craters. Today it is called the Laki fissure. The eruption was fed by the Grímsvötn volcanic system, one of Iceland's 30 active volcanic systems.[2]

Figure 1: The Laki fissure today, as seen from Mount Laki. Photo by Katrin Kleemann.

The Laki fissure is located in the remote Icelandic highlands. The nearest settlement at the time was Kirkjubæjarklaustur, a small village near the coast in the southeast of Iceland, located around 35 kilometers away from the Laki fissure. The two glacial rivers, the Skaftá and the Hversfisfljót, which feed Kirkjubæjarklaustur, both dried up and were replaced with lava flows. These events were described by the village's reverend, Jón Steingrímsson, who kept a journal. In Iceland, the eruption is remembered as skaftáreldar, the Skaftá Fires. A few farms, churches, and livestock were lost to the lava, although fortunately there were no human fatalities.

2 Thorvaldur Thordarson and Armann Höskuldsson, *Iceland* (Edinburgh: Dunedin, 2014), 10.

Lava, however, was only one product of the eruption. Another product had more deadly effects on the Icelandic population: volcanic gases. The aftermath of the Laki fissure eruption is also known as *móðuharðindin*, the famine of the mist. It is considered the worst catastrophe in Icelandic history and still occupies a place in the country's cultural memory. In addition to the ashfall that occurs after a volcanic eruption, the fissure also produced exceptionally large amounts of fluorine, a highly toxic halogen. In small doses, such as in toothpaste, fluorine is beneficial to human health; in large quantities, it can cause dental or skeletal fluorosis, which results in bone fractures and deformations. Fluorine from the eruption contaminated lakes and fields, and thus wrought havoc on livestock. By the summer of 1785, about one-fifth of Iceland's population of 50,000 had perished—people died of diseases such as fluorosis or dysentery, died of hunger, or simply froze to death in the subsequent cold winter.

1783: *Annus Mirabilis* in Europe

The Laki fissure eruption released 122 megatonnes of sulfur dioxide, which produced a dry fog that was visible above large parts of Europe between June and August of 1783.[3] The fog, which was also described as a haze or mist, was characterized by its dryness and its sulfuric smell. Large quantities of aerosols in the atmosphere resulted in "blood red" sunsets and sunrises.

Figure 2:
The location of the Laki fissure and Iceland in contrast to the rest of Europe. Image by the European Space Agency, contains modified Copernicus Sentinel data (2017), processed by Sinergise/ESA. The satellite image was modified by the author. Used with permission.

People outside of Iceland were oblivious as to the cause of the dry fog, the red sunsets, and the other unusual phenomena of that summer, which prompted them to dub 1783 an *annus mirabilis,* a year of awe. The most perplexing of all was the dry fog—what could have caused it? Speculation was rife as to the origin of these extraordinary phenomena. In the midst of the Enlightenment, there was no shortage of ideas.

3 Thorvaldur Thordarson and Stephen Self, "Atmospheric and Environmental Effects of the 1783–1784 Laki Eruption: A Review and Reassessment," *Journal of Geophysical Research* 108 (2003): 1–29.

Among the cornucopia of ideas were propositions ranging from the terrestrial, such as the belief—oh so close to the truth!—that they were the result of an eruption of Hekla, one of Iceland's best-known volcanoes, to the extraterrestrial, with some pointing the finger at a meteor, whose tail, it was suggested, swept across Earth's path, shrouding it. A few suggested that earthquakes in Italy had caused a crack in the Earth, which let sulfurous gases out into the atmosphere; reports of earthquakes in western Europe and news about the new "burning island" off the coast of Iceland led some contemporaries to believe they lived in the time of a "subsurface revolution." A fleeting theory was that volcanic activity within the German Territories was the cause.[4] This turned out to be false and was retracted a few weeks later. Electricity was also considered a possible culprit, either too much or too little of it: the large number of thunderstorms that occurred during the summer triggered a breakthrough for installations of the lightning rod in the German Territories, which some believed to be the cause of the dry fog, as the air was now lacking its natural electricity.[5]

The impacts of the Laki fissure eruption reached far beyond Europe. The dry fog was observed as far away as the Altai Mountains in Central Asia. A recent study by Joe Manning et al. establishes that Laki and other eruptions contributed to the suppression of the Nile summer flooding, which caused hunger and revolt.[6] Alaska also saw an extremely cold summer that year.[7] Both these examples raise questions as to how far and wide the eruption's sphere of influence actually was.

Eighteenth-Century Science Communication

It would take until early September for any news about the volcanic eruption to reach Denmark and subsequently the rest of Europe. The summer was almost over and the most obvious visible and olfactory consequences of the eruption were by then literally

4 John Grattan, David D. Gilbertson, and Andreas Dill, "'A Fire Spitting Volcano in Our Dear Germany': Documentary Evidence for a Low-Intensity Volcanic Eruption of the Gleichberg in 1783?" *The Archaeology of Geological Catastrophe* [Geological Society London, Special Publications] 171 (2000): 307–15.

5 Oliver Hochadel, "'In Nebula Nebulorum': The Dry Fog of the Summer of 1783 and the Introduction of Lightning Rods in the German Empire," *Transactions of the American Philosophical Society* 99, no. 5 (2009): 45–70.

6 Joseph G. Manning, Francis Ludlow, Alexander R. Stine, et al., "Volcanic Suppression of Nile Summer Flooding Triggers Revolt and Constrains Interstate Conflict in Ancient Egypt," *Nature Communication* 8 (2017): 900, https://doi.org/10.1038/s41467-017-00957-y.

7 Gordon C. Jacoby et al., "Laki Eruption of 1783, Tree Rings, and Disaster for Northwest Alaska Inuit," *Quaternary Science Reviews* 18 (1999): 1365–71.

yesterday's news. The news of a volcanic eruption in Iceland did not contribute to the understanding of the dry fog or the other unusual phenomena.

The connection between the dry fog and the eruption of the Laki fissure did not seem to be fully understood until the much larger eruption of the Indonesian volcano Krakatau in 1883 produced similar red sunrises and sunsets around the globe.[8] In the one hundred years since the Laki fissure eruption, telegraphy had been invented and it connected the world. It did not take months for the news of the Krakatau eruption to reach Europe, merely days. The story of the Laki fissure eruption is therefore at least partly one of communication—or the lack thereof. In 1783, people could not correspond faster than ships could travel.

In the aftermath of the Laki fissure eruption, the sciences were not yet far enough advanced to reliably identify the cause of this unusual weather. Yet the population still needed a narrative to make sense of what was happening to them. The story of the dry, sulfuric-smelling fog popped up in the newspapers of the time again and again, with different explanations that tried to make sense of it. Most theories that were argued were believable. But, in the end, all turned out to be wrong.

Today, we look back 236 years to how people in 1783 dealt with their own reality when they faced something that was hard to explain. They were ignorant through no fault of their own. They used the tools that were at their disposal—the knowledge, theories, and experiments they had at hand—to understand and document the situation they were in. It is quite extraordinary how people document situations even if they do not fully understand what is happening. And some of their explanations came—in fact—pretty close to the truth: the eruption of either a German volcano or of the Icelandic volcano Hekla, would have explained all the phenomena they were witnessing. They were just off with regard to the location.

Back in the eighteenth century, people were adept at using stories to help them understand the effects of the Laki fissure eruption, even though they did not have the science to understand exactly what had happened and where. What this shows us is that science does not exist in a vacuum, but it has always been something that has to be contextualized and interpreted using stories, especially stories from the past.

8 George Symons et al., *The Eruption of Krakatoa, and Subsequent Phenomena* (London: Harrison and Sons, 1888).

In our particular moment of anthropogenic climate change, we hear many stories of extreme weather events with devastating consequences, such as wildfires, hurricanes, or coral bleaching, to name but a few. All of these are made more likely and prolonged by climate change. At the same time, we have plenty of scientific data to support the argument that present-day climate change is caused by human fossil-fuel emissions. The challenge is combining the stories with the science, and communicating this in a way that everybody can grasp. This would lead to a better understanding of the magnitude of anthropogenic climate change, which in turn may persuade people to change their own behavior and demand meaningful action from their politicians. What we really need, therefore, are interdisciplinary modes of action that find ways of recontextualizing and telling stories about science that are able to truly explain what is happening and to outline modes of human response and adaptation.

Interdisciplinary Climate History

Today, we are already 1°C above preindustrial levels; although it is debatable when "industrial" began, this is used as the baseline of natural climatic variability before the effects of industrialization became measurable. A change of 1°C does not sound like much, but if you look at the climate history of the last millennium, you will quickly realize that even 1°C can make a huge difference. As recently as the early modern period, prior to the onset of anthropogenic climate change, our ancestors were faced with the Little Ice Age. This period affected the entire early modern period on a global scale, and saw glaciers advance in both hemispheres. Lasting from about 1250 to 1850, this was a time of predominantly colder-than-average weather with the overall average global temperature about 1°C below the 1900–1960 norm. The frequency of extreme weather events was also high compared to the present.[9]

Looking at the early modern period shows not just the foundation of the present world, but also how much has changed. The systematic knowledge upon which people now draw was constructed over generations and centuries, leading to an ever more detailed understanding of our physical reality. Today, historians and climate scientists work together across disciplines in a relatively young field called climate history, which studies the climates of the past and how societies responded to the shifting climate and

9 Dagomar Degroot, *The Frigid Golden Age: Climate Change, the Little Ice Age, and the Dutch Republic, 1560–1720* (Cambridge: Cambridge University Press, 2018), 2.

weather. The consequences of anthropogenic climate change are already visible today: an increasing number of extreme weather events can be attributed to climate change. Extreme weather events or a changing climate are nothing new per se. The climate on our planet shows a high degree of natural variability; for some periods it is more stable than for others. Some climatic changes occur on very long timescales over hundreds of thousands of years, some on shorter decadal or multidecadal timescales. They can occur abruptly (induced by volcanic eruptions, for instance), but what we are seeing today is unprecedented. Human actions and fossil-fuel emissions are causing the climate to change at a previously unseen pace.

Several interdisciplinary initiatives exist already that aim to further cooperation between the climate sciences and the humanities. One example of cooperation between the (paleo-)sciences and the humanities is Past Global Changes (PAGES), which is a core project of the global sustainability science program Future Earth. PAGES has several working groups that work on flood events, sea-ice dynamics, and coral archives, just to name a few, as well as past volcanic eruptions. The latter working group is called Volcanic Impacts on Climate and Society (VICS), which brings climate scientists, climate modelers, climate historians, archeologists, tephrochronologists, dendrochronologists, and others together in order to "foster interdisciplinary activities towards a better understanding of the impacts of volcanic forcing on climate and societies."[10] There are other initiatives in the field of historical climatology, such as the Climate History Network founded by Dagomar Degroot and Sam White, which is a forum for climate and environmental historians as well as climate scientists. The collaboration between climate scientists and climate historians has produced reconstructions—histories—of past climates that offer a new perspective on how to understand the climate change we are facing in the present and future, and how we as humans can respond to it.

This sort of truly interdisciplinary research is the future. Some interdisciplinary collaborations in the field of climate change research already exist, but they are few and far between. The problem lies within tertiary education: most universities regard the humanities and the natural sciences as entirely different entities that rarely cross paths, which is reflected in how research and teaching are institutionalized and thereby rein-

10 The introduction text to the Volcanic Impacts on Climate and Society (VICS) on the Past Global Changes website, http://pastglobalchanges.org/ini/wg/vics/intro.

scribe disciplinary divisions. Going forward, if university students were to attend classes in both humanities and natural-sciences subjects, they would develop a basic sense of both. These insights would give the scholars of tomorrow a better foundation for presenting their work across disciplines and communicating effectively in interdisciplinary collaborations, which will only become more important and pressing in our warming world. Likewise, interdisciplinary collaborations need to be conceptualized from the beginning by both scientists and historians (or other humanities scholars), in order to walk truly novel ground. Applying new methods or combining methods from different fields will lead to fresh perspectives on old and new questions, which can lead to new insights into past and present climate change and might give us new strategies to deal with future climate change.

In the reconstruction of volcanic eruptions, the technological and methodological advances have been great in the past years and many volcanic eruptions can be dated more precisely using multi-proxy approaches, which means combining ice-core, tree-ring, tephra, and other records, as well as historical documents.[11] The results obtained may not be the absolute truth yet, and we might never know the absolute truth; as Jeroen Oomen points out in his article, "truth is in fact unattainable" (Oomen, this issue, p. 29). But we can produce more extensive and applicable knowledge with new tools, technology, and methods, which were simply unavailable to previous generations. The critical thing is that we don't lose sight of the need to contextualize and interpret this science. Science as an ideal is (inherently) interdisciplinary because it ought to entail that research has not only been validated by the methods and peers from one discipline, but works with the findings of at least two different disciplines.

Conclusions

Unlike those living in 1783, in our particular moment we do not need more science but more histories: when historians and climate scientists come together, they can write probable stories of how the climate has changed in the past and how societies responded to these changes. In this way, we can learn how to adapt to our own changing climate. Climate history will benefit from closer collaboration with climate scientists

11 Michael Sigl, Mai Winstrup, Joseph R. McConnell, Kees C. Welten, Gill Plunkett, Francis Ludlow, Ulf Büntgen, et al., "Timing and Climate Forcing of Volcanic Eruptions for the Past 2,500 Years," *Nature* 523 (2015): 543–49, https://doi.org/10.1038/nature14565.

and indeed, climate scientists will benefit from close collaboration with historians who can interpret historical documents, the context in which they have been produced, as well as the sources' reliability. It is crucial for these groups to come together and talk to one another, as so many opportunities have previously been lost, simply because of miscommunication—historians and scientists visit different conferences, use different terminology, and publish in different formats.

I agree with Jeroen Oomen: we should not decenter the scientist at any cost. The "Western scientific project has provided a very real (albeit particular) understanding of our world, and . . . no other knowledge system has seen such systematic accumulation of technological successes" (this issue, p. 29). At the moment we simply do not have a promising alternative to this concept of knowledge production. Science has never existed in a vacuum; (climate) science stimulates and is being stimulated by other disciplines as well as local knowledge. What is necessary to aid this stimulation is communication—communication as a way of narrating and interpreting science. The story of the Laki fissure eruption also shows us how important communication is. In terms of climate history, it very much plays in our favor that unusual weather seems to be more memorable than "normal" weather. Every story has a beginning, a middle, and an end. For the story of successful climate science communication to have a middle and an end, it needs to have a beginning. The beginning is history and science accepting and adopting an interdisciplinary approach, working with and complementing each other. Without this cooperation, we risk this story becoming simply a scattering of words.

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Linden Ashcroft

Rescuing Climate Data as a Scientific and Communication Bridge

Citizen science is a broad term, but here I will use it to describe nonprofessional or nonworking scientists taking part in scientific endeavors. Citizen science (using this definition) has been a key component of science for several centuries, but has undergone a resurgence in the last decade or so to become a valuable component of many mainstream research activities.[1] Not only does citizen science make it possible to conduct an investigation well beyond the capabilities of a small research team, it also gives people who do not conduct research in their regular jobs a chance to connect with and feel a sense of ownership of the scientific process and its outcomes.

One form of citizen science in the climate sphere is the rescuing of historical documents and weather observations to improve understanding of past climate variability. Although not as active as recording the weather in the backyard, these "data rescue" projects connect the public with climate research, including retired or remote members of the community who may feel disconnected from mainstream science.

In this essay, I argue that citizen science projects to rescue historical weather observations are an ally of climate communication. Despite Walsh's suggestion (Walsh, this issue, p. 17) of citizen scientists being "free labor" and the potential contradiction associated with exploring the past in order to face a problem of the present and future, I suggest that recovering historical weather data offers a pathway for communication between citizens and researchers that respects the past experience of citizens. Connecting with the weather of the past—and the personalities behind historical observations—provides an accessible way to develop a relationship with climate science and its intricacies.

The Value of the Past

Churchill's famous quote posits that "the longer you can look back, the further you can look forward." This is especially true for climate science. Understanding past climate variability is crucial for separating the natural behavior of our atmospheres and oceans from what is human-induced.

1 Rick Bonney, Jennifer L. Shirk, Tina B. Phillips, Andrea Wiggins, Heidi L. Ballard, Abraham J. Miller-Rushing, and Julia K. Parrish, "Citizen Science: Next Steps for Citizen Science," *Science* 343, no. 6178 (2014): 1436–37, https://doi.org/10.1126/science.1251554.

The primary source of information about regional and global climate is instrumental weather observations. These are our ground truth, the most accurate representations of the atmosphere we have. Most national climate datasets, however, only begin around the start of the twentieth century, and from the mid-twentieth century in many developing countries.[2]

There are many more sources of weather data available from before this time. Colonial observational networks, astronomers, doctors, farmers, and "gentlemen scientists" (the original citizen scientists) have been keeping weather diaries for decades, even centuries.[3] These observations have the potential to put current climate variability in a much longer and more accurate context than is currently possible, but are all too often consigned to archives, lost in a sea of boxes and microfiche. This is particularly the case for observations taken in regional and remote areas of the world, as the focus of past data rescue activities has largely been in capital cities.[4] It would take many scientific lifetimes to find all of these climate treasures, and many more to bring the precious numbers from dusty pages to modern databases.

Many Hands Make for Better Digging

With the help of citizen science, the painstaking work of finding and rescuing weather observations is slowly happening. Whether they are the logbooks of sailors, farmers' diaries, observatory records, or newspaper reports, the scientific community is clamoring for them to be recovered, and begging people to be a part of the recovery effort.[5]

2 Manola Brunet and Phil Jones, "Data Rescue Initiatives: Bringing Historical Climate Data into the 21st Century," *Climate Research* 47, no. 1 (2011): 29–40, https://doi.org/10.3354/cr00960.

3 Georgina H. Endfield and Carol Morris, "Exploring the Role of the Amateur in the Production and Circulation of Meteorological Knowledge," *Climatic Change* 113, no. 1 (2011): 69–89, https://doi.org/10.1007/s10584-012-0415-7.

4 See, for example, Linden Ashcroft, Joëlle Gergis, and David John Karoly, "A Historical Climate Dataset for Southeastern Australia, 1788–1859," *Geoscience Data Journal* 1, no. (2014): 158–78, https://doi.org/10.1002/gdj3.19; David E. Parker, Tim P. Legg, and Chris K. Folland, "A New Daily Central England Temperature Series, 1772–1991," *International Journal of Climatology* 12, no. 4 (1992): 317–42, https://doi.org/10.1002/joc.3370120402; and Victoria C. Slonosky, "Wet Winters, Dry Summers? Three Centuries of Precipitation Data from Paris," *Geophysical Research Letters* 29, no. 19 (2002): 34-1–34-4, https://doi.org/10.1029/2001GL014302.

5 P. W Thorne, R. J. Allan, L. Ashcroft, P. Brohan, R. J. H. Dunn, M. J. Menne, P. R. Pearce, et al., "Toward an Integrated Set of Surface Meteorological Observations for Climate Science and Applications," *Bulletin of the American Meteorological Society* 98, (2017): 2689–2702, https://doi.org/10.1175/BAMS-D-16-0165.1; Alexandra Eveleigh, Charlene Jennett, Stuart Lynn, and Anna L. Cox, "'I Want to Be a Captain! I Want to Be a Captain!': Gamification in the Old Weather Citizen Science Project," *Gamification '13 Proceedings of the First International Conference on Gameful Design, Research, and Applications*, (2013): 79–82, https://doi.org/10.1145/2583008.2583019.

The typical structure of a citizen science project is that professional scientists coordinate an activity, under the umbrella of a larger research project. Having professional scientists organize the project this way ensures that the methodology is rigorous[6] and that the questions being asked are connected to current leading edges of scientific research. Connecting the activities with a larger project is also motivating for many, and makes people feel like they are contributing to the public good.[7]

There are many citizen science projects that don't fit this typical structure, and climate data rescue projects are no exception. Some are global in nature, calling on participants to follow ships across the oceans and recover the weather records taken onboard through sophisticated online interfaces.[8] Others are smaller in scale, with Excel spreadsheets and Dropbox links being emailed back and forth between a handful of team members.[9]

The climate data rescue projects I am involved in do include professional scientists, but they are often just consultants, advisers in what are really volunteer-led initiatives. The projects are coordinated by volunteer groups and typically led by retired professionals from a range of backgrounds. They are the ones who have found the data, and embarked on a journey to recover a slice of history. Engaging professional scientists is in some ways an afterthought, to see if their work would be useful to anyone else.

The Benefits of Connecting to the Past

These kinds of rescue activities connect people with data— the basis of so much climate science. Rescuing historical observations shows people how complicated it can be to work with the raw instrumental record. Handwriting that is hard to read, along with changes in units, instruments, formats, and variables, are all common obstacles in data rescue efforts.[10] Not only that, but recovering the weather records of a farmer, explorer, or notable personality may make those in nearby communities appreciate that observa-

6 See, for example, World Meteorological Organization, "Guidelines on Best Practices for Climate Data Rescue 2016," https://library.wmo.int/opac/doc_num.php?explnum_id=3318.
7 Carol Morris and Georgina Endfield, "Exploring Contemporary Amateur Meteorology through an Historical Lens," *Weather* 67, no. 1 (2012): 4–8, https://doi.org/10.1002/wea.800.
8 For example, Eveleigh et al., "'I Want to Be a Captain!'"
9 Linden Ashcroft, Rob Allan, Howard Bridgman, Joëlle Gergis, Christa Pudmenzky, and Ken Thornton, "Current Climate Data Rescue Activities in Australia," *Advances in Atmospheric Sciences* 33, no. 12 (2016): 1323–24. https://doi.org/10.1007/s00376-016-6189-5.
10 S. Brönnimann, J. Annis, W. Dann, T. Ewen, A. N. Grant, T. Griesser, S. Krähenmann, C. Mohr, M. Scherer, and C. Vogler, "A Guide for Digitising Manuscript Climate Data," *Climate of the Past* 2, no. 2 (2006): 137–44, https://doi.org/10.5194/cp-2-137-2006.

tions made by people on the land are important, leading to an empowering sense of connection with the science being undertaken.

In turn, citizen science activities that connect people with historical data may offer a way to build a personal sense of ownership of modern climate-change research. Getting "up close and personal" with one of the many different sources that contribute to climate science can only improve engagement with the field, particularly if one is familiar with the history or the geographical region represented by the data.

A Conversation between Local and Professional Knowledge

The idea of becoming immersed in the weather of the past may seem like a great way to learn firsthand how much things have already changed. However, while rescuing old data is valuable, the process of transcribing observations from page to screen can be tedious and far removed from the weather outside. Climate change is not a linear beast either; there were hot days in the past too. The location of historical instruments, particularly thermometers, has often been suboptimal, and can lead to temperature recordings that are anomalously high or low. Untangling the impact of historical instrument placement on a measurement is a fundamental part of tracing the fingerprint of climate change, and is not a trivial task.[11] This process can, however, cause people to claim that data manipulation has occurred if it is not communicated clearly.

The fact that temperature observations were taken in Fahrenheit until relatively recently can also make things more confusing outside the US when comparing past to present, as people have to convert values from Fahrenheit to Celsius. However, historical mentions of snowfall in an area where snowfall no longer occurs can be a powerful emotional discovery as well as a scientific one.

Finally, if these activities, whether led by volunteers or by professional scientists, occur without engaging outside of their own community, then opportunities are lost for building positive change. A historical group in regional Australia, for example, might transcribe an entire weather diary and share it with their community. It would likely be a boon for the town to uncover this slice of history and science, and an enjoyable exercise

11 Blair Trewin, "Exposure, Instrumentation, and Observing Practice Effects on Land Temperature Measurements," *Wiley Interdisciplinary Reviews: Climate Change* 1, no. 4 (2010): 490–506, https://doi.org/10.1002/wcc.46.

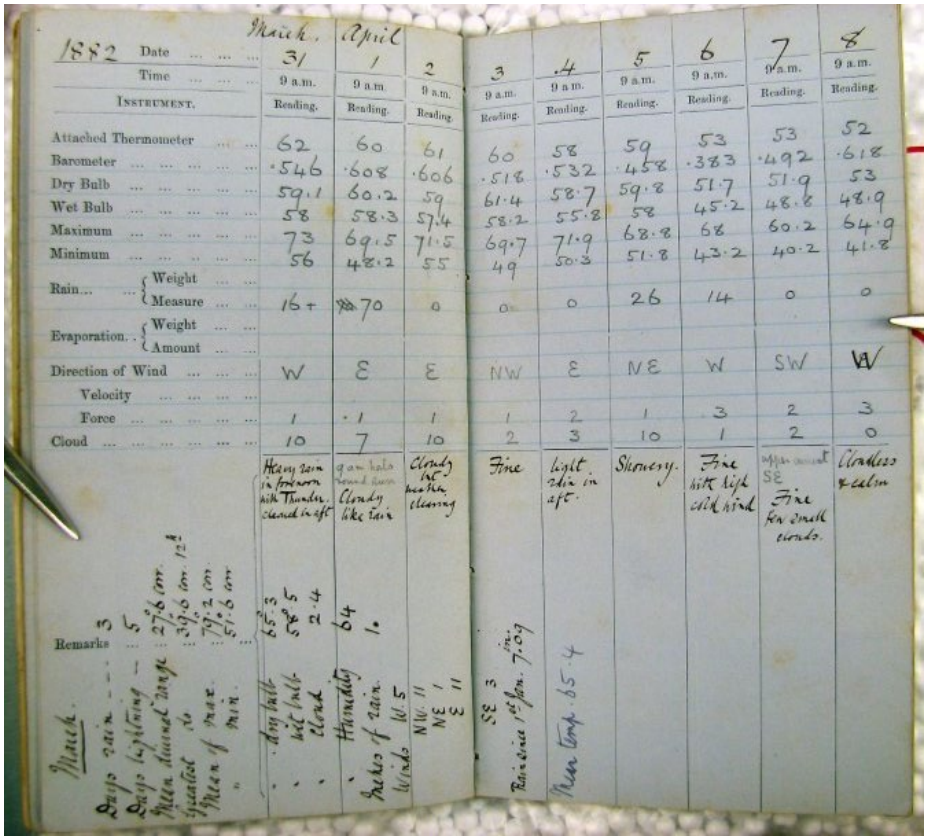

Figure 1:
Page from the journal of Algernon Henry Belfield, a grazier from New South Wales who diligently recorded the weather at his farm near Armidale from 1877 until shortly before he died in 1922. His diaries were donated to research by his descendants, and the digitization and study of this valuable set of observations has been primarily conducted by volunteers, or citizen scientists. Image source: Cultural Collections, The University of Newcastle.

for the volunteers involved. However, including historical climate experts in the team would open up many more doors for sharing knowledge in both directions, enriching scientific research while enabling the community to have a true sense of ownership of the study of climate in their town. Similarly, a scientist setting up an online data rescue portal without close and regular contact with those who are engaging with the data is not a successful enterprise from a scientific or communication point of view.

Conclusions

Citizen science activities offer a way for the public and academia to work together. As Walsh's argument suggests (Walsh, this issue), a successful citizen science endeavor is one where both the professional scientist and citizen scientist respect and learn from each other. I posit that weather data rescue activities have great potential to fit this definition. Communication between professional scientists and those actively seeking to recover historical information leads to greater scientific and historical discoveries, an increased mutual respect between citizens and the scientific community, and a chance for citizens to feel ownership of the research being conducted on a small and large scale. It is the combined work of both sets of "experts" that will result in the greatest benefits for knowledge and society.

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Negotiating Knowledge

Emma Shortis

Lessons from the Last Continent: Science, Emotion, and the Relevance of History

When the world seemed on the verge of opening up the last great untouched continent to mining, environmentalists let out a collective howl of outrage. In 1978, the World Park Antarctica campaign was established to oppose efforts, under the auspices of the 1959 Antarctic Treaty, to negotiate an Antarctic mining agreement. Spearheaded by the Antarctic and Southern Ocean Coalition and Greenpeace International, the World Park campaign insisted that the Antarctic "wilderness" was too precious and fragile to allow any kind of mining to take place. It was, in the words of Jim Barnes, the founder of the Coalition, "fundamentally crazy to be thinking about obtaining oil and other minerals that may be in the Antarctic, particularly in view of the latest reports from the scientific community in the climate context."[1]

The World Park Antarctica campaign has been hailed as one of the most successful campaigns in the history of international environmentalism. For six years, environmentalists waged an international offensive against the Antarctic minerals negotiations. They held public protests, lobbied states and international organizations, grabbed media attention, steadily increased international awareness, and recruited international celebrity Jacques-Yves Cousteau to their cause.

In 1988, despite these efforts, the parties to the Antarctic Treaty adopted the Convention on the Regulation of Antarctic Mineral Resource Activities, which, had it come into force, would have opened the continent to mining. But less than a year later, due largely to the World Park campaign's success in convincing much of the world that mining in Antarctica would be "fundamentally crazy," Australia and France announced that they would no longer support the Convention. Instead, they would fight for Antarctica to be designated a "Nature Reserve–Land of Science."

In 1991, the alliance between the Australian and French governments and the World Park Antarctica campaign resulted in the adoption of a comprehensive environmental

1 James Barnes, "The Antarctic Treaty System in Crisis: Some Observations and Suggestions," 9 October 1990, 3. Antarctic and Southern Ocean Coalition (ASOC) digital archives, in author's possession.

protection agreement for the entire continent, and an effectively indefinite ban on Antarctic mining. In a landscape littered by failures and half-measures, the 1991 Environmental Protection Protocol to the Antarctic Treaty stands out as a stunning success in environmental campaigning and diplomacy.

How did this happen? Why was the World Park Antarctica campaign so successful? And what might it teach us about effective environmental campaigning and communication that could be relevant to our current predicament?

As Lynda Walsh notes in this volume (p. 20), "success will always be situational." The unusual success of this campaign, however, is precisely what makes it so relevant to understanding the collective failure to effectively communicate the science of climate change and reach global agreement over mitigation. Dagomar Degroot points out in his recent book that "historians rarely feature in discussions about global warming."[2] Degroot, and Walsh in this volume, rightly suggest that this marginalizing of the humanities in the communication and construction of the science and policy of climate change has been to our great collective detriment. Historians have important contributions to make to this debate, particularly in challenging the more recent neoliberal capture of climate science, which renders it a discourse grounded almost exclusively in market solutions, numbers, and statistics. The success and nature of the World Park Antarctica campaign of the 1980s challenges this dominance, demonstrating the important added value historians and history can bring to current debates. A study of the campaign offers one of the elusive "alternative models" of climate communication Walsh calls for: specifically, models "that do not position climate science and scientists as the final authority" (this issue, p. 15).

Science and the pursuit of scientific knowledge are fundamental to modern Antarctic politics and history.[3] From the beginning of the World Park campaign, environmentalists insisted that opening Antarctica to mining would dangerously undermine the continent's role as a place of peace and science. In the 1980s, Antarctic science was itself providing ample justification for the environmental protection of the continent. In the midst of the World Park campaign, as activists consistently noted, understandings of both human-induced damage to the ozone layer and global climate change emerged

2 Dagomar Degroot, *The Frigid Golden Age: Climate Change, the Little Ice Age, and the Dutch Republic, 1560–1720* (New York: Cambridge University Press, 2018), 307.
3 For more on the role of science in the history and politics of Antarctica, see Adrian Howkins, *Frozen Empires: An Environmental History of the Antarctic Peninsula* (New York: Oxford University Press, 2017).

directly from Antarctica.[4] Scientific studies were also suggesting that an oil spill in Antarctica—which World Park campaigners insisted would be inevitable should drilling go ahead—would be far more devastating, and far more difficult to clean up, in the remote and unique Antarctic ecosystem. World Park activists frequently cited these scientific studies and developments to support their cause, evoking the specter of terrible—and preventable—accidents that had already happened elsewhere, such as the catastrophic *Exxon Valdez* spill in Alaska. "Transferred to Antarctica," Jacques Cousteau asked a captivated television audience during his 1990 documentary on the continent, "could such an accident ever be erased?"[5] Scientific studies suggested that it could not. Perhaps more importantly, recent history suggested that this knowledge would not prevent states or industrial interests from proceeding with oil drilling anyway, should they be given the chance.

During their highly publicized expeditions to the Antarctic, Greenpeace activists also conducted some "citizen science," undertaking research of their own and experimenting with low-impact, environmentally friendly base construction. In conducting its own "World Park" expeditions, Greenpeace explicitly challenged the monopoly that state-sanctioned science had on the continent. Part of Greenpeace's mission was to "expose" the current practices of those state-sanctioned scientific organizations, which included leaving leaking fuel drums in the open and amassing large trash heaps. By drawing attention to these practices, Greenpeace challenged the institutional epistemic authority of organizations like the US National Science Foundation, while still supporting individual scientists and their research. The World Park expeditions insisted that state-sanctioned institutions were not the only organizations that had the right to speak for, or about, the continent, and that those institutions—as opposed to the individual scientists working for them—were not always the benign, apolitical actors they claimed to be.

Greenpeace's citizen science and the sometimes troubling role of state-sanctioned science on the continent, though, were only one aspect of a much larger narrative deployed by the World Park campaign. From the beginning, the fight against mining in Antarctica focused

4 Marcus Haward and Tom Griffiths, eds., *Australia and the Antarctic Treaty System: 50 Years of Influence* (Sydney: UNSW Press, 2011), 348. On activists' observations, see for example Cousteau Society/Fondation Cousteau, "Antarctica in the 1990's: Challenge for a True Global Environmental Policy," January 1990, 2, 5, 6, and 7, Records of the Australian Conservation Foundation, National Liaison Office, Canberra, National Library of Australia, MS 9430/26/1322.

5 *Lilliput in Antarctica: A Cousteau Journey*, produced by Jacques-Yves Cousteau with Hedwige Bienvenu (Chesapeake: The Cousteau Society, 1990), digitized VHS.

Figure 1: Greenpeace ship *MV Greenpeace* in the Antarctic. Blue-eyed shags on an iceberg in the foreground, 1 January 1988 Credit: © Greenpeace / Steve Morgan

not so much on the scientific "proof" that it was dangerous, but on the multiple, overlapping, and unquantifiable "values" of Antarctica to all of humanity. Antarctica was of "paramount importance to mankind," as the 1981 International Union for the Conservation of Nature Resolution on Antarctica asserted, because of "science," yes, but also because of the impact of its "wilderness qualities" on "education and inspiration."[6] Combined with some very effective international and domestic political campaigning, this emotional framing of the continent as an "inspirational space" with its own inherent value is central to explaining the popular appeal, and thus the ultimate success, of the World Park campaign. Science was integrated into a larger emotional framework that evoked fear, empathy, awe, and hope for the "last continent" and its nonhuman inhabitants.

Those animal inhabitants played an essential role in the campaign. World Park activists insisted that mining, and the inevitable accidents and spills that would come with it, would pose an unacceptable risk to the unique and fragile wildlife that called the continent home. Vulnerable and distressed penguins in particular featured heavily in

6 International Union for the Conservation of Nature (IUCN), Resolution 15/20, "Antarctica Environment and the Southern Ocean," 1981, https://portals.iucn.org/library/sites/library/files/resrecfiles/GA_15_RES_020_Antarctica_Environment_and_the_South.pdf.

campaign activities and material. Protestors dressed up as penguins, marching around and carrying placards in front of minerals negotiation meetings. Activists linked Antarctic oil drilling and the possibility of spills to other iconic marine mammals found in Antarctica: in 1989, for example, Cousteau asked members of the American press "Why silence forever the whales and seals that sing under the ice?"[7] In the 1970s and 1980s, the "silencing" of whales had become a real possibility. Cousteau and his colleagues in ASOC and Greenpeace deliberately evoked this fear and linked it directly to the minerals negotiations.

Figure 2:
"Trash at the McMurdo Base" Antarctica 1989 Expedition camp. Trash, 1 January 1989
Credit: © Greenpeace / Keith-Nels Swenson

If the Antarctic Minerals Convention was adopted, activists insisted, the habitat these animals relied on for their very survival would be gravely threatened. Cute and vulnerable penguins, and emotionally intelligent and mysterious whales, required that humans, with our destructive tendencies, simply stay away. During the campaign—indeed, even today—activists characterized Antarctica as a "pristine wilderness." It was, as Cousteau described it, "the last unspoiled area of our planet." Allowing mining to occur there would not only threaten vulnerable species and ecosystems; it could lead, Cousteau warned, "to the destruction of the continent."[8] This potential loss was almost never de-

7 Phil McCombs, "Cousteau's Washington Plunge: Charming the Town for Antarctica," *The Washington Post*, 21 September 1989.
8 "Cousteau Launches Effort to Scuttle Antarctica Treaty," *Tulsa World*, 21 September 1989; Robert Hennelly, "The End of Antarctica?" *Christian Science Monitor,* 7 February 1990.

scribed in economic or political terms. It would be a great loss to humanity if Antarctica were destroyed because of what it represented to us: the possibilities for peace, our ability to curb our own destructive tendencies, and the awesome inspiration of a place that neither required nor welcomed our presence.

By helping to place Antarctica at the emotional center of broader environmental fears about oil spills, vulnerable animals, ozone depletion, climate change, and our plundering of the globe, the campaign thus transformed Antarctica into a stage from which to campaign for the very "survival of the planet."[9] Activists insisted that allowing mining in "the last remaining unspoiled world" and the ensuing inevitable accidents would amount to nothing less than a total failure of humanity to protect its common heritage. As the French Prime Minister Michel Rocard argued—in a clear echo of contemporary debates about climate change—the World Park campaign was about the "right of future generations to inherit from us a planet that is still fit to live in."[10] Protecting Antarctica would mean that humanity could still hold some hope for the future. Humans had destroyed almost everywhere else, but this one pristine place could remain untouched, and leaving it intact might mean there was hope for other places, too. What happened to Antarctica, then, was intimately connected to fear and anger about what was happening to the rest of the world, and simultaneously, to hopes for a better future.

In fostering this narrative, World Park activists ensured that mining in the "last unspoiled world" became an incomprehensible prospect for millions of people—and eventually, their political leaders. A petition against the 1988 Minerals Convention organized by ASOC and the Cousteau Society gained 1.5 million signatures in less than a year.[11] The World Park campaign, unlike the "neoliberal" underpinnings of communication Walsh outlines in this volume, conceptualized "civil society" as a "democratic source of potential resistance to state and industrial interests." For the World Park campaign, that democratic resistance to the Minerals Agreement proved essential to their eventual success. The domestic and international political pressure brought to bear by the campaign led directly to the Australian and French decisions to renege on the Minerals Convention, and was central to the subsequent adoption of the environmental protection agreement.

9 Mort Rosenblum, "Battle Over Antarctica: Exploit it or Preserve It?," *The Record*, 8 October 1989.
10 Associated Press, "Antarctica Meeting Opens With Calls for Preservation," *Tulsa World*, 10 October 1989.
11 Associated Press, 10 October 1989; Hennelly, "The End of Antarctica?"; "Sunday's People," *The Record*, 22 October 1989.

By insisting that Antarctica was valuable to humanity as more than just another place to mine, and that people everywhere were stakeholders in its future, the World Park campaign forced the parties to the Antarctic Treaty to consider more than just environmental regulation, industrial interests, and economic cost-benefit analyses. The campaign, in Walsh's words, managed to successfully "resist the neoliberal paradigm" (this issue, p. 18). In doing so, the World Park campaign also, perhaps, offers some solace to those, like Jeroen Oomen in this volume, justifiably concerned about the erosion of trust and "a future that does not have a common narrative of truth" (this issue, p. 29). While the World Park campaign "decentered" science and scientific knowledge in order to build a broader narrative embedded in values and emotion, in which everyone was a "stakeholder," the campaign still placed great value in that science—fostering "trust"—but found that value in a greater human story.

Of course, there may be no specific "lessons" in this particular story.[12] It is entirely possible that the World Park campaign happened at a unique moment in time, in a unique political and historical space. Preventing mining in the last unspoiled world was, compared to the wicked policy problem of climate change, relatively straightforward. Politically and economically, the sacrifices made to "save" Antarctica were minimal, and for industrial interests, theoretical rather than immediate. It's worth noting, however, that environmentalists are attempting, right now, to replicate this rare success. In its current campaign for an Antarctic Ocean Sanctuary, Greenpeace is using many of the same techniques: petitions, celebrity engagement, a focus on unique and vulnerable wildlife, political lobbying, and an underlying narrative focused on the inherent value of nature and our hope for the future. If we can do this again in Antarctica, Greenpeace suggests, we might just be able to do it elsewhere, too.

The success of the World Park campaign demonstrates that it is at least possible, given the right circumstances, to develop and maintain narratives that value and include, but don't center, scientific authority. The World Park campaign was partly justified by scientific knowledge, but found value well beyond the quantitative data science gives us about the history and future of our climate. The campaign instead deployed an emotionally resonant narrative based in the inherent value of the global environment, our re-

12 Tom Griffiths, "The Transformative Craft of Environmental History: Perspectives on Australian Scholarship," in "Visions of Australia: Environments in History," ed. Christof Mauch, Ruth Morgan, and Emily O'Gorman, *RCC Perspectives: Transformations in Environment and Society* 2 (2017): 117, https://doi.org/10.5282/rcc/7915.

sponsibility to protect it, and our hope for the future, suggesting to the millions of people inspired by the campaign that another story was possible. Such stories, as Tom Griffiths so beautifully put it in a recent volume of *Perspectives*, are "the most powerful educational tool we possess."[13] In the 1980s, as now, Antarctica served as an inspirational reminder that the planet is not just here for us. Historians, and activists, in addition to scientists, have an important role to play in telling and retelling that story.

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13 Griffiths, 118.

Saskia Brill

Between Science and the Expertise of the Elders

"Knowledge is not only powerful, it is political and it plays a central role in the struggle among social forces in places and spaces."[1]

Established forms of science and expertise seem to be increasingly flouted, and not only by climate-change deniers, creationists, or conspiracy theorists who refuse to accept anthropogenic climate change as "truth," as Oomen describes in this volume. There are also militant ecological movements, who perceive that action is not being taken fast enough and who seek to "short-circuit" the scientific community and its expertise.[2] And paradoxically, there are scientists behind each of these interest groups, who are oftentimes accused of creating scientific results only to support their respective political arguments.[3] However, they are usually not acknowledged as credible scientists by the majority of the established scientific community. This contradiction shows that for certain groups science has become something akin to a secular "religion" one can choose to believe in or not,[4] depending on the promises it makes and the networks it is embedded in. So here we are, already on the threshold of a wired entanglement of scientific findings, political evaluations, economic interests, and diverging value systems which are hard to unravel when it comes to environmental policy making.

What Kind of Science Are We Talking About?

To grapple with the problem we are facing in this volume, namely how we can bring "science" back into climate communication and action, we should start by looking at what science is in the first place and what functions it fulfills. Therefore, I want to fall back on Latour's image of the Janus-faced science:[5] On one side, there is Science (with a capital

1 Gabriela Kütting and Ronnie D. Lipschutz, eds., *Environmental Governance: Power and Knowledge in a Local–Global World* (New York: Routledge, 2009), 9.
2 Bruno Latour, *Politics of Nature*, trans. Catherine Porter (Cambridge, MA: Harvard University Press, 2004), 4.
3 Naomi Oreskes and Eric M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury Press, 2010).
4 Latour, *Politics of Nature*, 223.
5 Bruno Latour, *Science in Action* (Cambridge, MA: Harvard University Press, 1987), and *Politics of Nature*.

S), a heavy homogenous body, capable of answering questions about the nature of the earth, humankind, and the interconnections between the two. Science in this sense thus has the power to create irrevocable truths. On the other side, we have the sciences (in lower case), consisting of a multiplicity of disciplines characterized by constant curiosity and the posing of questions about all matters of interest, whilst rejecting universal truths. Both of them are equally part of the same coin that we typically subsume under the term "science." Depending on the stage of a research project and the perspective from which we look at it, one side or the other will be more obvious and visible. And between the two, claims for more decentered sciences as well as a more centralized Science can be located. While Lynda Walsh proposes finally leaving dusty old hegemonic Science behind, or at least covering it up with a thick cloth, so that it is on mute, Jeroen Oomen speaks for the old guy (even though he wants him to listen to his counterpart), as Science seems to be the only authority that we can still rely on.

Figure 1: Biologists and indigenous experts taking herring egg samples. Photo by the author.

Both approaches end up being highly political; each follows a very specific moral notion of what seems to be "right" or "necessary" for this planet, for us humans, and for the particular entanglement of nature and society that we are facing today. And since action seems to be so hard when confronting current climate and environmental challenges, trying to find a voice or a strategy that is stronger, more convincing, or more authoritarian than the arguments of conspiracy theorists or environmental fundamentalists seems to be central to making any progress towards that goal. It may be that hard facts finally tell the conspiracy theorists they are wrong, or it may be the local knowledge holders who are out of the line of fire against the old hegemonic structures, thereby being seemingly more democratic. I argue that we have to deal with both approaches—a strong Science and more openness in the sciences—no matter what. Both sides can be empowering as well as harmful. And yes, as soon as we establish ourselves somewhere along the line, we will lose the benefits of the other end. But maybe it is not an "either-or" situation, but a case of "one after the other," or even "both at the same time."

Let me start with having a closer look at Science, the old hegemonic knowledge producer that doesn't accept any form of doubt or creativity. The one that holds the authority that nobody can go beyond. The one that, throughout most of its existence, has been created and used by the powerful—usually male, rich, educated, and white elites.[6] The rightful critique here is that Science usually supports existing power relations and is closely linked to established formal bodies of expertise such as the Intergovernmental Panel on Climate Change (IPCC) or the United Nations Framework Convention on Climate Change (UNFCCC), and overlooks important concerns about how expertise is created and defined.[7] These bodies consist of a network of professionals—epistemic communities—with an authoritative claim to policy-relevant knowledge within their respective domains.[8] These professional networks have been in charge of defining the role of expertise in shaping international agreements on ozone layer protection, climate change, and other topics.[9] These structures apply just as much to the knowledge underpinning environmental policy, which is assumed to be accurate, authoritative, and urgent.[10] But the authority Science holds can equally be wielded by those with less power—the non-male, the non-rich, the non-educated, the non-white, etc., to adopt a Western binary framing—to give their specific forms of knowledge a framework and a language that can be understood and categorized beyond their narrower social context. Not to speak of all the indigenous scholars, for example, who have emerged as a strong academic force, challenging the long-established perspectives, methods, and language of Science from within.

Science . . .

To exemplify the diplomatic chances Science can offer thanks to its political standing, let me take you to Canada's Pacific coast. The region is populated by numerous indigenous nations that have been marginalized for centuries due to colonialism and the structures and politics it left behind. In the ongoing process of reconciliation, First Nations people

6 Latour, *Politics of Nature*, 20.
7 Tim Forsyth, "Democratizing International Environmental Expertise about Forests and Climate," in *Environmental Governance: Power and Knowledge in a Local-Global World*, ed. Gabriela Kütting and Ronnie D. Lipschutz, 170–85 (London: Routledge, 2009), 170.
8 Peter M. Haas, "Introduction: Epistemic Communities and *International Policy Coordination*," *International Organization* 46, no. 1 (1992): 1–35.
9 Forsyth, "Democratizing International Environmental Expertise," 170.
10 Forsyth, 170.

are claiming a greater say in political decision-making on matters that pertain to their traditional territories and social life, if not complete self-determination.[11]

Many indigenous groups nowadays actively invite scientists from research institutions all over the world to investigate historical sites, natural resources, environmental alterations, and much more. For this purpose, they create administrative departments to oversee and carry out diverse research projects. Many even have their own permit systems, meaning that scientists must obtain permission from the First Nation claiming the area of research to be within their traditional territory, in addition to gaining approval from the state. Findings are oftentimes used in preparation for court cases involving Aboriginal rights and titles, as well as for all different kinds of negotiations with the provincial and federal governments and with corporations.[12]

Whether it is the discovery of one of the oldest ever uncovered settlements in North America, the rediscovery of ancient environmental management practices like clam gardens, or the intense observation of livestock developments such as herring populations; many of these findings "are an affirmation of what we already know," says Kelly Brown, director of the Heiltsuk Integrated Research Management Department (HIRMD).[13] Thus research in this context is generally not conducted on things that are completely unknown to the local communities. It is much more common for research to be carried out in close cooperation between scientists and local knowledge carriers. The results then show that local knowledge is not necessarily something completely separate from, or even opposed to, scientific knowledge. Even though both forms of knowledge might arise from completely different ontological backgrounds and are embedded in very different networks and power relations, they often end up reaching the same conclusions. These results "are unfortunately what the outside world wants" but "they really help the conversations we are having with other governments and the industry," states Kelly

11 Amanda Morris, "Twenty-First-Century Debt Collectors: Idle No More Combats a Five-Hundred-Year-Old Debt," *Women's Studies Quarterly* 42, no. 1/2 (2014): 242–58.

12 Robert J. Muckle, *The First Nations of British Columbia: An Anthropological Overview* (Vancouver: University of British Columbia Press, 2014), 34.

13 Quotes from a personal conversation with the author in March 2017. On the discovery of the oldest uncovered settlement, see Randy Shore, "Heiltsuk First Nation Village among Oldest in North America: Archeologists," *Vancouver Sun*, 28 March 2017, http://vancouversun.com/news/local-news/heiltsuk-first-nation-village-among-oldest-in-north-america-archeologists. On clam gardens, see Amy S. Groesbeck, Kirsten Rowell, Dana Lepofsky, and Anne K. Salomon, "Ancient Clam Gardens Increased Shellfish Production: Adaptive Strategies from the Past Can Inform Food Security Today," *PLOS ONE* 9, no. 3 (2014): e91235. On observations of livestock development, see R. W. Tanasichuk, "An Investigation of the Biological Basis of Recruitment, Growth and Adult Survival Rate Variability of Pacific Herring (*Clupea pallasi*) from British Columbia: A Synthesis," *Fisheries Oceanography* 26, no. 4 (2017): 413–38.

Brown. They can in sum lead to negotiations about treaties, land rights, resource management, and environmental protection, such as the Great Bear Rainforest Land Use Order[14] or the ocean protection agreement that includes marine spatial planning and the development of a network of Marine Protected Areas.[15]

Thus, it appears that the authority Science holds is what enables it to affirm local knowledge, by approving it with standardized scientific methods and translating it into a more commonly understandable language. It is this transformation that makes local knowledge politically valuable.

. . . or rather sciences?

The examples above go beyond the notion that local community knowledge, in a general sense, is per se opposed to or oppressed by Science, and show how Science can also have empowering effects in today's world, as it has the authority to back up place-based knowledge. It therefore helps to communicate environmental and climate issues from remote or marginalized perspectives and areas.

But still, we should think about where we want to go from here. What role can scientists possibly play in present and future scenarios? How can they interact with politics and the economy to find an equilibrium between a general openness in the sciences and the diplomatic authority of Science? And how can we make sure that scientists revise the authoritative structures that exclude so many in the first place? One first step could be to make more apparent the politics that underlie the creation of knowledge that in turn underpins environmental policies, and to ask with whose participation and based on whose assumptions this knowledge has been created.[16] I assume that the above-mentioned model of cooperation between scientists and local communities could also lead the way for future research projects.

14 British Columbia, Great Bear Rainforest Land Use Objectives Order, 2016, https://www2.gov.bc.ca/gov/content/industry/natural-resource-use/land-use/land-use-plans-objectives/west-coast-region/great-bear-rainforest/great-bear-rainforest-legal-direction-agreements.

15 Karin Larsen, "Trudeau and B.C. North Coast First Nations Announce Ocean Protection Agreement," *CBC News,* 21 June 2018, https://www.cbc.ca/news/canada/british-columbia/trudeau-and-b-c-north-coast-first-nations-announce-ocean-protection-agreement-1.4715786.

16 Forsyth, "Democratizing International Environmental Expertise," 182.

Each of the projects is constituted by a multiplicity of people from different disciplines and with different skills: from archeologists who excavate long-abandoned settlements or discover ancient clam-garden structures, to physicists doing radiocarbon dating, or biologists who observe clam behavior in different habitats or the quality of herring spawn. They all work jointly in their respective research groups; none can generate comprehensive results on their own. Moreover, these fields of interest wouldn't even exist without the knowledge of the Elders who pointed scientists in worthwhile directions, or the indispensable support of local knowledge carriers who know the territories like the back of their hands and therefore make it accessible to outsiders (which researchers usually are). The methodology and findings of these projects strengthen traditional knowledge, often transferred through oral histories, as a reliable source of information, without leaving any of their scientific accuracy behind. Additionally, the provincial and federal governments, as well as industry, are usually closely involved, depending on the subject of investigation and interest. These projects are cooperations in terms of knowledge sharing as well as knowledge creation.

Forsyth argues that in such cooperations—in the interactions between researchers, local knowledge holders, politicians, and company representatives—we can see the norms already embedded in certain notions of environmental causalities.[17] They moreover offer chances to ask which social norms govern how we would like the world to be and what kind of societies we want to empower. Through these encounters, cooperations acknowledge that "facts" and "values" have to be evaluated simultaneously since they are inseparable when it comes to environmental questions. It is certainly not always clear in advance how these cooperations will unfold, and whether they will be successful or even peaceful. They can just as easily end up in complete misunderstanding, or face stagnation or even surrender. But through the process of cooperating, especially when facing conflicts, there is a chance to ask what kind of norms give rise to what kind of environmental expertise, rather than just seeking one correct answer concerning one specific issue. These inclusive, flexible forms of environmental knowledge production and governance based on coproduction do not reject out of hand any norms or desires concerning nature; not from other, less established experts, and maybe not even from the extreme ends of the political spectrum (from creationists to environmental fundamentalists). Rather, it would place them as one vision among the many that can guide environmental policy; but these have to be negotiated.

17 Forsyth, 180–81.

If we want to go one step further and follow Latour's request to include nonhumans in discussions about environmental policies, cooperations have to be understood even more broadly. Latour states that through the creation of laboratories and related techniques, scientists have invented forms of speech prosthesis that allow nonhumans to indirectly participate in the discussions of humans. In these constellations scientists are then the ones to take over the role of spokesperson for the nonhumans in question.[18] If we were to say that the invention of speech prostheses and the accompanying role as a spokesperson is what makes someone an expert, other "local" knowledge holders might have analogously invented equivalent kinds of tools, but in different forms. Thus, discussions between different groups of experts in cooperative research projects can now go beyond the negotiation of standpoints from different human interest groups to incorporate what humans should argue for on behalf of their nonhuman protégés.

Which Way to Go?

This procedure will not erase existing power relations nor will it make communicating climate and environmental issues any easier. The integration of less established experts as well as nonhuman actors, however, may put scientific results on firmer political ground, supporting the search for more sustainable and socially just climate-change policies.[19] That all finally sounds very much like a proposal for more sciences and less Science, instead of an intercession for "one after the other" or even "both at the same time." But with regard to the multiplicity of voices, we are in urgent need of a lingua franca, a diplomatic tool, which findings and arguments can be translated into and through: a common ground for scientific as well as political results, which is accessible to other environmental and political contexts. For this purpose, we need strong institutions that have the authority to translate and to build bridges. But, and that is the important point, that authority should come from the capability to reveal the discursive processes that lie behind the "facts and figures" these scientific institutions produce. This way we might be able to work towards valuable scientific research as well as democratic political action at the same time.

18 Latour, *Politics of Nature,* 64ff.
19 Cf. Forsyth, "Democratizing International Environmental Expertise," 183.

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Emilie Schur Petri

Promoting Health, Combating Climate Change: How the *Promotores de Salud* Network in the US-Mexico Borderlands is Building Climate Resilience

The impacts of climate change, as scientists outline them, sound insurmountable. The National Climate Assessment of the United States classifies the impacts of climate change in the southwest region into five categories: declining snowpack and streamflow, threats to agriculture, increased wildfire, sea level rise and coastal damage, and heat threats to health.[1] Furthermore, these climate-related risks are unevenly distributed across the region and population, and those living within the US-Mexico borderlands are particularly vulnerable to the impacts of climate change. In this region, stretching 3,219 kilometers east to west and one hundred kilometers north to south, a hotter and drier climate is already resulting in a cascade of social vulnerabilities. These include increasing costs for energy and food, and greater demand for adequate healthcare, but it is water scarcity and increasing competition for water resources that are arguably the most salient concerns in this desert region, where a lack of surface water has created a historic dependence on groundwater.[2] Underground aquifers are now being depleted, as groundwater is extracted at unsustainable levels for agricultural, industrial, and residential use, and are not being replenished due to decreasing annual snowfall. In addition, climate change, together with human activities such as groundwater pumping and urbanization, aggravates levels of contaminants that naturally occur in groundwater basins along the US-Mexico border.[3] The threat of water contamination thus compounds the threat of water scarcity already experienced by people living in this region.

Climate scientists and social scientists alike argue that climate-change risks need to be addressed to protect both the environment and society. Yet overcoming these seemingly insurmountable challenges raises questions about how we can communicate complex

1 Gregg Garfin, Guido Franco, Hilda Blanco, Andrew Comrie, Patrick Gonzalez, Thomas Piechota, Rebecca Smyth, and Reagan Waskom, "Southwest," chap. 20 in *Climate Change Impacts in the United States: The Third National Climate Assessment,* ed. Jerry M. Melillo, Terese (T. C.) Richmond, and Gary W. Yohe, (Washington, DC: US Global Change Research Program, 2014), 462–86, https://doi.org/10.7930/J08G8HMN.

2 Margaret Wilder, Diana Liverman, Laurel Bellante, and Tracey Osborne, "Southwest Climate Gap: Poverty and Environmental Justice in the US Southwest," *Local Environments* 20 (2016): 1332–53, https://doi.org/10.1080/13549839.2015.1116063.

3 María Teresa Alarcón-Herrera, Jochen Bundschuh, Bibhash Nath, Hugo B. Nicolli, Melida Gutierrez, Victor M. Reyes-Gomez, Daniel Nuñez, Ignacio R. Martín-Dominguez, and Ondra Sracek, "Co-Occurrence of Arsenic and Fluoride in Groundwater of Semi-Arid Regions in Latin America: Genesis, Mobility and Remediation," *Journal of Hazardous Materials* 262 (2013): 960–69.

scientific knowledge to the communities most at risk and how to transform knowledge into action, as well as questions about climate justice. In this article, I will present a case study of two border communities suffering from groundwater contamination. Groundwater contamination in the US-Mexico borderlands is an example of a grounded climate-change risk where questions of environmental and climate justice are especially relevant, namely how to ensure that rights to access clean water are equitably distributed within and between communities, and that community members are recognized and included in decision-making on water management.[4] In addition, the process of tackling the problems caused by groundwater contamination involves negotiating between expert knowledge, technological solutions, and local action in communities. By themselves, neither scientific knowledge about climate change and groundwater contamination, nor decentralized water filtration stations funded by federal and binational development programs, had been successful in adequately communicating the risks or building resiliency. However, by partnering with a local network of community health workers, or *promotores de salud*, scientific knowledge was converted into community resilience through a process of identifying risks, communicating through community networks, and implementing appropriate solutions. This example may offer insights for how the inclusion of nonexpert voices in climate-change communication need not decenter science, but can connect it to sustainable local efforts that may be able to transform the hopeless list of climate-change impacts into grounded community action.

What Does Climate Change Look Like in the US-Mexico Borderlands?

Along the US-Mexico border, as many as 36 transboundary aquifers supply groundwater to meet agricultural, industrial, and residential demands.[5] However, the rate of groundwater extraction from numerous transboundary aquifers, particularly within the eight city pairs that straddle the border, is unsustainable. Unlike transboundary surface water, groundwater shared between the US and Mexico is not governed under any international treaty.[6]

4 Emilie Schur, "Potable or Affordable? A Comparative Study of Household Water Security within a Transboundary Aquifer along the US-Mexico Border," *Journal of Latin American Geography* 16, no. 3 (2017): 29–38.

5 Rosario Sanchez, Victoria Lopez, and Gabriel Eckstein, "Identifying and Characterizing Transboundary Aquifers along the Mexico-US Border: An Initial Assessment," *Journal of Hydrology* 535 (2016): 101–19, https://doi.org/10.1016/j.jhydrol.2016.01.070.

6 Stephen P. Mumme, "Minute 242 and Beyond: Challenges and Opportunities for Managing Transboundary Groundwater on the Mexico-US Border," *Natural Resources Journal* 40, no. 242 (2000): 341–78.

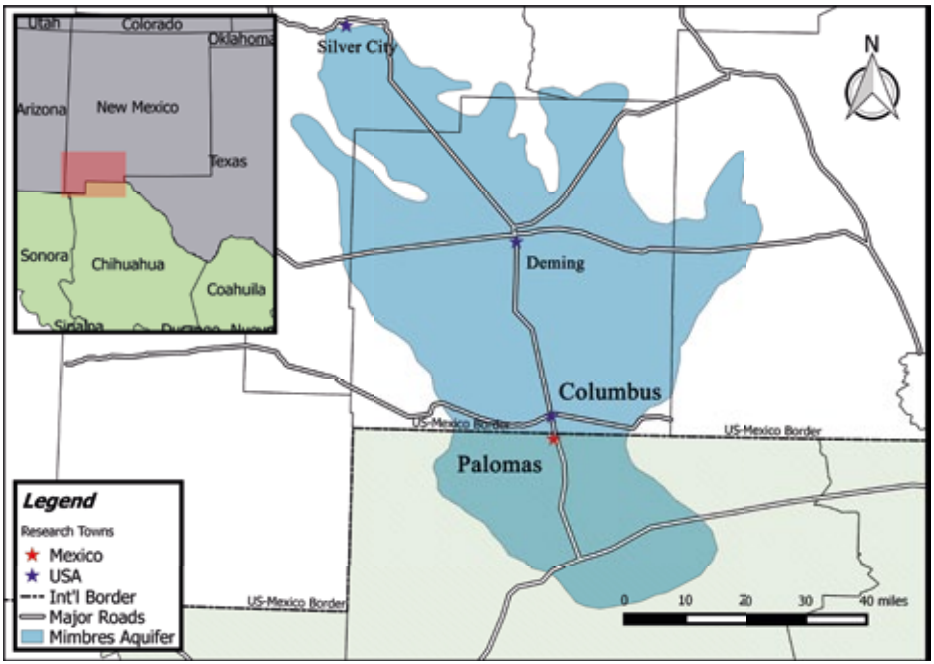

Figure 1:
Map of Study Area: US-Mexico border towns Palomas, Mexico, and Columbus, USA, and their underlying transboundary Mimbres Basin Aquifer. Created by Carl-Philipp Petri.

Without a contractual route to co-manage transboundary groundwater, water scarcity and water contamination present ongoing threats to the population. The villages of Columbus, New Mexico, in the USA (population 1,625) and Palomas, Chihuahua, in Mexico (population 5,748) are particularly vulnerable to water contamination from their shared aquifer basin. Although the two towns are separated by the US-Mexico border they are intimately linked, particularly in their dependency on the Mimbres Basin Aquifer (MBA). The lifeblood of the MBA is the snow-fed Mimbres River, whose headwaters are in the Black Range on the Continental Divide. As the river flows south to the US-Mexico border, it disappears underground near Deming, New Mexico, to replenish and recharge the 13,313 square kilometer aquifer basin.[7]

Beginning roughly 50 years ago, as annual snowfall in the Black Range decreased and the groundwater pumping rates in the MBA began to fluctuate, the water quality at the terminus of the basin began to deteriorate rapidly. Water testing, dating back to the

7 John W. Hawley, Barry J. Hibbs, John F. Kennedy, and Bobby J. Creel, *Trans-International Boundary Aquifers in Southwestern New Mexico* (Las Cruces, NM: New Mexico Water Resources Research Institute, 2000).

1970s, revealed arsenic and fluoride in the groundwater at high enough concentrations to exceed the maximum contamination standards established by the US Environmental Protection Agency. The most contaminated groundwater in the MBA is consumed by the residents in Columbus and Palomas, presenting an ongoing public health challenge.[8]

Life in a Contaminated Aquifer

"My teeth are stained like the people who grew up in Palomas," a village council member in Columbus explained to me. "You can still tell," he admitted, pointing to his teeth. "It was very evident, all my life I grew up with the water problems." Arsenic and fluoride are the two most serious inorganic contaminants found in drinking water worldwide, causing health impacts like mottled teeth, brittle bones, skin discoloration, and cancer.[9] Boiling the water does not remove these inorganic contaminants; instead, the contaminated water requires a specialized treatment process like reverse osmosis (RO) filtration. In the RO process, contaminated water is pressurized and sent through a membrane filter, which discharges clean water and a concentrated brine. Although the government was aware of the water contamination as early as the 1970s, it wasn't until the early 2000s that both Columbus and Palomas received new RO technology and water/wastewater infrastructure to address water contamination.[10]

Despite these infrastructural improvements, both communities continue to suffer from water contamination. In Columbus, the local water utility adopted a centralized RO water filtration plant financed through federal and binational grants and loans, which improved access to clean water and reliability. But centralized water-filtration technology increased costs and reduced affordability in Columbus, which in turn affected that same access. In Palomas, the local water utility financed decentralized water, filtration stations through a binational grant, which inadequately resolved household water-supply contamination—with 61 of the one hundred households surveyed continuing to consume contaminated water.[11]

8 Janet Tanski, Adrian T. Hanson, Alfredo Granados-Olivas, and Zohrab Samani, *Water Quality Assessment Plan for Columbus, New Mexico, and Puerto Palomas, Chihuahua* (San Diego, CA: Southwest Consortium for Environmental Research and Policy, 1998).

9 "Arsenic Fact Sheet," World Health Organization, accessed 15 May 2017, http://www.who.int/en/news-room/fact-sheets/detail/arsenic.

10 Elaine M. Hebard, "A Focus on a Binational Watershed with a View toward Fostering a Cross-Border Dialogue,"*Natural Resources Journal* 40, no. 281 (2000): 281–340.

11 Schur, "Potable or Affordable?"

Thus, despite the technological improvements, households in both communities remain unevenly exposed to water contamination and costs. This example raises concern more broadly about how climate change impacts are communicated and moderated, which should be more finely attuned to climate justice. This will be discussed below.

Greater Recognition and Community Participation

One local initiative in Palomas could be the keystone to communicating the climate-change-related risk of groundwater contamination—the Promotores de Salud de Palomas. These community health workers are a group of eight women who promote health and wellness within Palomas using a wide variety of methods including nutrition and gardening workshops, home visits, health fairs, health surveys, and organized exercise events and classes. Since 2014, they have also provided basic healthcare services and counseling at their small clinic, which is financed through a mix of private and public funding.

Figure 2: Promotores de Salud Palomas Focus Group. Photo by the author.

The promotores are not unique to Palomas, but can be found throughout Mexico and the borderland areas of the United States. The broader promotores de salud network is an approach to cultivating culturally competent healthcare delivery, as the promotores serve as cultural brokers between their community and the formal healthcare system.[12] Within Palomas, the promotores play a crucial role in connecting the most vulnerable people in the community to care. As one Palomas promotora explained to me, "We have the pulse of the community, when something is wrong we know about it."

12 Emma K. WestRasmus, Fernando Pineda-Reyes, Montelle Tamez, and John M. Westfall, "Promotores de Salud and Community Health Workers: An Annotated Bibliography," *Family & Community Health* 35, no. 2 (2012): 172–82, https://doi.org/10.1097/FCH.0b013e31824991d2.

Early on in my research, I met with the promotores de salud to discuss the issue of groundwater contamination in Palomas. I learned from our focus groups that although community members realized something was wrong with their household tap water, they were unaware it was contaminated with arsenic and fluoride. I explained that a specialized filtration process is required to remove arsenic and fluoride, and that simply boiling tap water only concentrates these harmful contaminants. Based on their healthcare work in the community, several of the promotores voiced concern. They had observed that people typically consumed filtered water for drinking, but used unfiltered tap water for cooking. We decided to do a survey of one hundred households to better understand the risk of contamination.

After a month of survey work, we concluded that 61 percent of households continued to use tap water for cooking. Furthermore, 47 percent of households reported having a negative opinion about their overall water situation, which included complaints about water-related illnesses, the price of water, or the inaccessibility of the decentralized water filter stations.[13] When these results were reported to the local water utility, they seemed unable to mitigate the situation. Without an outreach program or the routine publication and distribution of consumer reports, they couldn't reach the community. "Our responsibility is to maintain the water filter stations. We can't make people use them."

Luckily, the promotores had other ideas on how to communicate to the community the importance of using the decentralized water purifying stations, particularly for cooking. They organized meetings with key stakeholders in the community—including representatives of the local government, the school board, and NGOs—where we discussed how to share the results with the broader community and incorporate educational activities into the different sectors of society. These include environmental education campaigns to raise awareness about proper water-treatment options led by the promotores and teachers, water-conservation workshops led by local NGOS, and rainwater-harvesting initiatives organized by community members. One US-based NGO, Border Partners, has also collaborated with New Mexico State University to develop an inexpensive and effective household water filter, which uses activated carbon.[14] Taken together, these initiatives successfully translate scientific findings into local community action and thus mitigate the effects of climate change.

13 Schur, "Potable or Affordable?"
14 For more on the work of Border Partners, see their website, http://borderpartners.org.

Conclusions

This article asks the question: How should we (scientists, researchers, academics) responsibly communicate climate change knowledge to communities most at risk and transform knowledge into action, and what is the role of science in the way we communicate climate-change-related phenomena? In the case study example, the lack of decision-making power given to the communities to choose their preferred water-filtration technology in Palomas and Columbus resulted in a technological mismatch. Although these types of top-down infrastructure projects are vital to building resiliency to climate change worldwide, without robust community networks to champion the initiative they fail to reach their full potential. Throughout the borderlands, more funding should be awarded to local initiatives and NGOs, in addition to infrastructure, to successfully integrate the projects and combat climate change risks.[15] Following the *Promotores de Salud* example, I propose a three-step model to enhance climate change communication:

1) Identify grounded climate-change risks: Climate-change projections are often too abstracted or too general for communities to respond and adapt to, such as projected increasing temperatures and decreasing precipitation in the borderlands. But, by surveying and interviewing community members in the field, the most salient impacts of these projections are more easily identifiable (such as water contamination in the case study).

2) Communicate through community networks: Instead of creating entirely new programs with external funding or limited contracts, researchers and scientists should support already existing community networks whenever possible (such as the unlikely partnership with the promotores de salud to communicate the risks of climate change).

3) Turn risk into resilience: If the risks of climate change are communicated through robust networks, this can lead to often simple, but powerful actions that build community resiliency (such incorporating the health impacts of climate change into broader community health initiatives).

15 Allyson Siwik, Elaine Hebard, and Celso Jaquez, "A Critical Review of Public Participation in Environmental Decision Making along the U.S.-Mexican Border: Lessons from Border 2012 and Suggestions for Future Programs," in *Southwest Consortium for Environmental Research and Policy* SCERP Monography Series No. 16, ed. Erik Lee and Paul Ganster, 105–44 (San Diego, CA: San Diego State University Press, 2012).

Alongside expert knowledge and technological solutions, this article argues that non-expert voices are particularly powerful in communicating climate change risks and building resiliency within their communities. The approach of the promotores includes several initiatives, among them a broad wellness campaign—which now includes an education piece about cooking with filtered water—and a partnership with the NGO Border Partners to incorporate cost-effective rainwater harvesting systems or to install filters on water faucets so that large water users (like schools) can be connected to clean water without having to travel to the decentralized water stations.

The inclusion of nonexperts in climate change communication is not decentering science, but connecting it to sustainable local efforts. If we (scientists, scholars, practitioners, and researchers) prioritize fieldwork, we become better attuned to community priorities. By forging this connection to local networks, climate change risks can be communicated in a sustainable and trustworthy manner and solutions can become reflective of the values and preferences of the community. If we work toward these goals, there is reason to hope for climate resilience.

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Dorothea Born

Remembering Nature in Climate Change: Re-thinking Climate Science and Climate Communication through Critical Theory

Imagining Climate Change

Let's start by imagining a picture: we visualize a polar bear on an ice floe in the open sea, seemingly lost or possibly even trapped, drifting towards a precarious future. In evoking this image in your mind, I rely on the fact that it has become iconic of climate change and is now part of our popular imagination and consciousness.[1] It is also typical of a certain (and possibly dominant) way of communicating climate change, often found in popular science magazines. Such magazines occupy an interesting position within climate-change communication since they are located at the threshold between scientific journals and the mass media,[2] upholding an ethos of scientific accuracy and thus representing and reproducing a conception of science as the bringer of truth, reinforcing scientific authority over other forms of knowledge and expertise.[3]

Lynda Walsh, in this issue, rightly criticizes the unquestioned authority of science, arguing that this authority is based on science's "imbrication with global economic development" (Walsh, this issue, p. 15). According to Walsh, even attempts to include civil society in the process of knowledge production mostly serve industry and government interests. So-called Mode 3 models of knowledge production, which ultimately aim to incorporate a "quadruple helix" of government, industry, academia, and civil society, "double down on the neoliberal 'neocorporatist' logics of Mode 2" (Walsh, this issue, p. 18). Thus, Walsh argues, climate science is "the centerpiece of a powerful knowledge-production regime driven by neoliberal economic logics." She consequently proposes to "decenter science in climate change communication." While Jeroen Oomen agrees with Walsh's proposal to include the lay knowledge of local communities, he perceives a risk in questioning the "normative authority" of science, as this might open the door for all kinds of relativism and conspiracy theories, and, in the case of climate change,

1 Birgit Schneider and Thomas Nocke, eds., *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (Bielefeld: transcript 2014).
2 Sigrid Stöckel, Wiebke Lisner, and Gerlind Rüve, eds., *Das Medium Wissenschaftszeitschrift seit dem 19. Jahrhundert* (Stuttgart: Steiner, 2009).
3 Dorothea Born, "Bearing Witness? Polar Bears as Icons for Climate Change Communication in National Geographic," *Environmental Communication* (2018), Online first, https://doi.org/10.1080/17524032.2018.1435557

skepticism or denial. Oomen states that scientific knowledge production—"systematic inquiry"—can lead to truth and that such a truth is necessary as a "principle of ordering, a common ground upon which to meet" (Oomen, this issue, p. 29, p. 30).

In the following contribution, I argue that both these positions are simultaneously partly right and partly wrong because they express a contradiction manifest in today's capitalist society. In my opinion, this contradiction has been aptly named and addressed by Critical Theory as put forward by Theodor W. Adorno and Max Horkheimer. While not equating science with capitalism, I hope to make clear that a critique of science also always has to be a critique of the larger system out of which it emerged and in which it is embedded. Therefore, I first want to briefly elucidate Adorno and Horkheimer's critique of science and its entanglements with power based on their book *Dialectic of Enlightenment* and then, by way of an example, apply it to my own research on climate-change visuals in popular science magazines. Coming back to the image described above, I will show how it puts forward a particular conception of, and relationship to, science and nature. Building on insights from Adorno and Horkheimer's critique, I further want to speculate how such conceptions could be opened up and reimagined in climate change communication.

Enlightenment's Dialectics

Critical Theory goes back to Max Horkheimer's programmatic essay from 1937,[4] in which Horkheimer contrasts a "traditional theory" that does not recognize how it is part of the current economic (capitalist) system to a *Critical Theory*, which aims at showing how theory is always immersed in, and thus reproducing, a specific set of social and historical circumstances. One thus cannot simply apply the critique put forward in the 1930s and 1940s to today's science and its relation to the capitalist system. Rather, one must always assess how theory is embedded in specific historical conditions. Yet, as the fundamental structure of society has not changed, I do believe that Adorno's and Horkheimer's basic arguments of how science and capitalism are entangled, as well as their proposition for how to overcome these entanglements, are still valid and worth revisiting. After all, the aim of Critical Theory was always to criticize a situation in order

4 Michael Schwandt, *Kritische Theorie* (Stuttgart: Schmetterling Verlag, 2009).

to change it. Thus, Critical Theory is not only a theory but also a practice,[5] a thought that might be inspiring for many social scientists who also hope to achieve change through their work—as do we, writing the contributions to this issue.

Dialectic of Enlightenment, written cooperatively in exile and against the backdrop of German Fascism and anti-Semitism, is indebted to this programmatic aim of Critical Theory. On the very first page of *Dialectic of Enlightenment* Adorno and Horkheimer state: "Enlightenment, understood in the widest sense as the advance of thought, has always aimed at liberating human beings from fear and installing them as masters. Yet the wholly enlightened earth is radiant with triumphant calamity."[6] The authors' intention is to investigate why enlightenment has failed to fulfill this aim to free humanity. Thus, they also make clear that they are ultimately sympathetic to enlightenment's initial goal, but that the project of enlightenment has not delivered what it originally promised. Adorno and Horkheimer link this failure to the ways in which enlightenment tried to "break out of natural constraints (Naturzwang)."[7] Their critique of modern science is ultimately linked to a critique of the "domination of nature," the brutal ways through which nature was exploited and destroyed in the name of enlightenment, which makes their approach also fruitful for radical ecological thinking.[8] Furthermore in their conceptualization of nature, Adorno and Horkheimer do not only include *external nature*—what can be referred to as "the environment"—but extend their conception of nature to humans, conceiving every individual's fundamental needs and drives as their *inner nature*.[9] The critique of external nature's domination through enlightenment is thus linked to the oppression of humans, as both natures have been dominated by enlightenment: external nature through the blind exploitation of resources, and humanity's inner nature, since every individual has to suppress their needs and wishes in order to conform to the system.

Adorno and Horkheimer's critique is linked to a critique of the capitalist mode of production, which they perceive as opposed to human freedom. The rise of capitalism is

5 Max Horkheimer, "Traditional and Critical Theory," in *Critical Theory: Selected Essays*, 188–243 (New York: Herder and Herder, 1972).
6 Max Horkheimer and Theodor W. Adorno, *Dialectic of Enlightenment: Philosophical Fragments,* ed. Gunzelin Schmid Noerr, trans. Edmund Jephcott (Stanford, CA: Stanford University Press, 2002), 1.
7 Steven Vogel, *Against Nature: The Concept of Nature in Critical Theory* (Albany: State University of New York Press, 1996), 55.
8 Vogel, *Against Nature.*
9 Alison Stone, "Adorno and the Disenchantment of Nature," *Philosophy & Social Criticism* 32, no. 2 (2006): 231–53, https://doi.org/10.1177/0191453706061094.

ultimately connected to and entangled with the advances of enlightenment and modern science. At the beginning of modernity, direct and personal dominion was replaced with a system of abstract and impersonal rule. This abstract rule is also reflected within enlightenment and modern science, which are based on the principle of *instrumental reason*,[10] where things are reduced to serving a single purpose. In order to preserve the system and produce surplus value, instrumental reason eliminates all qualities and peculiarities of things.[11] This applies especially to nature, which becomes a resource to be exploited or a presentation of a problem to be understood and solved by science's identifying thought: "Nature, stripped of qualities, becomes the chaotic stuff of mere classification."[12] This becomes especially visible when thinking about climate change. Even though we are quite aware of the large-scale catastrophic consequences of the exploitation of nature, instrumental reason further enhances this exploitation in order to preserve the capitalist system.

Every step aimed at delivering humanity out of the brute forces of nature has increased the domination of both external nature and human's inner nature. Therefore, "reconciliation with nature"[13] must always mean both changing the ways we conduct ourselves towards the environment, as well as towards our own wants and needs. Thus, Critical Theory is therefore also ultimately a critique of all totalitarian systems that oppose human freedom and the fulfillment of individual needs.

Even though Adorno and Horkheimer radically criticize modern science by showing how it is ultimately entangled with capitalist modes of production, they do not suggest abolishing rational thought altogether. Rather, although enlightenment has not fulfilled its promises, they argue that it also provides the tools to finally overcome domination: critical thought. By thought becoming self-aware and reflexive of its own entanglements with power, the totalitarian tendency within enlightenment might be overcome: "For not only does the concept, as science, distance human beings from nature, but as the self-reflection of thought—which, in the form of science, remains fettered to the blind economic tendency—it enables the distance which perpetuates injustice to be measured."[14] Thus, Adorno and Horkheimer do not propose decentering science but using one of

10 Max Horkheimer, *Eclipse of Reason* (New York: Oxford University Press, 1947).
11 Horkheimer and Adorno, *Dialectic of Enlightement*, 4.
12 Horkheimer and Adorno, 6.
13 Horkheimer and Adorno, 54.
14 Horkheimer and Adorno, 32.

the main principles of science, critical thinking, to overcome the totalitarian tendencies inherent to this very science. Again, nature plays a central role here. It is through engagement with nature, through perceiving its domination, the suffering and harm done to it by humans, that this self-reflection of critical thought might be sparked. "Through this remembrance of nature within the subject, a remembrance which contains the unrecognized truth of all culture, enlightenment is opposed in principle to power."[15] As Horkheimer put it in his book *Eclipse of Reason*: "The sole way of assisting nature is to unshackle its seeming opposite, independent thought."[16] In practice, remembering "nature within the subject" and becoming aware of all the suffering done to nature through enlightenment would consequently entail also the end of capitalism. Only if we find a different mode of production that does not include the blind exploitation of natural resources to produce surplus value can nature—both external and each human's inner nature—be reconciled.

Coming back to the seemingly contradicting positions put forward by Walsh and Oomen, I now want to make clear why, based on this critique of enlightenment, they are each both right and wrong at the same time. Walsh rightly criticizes science's entanglements with power and the capitalist mode of production. Yet, to decenter science could lead, as Oomen rightly points out, to relativism and indifference. Thus, I do believe that rational thought and critical thinking are necessary to understand and overcome science's entanglements with power. But, it will not do to see science as "a principle of ordering, a common ground on which to meet" (Oomen, this issue, p. 30). Rather, we need to make visible and reconsider how this ordering principle is entangled with the modes of production in contemporary societies and how these lead to a domination of both our external environments as well as our own inner dreams, needs, and drives.

Re-imaging Climate Change

Based on this short account of some aspects of Critical Theory's critique of enlightenment, I now want to come back to the issue of climate change. What could these insights mean for the practices of climate change communication?

15 Horkheimer and Adorno, 32.
16 Max Horkheimer, *Eclipse of Reason* (New York: Oxford University Press, 1947), 89.

So let's return to the image I asked you to imagine at the very beginning of this contribution and explore what is made visible as well as invisible by this picture. The image of the polar bear may catch the viewer's attention, as the fate of the cute cuddly bear is linked to climate change. The icon of the polar bear thus allows this abstract and remote issue to be personalized and localized. Yet, the image also promotes a certain gaze. The bear itself is depicted as vulnerable and helpless, in need of human rescue. Such anthropomorphizing and romanticizing imaginations deprive the bear of agency.[17] While hunting polar bears for their fur is restricted and viewed with contempt, photojournalists now hunt for polar bears' pictures. Through the practices of imaging, the polar bear is "captured" in a specific place and situation.[18] Humans themselves remain absent in these pictures; they are the ones behind the camera, or in control of taking and looking at those images, while the polar bear is objectified, a surface for all kinds of human projections. Thus, the "photographic gaze" incorporates and perpetuates human domination over nature.[19]

What remains invisible in the image of the lone polar bear are those people living in the Arctic, whose home is already affected by the consequences of climate change. Furthermore, the icon of the polar bear does not foster an understanding of the wider circumstances and causes of climate change. It does not show how the burning of fossil fuels, and contemporary lifestyles, are linked to increasing greenhouse-gas concentrations and global surface temperatures. Nor does the image explain how this exploitation of natural resources by humans is linked to capitalist modes of production.

Coming back to Adorno's and Horkheimer's argument about science's entanglement with the capitalist system that provides the wider framework within which science is produced, I argue that climate scientists, as well as climate-change communicators, need to become aware of the circumstances in which climate(-change) knowledge is produced. A solely scientific understanding of climate change reduces nature to a physical phenomenon that can be observed and controlled by the means of the natural sciences.[20] This fosters a nature-culture divide, which deprives nonhuman actors of agency.

17 Donna Haraway, *How like a Leaf: An Interview with Thyrza Nichols Goodeve* (New York: Routledge, 2000).
18 Donna Haraway, "Teddy Bear Patriarchy: Taxidermy in the Garden of Eden, New York City, 1908–1936," *Social Text* 11 (2000): 20–64, https://doi.org/10.2307/466593.
19 Born, *Bearing Witness?*
20 Julie Doyle, *Mediating Climate Change* (Burlington, VT: Ashgate, 2011).

Furthermore, communicating climate change as a solely scientific problem inhibits a wider understanding of how climate change is ultimately also a social and political issue.[21]

This brings us back to the contradiction inherent in the question of whether or not to decenter science in climate-change communication, identified in the introduction. Before it is possible to tackle this question, we need to make visible how science is ultimately entangled with capitalist modes of production and how this might restrict us from finding solutions for the issue of climate change. The domination of external nature is intrinsically linked to the domination of each human being's inner nature. So it is only by reconciling with nature that we as humans might ultimately be free. To communicate this interconnectedness is a challenge, which involves radically rethinking our self-understandings as climate scientists, climate-change communicators, and researchers of climate communication. Yet, it is a challenge we should be willing to face if we truly want to overcome the domination of human and nonhuman beings.

21 Mike Hulme, *Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity* (Cambridge: Cambridge University Press, 2009).

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From Knowing to Action

Vera Karina Gebhardt Fearns

Experiencing Tomorrow: The Importance of Immersive Scenarios for Climate Science Communication.

Scientists all over the world agree that climate change is happening,[1] that humans are the dominant cause, and that we urgently need to change our behavior. And yet, although the scientific and public consensus grows stronger, too many people seem to be unmotivated to take action.[2] What has caused this divide between expert, academic knowledge on climate change and public behavior? I argue that the communication of climate-change science is to blame, which at present relies heavily on the idea that facts alone can convince people to take individual or collective action. It is well established that the academic community has for centuries seen itself as the main and most impactful producer of knowledge, and although there is now a greater diversity of actors involved, science still wants to retain its supremacy. Thus, we end up with models of climate-change communication that center science, following the logic that if knowledge exists, it is the responsibility of the public to understand it and act on it. However, more information does not always lead to better understanding,[3] and when it does, it does not necessarily result in action.

This essay highlights the important role of contemporary immersive art, speculative design, and multimedia storytelling, which transmit information very differently than formal scientific thought and political debates do. Consequently, I call for scientists and policymakers to team up with arts and communication experts to engage the public to take action in a more effective way.

In recent decades, a considerable number of studies have examined what influences public attitudes and behavior related to climate change.[4] They have shown that a variety of factors affect individual pro-environmental behavior, including worldviews, social

1 See various sources on https://climate.nasa.gov/scientific-consensus.
2 See, for example, Kari Marie Norgaard, "'People Want to Protect Themselves A Little Bit': Emotions, Denial and Social Movement Nonparticipation," *Sociological Inquiry* 76, no. 3 (2006): 372–96.
3 Dan M. Kahan, Ellen Peters, Erica Dawson, and Paul Slovic, "Motivated Numeracy and Enlightened Self-Government," *Behavioural Public Policy* 1 (2013): 54–86; Yale Law School, Public Law Working Paper No. 307.
4 See, for example, Martin Patchen, *Public Attitude and Behavior about Climate Change*, Purdue Climate Change Research Center. PCCRC Outreach Publication 0601 (2006).

norms, political viewpoint, knowledge, personal disagreement with certain actions, and perceived usefulness of one's actions. Hence, knowledge is just one aspect that can influence human behavior, but it is not the only one and must be understood in a much broader sense: the mental action or process of acquiring knowledge and understanding works through thought, experience, and the senses.[5]

Hence it is important to communicate factual information that appeals to our rational and conscious sense-making, alongside emotional pleas that arrive from stimuli through our senses. Emotions have been identified as the missing link in how we become aware of the relationship between personal experiences on the one hand, and society and environment on the other, and they have been emphasized in the study of social movements in recent years. Going one step further, merely knowing about the causes and effects does not inspire people to take action because they do not perceive the effects as alarming or even relevant, especially because of what is called the "present bias."[6] In other words, people put greater weight on satisfying their present needs than considering what may serve them best in the future. This psychological distance can be explained by construal-level theory: the less immediate an individual experience or situation is, the more abstract and less concrete it seems—people don't seem to care about the effects of climate change, because these slowly creep in and are often not something people can feel all of a sudden in their daily lives. Given these cognitive barriers, might more people change their behavior if we make climate change seem more immediate, more tangible, and more connected to their daily life? Put another way, if people could experience the possible futures that academics model based on climate-change data, would they act differently?

Embodied theories (which refer to the assumption that thoughts, emotions, feelings, and behaviors are grounded in sensory experiences) started gaining momentum within social psychology at the start of the new millennium, but the topic of embodiment and efforts to understand the power embodied experience has over people are long established in other fields. Within art and media history, the phenomenon of creating illusionary, experienceable spaces is described as "immersive culture" and dates back to

5 Definition of cognition, https://en.oxforddictionaries.com/definition/cognition, retrieved 25 January 2019.
6 Sheldon Ungar, "Public Scares: Changing the Issue Culture," in *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change*, ed. Susanne C. Moser & Lisa Dilling (New York: Cambridge University Press, 2007), 82–89.

Figure 1, 2 & 3: Impressions of the exhibition "Singing Sentinels" in Amsterdam 2012. Images by Liam Young.

antiquity.[7] In every epoch, people have used the technologies available to them to produce spaces that were, or still are, impossible to access, be they distant places on earth or in the universe; imagined places like paradise, the past, or the future; or forbidden places that the public was or is not allowed to access. These illusions offer possibilities for thought experiments, imagination, testing concepts, anticipating other worlds, and probing options. Fields like critical and speculative design are currently using this experiential approach to explore future possibilities. After years of speculating about technological developments and probing their possible effects on the individual and society,[8] scholars and practitioners of speculative design today are creating works that increasingly address climate futures. At the same time, planning and foresight fields

7 Oliver Grau, *Virtual Art: From Illusion to Immersion* (Cambridge, MA: MIT Press, 2002).

8 See, for example Anthony Dunne and Fiona Raby, *Speculative Everything: Design, Fiction, and Social Dreaming* (Cambridge, MA: MIT Press, 2013), or Stuart Candy, "The Futures of Everyday Life," PhD diss., University of Hawaii, 2010.

are teaming up with speculative artists and designers to offer a better understanding of possible future developments to decision makers who are grappling with long-term developments.

In 2012, Liam Young created an installation called "Singing Sentinels: When Birds Sing a Toxic Sky" at the Mediamatic Fabriek in Amsterdam, using canaries to show how rising levels of carbon dioxide in the atmosphere would affect our environment, especially birdsong. Canaries were once used in coalmines to keep miners safe: underground mines can contain potentially deadly gases, which are odorless and colorless. Canaries are much more susceptible to the gas, and react more quickly than humans do, thus alerting the miners of dangerous gas leaks through their behavior. In Young's installation, birds were once again used to monitor the air: living birds were introduced into the exhibition space as an ecological warning system, providing audible feedback on the state of the atmosphere. Across the course of the intervention, Young, equipped with a gas mask, performed "Silent Spring" and altered the air of the room in line with the predicted atmospheric composition for 2050, making Rachel Carson's 1962 forecast tangible. To accompany the experience, visitors were given binoculars and a "Birdwatcher's Guidebook to Toxicity Sentinels" so that they could fully immerse themselves in the experience of accelerated atmospheric change and listen to the birdsong being subtly silenced.[9] Young's installation blurred the boundary between the present and a possible future by creating an installation that allowed visitors to experience a future scenario themselves, addressing various senses. This had the effect that the information was made more present, tangible, and personally relevant than facts presented in a formal academic article. In this sense, the installation is similar to distortion of reality in contemporary Virtual Reality (VR) experiences, which sets it apart from traditional forms of media and content used within the context of contemporary climate change science in three ways: different levels of immersion, interactivity, and presence.[10] Immersion is best described as the sensation of being completely surrounded by another reality. A physical immersion might be being submerged in water, whereas a psychological immersion can be created by affecting the senses on different levels, without being in the specific environment. This is interwoven with the second factor, interactivity, where the visitor or user can experience and

9 For an impression of the installation, see Young's video "Silent Spring," https://vimeo.com/43378138.
10 Bob G. Witmer and Michael J. Singer, "Measuring Presence in Virtual Environments: A Presence Questionnaire," *Presence* 7, no. 3 (1998): 225–40.

Red Radars

Highlight
Geomagnetic Orientation capabilities are engineered to detect subsurface anomalies

Description
The Red Radars of the Archaeology Institute scan the land for remnants of abandoned towns and lost villages. Geomagnetically sensitive to the presence of underground ruins, the birds gather and flock above the walls of buried settlements throughout the countryside. Being typically locked away in a university's Archaeoptical Aviaries means that natural sightings are quite rare, but the chance to see the birds' red plumage trace the ghosted lines of forgotten cities against a blue sky is well worth the trip to any distant dig site.

Plate 5

12

11

Figure 4 & 5:
Red Radars. Excerpt from "A Field Guide to Singing Sentinels." Images by Liam Young. Used with permission.

interact with the created environment through touching, feeling, smelling, hearing, and seeing the other world, adding other levels of realism. Presence tricks the visitor's mind into perceiving something as real.[11]

Recent research into VR's impact on sustainable behavior in the real world supports the assumption that immersive environments influence behavior.[12] In one experiment, Ahn et al. compared the effects of hearing about a tree being cut down to the effects of virtually cutting down the tree. After the experiment, they tested how many paper napkins each group used when the researcher "accidentally" spilled water. Those who had virtually felled a tree used 20 percent fewer napkins—a statistically significant

11 James J. Cummings, Jeremy N. Bailenson, and Mailyn J. Fidler, "How Immersive Is Enough? A Foundation for a Meta-Analysis of the Effect of Immersive Technology on Measured Presence," in *Proceedings of the International Society for Presence Research Annual Conference*, 24–26 October 2012, Philadelphia, Pennsylvania, USA.

12 Sun Joo (Grace) Ahn, Jeremy N. Bailenson, and Dooyeon Park, "Short- and Long-Term Effects of Embodied Experiences in Immersive Virtual Environments on Environmental Locus of Control and Behavior," *Computers in Human Behavior* 39 (2014): 235–45.

finding that suggests VR can influence climate-change-related behavior in the real world. Research on immersive spaces (especially using new media forms like VR) and their impact on human behavior is in its infancy, but early experiments point to the potential for using immersive environments to affect unconscious decision-making. Immersive installations, regardless of whether they are created with traditional or advanced forms of media, offer researchers not just an exciting tool with which to test new hypotheses, but also the possibility to mobilize on a large scale and to enable positive (as well as negative) behavioral change.

Young's installation and Ahn et al.'s experiment reveal that the tangible immediacy of an immersive event resonates on a deeper emotional level than factual communication through a conventional channel does. These examples also highlight a new truth for climate-change communication: exploring the possible effects of climate change on society and communicating those findings to the public are crucial, but it is similarly important to consider how those messages are communicated. This is especially urgent if research is to be impactful and foster change. Scientific knowledge used to be produced foremost for academic peers, and scientists advanced their skills on communicating for this specific purpose. Yet the moment climate-change science aims to address a wider audience—which at its broadest is all of humankind—other forms of communication need to be added to be successful in this new context. This, too, requires a new skillset and therefore this essay is also a call for action for a new, communications-focused, interdisciplinary approach to research related to climate-change science. Thus, the challenge is not the decentering of science in climate-change communication per se, but rather pushing scientists to communicate in new ways. Companies and government services have already started collaborating with experts in communication to translate research on unknown technological and social futures into emotional appeals to bring insights to a broader audience. Climate-change researchers must follow.

Suggested Further Reading

Ahn, Sun Joo (Grace), Jeremy N. Bailenson, and Dooyeon Park. "Short- and Long-Term Effects of Embodied Experiences in Immersive Virtual Environments on Environmental Locus of Control and Behavior." *Computers in Human Behavior* 39 (2014): 235–45.

Candy, Stuart. "The Futures of Everyday Life." PhD diss., University of Hawaii, 2010.

Cummings, James J., Jeremy N. Bailenson, and Mailyn J. Fidler, "How Immersive Is Enough? A Foundation for a Meta-Analysis of the Effect of Immersive Technology on Measured Presence." In *Proceedings of the International Society for Presence Research Annual Conference*, 24–26 October 2012, Philadelphia, PA.

Dunne, Anthony, and Fiona Raby. *Speculative Everything: Design, Fiction, and Social Dreaming.* Cambridge, MA: MIT Press, 2013.

Grau, Oliver. *Virtual Art: From Illusion to Immersion.* Cambridge, MA: MIT Press, 2002.

Kahan, Dan M., Ellen Peters, Erica Dawson, and Paul Slovic. "Motivated Numeracy and Enlightened Self-Government." *Behavioural Public Policy* 1 (2013): 54–86.

Norgaard, Kari Marie. "'People Want to Protect Themselves A Little Bit': Emotions, Denial and Social Movement Nonparticipation." *Sociological Inquiry* 76, no. 3 (2006): 372–96.

Patchen, Martin. *Public Attitudes and Behavior about Climate Change: What Shapes Them and How to Influence Them.* Purdue Climate Change Research Center. PCCRC Outreach Publication 0601 (2006).

Ungar, Sheldon. "Public Scares: Changing the Issue Culture." In *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change*, edited by Susanne C. Moser and Lisa Dilling, 82–89. New York: Cambridge University Press, 2007.

Witmer, Bob G., and Michael J. Singer. "Measuring Presence in Virtual Environments: A Presence Questionnaire." *Presence* 7, no. 3 (1998): 225–40.

Young, Liam. *Silent Spring: A Climate Change Acceleration Performance.* Performed April 2012. https://vimeo.com/43378138.

Eline D. Tabak

Science in Fiction: A Brief Look at Communicating Climate Change through the Novel

Responding to Lynda Walsh's argument for looking at alternative models of knowledge production—and taking into account Jeroen Oomen's argument in favor of the pursuit of scientific knowledge—I am using this paper to take a serious albeit brief look at one of society's more creative opportunities for communicating the climate: the contemporary climate-change novel.

Looking at novels as means for communicating climate change immediately raises the following question: can novels, as singular works of literary fiction, still enter and influence public debate in the twenty-first century? Answering that particular question goes beyond the scope of this paper; the examples of influential novels that are most often cited are from the late eighteenth and nineteenth centuries, such as the 1852 classic Harriet Beecher Stowe's *Uncle Tom's Cabin*, suggesting that evidence for novels changing public opinion in this day and age is scanty. Nevertheless, in this paper, I make the assumption that a novel, containing the "right" elements, has the potential to influence public opinion and debate on climate change. Taking a look at the most successful examples of climate fiction, it appears as though the inclusion of science—both on the levels of the plot itself and as a paratext—is vital for their positive reception as a convincing or "good" book on the topic of anthropogenic global warming. (That said, some are more ambiguously received than others.) As a result, the novel can be an important channel in which complex discourses can be communicated.

I will look at three successful American books that reflect upon anthropogenic climate change: Susan M. Gaines's *Carbon Dreams* (2001), Barbara Kingsolver's *Flight Behavior* (2012), and Michael Crichton's *State of Fear* (2004).[1]

As scientific knowledge plays an important role in the books, the way these novels treat scientists—and their scientific findings—provides great insight into how society gener-

1 Susanne M. Gaines, *Carbon Dreams* (Berkeley: Creative Arts Book Company, 2001); Barbara Kingsolver, Flight Behavior (New York: HarperCollins, 2012); Michael Crichton, *State of Fear* (New York: HarperCollins, 2004). The author consulted an e-book edition (iBooks) of *State of Fear,* which contains additional materials not found in the print edition; page numbers correspond to the print edition.

ally regards the practice of science. And then there is another layer: its presentation in the paratext. My chosen books were written by authors who are in some way educated and knowledgeable in the natural sciences—particularly Gaines and Kingsolver—and in a way depend on this education and knowledge for the credibility of the science communicated in their work. This assertion and performance of the authors' expertise occurs in the paratext, or everything besides the story itself, "in order to *present it . . . to make it present*, to assure its presence in the world, its 'reception' and its consumption."[2] With this in mind, I will trace the role of the scientist in the plots and the paratextual elements of the aforementioned novels, and the ways in which they frame these books as communicating scientific "truth" and "good" climate science.

A Geochemist, an Ecologist, and a Climate Skeptic Walk into a Bar

In stark contrast with other climate change novels (including *Flight Behavior*), the main scientist and protagonist of Gaines's *Carbon Dreams* is a young woman: geochemist Dr. Cristina Arenas discovers a means of analyzing the organic residues found in biomarkers to gain insight into the Earth's carbon levels and their correlation to global temperatures throughout the millennia. While plagued by a lack of funding and other academic troubles, including the responsibility as a scientist to stay rational and not speculate about her findings and present-day climate change, Cristina's hypothesis reaches and intrigues not only her academic colleagues, but also the broader public and even the US Congress. Where Cristina is the embodiment of scientific rationality, her partner—gardener and organic farmer Chip—represents a more emotionally driven response to the changing environment and the looming realization and threat of climate change. When Cristina's research is misinterpreted by a different scientist in a skeptical piece on climate change in the *New York Times*, it is Chip who convinces Cristina to write to the newspaper in an attempt to rectify their mistake. Chip also points out the ways in which scientists are funded and bribed by the fossil-fuel industry, much to Cristina's disbelief: "Money and power? . . . I think you've got things a little mixed up. That's what economists and politicians do. I'm a scientist, in case you haven't noticed."[3] Later, when Cristina has to testify in Congress, she decides to look deeper into the issue Chip raised and finds out that there is indeed an issue with science being funded by the fossil-fuel industry.

2 Gérard Genette, "Introduction to the Paratext," trans. Marie Maclean, *New Literary History* 22, no. 2 (1991): 261–72, print, quote on 261.
3 Gaines, *Carbon Dreams*, 243.

While the scientist is not decentered in Gaines's book—I would say the figure is central—the author does emphasize that scientific knowledge cannot stand its own, isn't free from politics, and needs that little bit extra to make an impact. Above all, the relationship between Cristina and Chip in *Carbon Dreams* shows that a symbiosis is needed. Neatly packaged—albeit in a bit of a cliché—as a romantic relationship between a scientist and an organic farmer, Gaines's novel presents the message that science is certainly in need of other means to disseminate its findings to the broader public: publishing hypotheses in academic journals and presenting papers at conferences is not enough. Both a simpler and more convincing way of communicating *and* a certain drive are needed to send the messages of climate science out into the world.

Flight Behavior, praised for how it combines the conventions of the realist novel—a localized narrative by means of the genre—with the global effects and discourse of climate change, focuses on the life of Dellarobia Turnbow, a Tennessee local who gave up her college dreams after getting pregnant at seventeen. Unhappy, Dellarobia seeks out an affair and stumbles across a field full of monarch butterflies. It is a sight of "unearthly beauty," but unfortunately also a warning: the monarch butterflies that Dellarobia finds are migrating far too early and to the wrong place. Most likely due to a changing climate, the monarchs made the collective decision to migrate to Tennessee rather than Mexico and, because of this, they risk extinction. While Dellarobia first believes the monarchs to be a gift from God—which, unlike climate change, she believes in—the arrival of entomologist and ecologist Ovid Byron slowly introduces Dellarobia to the reality of the phenomenon. And, of course, to the science of climate change and its consequences for Earth's fauna. This realization is facilitated by a scientist, which, like in Gaines's novel, makes the figure of the scientist once again central in the narrative.

In contrast with *Carbon Dreams*, it is not the scientist who needs to be reminded by others to share their message with the world; instead, Dellarobia's life—a very personal and localized narrative—is used as a means to create a more human (and emotional) story through which to share the scientist's message. We read how Dellarobia, rather than the scientists with years of experience and expertise, is approached by local newspapers and news channels to talk about the phenomenon because her story is the one people want to hear. The message is clear: academic actors alone are not enough to disseminate the science of climate change. While important, we need different means of sharing scientific findings with the public. This does not mean that scientific discourse needs

to be completely marginalized or decentered. Near the end of the book, Dellarobia decides to go back to school to study. She talks to one of her children, explaining how she and her husband Cub will separate, and what this means for them: "You get to go here and go there, you'll migrate. Like the monarchs."[4] Ultimately, scientific discourse has wormed its way into Dellarobia's life.

The plot of Michael Crichton's *State of Fear* is perhaps too complex—or chaotic, even unbelievable—to fully explore within the scope of this essay. Still, I want to discuss briefly its representations of scientists in academia. The book centers around the conviction—consistent with Crichton's own beliefs—that anthropogenic climate change is grossly exaggerated, even untrue, and part of a "politico-legal-media complex" (PLM complex) that is dedicated to deliberately "promoting fear in the population—under the guise of promoting safety," as explained by one of the characters, Professor Hoffman.[5] Hoffman points out universities specifically as being part of this PLM complex. Caught up in political games and the search for funding, universities actively scheme with politicians and feed the public fear of climate change. In *State of Fear*, scientists and academia as a whole (with the necessary exceptions, like Hoffman) are portrayed as being part of a conspiracy. Rather than creating a symbiosis between the knowledge of "rational" scientists and more "emotionally driven" characters, as Gaines and Kingsolver do, *State of Fear* follows a millionaire, his assistant, and a lawyer around the globe to expose the reality behind climate change. Besides decentering their role, *State of Fear* also appears to attempt to discredit the work of scientists. Scientists who endorse theories of anthropogenic climate change, that is.

Science and the Scientist in the Paratext

The importance of "the scientist" is traceable beyond the fictional narratives in these books. Interestingly, "objective" scientific knowledge is also performed in the books' paratextual elements and their presentation of the authors' knowledge and credibility.[6] In her acknowledgements, Gaines thanks several people: a couple of farmers, a geologist, a chemist, and a biologist for their advice and "stimulating conversations that

4 Kingsolver, *Flight Behavior*, 426.
5 Crichton, *State of Fear*, 456.
6 Although it is likely these paratextual elements were written and decided upon by the authors' publishers, I will refer to the authors themselves for the sake of simplicity and readability.

contributed to the making of this book."[7] It is only in the back that Gaines mentions the scientific resources she consulted, including that the "discussions of geochemical process in *Carbon Dreams* are based on those prevalent in the scientific community in the early 1980s. . . . Basic principles of the earth sciences are presented as reliably as possible within the novel's historic and aesthetic constraints, with many omissions and oversimplifications."[8] After this follows a list of recommended sources. *Carbon Dreams*' paratext is concise, yet leaves no doubt that Gaines, who is "educated in the sciences, with degrees in chemistry and oceanography,"[9] has done her research on the topic and has written a book containing science we should trust.

The paratext of *Flight Behavior* approaches scientific credibility in yet a different way. The book begins with a short biographical note, mentioning Kingsolver's success as an author and that, before she became a writer, she "earned degrees in biology and worked as a scientist."[10] Kingsolver gets polemical in the author's note, however. She pinpoints what elements of her novel are fiction, and which ones are "unfortunately true."[11] Just like Gaines, this is also when Kingsolver goes into detail and names the experts and sources she consulted. Most remarkably, Kingsolver asserts her own position as a scientist when she thanks Dr. Preston Adams (after whom she also named a character) who "was the first person ever to tell me I was a scientist. I've not forgotten."[12] As is made clear in the biographical note, Kingsolver considers herself both a writer of fiction (and nonfiction) and a scientist, and this appears to be a central point in her personal presentation.

While Gaines and Kingsolver (almost humbly) perform their own positions as scientists—an oceanographer and a biologist respectively—and assert the reliability of their sources in the paratext, Crichton takes it to another level. The controversial topic of his novel might be the reason for this, but it is certainly worth taking a closer look at *State of Fear*'s paratext. Crichton's book begins with a disclaimer: a firm reminder that we are reading a work of fiction. "However," the author writes, "references to real people, institutions, and organizations that are documented in footnotes are accurate. Footnotes are real."[13] The novel also includes two appendices: the first is an essay by Crichton on

7 Gaines, *Carbon Dreams*, v.
8 Gaines, 353.
9 Gaines, 355.
10 Kingsolver, *Flight Behavior*, i.
11 Kingsolver, 435.
12 Kingsolver, 436.
13 Crichton, *State of Fear,* iii.

the danger of politicizing science and the second documents the graphs used in the novel. This is followed by an extensive bibliography (spanning no less than 30 pages) documenting his research and the sources used in the novel, with a personal remark from Crichton following most sources.

And there is more. For those who choose to read the e-book, there are three speeches by Crichton included on media speculation and the environment. "Years before starting a novel," we read, "Crichton often explores his views on a particular subject by giving speeches before an audience." So we learn that Crichton has not only been working on this for years, reading extensively and becoming familiar with the subject, but that he has also given successful lectures on the topic. In almost humorous contrast to the proof of Crichton's extensive research, the "About the Author" section comprises three short sentences and merely mentions his most popular works of fiction. It almost looks as if Crichton is purposely separating his role as a remarkably prolific author and his role as climate change skeptic. Yet note: he doesn't present himself as a scientist. Looking at the shorter paratexts of Gaines and Kingsolver's novels, which do combine the roles of author and researcher, one has to wonder why Crichton and his publishers made the strategic choice to present his novel in this way.

The influence of *State of Fear* on American politics is documented. Republican and then chair of the Senate Environment Committee Jim Inhofe (known for taking a snowball to Senate as evidence that global warming is a hoax) required his committee to read the book and even invited Crichton as a Senate witness, where the author had the opportunity to join the debate and answer questions. Rather than an author with a background in anthropology and medicine, Crichton was treated as an expert on the subject of global warming because of his novel. Crichton's climate skepticism, whilst it did nothing to undermine the centrality of "science," was certainly successful both in destabilizing accepted understandings of climate change and raising critical awareness of the issues in the novel; it shows how scientific facts come embedded in emotional and political contexts, both inside and outside of climate fiction.

Concluding Remarks

Climate-change communication does not solely consist of disseminating scientific knowledge, or crudely put, throwing around facts and numbers. It thrives across a diverse array of media that share and reflect on this knowledge. Risk psychology tells us that people generally do not act in the face of climate change because the risk seems too far away—both geographically and temporally; publications on risk and climate change show us that a more emotional approach could in fact be the missing link.[14] (See the suggested further readings for more on this.) At the risk of speculating—which Cristina, the rational protagonist of *Carbon Dreams* would certainly disapprove of—this connection between scientific and more emotional narratives could perhaps even be a means of bringing closer together what Kari Norgaard terms the "double realities" of climate change.[15] If this is so, and we are in need of a medium that brings the far-away closer to home and elicits emotions, one does not need to look further than the novel.

And yet, simply introducing science into fiction—whether it is sound or not—does not make the cut. Rather, I would argue that positioning in the paratext is just as important as—if not more so than—the textual elements of the novel, if it is to successfully influence public debate and public opinion surrounding climate change. A novel's literary merit and success are related to its real-life social influence, but they are not the only elements that matter. A quick roundup of reviews shows that all three novels have been received in different ways. *Carbon Dreams* is overwhelmingly commended for its realist depiction of science, also noting the educational potential of Gaines's novel. Reviews of *Flight Behavior* are also overwhelmingly positive, but rarely mention the scientific aspects of Kingsolver's work. And then there is Crichton. *State of Fear* was described in the *New York Times* as "not so hot" and in *Entertainment Weekly* as "one of Crichton's best," but the general reception of Crichton's popular thriller is dominated by critics debunking the science presented throughout the work. Rather than critics and readers alike focusing on the quality of the thriller, there are essays, reviews, and entire web pages dedicated to criticizing Crichton's scientific knowledge. In May 2018, a simple search on the Internet

14 See Susanne C. Moser, "Communicating Climate Change: History, Challenges, Process and Future Directions," *WIREs Climate Change* 1 (2010): 21–53, and Sabine Roeser, "Risk Communication, Public Engagement and Climate Change: A Role for Emotions," *Risk Analysis* 32, no. 6 (2012): 1033–40.

15 Kari Norgaard, *Living in Denial: Climate Change, Emotions, and Everyday Life* (Cambridge, MA: MIT Press, 2011), print.

resulted in 139,000 hits for *Carbon Dreams*, 107,000 for *Flight Behavior*, and 547,000 for *State of Fear*. While Kingsolver's novel is the most lauded amongst literary scholars and critics, Crichton's *State of Fear* is arguably the most widely influential of these three novels so far—despite (and quite likely *because of*) its questionable science. It appears, then, that performativity of expertise in the paratext also has its limits—especially about such a controversial topic as climate change.

For in the end, we are still talking about fiction as a commercial activity. In order for a book to be bought by publishers and readers, and to be widely read and discussed, it needs to be good. Interesting characters, a solid plot, and *good writing* are what make us want to read in the first place. Looking at the real-life impact of Crichton's *State of Fear*—which still checks all the boxes of an entertaining mass-market thriller, despite its questionable science, the resulting controversy, and the fact that it will never become a literary classic—the potential influence of a solid novel, in combination with scientific knowledge, as a means of communicating climate change seems enormous, and certainly warrants further analysis.

Suggested Further Reading

Marshall, George. *Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change*. London: Bloomsbury, 2014.

Mehnert, Antonia. *Climate Change Fictions: Representations of Global Warming in American Literature*. Basingstoke: Palgrave Macmillan, 2016.

Weik von Mossner, Alexa. *Affective Ecologies: Empathy, Emotion, and Environmental Narrative*. Columbus: Ohio State University Press, 2017.

Grit Martinez

Let's Say It in Their Own Words

At stake in society's responses to climate change are the socially constructed ways in which climatic changes come to be realized and addressed. Lynda Walsh (in this volume) suggests approaching societal actors in decentralized ways—through all available channels and moderated by a variety of actors—when communicating the dramatic changes our climate undergoes; while Jeroen Oomen (also in this volume) advocates the opposite—a centralized, governmental-led approach. However, is this really a discussion to be overly concerned with? It is well documented that different societal groups think, feel, and, in turn, act differently.

Anthropologists, who consider culture their defining concept, have provided empirical evidence that societal groups are bound by specific codes and values that are expressed semantically and materially in their respective environment.[1] The work of linguists has also been vital here. Although the "Cultural Ecology" theory—which was developed in the mid-twentieth century and holds that cultures are shaped by, and adapt to, their (changing) environments—has received criticism for the way it potentially oversimplifies social processes and communication amongst social groups, there is no doubt that societies are intricately bound up with their natural environments. Recently, other disciplines such as communication, political science, and education have brought new perspectives and approaches to the study of culture, focusing, for instance, on matters such as the self-interested power to influence what is seen as acceptable within a culture.[2]

For the purpose of this *Perspectives* issue, I am concerned with the role of culture and history in relation to local knowledge and values, as these are displayed in the interpretations and actions of distinct groups regarding climate change. I argue that it makes sense to communicate the climate in a manner appropriate to the given cultural-historical context and imaginary, and to the relevant semiotic and material views of the people in it.

1 Clifford Geertz, *The Interpretation of Cultures: Selected Essays* (New York: Basic Books, 1973); Alfred L. Kroeber and Clyde Kluckhohn, *Culture: A Critical Review of Concepts and Definitions* (Cambridge, MA: Peabody Museum, 1952); Julian H. Steward, *The Theory of Cultural Change: The Methodology of Multilinear Evolution* (Urbana: University of Illinois Press, 1955).

2 Judith N. Martin, Thomas K. Nakayama, and Lisa A. Flores, eds., *Readings in Intercultural Communication: Experiences and Contexts* (Boston, MA: McGraw Hill, 2002).

I will first take you on a little excursion to the origins of science and climate science. This is followed by an illustration of the role of climate science and the reactions of societal actors to it in different cultural settings. I will end with some reflections on climate-change communication

Science and Climate Science

Human beings have emerged out of a long evolutionary process. Social and cultural contacts, made possible by trade, shipping and transport, and war and conquest, paved the way for the emergence of free thought and eventually the beginning of science. The social division of labor created estates, classes, and castes, giving a certain amount of leisure to privileged individuals who gained the freedom to think and observe without the pressure of having to meet their immediate needs. Quickly, different schools of thought emerged, different understandings of the physical world and our role in it as humans, and diverse styles of producing and communicating knowledge.[3] With the dramatic increase in scientific knowledge around the nineteenth century, more complex fields of expertise arose. This resulted in a process where knowledge that was formerly integrated ("Der Universalgelehrte") became separated, and in the establishment of scientific disciplines. Conversely, it also affected the production and sharing of knowledge.[4] In other words, science became powerful, with its power resting in the knowledge it produced, making it an authority in certain fields. For example, in Germany a "psychology of consciousness" was born and became firmly embedded in the new model of universities, in which "pure research" for its own sake became a social principle. In the English-speaking world, on the other hand, a trend towards the practical application of science arose.[5]

Climate science is the scientific study of climate within the field of atmospheric sciences. It is a relatively new discipline and it is heavily politicized. Disseminating climate forecasts and mitigation and adaptation options for the world (e.g., the IPCC reports) or for a region (e.g., the BACC reports for the Baltic Sea region) has become a huge

3 Hans Joachim Störig, *Kleine Weltgeschichte der Wissenschaft,* vol. 1 (Cologne: Parkland Verlag, 2004), 53–54.
4 Grit Martinez, Clara Armaroli, Susana Costas, Mitchell D. Harley, and Michael Paolisso, "Experiences and Results from Interdisciplinary Collaboration: Utilizing Qualitative Information to Formulate Disaster Risk Reduction Measures for Coastal Regions," *Coastal Engineering* 134 (2017): 62–72, https://doi.org/10.1016/j.coastaleng.2017.09.010 (accessed 14 December 2018).
5 "Science as an Institution," *Psychistorian's Weblog*, 6 October 2008, https://psychistorian.wordpress.com/2008/10/06/science-as-an-institution/ (accessed 14 December 2018).

responsibility and a moral obligation for the various actors involved, from the scientists producing the knowledge to the social actors who consume, interpret, and apply it, including politicians, citizens, businesses, and media. How scientific knowledge about our changing climate is perceived, interpreted, used, or ignored differs across nations, regions, and places amongst the various "stakeholders." Although climate science, like any other scientific discipline, cannot create values, it can undermine or support them, depending on whose interests and values are at stake.

Why Would One Ban Climate Science?

When it comes to climate change, many of the readers of this volume probably have "zero tolerance" for climate skeptics or climate deniers. Yet, there are many people who deny the existence of climate change, and some who even design laws to ban the application of knowledge produced by climate scientists.

The case of North Carolina's Bill HB819 (Paragraph 113 A-107.1 Sea level policy)—a bill that forbids climate scientists to extrapolate future sea-level rises in North Carolina based on their current knowledge—is a prime example that can illustrate the entanglement between cultural values and policies.

The bill states that "No rule, policy, or planning guideline that defines a rate of sea-level change for regulatory purposes shall be adopted" and further designates that the Coastal Resources Commission "shall be the only State agency authorized to define rates of sea-level change for regulatory purposes" (§ 113A-107.1. Sea level policy). What is behind the bill? Why and in what cultural context was it issued?

North Carolina is a coastal state in the USA with over 19,000 kilometers of inland sound coastline and more than 500 kilometers of Atlantic Ocean coastline along the barrier islands. The state is highly vulnerable to sea-level rise and has a long and continuous history of battling shoreline erosion. Many houses are built in low-lying areas next to the sea on very vulnerable locations, some even within the sand dunes. The aesthetics of the location are generally considered the most valuable aspect of a house. Traditional fishing practices and lifestyles are declining, and shoreline areas, especially in Carteret County, have changed their character as permanent residential populations have been

replaced by a seasonal population (second-home owners) and later by different groups of year-round residents such as retirees. These are mostly white, well-off residents who tend to live along the oceanfront, often protected by costly safety measures while "in return" contributing significantly to the income of the county via their property taxes. This creates a dependency on local property taxes, is an important driver for local politics, and defines the voice of the political attitude towards climate change and discussions about sea-level rise.[6] Today, North Carolina is known as a state where religious right-wing politicians and neoconservatives are in the majority. Many of them deny climate change as much as they disagree with a liberal policy. In 2012, the Board of Commissioners and the county manager of Carteret County adopted a resolution "Concerning North Carolina's Sea Level Rise Reports, Policies and Monitoring Efforts," where the concern was expressed that "exaggerated sea level rise projections and resulting policy/ rules can cause irreparable economic harm to the coastal plain of North Carolina by adversely changing land/ property values, uses, insurances, and construction/ maintenance costs of both private and public infrastructure."[7]

The entanglement between property owners, county commissioners, and ultra-conservative policy makers in North Carolina came at the expense of climate-science findings, their communication, and the application of mitigation and adaptation measures. Finally, when speaking about climate change we should not forget the Thomas theorem, that it is not important whether the interpretation of a situation is correct or not: "If men define situations as real, they are real in their consequences."[8]

However, this is only one explanation. In his classic 1893 essay,[9] Frederick Jackson Turner argued that the American frontier promoted individualism and the possession of land and goods. Half a century later, Herbert Hoover used the phrase "rugged individualism" during his time as US president to refer to the idea that individuals should be able to rely on

6 Grit Martinez, Mike Orbach, Fanny Frick, Alexandra Donargo, Kelsey Ducklow, and Nathalie Morison, "The Cultural Context of Climate Change Adaptation: Cases from the U.S. East Coast and the German Baltic Sea Coast," in *Social Dimensions of Climate Change Adaptation in Coastal Regions*, ed. Grit Martinez, Peter Fröhle, and Hans-Joachim Meier, vol. 5, Klimawandel in Regionen zukunftsfähig gestalten (München: oekom publishing, 2014), 92.

7 North Carolina Carteret County, Resolution Concerning North Carolina's Sea Level Rise—Reports, Policies, and Monitoring Efforts. Adopted 19 March 2012. Available online: http://www.nc-20.com/pdf/CountyofCarteret-SLR.pdf. Accessed 14 December 2018.

8 W. I. Thomas and Dorothy Swaine Thomas, *The Child in America: Behavior Problems and Programs* (New York: Knopf, 1928).

9 Frederick Jackson Turner, "The Significance of the Frontier in American History," essay published in the Proceedings of the Forty-First Meeting of the State Historical Society of Wisconsin, 1893.

Figure 1:
Atlantic Beach, North Carolina, 2012. Photo by the author.

themselves and that the government should not overreach when it comes to intervening in people's economic lives or the nation as a whole. We should not forget this historical context when trying to make sense of the bewildering sea-level rise policy that North Carolina's authorities implemented—not to justify it of course but to understand how it emerged and how to plan climate communication efforts wisely under such circumstances.

Interestingly enough, in the state of Louisiana, just a half day's drive away from North Carolina, recent climate data, especially storm and land-loss data, prompted the state government to the opposite reaction. Instead of banning policy makers from considering data and climate science altogether, officials took the first necessary steps to relocate the population to higher ground. This is neither mitigation nor adaptation; this is retreat, the "hottest" topic in Europe and hardly practiced anywhere yet. Recently, a "$92.6 million award was split up into two projects, the implementation of the resilience policy framework known as Louisiana's Strategic Adaptations for Future Environments (LA SAFE) and the resettlement of the Isle de Jean Charles community located in coastal Terrebonne Parish."[10]

10 Resilient Cities (website), "Biography: Dakota Fisher," https://resilientcities2018.iclei.org/speaker/dakota-fisher/ (accessed 25 April 2018).

Why Would One Express Uncontested Trust in Climate Science? The Story of "We Have to Adapt Immediately!"

In sharp contrast to how coastal policy makers in North Carolina ridiculed climate scientists, regional political decision makers on the German Baltic Coast take climate change and climate science quite seriously.[11] Based on information from a survey exploring the construction of perceptions, city and village mayors in Germany were inclined to perceive the threat of climate change as more imminent than climate scientists themselves were and, in turn, advocated for preventive strategies such as mitigation and adaptation measures.[12] Given the fact that sea-level rise for the German shores of the Baltic Sea is predicted to be rather conservative compared with the global outlook,[13] this might come as a surprise to policy makers and scientists alike. When looking at the sociocultural context in which these perceptions are embedded, it might seem less surprising. Historically, scientists and academic bodies in general enjoy a high societal regard and a good reputation in Germany. If regional political decision makers in Germany seem to easily accept the fact that climate change puts their communities at risk and, in turn, demand prompt action—despite the fact that climate predictions for the region in which they live are rather conservative—this points to significant trust in climate science and in governance. Moreover, Germany has a "cradle-to-grave" welfare system ranging from governmental healthcare and pension schemes to an obligation for coastal protection and risk management. The process where the government takes care of citizens was mostly initiated in the aftermath of the founding of the German Empire in 1871. Only one year after the kingdom was formed the 1872, a "one in a thousand year flood" accelerated the process. After the devastating storm surge, public defense programs were systematically planned and implemented by the Prussian authorities along the German Baltic Sea coast. In addition to other development trajectories, these contributed to a culture of strong state welfare and trust in climate science in Germany.

11 Dennis Bray and Grit Martinez, "A Survey of the Perceptions of Regional Political Decision Makers concerning Climate Change and Adaptation in the German Baltic Sea Region," *International BALTEX Secretariat Publications* 50 (2011).

12 See Dennis Bray, "A Survey of the Perspectives of Climate Scientists concerning Climate Change and Climate Science in the Baltic Sea Basin," *International BALTEX Secretariat Publications* 48 (2010), and Bray and Martinez, "A Survey of the Perceptions of Regional Political Decision Makers."

13 Marcus Reckermann, "Der Klimawandel und seine Ausprägungen im Ostseeraum unter besonderer Berücksichtigung der südlichen Küsten der Ostsee," http://docplayer.org/27304813-Der-klimawandel-und-seine-auspraegungen-im-ostseeraum-unter-besonderer-beruecksichtigung-der-suedlichen-kuesten-der-ostsee.html (accessed 11 December 2018).

The following example of dealing with the climate-change-induced risk of sea-level rise in the community of Timmendorf Beach, illustrates how cultural knowledge and values shaped the self-understanding of the community, which became instrumental for the development of specific climate-change adaptation measures while at the same time documenting high trust in climate science and the authorities. In the Timmendorf Beach community, located near Hamburg, more than 4,000 inhabitants lived less than three meters above sea level until 2012. The state authority for coastal protection, supported by climate scientists, explained to the community that existing defense structures would not withstand the projected increase in extreme storm surges in the region. The authority put forward technical solutions to the municipality for raising the dyke. In the tourism-dependent community, however, there was fierce local resistance to this solution, which was considered visually intrusive. Instead, the community developed their own adaptation measures, a landscaped sea wall offering protection from storm surges whilst also preserving the sea view so essential for tourism. Congruence can be noted between the interests of coastal protection, adaptation to climate change, and tourism development. The rapid development of tourism in the region in the early twentieth century can be understood as a founding myth, enabling the community to quickly establish itself as a well-respected spa town and coastal resort. Tourism has always been a key driver of developments and represents the centerpiece of community identity. Apart from generating material wealth, this has also shaped the immaterial values of the community, promoting for example entrepreneurial thinking and investment in infrastructure.[14]

Communicating the Climate according to the Audience's Reality

As illustrated above, culturally filtered knowledge and values hold the potential to form reactions to climate change. In Germany, the general framing is that anthropogenic climate change is an "issue to be solved" (i.e., by reducing emissions or adapting to changing circumstances) through politics, science, technology, and environmentally friendly behavior. Although there is no perception of acute danger at the shores of the Baltic Sea yet, adaptation measures are widely accepted by residents, taken as reassuring evidence

14 Grit Martinez, Fanny Frick, and Kira Gee, "Socioeconomic and Cultural Issues in the Planning, Implementation, and Transfer of Adaptation Measures to Climate Change: The Example of Two Communities on the German Baltic Sea Coast," in *Social Dimensions of Climate Change Adaptation in Coastal Regions,* ed. Grit Martinez, Peter Fröhle, and Hans-Joachim Meier, vol. 5, Klimawandel in Regionen zukunftsfähig gestalten (München: oekom publishing, 2014), 203–19.

that the authorities are managing the risks. While some opposing positions do exist, there is not as much dispute about climate change as in the USA, where the scientific basis used to estimate sea-level rise is an issue of political contestation.

In Germany's rather open, problem-solving societal atmosphere, communicating the climate and appropriate mitigation or adaptation measures can come in many formats (participatory bottom-up, top-down, spontaneous, social-norm campaigns, and others), but certainly is not a matter of a centralized or a decentralized approach. It is rather an issue of fitting the approach into the knowledge and values in the place-based context of a community or institution.

In contrast, in the USA, climate change has become a politically charged cleavage between Republicans and/or conservatives and Democrats and/or liberals. On the other hand, at the sub-federal level, many US states have made room for climate policies in the recent past. US scientists also used to be the leaders in the production of climate-science information.[15]

Diverse cultural embedded responses to climate changes require a better understanding about how the absorption of knowledge functions in a given societal context and which interventions can prompt action. Regardless of whether our audiences are decision makers, experts, or lay people, knowledge, especially climate knowledge, is only one of the many components that together form audiences' views on climate change. This knowledge can be simplified or distorted, repressed or overemphasized, depending on the recipient's economic, social, and political culture. The footprint of climate-change communication is visible. Museum exhibitions, newspapers, novels, theatre plays, films, and other media discuss our changing climate. Yet these cultural industries are often reduced to serving as a channel to communicate the possible societal implications of our changing climate. As Bukeley points out, "climate politics are cultural politics . . . [and] adopting this perspective requires that we think of the nature and workings of power as always and already cultural, and of culture—the meanings, artifacts and practices that animate society—as intimately political."[16] In other words, whether stakeholders are

15 Bernd Sommer, ed., *Cultural Dynamics of Climate Change and the Environment in Northern America*, Climate and Culture 3 (Leiden: Brill), 9.

16 Harriet Bulkeley, Matthew Paterson, and Johannes Stripple, eds., *Towards a Towards a Cultural Politics of Climate Change* (Cambridge: Cambridge University Press, 2016).

approached using a form of communication in which science is centered or decentered is not an issue we need to be overly concerned with, as long as we and others communicate the climate to our audiences in a manner appropriate to their cultural context, and as long as we are truly interested in a joint social-learning process towards changing consumption patterns and lifestyles. Even though climate change is a global threat, most action is still local and regional, and it has to be taken by those who inhabit and govern the world regions.

Suggested Further Reading

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Linden Ashcroft is a lecturer in climate science and science communication at the University of Melbourne, Australia. Her work spans the fields of climate-data quality control and homogenization, historical climate variability, citizen science, and climate-change impacts in southern Australia. Her previous positions include project manager for a national phenology citizen-science program in Australia, senior researcher at the Centre for Climate Change at Universitat Rovira i Virgili in Catalonia, and climatologist at the Australian Bureau of Meteorology. She is currently the editor in chief of the Royal Meteorological Society's *Geoscience Data Journal,* and the *Bulletin of the Australian Meteorological and Oceanographic Society.*

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Dorothea Born holds a master's degree in ecology from the University of Vienna. Since then she has been pursuing a PhD at the Department of Science and Technology Studies at the University of Vienna, where she also worked as a university assistant (pre-doc) until 2017. Since 2018, she has been a visiting researcher at the Rachel Carson Center and the Munich Center for Technology in Society at the Technical University Munich, funded by the Marietta Blau grant of the Austrian Agency for International Cooperation in Education and Research (OeAD). Her research interests center around climate-change communication in visual cultures, popular science magazines, conceptions of nature, and Critical Theory. Her PhD project investigates the visual climate-change communication strategies of the two popular science magazines *GEO* and *National Geographic*, with a special focus on images and imaginations of nature.

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Saskia Brill studied social and cultural anthropology, economics, and communication at LMU Munich and the Université Laval, Québec, and is now a doctoral candidate in anthropology and a member of the Doctoral Program Environment and Society at the Rachel Carson Center. She is especially interested in the economic aspects of human-environment interactions and the sense-making processes relating to various products. Her current research project focuses on offset markets and the creation of carbon emission rights in British Columbia, Canada, where she is looking at the different forms of collaborations and relations between humans and nonhumans that allow carbon credits to emerge.

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Jeroen Oomen works as a postdoctoral researcher at the Urban Futures Studio at Utrecht University. His research interests include the sociotechnological creation of futures, climate, and collective imaginations. In particular, he is fascinated (and worried) by the ways cultures, histories, and discourses simultaneously maintain and change societies, and the way science, technology, and knowledge are mobilized to shape imaginary futures. His wrote his PhD dissertation, "Dreaming the Designer Climate," at the Rachel Carson Center, LMU Munich, as part of the Marie Curie ITN ENHANCE. In his thesis, he reflected on the sociotechnical development and history of climate engineering research in Germany and the US.

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Emilie Schur Petri is an independent research consultant and a teacher based in Hof, Germany. Her interests include comparative environmental policy, climate justice, international development, and environmental education. She holds a graduate degree in human-environmental geography from the University of Arizona and an undergraduate degree in geology from Macalester College. Her current research for NOAA's Climate Assessment for the Southwest focuses on the linkage between climate extremes and chronic underdevelopment in the southwestern US. She also teaches part-time at Hof University of Applied Sciences.

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new agreement guaranteeing the comprehensive environmental protection of the entire continent. In a political climate in which the outcomes of international environmental negotiations are of increasing complexity and significance, this research aims to generate greater understanding of the construction of successful environmental outcomes. In 2017–18, she held a Fox-Zucker International Fellowship at Yale University. Emma holds a master's degree in international and European studies from Monash University, and a bachelor's degree from the University of Melbourne.

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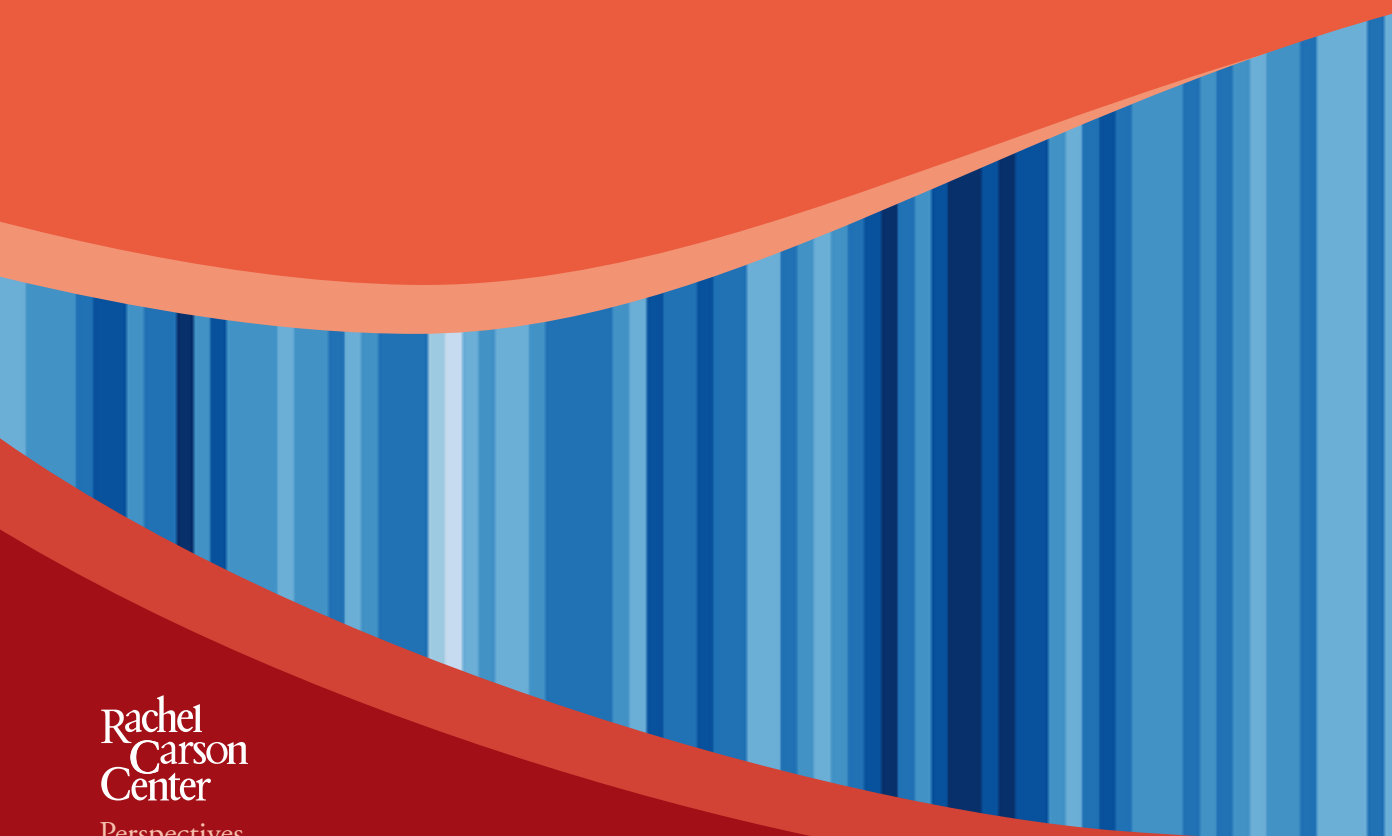
For decades, climate scientists have been producing data demonstrating that climate change is a real, urgent threat to humanity. Yet this has not translated into political action—or even widespread public concern—at the scale needed to tackle the problem in time. Has climate science failed us? This volume addresses the question of what role—if any—science can play in the future of the climate-change debate. Should science be centered when communicating about climate risks on the ground? Who is able to access and use the knowledge science produces, and to what ends? How does science relate to other ways of knowing the world around us? The pieces in this volume, predominantly by emerging scholars, approach these questions from different angles to ask how we know and experience the climate and, ultimately, how we can transform this knowledge into action.



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