Producing the Climate: States, Scientists, and the Constitution of Global Governance Objects

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Abstract This paper argues that the climate came to take on a geophysical rather than a bioecological form in global governance because it emerged from a dynamic, interactive process between states and scientists. In the 1950s, state agencies, especially elements of the US military, steered and accelerated the development of the geophysical sciences, which set the discursive frame within which climate politics now plays out. In the 1990s, scientists and IO experts responded to states' requests to study carbon sinks by expanding the climate to include new greenhouse gases and land-use practices. Drawing on Science and Technology Studies as well as discursive theories of global governance, I theorize object constitution as a process of co-production in which states steer the development of scientific knowledge and scientists assemble epistemic objects. This contingent interaction of political and scientific actors shapes the form and content of global governance objects. The argument extends and challenges the epistemic communities literature and theories of the global governance life cycle that focus on how problems end up on the agenda of states rather than the processes of problem construction.

Global climate governance is rapidly expanding as a multilevel structure of linked carbon taxes, cap-and-trade schemes, energy investments, technology transfers, and land-use projects to reduce greenhouse gas emissions.[1] Given the dramatic increase in climate governance, it is striking that sixty years ago the concept of global climate did not exist. From 1600 to the 1950s, the word *climate* referred to local weather patterns but today it refers to a global geophysical system subject to multiple forms of governance.[2] It is intuitive to assume that the climate is a natural kind that can be represented scientifically in only one form. However, there are competing, contested representations of the climate in the scientific literature and a variety of ways to translate them into governance arrangements.

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1. See Bulkeley et al. 2014; Keohane and Victor 2011; and World Bank 2015.
2. Hart and Victor 1993; and Miller 2004.

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The core institutions of global climate governance are built on a geophysical model that presents a gradualist, determinist, and predictable image of the climate rooted in Newtonian laws. This model suggests that manipulating greenhouse gas concentrations in the atmosphere can precisely control global temperature. By contrast, the biological, ecological, and complexity sciences present a nonlinear, indefinite, and volatile image of the climate embedded within the biosphere as a whole. They do not depict the climate as a single, integrated system of molecules but as a heterogeneous set of interlocking subsystems governed by feedback loops and threshold effects. The Arctic sea-ice cycle, Amazon forest ecosystem, Greenland ice sheet, Atlantic thermohaline circulation, and West African Monsoon are presented as nonlinear subsystems in an unpredictable climate system.[3] Embedding the climate in the biosphere as a whole reveals the complex economic and social practices that cause climate change by highlighting how human activity disrupts earth systems. At stake in the differences between these two models is which elements of the biosphere are foregrounded in climate policy discussions and therefore what elements are targeted by the rationalities and technologies of global climate governance.

The fact that the climate might have been produced in other ways presents a deeper set of questions. Why was the climate constituted as one kind of object rather than another? Why is it represented as a geophysical rather than a bioecological system? I argue that the climate emerged from a dynamic, interactive process between states and scientists. State agencies, especially elements of the US military, steered the production of climate knowledge in two key moments. In the 1950s, the geophysical sciences benefited from US government support, progressed rapidly, and set the discursive frame within which climate politics now plays out. In the 1990s, scientists and international organization (IO) experts responded to states' requests to study the carbon sinks by expanding the climate to include new greenhouse gases and land-use practices. Scientists and experts created knowledge that would not exist in the form it does today, if at all, without state influence. Thus, the landscape of problems and objects that structures international politics is not the autonomous or determined product of scientific and technological development. Rather, it emerges from a contingent interaction between state power and the authority of scientists and experts.

The global climate change literature, like International Relations (IR) theory generally, has more to say about agenda setting, bargaining, institutional design, and the success or failure of regimes than it does about where the problems or objects of global governance come from. Research on climate governance has thus far focused on characterizing the structure and composition of emerging institutions or explaining why states have not created a robust international regime.[4] This work takes the emergence of the climate and other physical objects in global governance

3. Lenton et al. 2008.

4. On agenda setting, see Hart and Victor 1993; Bodansky 2001; and Hadden 2015. On governance structure, see Bulkeley et al. 2014; Keohane and Victor 2011; and Abbott 2012. On international negotiations, see Victor 2001; and Thompson 2010.

for granted. However, the production of governance objects is neither natural nor inevitable and has important effects on how global problems are understood and governed. To account for the production of governance objects, IR needs a theory of "problem construction."[5] I build on recent discursive theories of global governance that conceptualize problem construction as a process of constituting "social kinds" or "governance objects."[6]

I theorize problem construction as a dynamic process that unfolds between state agencies, scientists, and IO experts who constitute and reconstitute objects of global governance. To become a problem in global governance, an object must be *designated* as a distinct entity, *translated* into a legible or abstract object, and *problematized* through articulation to discourses and practices of state interest, national identity, or threat. To capture the complex interactions that drive object constitution, I adapt the idiom of co-production from Science and Technology Studies where it is deployed to capture the idea that knowledge and political order "co-produce" one another in a continually changing yet self-perpetuating relationship.[7]

This account builds on and challenges the epistemic communities literature.[8] First, whereas that literature takes the production of knowledge by scientists for granted, I show that states and other political actors are bound up with the production of knowledge. Second, the analysis here shows that scientists do not only change state interests via persuasion or institutional capture. They also shape state interests by wielding a productive form of power that populates the world with new entities and problems. Third, the epistemic actors in the climate case do not form an epistemic community because they do not necessarily share consensual causal or principled beliefs. Instead, heterogeneous groups of experts can participate in the constitution and governance of the same object because they deploy compatible modes of abstraction that allow transcriptions and forms of knowledge to be linked to one another.

Problem Construction and the Production of Knowledge

IR scholars begin their analysis of the global governance policy life cycle when activists and norm entrepreneurs select problems and work to place them on states' agendas.[9] However, this ignores an earlier stage in which the world is populated with entities and problems. Properly construed, the life cycle of global governance encompasses four stages: object constitution (the construction of entities and problems); political selection (issue emergence and agenda setting); institutionalization

5. Wendt 2001, 1023.
6. Barnett and Finnemore 2004; Barnett and Duvall 2005; Lövbrand, Stripple, and Wiman 2009; Corry 2013a, 2013b.
7. Jasanoff and Wynne 1998; Jasanoff 2004; Miller 2004; Jasanoff 2010.
8. Haas 1992; Davis Cross 2013.
9. Finnemore and Sikkink 1998; Hafner-Burton and Pollack 2002; Carpenter 2007.

(bargaining, rule making, and institutional design); and implementation (monitoring, enforcement, learning).

Rationalist theories of global governance focus on the later stages of bargaining, institutional design, monitoring, and enforcement. The rational design literature, for example, explains institutional design as a function of state interests.[10] In this view, the emergence of climate governance can be explained by the fact that climate change affects state interests and so demands an institutional solution. However, as Wendt argues, this functionalist logic brackets the stage in which objective conditions are translated into an intersubjective problem that states can address.[11] An explanation for the emergence of governance institutions is at best incomplete if it does not include an account of how the problem is constructed and how states come to have an interest in solving that problem instead of some other one.[12] Problem construction is important because it shapes the later stages of global governance by influencing the set and form of possible solutions. Even if the emergence of the climate is a foregone conclusion, it could be constituted as a problem in various ways, each of which may lead to distinct governance outcomes.

Existing constructivist accounts analyze the intermediary agenda-setting and issue-emergence stages but do not theorize where problems and objects come from. Finnemore and Sikkink's norm life cycle presumes that problems exist, theorizing how norm entrepreneurs frame them for governance elites.[13] Carpenter defines issue emergence as "the construction and acceptance of specific problems as international issues."[14] However, Carpenter's analysis assumes the world is already populated with entities and problems in order to focus on which ones become issues for transnational advocacy campaigns.[15] Similarly, the agenda-setting literature studies how problems come to decision makers' attention but not how those problems are constructed.[16]

The epistemic communities literature argues that scientists produce knowledge that influences state behavior but curiously brackets the production of knowledge itself.[17] Haas's seminal article on the ozone reveals how a small group of scientists discovered and politicized the ozone hole.[18] However, Haas's empirical analysis of knowledge production mentions only that a small transnational group of ozone scientists separated themselves from the mainstream of atmospheric physics to share and diffuse information.[19] He contends that "[as] the science improved, the credibility of the epistemic community was enhanced," allowing it to shape the agenda and interests of states.[20]

10. Koremenos, Snidal, and Lipson 2001.
11. Wendt 2001, 1023. See Thompson 2010 for a rationalist critique of the rational design argument.
12. Wendt 2001, 1023.
13. Finnemore and Sikkink 1998.
14. Carpenter 2007, 101.
15. Carpenter 2007. For a similar approach in the climate case, see Hadden 2015.
16. Hafner-Burton and Pollack 2002.
17. Haas 1992; Davis Cross 2013.
18. Haas 1992.
19. Ibid., 193.
20. Ibid., 196.

This effectively separates the production of knowledge from politics to clearly show how authoritative scientific information is exported into the political realm. However, as we shall see clearly in the climate case, political actors can play a central role in knowledge production, so a model of science and politics that separates the two domains can be misleading.

Scholars working from a discursive or Foucauldian perspective do not take the constitution of global politics for granted. They argue that the world is produced by knowledge that is already and always political.[21] Barnett and Finnemore argue that IOs are powerful because they "constitute social kinds, tasks, and rules and so help generate the world in which they live."[22] By categorizing and classifying the world, experts within IOs "influence what problems are visible to staff and what range of solutions are entertained."[23] Similarly, scholars working from the global governmentality perspective argue that discursive rationalities and technologies of governance operate as a diffuse form of productive power that constructs state practices of neoliberal rule and shapes individuals as autonomous liberal subjects.[24] These effects are produced by global discourses and technologies of surveillance, classification, and judgment that normalize thought and behavior.[25] Applications of global governmentality to climate change posit a "disparate and heterogeneous set of practices that, in a more or less systematic manner, structures the field of possible action."[26] Methmann argues that a global mentality depoliticizes climate change politics by representing the climate as "as an autonomous and 'natural' entity" that can be managed within the dominant liberal order via market mechanisms.[27] For Lövbrand, Stripple, and Wiman, a global network of rationalities and technologies embodied in monitoring systems, satellites, and archives provides the data and knowledge necessary to imagine the earth as a "single, self-regulating system" that can be technically controlled.[28] The constitution of the climate as a single system then provides the foundation for climate governance practices that shape both states, which can now bargain over and trade carbon, and individuals who are molded as carbon-conscious subjects.[29]

Corry has recently generalized the insights of this literature into a vision of global governance as multiple actors oriented to objects embedded in an underlying discursive frame.[30] In his account, objects are not necessarily physical or territorial; they can be any entity that is rendered "distinct, malleable, and politically salient."[31]

21. Foucault 2007; Barnett and Duvall 2005.
22. Barnett and Finnemore 2004, 31.
23. Ibid., 23.
24. Merlingen 2003, 366–70; Neumann and Sending 2010, 182; Corry 2013a, 49–54.
25. Merlingen 2003; Neumann and Sending 2010.
26. Lövbrand, Stripple, and Wiman 2009, 8. See also Oels 2005, 198–99; and Methmann 2013, 72.
27. Methmann 2013, 76.
28. Lövbrand, Stripple, and Wiman 2009, 9.
29. Lövbrand and Stripple 2011, 188, 192, 196.
30. Corry 2013a, 85–87.
31. Ibid., 87.

Corry's object-centered theory shifts the analytical focus from actors or subjects to entities themselves. While this is a significant breakthrough, Corry does not explain where objects or problems come from or theorize the conditions under which global objects are likely to emerge. Moreover, as in the global governmentality literature he aims to move beyond, Corry's image of disparate groups of actors oriented to the management of objects flattens the distinctions between states and other actors.[32] As a result, these approaches miss the central role of state power and state imperatives in the processes of knowledge production that constitute governance objects.

The Constitution of Governance Objects

I theorize how phenomena become objects or problems of global governance in two stages. First, I lay out the necessary conditions for the emergence of any global governance object. Second, I theorize the central actors and mechanisms that drive object constitution. In the first stage, the theory applies to all possible governance objects, but in the second stage I focus on the constitution of the climate and other objects rooted in scientific knowledge so that I can theorize the mechanisms more precisely.

The Processes of Object Constitution

Governance objects are entities or practices that have been constituted as self-contained units distinct from other objects, events, and actors.[33] Objects of global governance include the climate, gender, the economy, human rights, terrorism, public health, and international trade. Some of these are more obviously classified as distinct systems, while others are more intuitively thought of as sets of practices. Referring to these entities as objects helps to highlight that they are hybrid entities, not disembodied ideas or norms, which have both a knowledge and a physical or practical component.

Not all entities become global governance problems. To theorize why some entities become problems and others do not, it helps to think about the necessary conditions for an object to enter the stages after object constitution, namely issue emergence and agenda setting.[34] Three processes produce objects with the necessary properties: the

32. Ibid., 9; Corry 2013b, 224.

33. Corry 2013a, 87. There are also literatures on objects in the history of science (Daston 2000); Science and Technology Studies (Latour 1987, 1990; Mitchell 2002; and Jasanoff 2010), historical sociology (Madsen 2011); metaphysics (Harman 2010), and governmentality studies (Lövbrand, Stripple, and Wiman 2009; and Corry 2013b).

34. These conditions are drawn from Keck and Sikkink 1998; Hafner-Burton and Pollack 2002; and Carpenter 2007.

designation of objects via the observation and categorization of natural and social phenomena; the *translation* of objects into general, portable entities that can travel all over the world; and the political *problematization* of entities through links to grievances, state interests, discourses of identity or threat, and policy frames.[35] For heuristic purposes, these processes can be thought of as stages, but in empirical cases they overlap. Objects not constituted in these ways will become domestic issues, or nonproblems, perhaps of merely scientific and social interest. Objects so constituted may still fail to be placed on states' agendas, but that is to be explained by theories of issue emergence and agenda setting.

First, to become an object of governance, an entity must be designated via the observation and classification of natural and social phenomena. Designation is a process of drawing a boundary around a set of phenomena to demarcate an entity distinct from others.[36] The world must be categorized, classified, and ordered such that the climate is distinguished from weather, gender from sex, and so on. Designation is conditioned and made possible by rationalities, technologies, and practices for the investigation, representation, and articulation of physical and social reality. As such, the background conditions for designation shift according to changes in technology, the state of knowledge (both empirical and normative), and the state of the world (including biospheric systems, economic transactions, or the flow of political events).

Designation depends on a knowledge-based group to concretize and reliably reproduce the object within a shared discursive frame that "categorizes and organizes" its elements.[37] In some cases, this group is an academic discipline but it could be any number of professional or expert groups. The group might be an epistemic community but need not be because its members do not necessarily have to share both causal beliefs and normative goals. In the case of human rights, for example, a group of international lawyers and bureaucrats played a key role in the processes of object constitution but they did not necessarily share causal beliefs about what produces good human rights practices.[38]

Second, the entity must be translated into a portable, global object. This is a process by which the object is transformed into an entity that can be transferred from the laboratory, analytical context, or social situation from which it emerged to a variety of global political contexts.[39] Objects must be portable in the sense that they can move across borders—they have to be abstract or formal enough to be understood in similar ways all over the world while being flexible enough to be meaningful in a variety of cultural contexts and groups. In other words, the object must be rendered legible to states and publics.[40] Legible representations attain portability because they are

35. The designation, translation, and problematization schema elaborates the mechanisms implicit in Corry's conception of objects as distinct, malleable, and salient entities. Corry 2013a, 87. Distinctiveness is underwritten by designation, malleability by translation, and salience by problematization.

36. Abbott 1995.

37. Corry 2013a, 87, 95.

38. Madsen 2011, 2012.

39. Latour 1990, 24–26, 64; Jasanoff 2010, 233.

40. On legibility, see Scott 1998, 78.

built on standardized, uniform codes, measures, statistics, or lexicons that can be reliably reproduced in various contexts. Objects must also be portable in the sense that various knowledge-based groups and political communities can port their instruments and concepts into them. These groups need not share the same knowledge base or interpret the object in the same way. Instead, the object can operate as a unifying signifier into which various groups connect their practices or forms of knowledge.[41] Finally, to become global, objects must be represented as emerging from transnational causes and having transnational effects.

Multiple modes of abstraction might be used to translate the object into a legible, portable entity. Modes of abstraction represent objects using formal knowledges and transcriptions that remove elements of context to isolate specific properties.[42] For example, climate models rest on formal equations that isolate the geophysical properties of climate removed from social and bioecological elements. These formal equations also hide the processes of knowledge production that created them.[43] The human rights object rests upon philosophical and legal formalizations that extract humans from biological and cultural contexts. So modes of abstraction might draw on any number of discursive or representational techniques and need not be mathematical or quantitative. Modes of abstraction allow objects to be easily combined and recombined as actors seek to link entities together or form alliances with other groups.

Third, the object must be problematized by linking it to state interests and embedding it within policy frames. Weldes argues that the construction of a problem relies on linguistic connections to preexisting concerns or threats rooted in discourses of identity, security, and power.[44] Experts and activists need to persuade policymakers and publics that the object is problematic and deserving of scarce political time and resources. This could proceed via policy reports that precisely state how the object affects well-known state interests but it could also be achieved by creating a sense of injustice or crisis concerning the object. In addition, state agencies and policy entrepreneurs need to believe that something can be done to manage the object or solve the problem. Thus, the object must be connected to a discourse of management or be situated within a policy frame that suggests how the object can be governed.[45]

The constitution of governance objects authorizes and makes possible new forms of expertise and political action. The very actors that work to produce objects are

41. Similarly, Grynaviski (2014) has shown how actors that do not share intersubjective beliefs can agree on courses of action and cooperate.

42. Abbott 1988, 102–103. Although Latour (1987) critiques the concept of "abstraction," preferring to identify the chains of transcriptions that underlie objects, I think my formulation is consistent with his account.

43. Latour 1987.

44. Weldes 1999, 12, 219–20.

45. Foucault's definition of a political object is an entity to which "mechanisms are directed in order to have a particular effect on it" (2007, 43). See also Hafner-Burton and Pollack 2002; and Lövbrand, Stripple, and Wiman 2009.

constituted as a coherent and authoritative group by virtue of their orientation to and knowledge of the object.[46] These expert groups in turn develop technologies to intervene in the operations of the object.[47] However, as the object becomes more politically salient, the object and its constitutive forms of knowledge are opened up to processes of contestation and reconstitution. Stable knowledge is a hard-won, temporary achievement arrived at only through persistent struggles for power, resources, prestige, and legitimacy.[48]

The Actors and Mechanisms of Epistemic Object Constitution

The processes of object constitution outline the conditions under which objects emerge in global governance. To explain why objects are constituted in one way rather than another, we must identify the specific actors and mechanisms that drive designation, translation, and problematization. The actors and mechanisms are likely to vary according to the object's character, and so a theory that explains the constitution of the climate is likely to differ from one that explains human rights formation. The climate is an example of a scientific or epistemic governance object in which complex social and physical phenomena must be presented in knowledge-based tables, charts, models, and other scientific inscriptions.[49] In these cases, the history of the governance object is bound up with the history of knowledge production in scientific disciplines and expert groups.

Where existing theories bracket knowledge production, I draw on work in Science and Technology Studies (STS) to argue that objects emerge from a process in which knowledge and political orders co-produce one another in a complex ongoing relationship between states and scientists. STS emerged from sociological and historical analyses that opened the black box of scientific discovery and technological development to reveal practices of knowledge production and their effects on society.[50] A basic premise of the literature is that explanations must be symmetrical: the production of scientific knowledge is to be explained by the same social and political factors that explain the production and diffusion of other kinds of beliefs.[51] The central finding of this literature is not that the social and political construction of knowledge invalidates scientific knowledge, but that appeals to nature, data, methods, or reason alone cannot explain the form and power of scientific knowledge.[52]

STS depict scientific practices as bound up with social and political processes and so it rejects an idealized image in which science and politics are reified and separated

46. Foucault 2007, 76–77; Abbott 1988, 1995.
47. Foucault 2007, 106; Mitchell 2002; and Allan forthcoming.
48. Latour 1987; Jasanoff and Wynne 1998.
49. Latour 1987; Mitchell 2002.
50. Bloor 1991.
51. Ibid., 5–8.
52. Jasanoff and Wynne 1998, 4, 16–27.

as distinct spheres.[53] In STS, numerous studies have noted that the processes of knowledge creation shape the construction of political orders and that political orders shape the creation of knowledge.[54] This mutual constitution of science and politics is captured in the co-production idiom. The concept suggests that epistemic objects are not produced within autonomous scientific spheres. Rather, they emerge from a dynamic process that leaves the imprint of both scientific and political imperatives on the form and content of objects.

The co-production framework provides the beginnings of a theory to explain the emergence of epistemic objects but it leaves a central theoretical question unanswered: why does the interaction of political actors and scientists produce one form of an object rather than other? In my model, the interaction of states and scientists drives and shapes designation, translation, and problematization. I theorize two central mechanisms: state agencies *steer* the production of instruments and knowledges while scientists and experts *assemble* the objects themselves. Co-production proceeds as a dynamic, historical, and path-dependent process between state steering and scientific assembly that shapes the specific form and content of objects.

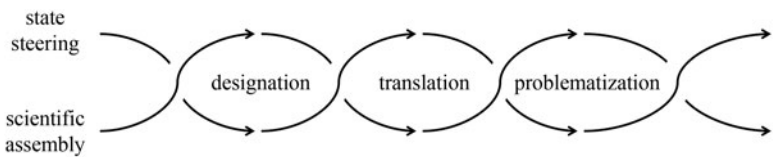

FIGURE 1. *The co-production of epistemic objects*

Figure 1 illustrates the argument's central elements. First, the arrows move from the top to the bottom (state steering) and the bottom to the top (scientific assembly) through the phases of object constitution. The scientific production of knowledge and objects changes state imperatives, which in turn shape how states steer knowledge production. The dynamic interaction of state steering and scientific assembly drives and influences the processes of designation, translation, and problematization. For simplicity's sake, these processes are depicted in a linear fashion. However, the phases are likely to overlap and recur so object constitution is never complete. The contingent historical interaction between political and scientific forces alters the course of constitution so that one version of the object, rather than other possibilities, emerges.

In this model, the state is not an integrated, unitary actor but an authoritative, hierarchically arranged structure of political institutions embedded in a concatenation of discourses and practices.[55] It therefore makes sense to focus on specific state agencies such as energy departments, executive offices, navies, and so on. State agencies are

53. Ibid., 7–12.

54. Ibid., 14; Jasanoff 2004.

55. Mitchell 1991, 86. See also Weldes's "concrete organizations of the US state" (1999, 108) and the state in historical institutionalism (for example, Steinmo 2008, 122–23).

large, authoritative institutions with the resources to steer societal discourses and the development of scientific knowledge. For example, during the Cold War, the US federal government provided about half of all research and development funding.[56] In 2013, government expenditures accounted for 28 percent of all research and development funding in OECD countries.[57]

State agencies steer the development of the natural sciences but do not determine their content or political implications.[58] State agencies take an active interest in scientific and technological development because it contributes to economic and military power, reduces uncertainty, and helps to legitimate rule.[59] State support creates demand for specific research programs that scientists might otherwise not study, such as the fluid dynamics of the ocean or the carbon density of forests. Moreover, government funding supports data collection and laboratory staff, which contribute to publications, more funding, and more successful research programs, all things equal.[60] Thus, state agencies influence the success and failure of specific research programs, which indirectly shape which objects are designated, which technologies achieve commercial viability, and so on.

However, states cannot directly control the development of science or the constitution of objects because scientists maintain authoritative jurisdiction over the modes of expertise necessary to assemble epistemic objects.[61] Object assembly involves putting together knowledges and transcriptions with formalizations and techniques beyond the control of state agencies. Steering by state agencies leaves room for the contingent influence of scientists, experts, and other actors in the processes of designation, translation, and problematization. Scientists and experts are central to designation because they wield a form of productive power that authoritatively classifies and orders physical and social phenomena. This influences the long-term orientation of domestic and global politics even though scientists and experts often fail to persuade decision makers to act in the short term.

Scientists and experts are powerful agents of translation in part because they control and reproduce modes of abstraction throughout transnational, interdisciplinary communities of practice. Shared modes of scientific abstraction also allow multiple scientific groups to combine their knowledge into multifaceted objects. That is, the abstractions at the heart of epistemic objects permit specialized forms of scientific knowledge to be ported into one another. For example, both climate scientists and economists use computer models that reduce complex phenomena to lines of equations that link economic, social, and geophysical phenomena together in simplified representations designed to isolate specific system dynamics.

56. Evangelista 1988, 3.
57. OECD 2015.
58. On the concept of steering, see Wendt 2001.
59. Thompson 1990; Drezner 2001; Taylor 2012.
60. Cozzens and Woodhouse 1995.
61. Abbott 1988, 102–105.

Scientific modes of abstraction such as mathematical formalization or computer modeling are especially effective in producing entities that can be transferred across borders. Since global politics unfolds within a diverse cultural landscape, states do not necessarily share the same representations of the world. However, to govern in concert, states must come to have similar understandings of what the global is made of and how it works. Scientific translations orient states to the same representations of the object, but those representations will be interpreted differently in various countries.[62] Nonetheless, epistemic objects are carried and reliably reproduced by transnational scientific and expert groups that make the collective governance of objects possible at the global level.

Finally, scientists and experts are often central to the problematization of epistemic objects. First, they can authoritatively connect objects to discourses of identity, security, power, and threat. This might take the form of a quantified risk assessment, but need not. Scientific discourse is powerful in part because it can forge links between objects and deeply rooted ideas about nature and the universe.[63] Second, scientists and experts are responsible for articulating the policy frames and governmental techniques that will be used to manage the object. Scientists and experts create and present strategies and policy options for dealing with the problem that enable policy-makers to envision and enact change.

Producing the Climate

To demonstrate that the form and content of the climate has been shaped by co-production, I reconstruct two moments of knowledge production that cannot be explained by looking only at the role of state interests (a rationalist alternative explanation) or scientists (an epistemic community alternative explanation). My account builds on existing studies that show how the climate object was constructed as a problem, but outlines the mechanisms of object constitution and the distinct roles of state agencies and scientific actors in this history.[64] First, I show that US patronage accelerated the constitution of the climate in geophysical terms in the early years of the Cold War. For this case, I rely on the secondary literature on the history of climate science. Second, I show that the impetus for expanding the climate object after 1990 came from states but that the expansion was made possible and shaped by the contingent work of scientists. Here, I trace the history of climate governance via primary documents (from the UN Framework Convention on Climate Change) and secondary accounts of climate negotiations (provided by the International Institute for Sustainable Development's Earth Negotiations Bulletin).

62. Jasanoff 2010, 239–40.
63. Allan forthcoming.
64. See Lövbrand, Stripple, and Wiman 2009; Paterson and Stripple 2012; Corry 2013b; Miller 2004; and Jasanoff 2010.

Designating a Geophysical Climate

The word *climate* was used widely throughout Europe in the mid-eighteenth century but it referred to local and regional weather patterns, not a system of circulating molecules. Many Europeans thought of weather events as acts of God that could be neither understood nor controlled.[65] Indeed, weather and geography were represented as forces that determined social and political outcomes.[66] These early representations of climate were slowly displaced over the course of the nineteenth and twentieth centuries as international efforts to collect systematic weather data produced aggregate, scientific images of the weather.[67] However, historical and local views dominated political understandings of the climate well into the twentieth century.[68]

Militaries had long desired better knowledge of the oceans and weather patterns to plan naval routes and prepare for battles.[69] But this motivation was intensified in the early days of the Cold War as the superpowers strove to gain control of land, air, sea, and space. Inspired by the success of physics and engineering during the Second World War, US agencies poured money into nuclear physics, aeronautics, materials science, as well as the geophysical sciences of oceanography, meteorology, and atmospheric physics.[70] Government agencies like the Navy (through the Office of Naval Research), Air Force, Department of Defense (through the Advanced Research Projects Agency), and Atomic Energy Commission (now the Department of Energy) supported this research by employing scientists in agencies themselves and offering a series of contracts to independent laboratories and think tanks.[71] Likewise, the Soviets funded institutes and academies to study nuclear physics, oceanography, polar research, and meteorology. While the Soviet scientists gathered lots of geophysical and ecological data, they lacked the computing power to translate the information into real insight.[72] Thus, the history of geophysics and climate science in the early decades of the Cold War is largely an American history.

US state power shaped the designation of the climate by unintentionally bolstering the geophysical study of climate processes. First, American earth and atmospheric scientists received unprecedented sums to study the full effects of nuclear explosions.[73] In the 1950s and 1960s, US government agencies sponsored the construction of a global atmospheric monitoring network to track nuclear fallout and study the effects of radioactive material on humans, plants, animals, water systems, jet-stream patterns, and so on. At first this monitoring network consisted of little more

65. Hamblyn 2009.
66. Deudney 1999; Hulme 2011.
67. Edwards 2010; Marlin-Bennett 2004, 128–36.
68. For example, Rotberg and Rabb 1981.
69. Edwards 2010, 88.
70. Friedberg 2000; Leslie 1993.
71. Doel 2003; Friedberg 2000; Masco 2010; Sapolsky 1990.
72. Graham 1993, 233–35.
73. Masco 2010, 14.

than a handful of "gummed-film collectors" that caught air particles, but it was developed into a sequence of 200 weather stations installed on US Air Force bases all over the globe.[74] This state-funded infrastructure made it possible to represent the atmosphere as a global system of molecules.[75]

Second, the US military wanted better knowledge of the ocean floor and thermal patterns in ocean circulation to assist submarine navigation. The Navy funded studies at the Woods Hole Oceanographic Institute and Scripps Institute of Oceanography which helped secure their position as leading geophysical research centers.[76] The Office of Naval Research and the Atomic Energy Commission funded a study at Scripps that led directly to a ground-breaking 1957 paper by Roger Revelle and Hans Suess on CO_2 circulation.[77] This paper brought together the ocean and atmospheric systems into a single model of "weather and climate" for the first time.[78] Although the study's patrons did not intend to fund climate science, Revelle's and Suess's interests directed government funds toward defining and ordering the climate as a global system of molecules and geophysical forces.[79]

In 1958, government agencies from around the world sponsored the International Geophysical Year (IGY) which funded 60,000 scientists from sixty-six countries to undertake expeditions and experiments that enhanced data sharing and advanced the understanding of large-scale geophysical processes.[80] The US Research and Development Board, operated by the War and Navy Departments, backed the IGY to provide cover for surveillance flights that would collect data from previously inaccessible regions.[81] The IGY produced infrastructure and collected data that fueled oceanographic and atmospheric research. For example, Roger Revelle directed IGY funds to Charles Keeling who constructed the CO_2 monitoring station at Mauna Loa, Hawaii.[82] The Mauna Loa station has provided near-continuous measurement of CO_2 levels in the atmosphere since 1958. The data capture the annual rise and fall of CO_2 levels within a clear upward trend over the decades.

Glaciology also benefited from military patronage. The first studies of Arctic ice thickness and polar warming were made possible by military interest in the Arctic as a potential theater of battle.[83] This support continued through the IGY and beyond as the military established bases with research stations at both poles. In this and many other ways, military patronage produced the infrastructure and data necessary to make the scientific case for anthropogenic warming.

74. Edwards 2012, 30.
75. Masco 2010, 13.
76. Doel 2003, 637; Weart 2003, 27–30.
77. Weart 2003, 26–27.
78. Revelle and Suess 1957, 20.
79. Weart 2003, 30–31.
80. Doel 2003, 647; Lövbrand, Stripple, and Wiman 2009, 9–10.
81. Doel 2003, 647.
82. Howe 2014, 19–20.
83. Doel 2003, 638–39.

The military, backed by Congress, also funded meteorology and atmospheric science because they wanted to modify the weather for military purposes.[84] Scientific entrepreneurs were able to convince government officials to expand funding for "narrow" trial-and-error weather modification experiments into broad basic meteorological research.[85] This early support left an imprint on the scientific community—the first label for the research program now called "climate science" was "inadvertent weather modification."[86]

With the support of US government agencies, the geophysical sciences of meteorology, atmospheric physics, and oceanography progressed rapidly. As they developed, these disciplines demarcated climate from weather, defined the central processes of climate, and rendered the object legible to transnational scientific networks. US government agencies' support accelerated and shaped the designation of the climate. As Weart explains, "without the Cold War, there would have been little funding for the research that turned out to illuminate the CO_2 greenhouse effect, a subject nobody had connected with practical affairs. The US Navy had bought an answer to a question it had never thought to ask."[87] Thanks to state support, global warming was discovered decades earlier than it might have been.[88] However, military patronage of the geophysical sciences did not merely accelerate the unavoidable or autonomous advance of scientific progress. It contributed to the hegemony of geophysical representations of earth systems at the expense of biological and ecological representations, which would only later be incorporated into the climate sciences.[89]

Geophysical representations of the earth were prized over biological representations because, as a 1961 Department of Defense document put it, "the Department of Defense has a vital interest in the environmental sciences since the military services must have an understanding of, and an ability to predict and even to control the environment in which it is required to operate."[90] Thus, as Doel argues, military patrons did not commission biological or ecological studies of oceanography because "they were deemed irrelevant to operational and utilitarian aims."[91] State support did not determine exactly how climate research unfolded, since scientists and laboratories had the freedom to pursue their own questions. However, state support bolstered a particular kind of science that promised operational control over the weather and the forces of land, sea, and air. Thus, the geophysical sciences and their implicit emphasis on control came to form the basis of a discursive frame that designates the climate as a "vast machine" subject to forms of governance.[92] As a result of the effects of state steering, other sciences, such as the biological or

84. Hart and Victor 1993, 657–58; Howe 2014, 25–26.
85. Hart and Victor 1993, 358–59.
86. Ibid., 664.
87. Weart 2003, 30–31.
88. Ibid., 30–31. See also Edwards 2012, 37.
89. Doel 2003, 636, 639, 645, 652.
90. Quoted in Doel 2003, 636.
91. Doel 2003, 652.
92. Edwards 2010.

ecological sciences, were not given the chance to designate the climate first. As we shall see, this has had a lasting impact on the development of climate science.

Translating the Climate

In the early years of the Cold War, the various geophysical research programs advanced in relative isolation from one another. As Hart and Victor explain, the history of "climate science" is the history of convergence in the sciences of meteorology, atmospheric physics, and oceanography.[93] In the 1960s, computer models integrated these geophysical research streams into a single abstract representation of "the climate." The process of translating the climate took the form of computational abstraction in which computer models extracted the climate from regional weather patterns and geophysical processes into a global system of circulating molecules and forces. But the history of this process reveals the influence of state support for scientific knowledge and techniques that defined the climate in deterministic terms that suggested the possibility of state control.

Computers were developed during the Second World War to calculate firing tables for artillery guns. After the war, John von Neumann, who also invented game theory and made important contributions to many scientific fields, adapted the first digital computer to produce weather prediction models.[94] Von Neumann initially argued that his meteorological models could help control the weather and successfully raised funds from the US Weather Bureau, the Army, the Air Force, and the Office of Naval Research.[95] These grand visions never materialized and in the late 1960s money for and talk about weather modification declined. [96]

Von Neumann's weather prediction models laid the basis for the "general circulation models" (GCMs) of climate processes that emerged in the 1960s. These models abstracted the climate into a global system and are the center of climate science today. GCMs initially simulated simple changes in atmospheric dynamics and temperature.[97] By 1969, bolstered by increases in computational power and better data, atmosphere-GCMs were connected to ocean-GCMs in the first atmosphere–ocean general circulation models (AOGCMs). GCMs begin dividing the world into a box grid that reflects a global distributional mapping of temperature, solidity, humidity, pressure, salinity, and so on. Mountains, rivers, ocean currents, and coastlines are abstracted into lines of equations that stand in for their physical properties. Within each box is a system of equations that simulate the behavior of the climate at a given atmospheric level or land-surface region. Within these boxes, models incorporate

93. Hart and Victor 1993.
94. Edwards 2010, 113.
95. Weart 2003, 57.
96. US weather modification experiments and Soviet biological testing were still sufficient to motivate the 1976 Environmental Modification (ENMOD) treaty banning the military use of environmental modification (Juda 1978).
97. Edwards 2010, 152.

complex systems like cloud behavior and ocean circulation as "parameters."[98] The "dynamical core" of the model runs the equations for each box and feeds the calculations back into the distribution baseline for the next iteration. These calculations simply compute Newton's laws for the equations given. Thus, the core of climate models is a geophysical, determinist system that links easily to the idea that these forces can be understood, predicted, and controlled.[99]

A climate object abstracted in bioecological terms, in contrast, might look more like the models in complexity theory: nonlinear, unstable, and difficult to precisely predict, let alone control. State support for determinist models of the world was no accident. After all, these models held out the seductive promise that weather and climate could be controlled. This promise was offered not just by scientific brokers like von Neumann but by the representations themselves. Whereas the climate had previously been rendered legible in statistical tables of local weather patterns, the models now depicted the forces of climate visible in a vivid, geophysical form. By abstracting the climate into lines of equations whose effects could be easily altered by varying inputs, computer models suggested the possibility that the molecules and forces underlying temperature and rainfall could be predicted and manipulated.

Problematizing the Global Climate

The designation and translation of the climate as a global system of molecules governed by geophysical laws drew a clear boundary between weather and climate, driving a shift in the scientific and political discourse around climate. The discursive shift made possible new forms of expertise that rested on claims to knowledge of the object, constituting the fields of climate science, climate economics, and so on. In turn, the rise of expertise contributed to the proliferation of intervention strategies designed to manage the object.[100] These new rationalities and technologies, in conjunction with the rise of the global environmental movement in the late 1960s and early 1970s, thrust climate change into the political realm.[101]

As late as 1966 a US National Academy of Sciences report had cautiously concluded only that human activities *could* influence the climate.[102] It was only over the course of the late 1960s and early 1970s that the rise of environmental activism and improved modeling techniques rendered the climate problematic. The rise of student activism against the war in Vietnam, revolutionary upheaval in Europe, and incipient North–South tensions created a sense of crisis in the burgeoning global society. In this context, the climate generated global attention as scientists and activists embedded it in existing environmental discourses. Timed to coincide

98. Flato and Marotzke 2013. This is the port by which biological and ecological sciences enter representations of the climate system.

99. Hulme 2011; Hart and Victor 1993, 666; Methmann 2013, 81–82.

100. Lövbrand, Stripple, and Wiman 2009, 8.

101. Guha 2000; Wapner 1996.

102. Weart 2003, 44.

with the UN Conference on the Human Environment in Stockholm in June 1972, two major reports, *Man's Impact on the Global Environment* and *Inadvertent Climate Modification*, argued that the climate was a "global environmental problem."[103] These reports transformed the abstract climate of interacting ocean and atmospheric models into a global system that affected everyone on the planet. Moreover, they ruled out "global cooling" hypotheses and predicted rising CO_2 would increase global temperature. In 1979, another US National Academy of Sciences report, chaired by Woods Hole climate scientist Jule Charney, authoritatively concluded that a doubling of CO_2 in the atmosphere would lead to 3°C (+/− 1.5°C) of global warming.[104] The Charney report was a watershed moment because it was the "first policy-oriented assessment to claim a concrete quantitative estimate of likely global warming."[105] This prediction proved to be quite stable and served as the basis for climate policy through the 1990s.[106] These developments linked the climate to the sense of environmental crisis in Europe and the United States, spurring domestic and global efforts to assess the scale of the problem.

After the Charney report, problematization quickly bled into issue emergence, agenda setting, and institutionalization as governments, scientific groups, and environmental activists studied and raised awareness about global warming.[107] Between 1985 and 1988, Bert Bolin, a long-time participant in international scientific efforts around climate, and Mostafa Tolba, the energetic head of the United Nations Environmental Programme, convened a series of international scientific meetings culminating in the 1988 World Conference on the Changing Atmosphere in Toronto, Canada. The Toronto report, against the wishes of state representatives, recommended that states phase in a 20 percent cut in CO_2 emissions by 2005.[108]

The Toronto report increased the salience of the climate problem not by offering a precise statement of the costs associated with a warming climate but by linking climate change to "global security" discourses. The report argued that climate change's "ultimate consequences could be second only to a global nuclear war."[109] It concluded that warming would "imperil human health and well-being," "diminish global food security," "increase political instability and the potential for international conflict," and "accelerate the extinction of animal and plant species."[110] Importantly, it also made policy recommendations, including calls for increasing energy efficient, establishing funds for research and development, and the careful management of carbon stocks. Thus, the Toronto report problematized climate by forging discursive links with preexisting environmental and security problems and available environmental regulatory techniques.

103. SCEP 1970; SMIC 1971; Hart and Victor 1993, 664; Edwards 2010, 361–65; Howe 2014.
104. Edwards 2010, 372; Weart 2003.
105. Edwards 2010, 376.
106. Torrance 2006, 35–36; van der Sluijs et al. 1998.
107. Bodansky 2001; Haas and McCabe 2001; Hecht and Tirpak 1995; Howe 2014; Torrance 2006.
108. WMO 1989, 300.
109. Ibid., 292.
110. Ibid., 293.

As early as 1986, Tolba's "strong leadership and hectoring ways" motivated the US government and others to gain some control over the presentation of climate science.[111] In 1988, states created the Intergovernmental Panel on Climate Change (IPCC) to synthesize the scientific and socioeconomic literature on climate change. Despite its intergovernmental status, the organization has proved to be quite independent.[112] Under the leadership of Bert Bolin, the IPCC produced its first assessment report on the state of the global climate in 1990. This coincided with a flurry of media attention around the world and the first high-level ministerial meetings on the issue.[113] While this raised the prospect that a robust international agreement was imminent, early talks established only a negotiating forum for further talks, the 1992 UN Framework Convention on Climate Change (UNFCCC). Nonetheless, between 1988 and 1992 climate had emerged as a global object to be governed by the IPCC and UNFCCC.

Governing and Reconstituting the Climate

After 1992, efforts to promote and govern the climate at the global level initiated a new dynamic of co-production between states, experts, and IOs that changed what counts as the climate to include other greenhouse gases and land-use activities. This redesignation was made possible by the creation of a new abstract unit, the "tonne of carbon dioxide equivalent" (tCO_2e), which grounded the Kyoto system in geophysical models and understandings of the climate.[114]

In 1992, the UNFCCC initiated the negotiating process that produced the 1997 Kyoto Protocol.[115] Kyoto aimed to reduce overall greenhouse emissions by 5 percent below 1990 levels by 2012. The treaty divided countries into Annex I (developed) and Annex II (developing) countries. Annex I countries made commitments to reduce greenhouse gas emissions and participate in an international cap-and-trade scheme. Annex II countries were included only as participants in the Clean Development Mechanism (CDM). Under the CDM, Annex I countries would pay for offset projects such as planting trees and installing greenhouse-gas-removal machines on factories in Annex II countries. Annex I countries could also fund offset projects in other Annex I countries via Joint Implementation projects. During the negotiations, the US and allies in the umbrella group (including Australia, Canada, Japan, Norway, and Russia) supported a climate treaty but wanted to minimize the costs of compliance by including carbon sinks as offsets under the CDM.[116] During implementation talks between 1997 and 2000, the US again pushed to

111. Haas and McCabe 2001, 332.
112. However, state representatives on the IPCC do try to strike any language from the summary for policy-makers that would conflict with their policy preferences (Stavins 2014).
113. Schreurs et al. 2001; Hecht and Tirpak 1995, 383–84.
114. Demeritt 2001.
115. Hecht and Tirpak 1995, 388–89.
116. IISD 2000, 10; 2001, 15; Thompson 2010, 280–82.

ensure the CDM rules were as permissive as possible.[117] The Europeans and developing countries resisted these moves but the collapse of the Hague climate talks in 2000 threatened to scuttle Kyoto and the Europeans came under enormous pressure to accept a compromise that included sinks.[118]

The Kyoto negotiations redesignated the climate, expanding it to include a range of greenhouse gases. In the 1980s, climate scientists had created an index of Global Warming Potential (GWP) that allowed carbon dioxide, methane, and other gases to be compared to one another.[119] The GWP underwrites tCO_2e, which serves as the basic unit of all climate governance. The IPCC initially noted that the GWP figures were estimates "subject to uncertainties, of the order of +/−35 percent."[120] Nevertheless, the GWP index entered climate governance as an optional methodology for reporting greenhouse gas inventories and projections.[121] Use of the index was contested and the debate fell along North–South lines. The EU, Japan, Australia, and the US supported the index, while China objected that the methodological "guidelines were too complicated for developing countries."[122] The 1995 decision on methodology reflected a compromise under which states should use methodologies "as appropriate … in the fulfillment of their commitments under the convention."[123]

In a subtle but important change, the Kyoto Protocol altered this by declaring that Annex I states "shall" use the GWP index, subject to review and revision.[124] But it proved difficult to revise the index in the 2000s because states used GWP values to calculate the value of offset projects under the CDM and similar provisions in the European Trading System. For example, throughout the 2000s a European company could pay a Chinese factory to install a device that decomposes HFC-23, a powerful greenhouse gas, in return for carbon credits.[125] Thus, states like China had a vested interest in maintaining the GWP conversion rates at existing levels because they generated lucrative payouts. Installing HFC-23-destroying machines raised capital for Chinese factories and so the CO_2e value of greenhouse gases was a part of Chinese interests in climate talks. In this way, uncertain findings and assumptions made their way into the global governance architecture where they were then stabilized because state interests latched onto calculable, but not necessarily settled, knowledge. As a result, the specific form of the climate as institutionalized in the UNFCCC was determined neither by scientific facts nor state interests alone but by their contingent interaction. Moreover, the form of the climate reflected the

117. IISD 1999; 2000; Lövbrand 2009, 408.
118. IISD 2000, 27; Thompson 2010, 285.
119. Paterson and Stripple 2012, 571.
120. MacKenzie 2009, 446.
121. INC 1995, 2; IISD 1995, 6.
122. Ibid., 6.
123. INC 1995, 2.
124. UNFCCC 1998, 6.
125. MacKenzie 2009.

dominance of the geophysical sciences which invite climate governance strategies that rest on precise molecular calculations.[126] But these calculations are not as straightforward as they seem and may have pathological effects. In fact, HFC-23 credits were eliminated from most markets in the early 2010s amid speculation that countries might build factories simply to produce and destroy HFC-23.[127]

The geophysical representation of the climate as a system of CO_2e molecules also permitted the expansion of the climate to include the creation and management of carbon stocks. Thompson argues that the US and the Umbrella Group pushed to include carbon sinks under Kyoto because they were uncertain about future costs of climate change and thus wanted to create flexible, nonbinding agreements that would allow policies to be updated in response to new knowledge.[128] The expansion of carbon sinks and other offset mechanisms maximizes flexibility because it allows states to delay potentially costly domestic action. It is tempting to move from this to a functionalist interpretation on which the expansion of the climate object into sinks was a foregone conclusion necessitated by states' preferences for a shallow treaty. However, the process of incorporating sinks depended on nongovernmental organizations, experts, and scientists who theorized and quantified the biophysics of land use. States can only negotiate with the knowledge experts create but, consistent with Thompson's theory, states did not passively accept existing representations of sinks and other offsets once their strategic and political importance was realized. Rather, state officials pressed IO experts and scientists to improve scientific understanding of sinks and other mechanisms that would provide compliance flexibility. At the 2007 talks, the US supported the inclusion of land-use mechanisms but since little was known about the effects of agricultural and other forms of land management on climate change, it was deferred to further study and discussion.[129] At the 2009 talks in Copenhagen, states explicitly asked the UNFCCC Subsidiary Body for Scientific and Technical Advice (SBSTA) to "explore ways of moving towards more comprehensive accounting of anthropogenic emissions by sources and removals by sinks from land use, land-use change and forestry."[130] Through the SBSTA, states created demand for new knowledge about the carbon implications of various forms of land use.

Subsequent scientific research and civil society action produced proposals for a further expansion of the climate to include avoided deforestation and land-use practices under the auspices of Reducing Emissions from Deforestation and Forest Degradation plus Land Management (REDD+). Avoided deforestation and degradation projects provide payments to countries in exchange for maintaining tree stocks that would normally be cut down for agricultural development or construction

126. Demeritt 2001.
127. European Commission 2011; Wagner 2011.
128. Thompson 2010, 277–83.
129. UNFCCC 2007, 20; IISD 2007, 20.
130. UNFCCC 2009, 14. Land-use changes and measures to prevent deforestation were ultimately excluded from the CDM under Kyoto (Lövbrand 2009, 408).

projects. Land-use management is more general, including changes that preserve carbon stocks in soil and swamps. The central idea is that since forest and land sectors contribute "approximately 17 per cent of global greenhouse gas emissions, or approximately 5.8 Gt of carbon dioxide equivalent (CO_2-e), per year" there must be a way to incorporate them into the global climate regime.[131] States have actively supported REDD+ and related research because it provides yet another flexibility mechanism, and so it is widely expected that REDD+ will be a component of any future climate treaty. However, these projects were initially presented and supported in 2003 by a coalition of scientists and civil society activists.[132] The continued expansion of the climate into land-use practices reveals that the content of the climate is not final or determined, but shaped by states, scientists, and other global governance actors.

Alternative Climates

To demonstrate that the production of knowledge has significant effects on climate governance it is important to consider counterfactual outcomes. Grynaviski argues that regular counterfactuals stated in the form if y, then x (or, if not y, then not x) allow for trivial causes to pass the counterfactual test such that irrelevant Cleopatra's nose explanations qualify as causes for political outcomes.[133] Instead, contrastive counterfactuals pose "contrastive–why" questions in the form if y, then x-rather-than-x′ that sharpen the logic of arguments.[134] Two contrastive counterfactuals demonstrate the importance of the state and the process of co-production in the constitution of the climate.

First, state support ensured that the geophysical sciences advanced faster than biology, ecology, and the complexity sciences and thus developed a frame for the climate as a whole-earth system earlier than biology or ecology did. Seuss and Revelle's landmark 1957 paper outlined the basis of the geophysical climate when ecology was still in its infancy. The Gaia hypothesis, which embeds the geophysics of the atmosphere within a macro-level bioecological perspective of the earth as a living organism, did not appear until the 1970s.[135] However, by then, the Study of Critical Environmental Problems and the Study of Man's Impact on Climate had already established climate change as an environmental problem in a geophysical frame.[136] If state funding for the geophysical sciences had not happened when it did, or if the biological and ecological sciences had received more generous state

131. UN-REDD 2011, 3.
132. Pistorius 2012, 640.
133. Grynaviski 2013, 838–40.
134. Ibid., 834.
135. Lovelock's first article on Gaia appeared in 1972 but the landmark book did not come out until 1979.
136. SCEP 1970; SMIC 1971.

funding earlier, then the history could have turned out differently.[137] Alternative forms of knowledge could have matured earlier and set the discursive frame for climate governance. Had that happened, geophysical models would likely still have been necessary to demonstrate the dangers of anthropogenic emissions. However, the model dynamics may have looked more like the unstable, fragile ecosystems common in ecology instead of smooth-functioning, largely linear machines.

Second, the historical account here helps explain why climate governance is oriented to the precise control of CO_2e levels rather than to precautionary action or societal steering. The geophysical climate that appears in GCMs links easily, via the unit tCO_2e, to economic models that promise precise control of the climate using pricing mechanisms and carbon sink projects. In short, the geophysical frame ports into a policy discourse centered on levers to precisely manipulate tCO_2e. This premise can be extended to support and legitimate geoengineering. The underlying emphasis on prediction and control that underlies this policy can be traced to the early Cold War when the geophysical sciences were supported because they held out the promise of increased control over the land, sea, and air. However, if other natural sciences formed the basis of climate policy discourses then climate governance today might look very different. For example, ecology and the complexity sciences present a discursive frame that constitutes a more fragile climate. Since the 1970s, Wally Broecker, Richard Alley, and others have contested the linear, gradual increases in temperature in the IPCC reports.[138] They argue that the climate exhibits abrupt shifts and nonlinear dynamics that could subvert policies based on precise control of greenhouse gas emissions levels. This representation of the climate links more clearly with a precautionary policy discourse. For example, Weitzman argues that we should take seriously the fact that climate policy today accepts the possibility of allowing abrupt climate change with extremely high costs.[139] In his view, we should replace the complicated, precise economic models that dominate climate policy with informal cost-benefit analyses that include a non-zero probability of catastrophe. Thus, climate change mitigation should be seen as an insurance policy taken out against the possibility of climate disaster. The policy implications of a fragile climate object look rather different: abandon the current orientation to long-term economic efficiency along an optimal emissions path and seek to prevent warming with significant action in the short run.

Another alternative discourse could build on the bioecological view of humanity as embedded within the climate system, which is in turn embedded within the whole

137. Ecology did receive some government support in the 1950s, predominantly through the Atomic Energy Commission for "health physics" research at Oak Ridge National Laboratory (Kingsland 2005, 192–93). The first government-funded "big science" ecological project was the International Biological Programme, 1968–1974 (Kwa 1987).

138. Weart 2003, 139; Alley et al. 2003; Lenton et al. 2008. On the production of this alternative object, see Mayer 2012, 171–76.

139. Weitzman 2007.

earth system.[140] This could be linked to climate policies that aim to reconfigure the social-ecological system as a whole. Instead of focusing on carbon pricing, climate policy would aim to steer a broader set of economic and social behaviors by altering energy infrastructure, transportation systems, agricultural practices, diet choices, consumer preferences, and so on.[141] These alternatives might be more prominent in policy discussions today had the knowledge of the climate developed differently.

Conclusion

The idea of climate emerged from a process of co-production in which both state imperatives and scientific knowledge shaped and reshaped the form and content of the climate. This challenges the idealized image of science and politics on which knowledge is produced *ex ante* within autonomous disciplines and then enters the political realm, where it is contested or corrupted. Instead, my theory expects that path-dependent interactions between state power and scientific knowledge shape the production of governance objects in complex, contingent ways. IR has neglected the study of problem construction to its detriment because the constitution of objects has important effects on the later stages of global governance.

The history of the climate reveals two important effects on climate governance and international politics more broadly. First, the constitution of the climate as a geophysical object has oriented climate policy to the precise control of the climate. The focus on managing and controlling the geophysics of climate has meant that the ecological and geochemical processes associated with climate have emerged in policy discussions later and in a more secondary role than they otherwise might have. Moreover, the focus on tCO_2e has encouraged the dominance of economic policy models and privileged carbon-pricing schemes designed to precisely manipulate greenhouse gas concentrations. The dominant climate governance strategy is premised upon the view that as the negative effects of climate change become visible, climate governance institutions can slowly bring down greenhouse gas concentrations, which in turn will slowly bring down temperatures, curbing the negative impacts. As Thompson points out, this strategy is favored in part because it increases participation and facilitates cooperation. However, if the abrupt models are right, a rapidly changing climate will undermine policies grounded in this chain of control and a broader range of climate policies will be needed. To the extent that the geophysical emphasis on prediction and control has narrowed the policy space and thereby delayed necessary experimentation with alternative policies, the geophysical frame that makes pricing the natural and obvious solution has been problematic. While the geophysical model may be more likely to facilitate international cooperation

140. Lovelock 2007.
141. See, for example, the proposals for infrastructure change in the 2014 Global Commission on the Economy and Climate report (2014).

focused on carbon pricing and geoengineering in the short run, the bioecological model may be more likely to enable environmentally effective cooperation in the long run.[142]

More generally, the analysis has implications for how to approach global science policy. Applications of the epistemic communities framework to science policy have focused on outlining how scientific consensus can be effectively represented and mobilized.[143] While useful to scientists, this advice is of limited value to policy-makers because it reduces their role to identifying epistemic communities that wield salient, legitimate, and credible knowledge. However, as scholars in STS have noted, the definition of saliency and credibility often reflects policy imperatives themselves.[144] My analysis builds on this by suggesting an approach to science policy that investigates how and why specific knowledges, devices, and assumptions came to constitute epistemic objects in the first place. Showing that governance objects and problems emerge from a contested history of knowledge production reveals how contingent events and interests structure the policy space within which decisions are made. Tracing the constitution of the policy space to processes of knowledge production may help to denaturalize assumptions and reopen policy spaces that have been unnecessarily narrowed. This approach encourages policy-makers not to question the credible and legitimate representations of science, but to recognize the contingent concatenation of political interests, technological devices, and policy frames attached to established and credible knowledge.

The constitution of the climate has also had structural effects on the international system as a whole. In Corry's object-centered theory, the international system is constituted by actors who orient themselves to entities and problems, so changing the landscape of objects and discourses changes the constitution of the system itself.[145] The production of the climate brought into being new forms of knowledge and practice that altered the system's composition and authority structure. First, the open, abstract structure of the climate object allowed new actors to combine in novel ways, making it possible to arrange global governance elements in novel ways. The fragmented and multilevel structure of actors in climate governance can nonetheless cohere around the common goal of reducing GHGs because the abstract unit tCO_2e allows them to port their knowledges and policies into one another. Second, as Miller argues, the constitution of the climate helped to produce the very idea of global governance.[146] The concept of global governance emerged alongside the creation of a series of global problems in the 1960s, 1970s, and 1980s. The planetary scale of the climate and its attendant images of whole-earth processes helped to shape the idea that certain problems were shared by all humans. The constitution of the climate was then part of a larger co-production dynamic between

142. Alley et al. 2003; Lenton et al. 2008.
143. Clark, Mitchell, and Cash 2006.
144. Jasanoff and Wynne 1998, 6–10.
145. Corry 2013a.
146. Miller 2004, 51. See also Jasanoff 2010.

scientific knowledge and the conceptual foundations of international politics. Thus, in assembling objects, scientists and experts do not only create new classifications or social kinds that shape interests and beliefs—they constitute the basis of the international system itself, laying the foundation for a shared system structure and common modes of problem solving.[147]

My theory of problem construction has important applications beyond the climate case. I expect that the designation, translation, and problematization phases introduced here will illuminate the histories of other global governance problems. For example, human rights also emerged from a co-production process between states and groups of lawyers and activists. As a result, the bundle of rights codified in global governance today is a specific subset of rights that has been shaped by the geopolitical context of the Cold War.[148] As early as the 1946 deliberations of the Human Rights Commission, the geopolitical realities of the Cold War constrained the content and form of human rights.[149] In the 1960s and 1970s, when Amnesty International and other groups worked to translate human rights into a universalist, global discourse, they did so in the shadow of Cold War competition. Amnesty in particular laid out a narrow legal doctrine of human rights that activists felt could be easily defended in the politicized geopolitical context.[150] Amnesty's work was also shaped by the fact that it, like many other human rights groups, accepted state patronage that shaped their work.[151]

However, the application of the theory to other objects will require some revision to the mechanisms that drive co-production. For example, states did not merely steer the constitution of human rights. In the 1940s and again in the 1970s states took an active role in assembling postwar human rights. Similarly, in the case of terrorism, while experts are increasingly deployed to create the risk profiles that underlie terrorist governance, states directly participate in the designation and problematization of terrorism.[152] The human rights and terrorism cases demonstrate that comparative analysis of multiple objects over the course of the twentieth century would be valuable in refining the mechanisms of object constitution and problem construction. But such comparison is likely also to reveal complex, path-dependent interrelations between the cases. For example, when activists worked to translate gender issues globally, they used the vocabulary of human rights.[153] Similarly, the history of the economy has shaped the history of climate governance in important ways. In political spaces where the demarcation of objects and jurisdictions is central, the histories of supposedly distinct domains will be intertwined.[154] Thus, the juxtaposition of

147. Allan forthcoming.
148. Madsen 2012.
149. Ibid., 260–61.
150. Ibid., 265–67.
151. Ibid., 268.
152. Aradau and Van Munster 2007; Keiber 2015.
153. Hafner-Burton and Pollack 2002.
154. Abbott 1988.

historical case studies is likely to reveal contingent historical entanglements across domains in the global Cold War.

From this perspective, the history of the climate presents a new way to interpret the effects of the Cold War. We are used to thinking of the Cold War's influence in military or ideological terms. However, the history here suggests that the Cold War also had long-term effects on human history by shaping the knowledge that underlies the landscape of social and political life. The climate came into view during the Cold War as US government agencies and the scientific establishment shaped and reshaped one another in a co-production dynamic of unprecedented scale and consequences. Cold War competition pulled financial and intellectual resources into nuclear physics, aeronautics, electronics, materials science, and geophysics, pushing the frontiers of scientific knowledge into previously unexplored territories.[155] That is, geopolitical imperatives set in motion a certain sequence of knowledge production with far-reaching consequences. The climate is part of a larger class of objects that exist in the form they do because US state agencies drove billions of dollars into the institutions of knowledge production, altering their priorities, trajectories, and products. The landscape of scientific objects and technologies in global politics has been irreversibly shaped by the confluence of state interests and expert authority in the context of a global geopolitical competition between the two superpowers. Retelling the history of this landscape as a history of object constitution pushes back against the determinist narrative suggested by the separation of knowledge and politics, revealing more contingency in the history of global politics than we previously saw.

The paper extends the insights of social theory to putatively material or physical phenomena. Climate, biodiversity, and so on, are hybrid objects that have both ideational and physical components. If hybrid objects are to be theorized appropriately, we must create new tools that do not reduce entities to either reductive material substrates or purely ideational representations. Instead, IR must strive with Timothy Mitchell to articulate how objects and worlds are *made*, rather than merely represented. But from this vantage point, I have told only half the story: I focused on the development of climate knowledge and climate governance and ignored the complex constellation of social, economic, technological, and political elements that drive fossil fuel use, resource consumption, and destructive land-use practices. This begs a complementary analysis to the one here that theorizes how interlocking social, economic, technological, and political elements made climate change. But the goal should be an integrated analysis of the constitution of the socio-technical practices and the production of the knowledge that rendered those practices problematic. Such an analysis will need to draw both on ideational approaches as well as new materialist theories that recognize the contingent influence of physical and infrastructural entities in global politics.[156]

155. On the negative effects of this, see Leslie 1993.
156. See Mayer 2012 for a new materialist view of the climate.

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