Chapter 8
Temporal Metaphor in Abrupt Climate Change Communication: An Initial Effort at Clarification

Chris Russill

Abstract Abrupt climate change has recently become the focus of significant attention. The belief that abrupt climate changes have not been given due weight in scientific reporting and policy discussion has become more vocal since the turn of the century. New research has incorporated these possibilities in terms of tipping points and tipping elements, and argued that projections of gradual change can lull society into a false sense of security. In this paper, I draw attention to the metaphorical quality of abrupt climate change discourse. I examine the discourse occasioned by such abrupt change warnings, and I illuminate how deeply embedded temporal assumptions orient evaluations of climate change danger. I suggest that many familiar points of dispute might be indexed to different visions of time and change, and I develop the role of metaphor for better understanding climate change communication on this matter, and more generally.

Keywords Abrupt climate change · Analogy · Climate change communication · Metaphor · Positive feedbacks · Punctuated equilibrium · Temporality · Time · Tipping point

Introduction

Abrupt climate change discourse is the subject of increasing scientific and popular attention. In 2000, Richard Alley's book, The Two Mile Time Machine, developed the idea that new knowledge of "[t]he existence of abrupt climate changes casts a very different light on the debate about global warming. . ." (p. 5). A year later, Mastrandrea and Schneider (2001) noted that integrated assessment models (IAM) assumed gradualist change, and they "confirmed the potential significance of abrupt climate change to economically optimal IAM policies, thus calling into question all

C. Russill (✉)
School of Journalism and Communication, Carleton University, 305 St. Patrick's Bldg, 1125 Colonel By Dr Ottawa, Ontario K1S5B6, Canada

W.L. Filho (ed.), *The Economic, Social and Political Elements of Climate Change*, Climate Change Management, DOI 10.1007/978-3-642-14776-0_8,

previous work neglecting such possibilities" (p. 433). In 2002, a National Academy of Sciences report raised significant concerns when it suggested that gradual changes can push climate systems past thresholds and result in unexpectedly quick or jumpy shifts: "Just as the slowly increasing pressure of a finger eventually flips a switch and turns on a light, the slow effects of drifting continents or wobbling orbits or changing atmospheric composition may 'switch' the climate to a new state" (p. v). Today, several research groups are studying the potential for abrupt change and proposing the development of "tipping point" warning systems (Lenton et al. 2008; Scheffer et al. 2009).

An interesting quality of the earliest concerns with abrupt climate change is their analogical or metaphorical character. Generally, it is historical analogies that are considered most relevant. Broecker (1999), for instance, argued directly for the importance of historical analogy in questioning the reliance of climate policy on computer model simulations. Existing climate model simulations are misleading and even dangerous, Broeker and others have argued, since they privilege gradualist forms of change. Given these assumptions, "one can imagine that man might be able to cope with the coming changes" (Broecker 1987, p. 123). However, if we examine the palaeoclimatological record, we see it is littered with abrupt climate changes (cf. Alley 2000; Lenton 2009a). The climate has switched, flipped, flickered, jumped, tipped, or altered drastically, often over the course of only a few years, according to evidence compiled through deep sea and ice core analysis, as well as other sources. If we reason analogically, abrupt changes are quite possible, and model projections of gradual change risk lulling society into a false sense security (Broecker 1987; Lenton et al. 2008; Lenton 2009a).

Critics have argued that fears over abrupt climate change are unscientific or overblown. Proponents of abrupt climate transitions are said to rely on non-scientific discourses of catastrophe, which introduce unwarranted alarmism into the communication of climate change (Hulme 2006). It is prejudice or politics that motivate such analogies, not science, as alarmists rely upon the apocalyptic rhetoric characteristic of Judeo-Christian culture to make sense of climate change. Moreover, warnings of abrupt climate change might create initial urgency but will result in fatalism (Nature 2006; Lowe 2005), a criticism anticipated in the National Academy of Sciences (2002) report. Discussion of worst-case scenarios in warning of potential impacts has even been said to represent "climate porn", where audiences respond to the "secretly thrilling" experience of viewing catastrophic scenarios (Ereaut and Segnit 2006). Abrupt change and tipping point warnings are often viewed in this way.

There is genuine debate regarding the importance of abrupt climate change scenarios. There are valid arguments and well-regarded proponents on each side, indeed, on the many sides implicated in the abrupt change discussion. It is conducted in a range of forums, including national newspapers in the US, UK, and elsewhere; important scientific journals (Climatic Change, Global Environmental Change, Proceedings of the National Academy of Sciences, Philosophical Transactions of the Royal Society); influential blogs (Real Climate, Dot Earth); professional scientific organizations, consultancies, and many places besides, including

popular culture (for example, Forbes Magazine, The Weather Channel, and the Hollywood film, The Day After Tomorrow).

How can disagreements regarding the danger of abrupt climate change be resolved or mediated, and what grounds can be articulated for preferring abrupt to gradualist projections of climate change? How should policy makers, politicians, and publics respond to abrupt climate change warnings? It is important not to view the wide array of different opinions simply in terms of a "contentious debate", but it is also necessary to articulate the grounds on which abrupt climate change danger is taken seriously or dismissed as irrelevant. In this paper, I suggest an indirect approach. I argue that greater acknowledgment of the analogical and metaphorical quality of climate change communication, and of temporal metaphor in particular, is needed in order to appraise the significance of arguments employing metaphor, and to better understand how people make sense of climate change.

Metaphor is ubiquitous in climate discourse. There are hothouses and greenhouses, atmospheric blankets and holes, sinks and drains, flipped and flickering switches, conveyor belts and bathtub effects, tipping points and time bombs, ornery and angry beasts, rolled dice, sleeping drunks, and even bungie jumpers attached to speeding rollercoasters. Perhaps most famously, there is Wally Broecker's (1997, 1999) warning that the climate is an "ornery" or "angry beast", which humans are poking with sticks. Other famous scientists have got into the game. Alley (2000) speaks of "the 'drunk' model of the climate system – when left alone, it sits; when forced to move, it staggers wildly" (p. 182). James Hansen (2005a) warns of a slippery slope, of a Faustian bargain, and of a timebomb, but has now settled on tipping points to convey dangers associated with abrupt climate change (cf. Russill 2008). The tipping point metaphor is a popular one, and has been promoted in scientific, policy, and media contexts (Kerr 2008; Russill and Nyssa 2009; Hulme 2009).

The failure to recognize the metaphorical quality of climate change discourse has several consequences. First, the deeply entrenched nature of metaphor in climate change communication is not acknowledged, and a limited understanding of analogy, metaphor, language, and communication is used to appraise its significance. Second, it means that disagreements rooted in competing temporal visions are explained in other ways, as the result of ignorance or a struggle for political advantage. Third, a wider range of temporal perspectives is not found or considered seriously in mainstream climate change communication. Some indigenous views, for example, are based in cyclical notions of temporality that challenge assumptions of linearity, progress, or abstraction from place (Deloria 1994). Fourth, the importance of metaphor to policy innovation and participatory sustainability efforts makes its recognition in climate discourse an important insight (cf. Gough et al. 2003; Ravetz 2003). Metaphor is central to the way climate change acquires public meaning. Metaphor is used to make complex science more accessible, but it also influences the very questions and problems driving social change. In short, climate change discourse may remain confused and overly exclusive if the metaphorical quality of communication is obscured or suppressed.

I open this line of inquiry by reviewing the research literature on metaphor in climate change communication generally. I then distinguish cyclical and directional

metaphors of time using Steven Jay Gould's (1987) dichotomy for describing long-standing debates in the earth and biological sciences. I then describe the emergence of tipping point warnings of climate change danger as an instance of generative metaphor, and summarize the implications of accepting the metaphorical quality of climate change discourse.

Metaphor in Climate Change Communication

How much significance should be accorded to metaphor in climate change communication? Discussions of metaphor in climate change discourse are infrequent. Occasionally, scientists share their reasons for preferring a particular metaphor (Hansen 2005a), or recommend the use of metaphors for dealing with news media (Schneider 1988). It is much less common to develop systematically the assumptions and implications of acknowledging the metaphorical function of climate change communication. The benchmark collection on climate change communication contains only two brief discussions (Bostrom and Lashof 2007; Ungar 2007), and a recent review of expert recommendations on climate communication did not find any advice on metaphor (Thompson and Schweizer 2008). However, there are two influential academic literatures that advocate for greater attention to the role and scope of metaphor in climate change discourse, although the intellectual traditions, strategic goals, and cultural contexts of these researchers direct their conceptualization of metaphor along different paths.

In the United States, proponents of metaphor often argue for the importance of "framing" in climate change communication. Recommendations for framing climate change have been developed from research into the psychology of risk perception, and from cognitive science more generally (cf. Lakoff 1987; Nisbet 2009). In this tradition, all understanding is framed, and people make sense of climate change discourse by using specific frames to interpret the significance of a message. George Lakoff's work has been definitive and perhaps even foundational in building widespread acceptance of this perspective among social and political marketing professionals. Lakoff and his associates postulate that people understand messages in terms of conceptual frames, and that they reason metaphorically in terms of these frames when drawing conclusions. One's understanding of a message involving data, an argument, an event, a problem, etc., depends less on these message features than on the frame of the message, and the cognitive/cultural model that is made salient by the frame.

The result is that professional communicators have great power to shape public understanding, and to build support for specific conclusions by accessing deeply shared metaphorical systems. Proponents of framing often emphasize three features in making recommendations: the malleability of frames, the place of values in deciding whether support for policy change will emerge, and the importance of disciplined repetition of messages for inscribing a frame. In short, frames direct reasoning, and the reasoning process is very different from the one that is usually

assumed, where conclusions and arguments are contested through an exchange of fact or evidence. Metaphor is of central importance in this process of reasoning and understanding; we "live by them", to echo the title of Lakoff and Johnson's (1980) famous book.

As applied to climate change discourse, frames emphasizing uncertainty or debate tend to result in a lack of public commitment to policy action. If climate change is framed as a debate among experts, or as uncertain, people will tend to reserve judgment; if it is understood as a war between energy companies and environmentalists, a polarized public will result and impede policy change (Nisbet 2009). If, however, climate change is intermixed with frames of economic progress and human health, wider public support for policy change will result (at least among certain classes of people in the United States).

In American applications of framing, metaphor use is often envisioned in a way that restricts public participation to expressions of policy support or dissent. Framing is used to popularize science, or to build support for pre-determined conclusions more often than it invites participation in the development of conclusions. The process through which public issues are framed and acquire meaning is conceived rather narrowly. It cannot be decided here whether the narrowing of public participation is entailed by the conceptual theory of metaphor preferred by Lakoff, or whether such uses reflect the preferences of those adopting Lakoff's perspective. It is likely that the historical contingencies and exigencies of US politics and policy have shaped the use of Lakoff's work, and of framing more generally, and that this accounts for the narrowness of many framing perspectives. Other perspectives on metaphor have broadened visions of public participation. Ungar (2007), for example, clearly values "bridging metaphors" as tools for involving of lay publics, an instance of the more general view that tropes can spark dialogue and the collaborative or negotiated search for meaning (Hellsten 2002, p. 22).

A more expansive vision of metaphor and its importance for public participation is found in post-normal science and participatory sustainability perspectives. Metaphor is considered in its poetic capacity, as generative of new meaning, insight, and creativity, and used to broaden public participation in domains typically dominated by scientists and experts. The strategy is to use metaphor to broaden public participation beyond "public perceptions gathering" (Gough et al. 2003, p. 42), and to develop dialogic, and pragmatic problem-responding capabilities (cf. Kasemir et al. 2003, p. 14). The inclusion of publics is conceived more broadly, and metaphor is important for illuminating and challenging a wider array of institutionalized epistemic and value commitments. Metaphor is understood in the context of power relations, and envisioned as a tool for making clear the tacit meanings of climate change discourse in order to force negotiation and debate, not unconscious adherence to expert policy preferences. These ideas resemble Mary Hesse's (1966) regard for the productive value of the ambiguity generated by metaphor. Importantly, the discussion on metaphor is oriented to questions of creativity in scientific inquiry and debates in philosophy of science, not the social

marketing concerns often dominating interest in climate change communication in North America.

Post-normal scientific perspectives attend closely to "the ways in which knowledge is condensed, packaged and brought into social discourse…" (Hulme 2009, p. 80), and an interesting dimension of this concern is the refiguring of computer model results as metaphorical. There are several well-elaborated positions in the philosophy of science that regard scientific models as analogical or metaphorical (Black 1962; Hesse 1966). In Ravetz's (2003) conception, computer models have a metaphorical function, and the relationship of experts and public participants is characterized in metaphorical terms (as a voyage). It is not simply that metaphor is important for simplifying or popularizing science. It is the capacity to generate novel insight and shifting perspectives that is encouraged. In fact, Ravetz argues that computer model results are misconstrued when evaluated in terms of prediction and control, and that efforts at integrated assessment modelling (IAM) will produce error and mistake if judged by those standards of evaluation. As Hulme (2009) puts the question of computer models, "Are they 'truth machines' to be believed in by all, or do they act more like metaphors to help us think about the future?" (p. 59). In post-normal science perspectives, the role of computer models in policy assessment, in issuing warnings, and in the envisioning of possible futures, requires an acceptance of their metaphoric function.

The post-normal science discussion has clear application to contemporary efforts to model abrupt change scenarios, and is supplemented in this paper with the pragmatic theory of generative metaphor developed in Donald Schön's work on problem setting in social policy. Schön (1979/1993) believed solutions to policy problems often emerged from the capacity of generative metaphor to create new perspectives on problems, and that policy disputes were usually rooted in "conflicting frames, generated by different and conflicting metaphors" (p. 139). Generative metaphor speaks mainly to the dislodging or displacement of a familiar description by "a different, already-named process…" (p. 141). Entrenched disputes are refigured by using metaphor to illuminate different aspects of complex situations, by rearranging these aspects in a new organizational pattern, and by re-weighting the importance or significance of these aspects. An initial effort might merely dislodge the prevailing description, and lead to the search for different metaphors during the process of trying to explain inappropriate or misplaced assumptions; initial efforts might also re-invigorate a metaphor that has become conventionalized – such that its metaphorical nature is recognized anew (cf. Brüning and Lohmann 1999). Perhaps most importantly, generative metaphors begin life as mistakes, and even a successfully developed metaphor is literally a mis-taking.

> "What makes the process one of metaphor making, rather than simply of redescribing, is that the new putative description already belongs to what is initially perceived as a different, albeit familiar thing…" (Schön, p. 141).

The emergence of scientific insight from mistake is often remarked upon in histories of scientific discovery, but not usually taken very seriously. Generative

metaphor provides a way of acknowledging these accounts. Put schematically, there is an initial and unjustified use of metaphor, then the formulation of an analogy able to restructure perception of an existing situation, and only then the potential development of a concept or general model (pp. 142–143; for a more analytical discussion distinguishing different types of metaphor, see Brüning and Lohmann 1999). The movement from personal or common experiences to more abstract conceptual schemes emphasizes the importance of context, and of the context bound nature of experience required for interpreting and using metaphor. It is, as Brüning and Lohmann say, "a process of communication" (p. 400), and the old adage of learning from mistakes is accepted as more than a cliché. The understanding of metaphor as generative encourages greater inclusion of public participation in policy issues because mistakes are construed as initiating insight and learning, and as eliciting sense-making frameworks, not simply as illiteracy, falsehood, or error.

There are several difficulties in experimenting with generative metaphor. Generative metaphors sometimes look like a silly mistake, and they often are. It is also likely that multiple metaphors will be required to sharpen the contrasts among different perspectives. The most successful metaphors rarely bear the traces of the earliest efforts to apply them. For example, the great ocean conveyor belt no longer prompts much pause or reflection, since it is now conventionalized. Its first use was almost whimsical, as the example of a fun-house ride was used to explain nutrient distribution in the sea (Brüning and Lohmann 1999). Today, images and descriptions of the conveyor belt are used to explain and even model the global nature of ocean circulation. The result is that helpful generative metaphors might be abandoned prematurely, since they fail to fit the criteria for accepting a concept or model.

An important feature of pragmatic metaphor is its problem-setting or problematizing dimension, an aspect that is important to efforts to evaluate the appropriateness of a metaphor (cf. Fischer 2009, on Schön and problematization). The problem-dependent feature of generative metaphor is often overlooked, since poor metaphors are discarded as bad mistakes, while successful ones resolve matters in a way that elides traces of the previously problematic situation. In this respect, generative metaphor encourages a conception of social discourse similar to proponents of post-normal science. The important feature of public participation is not that it deals with problem solving, or that it treat social concerns as problems to be eliminated, but that participation is construed in terms of problem-setting and problem posing. As Schön argued, "the essential difficulties in social policy have more to do with problem setting than with problem solving, more to do with ways in which we frame the purposes to be achieved than with the selection of optimal means for achieving them" (p. 138). It is through a collective process of problem formulation that people are able to make sense of and govern themselves in conditions of climate change, and to influence scientific practices. Metaphor is an important tool in this respect and reflects the inclusion of broad cultural sensibilities in expert dominated domains.

> "When we examine the problem-setting stories told by analysts and practitioners of social policy, it becomes apparent that the framing of problems often depends upon metaphors underlying the stories which generate problem setting and set directions for problem solving" (Schön 1979/1993, pp. 138–139).

It is with this understanding of metaphor in mind that we can examine Gould's account of metaphor in geological and biological disputes before turning to the role of metaphor in warnings of abrupt climate change danger.

Steven Jay Gould's Dichotomy of Temporal Metaphor

Among the best examples of generative metaphor is Steven Jay Gould's book, *Time's Arrow*, *Time's Cycle*. Although Gould (1987) preferred to speak of these temporal metaphors as "eternal metaphors", due to their long-standing influence on western culture, it is clear that he views them as constitutive or generative of scientific and popular understanding (p. 194, 199). Gould's discussion is particularly relevant to considerations of temporal metaphor in abrupt climate change communication, since Gould felt that entrenched preferences for incremental, cumulative change have blocked intellectual consideration of other possibilities.

Gould (1987) develops the contrast between directional and cyclical metaphors of time to demonstrate how deeply entrenched certain visions of temporality are in western culture. These metaphors are almost inescapable in Gould's account, since temporal metaphors underpin and intermix with theories, data, observations, and even first-hand experiences of physical objects or biological processes. People have looked at the same rocks and seen 6,000 years of divine touch or the momentary shard of a billion years' history; they have seen catastrophic change or gradual erosion; they have assumed the earth's imminent demise, or that it has in James Hutton's famous phrase, "no vestige of a beginning, – no prospect of an end" (Gould 1987, p. 79). Gould argues that direct observation cannot decide the question of whether to privilege directional or cyclical notions of time; instead, temporal metaphor constitutes the conditions of intelligibility for a wide range of phenomena. If he is right, it should be no surprise that 400 million year old ice from the Antarctica provokes similar disagreements today.

According to Gould, earth scientists have waged an epistemic war on behalf of gradual or incremental visions of change, a view not derived from field data or direct observation, but from cultural commitments. In his first published article, Gould (1965) took a historical perspective to show that scholars wrongly understood the motivation and basis for catastrophic scenarios of geological change. In his theory of punctuated equilibrium, co-authored with Niles Eldredge, Gould weighted abrupt shifts over finely graded increments as the significant events in biological evolution at macro-evolutionary scales, while granting the significance of gradualist assumptions for other scales, such as ecological changes. In *Time's Arrow, Time's Cycle*, Gould tries to disabuse scholars of the hubris with which

temporal visions are advocated or disparaged, and he models a pluralistic perspective designed to recover the significance and validity of employing the directional/cyclical metaphors to contemporary circumstances. Gould suggests the cultural roots of our various metaphors of time run deep, and he sets out to show how these shape understandings of geological time.

Geological or "deep time" suggests immensely long timescales against which human experience appears finite and insignificant. James Hutton is often credited with the recognition of deep time, and popular histories of geology and earth science argue for the importance of fieldwork and observational evidence in the making of his discovery. Gould offers a different account and argues that Hutton simply displaced directional accounts of time with a cyclical understanding of earth systems.

> "Hutton developed his theory by imposing upon the earth the most rigid and uncompromising version of time's cycle ever developed by a geologist" (Gould 1987, p. 79).

Why does this matter? In Gould's view, a narrow account of geological change won undue prominence by falsifying the history of its emergence, by employing spurious arguments, and by dismissing alternative possibilities out of cultural prejudice masked as scientific objectivity. The belief that significant geological change is the slow and gradual accumulation of insensibly fine increments has won out popularly through nefarious means, and the result is that non-linear, abrupt, or "punctual" change is not considered seriously.

Gould provides a revisionist history demonstrating how discussions of the significance of deep time have drawn upon and weighted differently the several aspects of time's passage. On the one hand, there is the metaphor of "time's arrow", which construes history as "an irreversible sequence of unrepeatable events", and where, "[e]ach moment occupies its own distinct position in a temporal series, and all moments, considered in proper sequence, tell a story of linked events moving in a direction" (pp. 10–11). On the other hand, there is "time's cycle", where "events have no meaning as distinct episodes with causal impact upon a contingent history. Fundamental states are immanent in time, always present and never changing. Apparent motions are parts of repeating cycles, and differences of the past will be realities of the future. Time has no direction" (p. 11).

Gould contrasts these metaphors to illuminate the genealogical development of temporal thinking. For instance, many modern views of history incorporate uniqueness and directionality, but these dimensions of time "arose at different times and in disparate contexts" (p. 13). Similarly, cyclical theories have become unfamiliar, even though the earliest proponents of deep time developed the idea "from their commitment to the unfamiliar view of time's cycle, and not (as the myth professes) from superior knowledge of rocks in the field" (p. 15).

Gould's goal is to recover the previous standing of cyclical visions of time, to argue that such visions were not defeated by empirical evidence or observation, and to suggest that the wrong-headed acceptance of spurious arguments has enshrined "a restrictive view about the nature of change" (p. 119). Cumulative change is the norm for interpreting geological and biological processes, and counter-examples or

anomalies can always be resolved into theoretical frameworks presuming gradual, directional change. Visions of directional time are deeply embedded in cultural and religious belief systems, and these visions are expressed in metaphorical terms that guide theoretical understanding and scientific observation. The hegemony of directional metaphors has resulted in the privileging of "one narrow version of geological process as true a priori", with the consequence that, "we lose the possibility of weighing reasonable alternatives" (p. 114). Theorists inverting this process to interpret catastrophic or abrupt shifts as definitive events in the earth's formation have been scorned as unscientific and ridiculed as purveyors of religiously motivated superstition. Gould recovers these competing conceptions of time by treating them in terms of metaphor, and argues that they represent equally plausible possibilities.

Gould argues that temporal metaphors are generative, and that both directional and cyclical metaphors are needed since they illuminate ineradicable dimensions of reality. Directional and cyclical views of the world cannot be avoided, cannot be eradicated, cannot be synthesized, but must simply be lived with and drawn upon with pragmatic finesse, which is to say employed differently "depending on the question asked or the perspective assumed" (p. 200). How can this pragmatic touch be developed and evaluated? Gould raised the matter but did not propose an answer extending beyond his specific subject matter. His main concern was geological and biological phenomena and the final question of his book treated the questions of competing temporal assumptions in terms of rocks and fossils, "How, then, can we judge the interaction of time's arrow and time's cycle within each object?" (p. 199).

The same question is of pressing importance for contemporary climate change discourse. How do we proceed if, as Gould phrases it, "nature says yes to both" (p. 200)? If gradualist and abrupt visions of change are incommensurable in their purest form, cannot be reconciled in practice, yet explain selected aspects of climate change in acceptable scientific terms, how are we to proceed? How can these temporal assumptions be intermixed pragmatically? In the next section, I address these questions in the context of efforts to develop an abrupt climate change warning system with policy relevance.

Metaphor and Analogy in Warnings of Abrupt Climate Change

Abrupt climate change warnings have used a variety of metaphors. Broecker (1987) once claimed that, "inhabitants of planet Earth are quietly conducting a gigantic environmental experiment", which he characterized as, "Russian roulette with climate" (p. 123). Other metaphorical warnings include: Al Gore's (1992) sandpiles approaching self-criticality; Broecker's (1999) angry beast poked by sticks; Richard Alley's (2000) resting then staggering drunk, his bungy jumper attached to a roller coaster, or his idea of a flipped light switch and flickering climate states; the NAS (2002) report's diagram of balanced yet sensitive scales; and James Hansen's (2004) timebomb. Today, it appears that tipping point is the most systematically

used and elaborated warning, and one suggestive of generative metaphor as described above (Russill and Nyssa 2009).

Tipping point, as a metaphor for abrupt climate change, has been discussed and clarified in terms of a number of more specific analogies. Winton's (2006) article, "Does the Arctic Sea Ice Have A Tipping Point?" primes the reader with the analogy of a slowly tipped glass that moves from an upright position to "a new stable equilibrium on its side" (p. 5). Lovelock (2006) uses tipping point as a synonym for threshold, and his book claims, "We are now approaching one of these tipping points, and our future is like that of the passengers on a small pleasure boat sailing quietly above Niagara Falls, not knowing the engines are about to fail" (p. 6). Hansen's (2005b) use of tipping point implies a similar sense of losing control and irreversible consequence: "we are on the precipice of climate system tipping points beyond which there is no redemption" (p. 8). Malcolm Gladwell's (2000) idea of tipping point is discussed in epidemiological terms and through ideas of contagious or infectious disease transmission. These metaphors suggest the ubiquity and significance of systems changes that are abrupt, and they are always contrasted against gradual or incremental assumptions.

In the examples of Lovelock, Hansen, and Lenton et al. (2008), the tipping point metaphor is intended to create urgency regarding the danger represented by an unanticipated form of change. The utilization of threshold-oriented language is designed to suit our usual experiences of crisis, and to meet the requirements of politicians in motivating policy change. It could be argued, however, that the metaphor encourages a completely different idea of climate, and how climate can change (cf. Hulme 2009, p. 60). If so, tipping point warnings are not a plea for citizens and policymakers to simply recognize new evidence, and to adapt policy frameworks accordingly. Instead, these warnings install a non-conventional view of climatic change, and a different understanding of the integrated nature of earth systems. Such paradigm shifts, if indeed tipping point warnings represent one, are not the result of unambiguously observed phenomena or evidence, or not decided merely on this basis. At any rate, it is clear that fitting geological timescales to ecological and policy timescales, and that sensitizing policy makers and the public to the idea of thresholds for change, has been done primarily through analogy and metaphor. Of particular interest is the intermixing of metaphors that remind of rather simple and familiar experiences with on-going conceptual innovation and model development.

Insight into Signals of Danger

It is in "the normative leap from findings of fact to policy recommendations" as Ogunseitan (2003) suggests, that generative metaphor is of special importance (p. 102). This leaping, like the flickering climate suggested in Alley's light switch metaphor, is likely to recur frequently before settling into a conventionalized and

commonly accepted use. It is also important to recognize the communicative process involved in applying metaphor.

There is a tendency to consider metaphors in isolation, but the contrast among competing metaphors often produces important insight. The terrifying pull of a strong undertow inspires the urgency of Lovelock's metaphor, and irreversibility is suggested by his comparison to an "event horizon", where the pull of gravity from a black hole is invisible yet inescapable (p. 52). Alley's light switch is not terrifying in this sense, but it better attunes one to the possibility of flickering states of climate. Contrasting Alley's drunk with Broecker's beast is also useful. In the image accompanying Broecker's (1999) warning, the beast is a large dragon – mythical, dangerous, and probably difficult to anticipate in its response to poking. By contrast, Alley's sleeping drunk suggests a certain predictably. There might be no response to repeated prodding, or minute signs of unrest that fail to escape notice. Yet, the eventual response might well be out of all proportion with gentle prodding, and an exaggerated reaction can occur during particularly sensitive moments. If considered more deeply, the analogy suggests delayed or slowed response times to perturbations that would generally solicit an immediate reaction from a sober person, as well as wandering, stumbling physical movement that is exaggerated, but which still resembles normal human activity. In fact, such "oscillations to perturbations" are sometimes taken as good evidence of an inebriated person. In this sense, the metaphor sensitizes us to warning signals.

It is these exaggerated movements and delayed responses that Lenton et al. (2009) emphasize in their rolling ball analogy, which encourages the development of a signalling system for danger. The goal is to perceive signals and an early warning of an approaching tipping point (it is worth noting that Lenton et al. (2009) use tipping elements and tipping points to encompass many modes of non-linear change, not simply rapid or gradual change).

> Picture the present state of the system as a ball in a curved potential well (attractor) that is being nudged around by some stochastic noise process, e.g. weather. The ball continually tends to roll back towards the bottom of the well – its lowest potential state – and the rate at which it rolls back is determined by the curvature of the potential well. The radius of the potential well is related to the longest immanent time scale in the system. As the system is forced towards a bifurcation point, the potential well becomes flatter (i.e. the longest immanent time scale increases). Consequently, the ball will roll back more sluggishly. It may also undertake larger excursions for a given nudge. At the bifurcation point, the potential well disappears and the potential becomes flat (i.e. the longest immanent time scale becomes infinite). At this point, the ball is destined to roll off into some other state (i.e. alternative potential well) (Lenton et al. 2009, p. 879).

The analogy is used to clarify indications of an approaching tipping point generally. It does not help create a general perception of ocean circulation or changes due to thermohaline circulation (the subject matter of Lenton et al.'s 2009 article), which are more adequately understood in terms of a conveyor or other metaphors than a rolling ball for most purposes. Instead, Lenton's ball is more like Alley's drunk: slowing response time to prodding is indicated either by fewer reactions than expected to each poke, or by exaggerated or staggering movements,

with longer periods required for the return to relative stasis or balance. A more rigorous comparison might be pursued with other metaphors. The mechanical scale diagram of the NAS (2002) report, where two curved scales are balanced and contain a single rolling ball, is helpful for envisioning conditions of sensitivity to threshold and state-change, or even the tipping nature of climate states, but less valuable for diagnosing greater proximity to tipping points in Lenton's definition.

The policy implications of Lenton's proposal remain to be worked out, but the conceptual element of generative metaphor, and its importance for developing policy implications from factual content through the generation of novel perceptions of familiar situations, is of significant value – both in popularizing complex ideas and in fostering new insights. The use of such metaphors, at least in the case of tipping points, should also be analysed in terms of three other elements: the intended domain of reference, over-extension and conflation, and conventionalization.

Theoretical References

The tipping point metaphor can elicit various theoretical frameworks for understanding abrupt change. Proponents of the term often have different domains in mind, and the use of more specific analogies can help clarify matters. Some scientists clearly intend no more than simple physical tipping (as when a glass or canoe is tipped), whereas others intend reference to chaos or complexity theory (of the sort inspired by Edward Lorenz work on non-linearity, or Rene Thom on catastrophe theory), or punctuated equilibrium (Gould), or epidemic change (Gladwell). Often, these theoretical frameworks are elicited differently as the referent shifts: non-linear science underpins reference to climatic or ecological sub-systems; Gould is a source of inspiration for policy analysts; Gladwell guides references to social change and communication. In most cases, however, the framework intended by the tipping point warning is not clear, and these four domains do not exhaust the range of possibility.

Overextension

Another problem is that proponents of specific metaphors are likely to overextend metaphors by intermixing or simply conflating different processes. Overextension can produce insight, nonsense, or damaging error. Broecker's earliest use of the conveyor metaphor, for example, did not address the connection of oceanic conveyor belt shutdown and global climate change. The connection was suggested by readers of his work and appears to have provoked Broecker to more seriously investigate the possibility, which he now endorses as a significant threat (Brüning and Lohmann 1999, p. 401). A less fortunate outcome has resulted from an overextension of the billiard ball metaphor for motion, a metaphor sometimes

used to suggest a purely mechanistic universe. Richard Lewontin (1966) even suggests that "the most important event in the history of science" might be Descartes's use of the machine metaphor, "bête machine", the foundation of a deterministic worldview (p. 25).

The most remarkable and problematic feature of tipping point warnings of abrupt climate change is the frequent conflation of physical and social processes. For example, Hansen and Lenton are prone to conclude that the dangers of tipping points due to anthropogenic climate change can be countered by attention to tipping points in socio-economic phenomena. Why select this particular view of social change from the wide array of competing theories, and why fail to reference the research or provide evidence for this preference? The lack of argument or evidence provided suggests that their preference for tipping point social change is an overextension of their efforts to map a generative metaphor onto climate change matters. However, there is an important difference between invocations of climatic and social tipping points. Social references to tipping points lack concern over the resiliency of the system undergoing change; crossing tipping points is usually stated as a danger in climate systems, yet viewed as beneficial rather than dangerous when social systems are the referent, and tipped social systems are rarely discussed in terms of runaway effects or as out of control (Russill and Nyssa 2009). In these examples, it is clear that the crossing of tipping points is encouraged, as a solution to public policy and social change problems.

The overextension of tipping point metaphors might be expected for two reasons. First, tipping point references were in popular circulation before their application to climate system components, and to climate change issues more generally. Russill and Nyssa observed that bulk of tipping point references in US and UK presses occurred from 2003 onwards, and that climate change tipping points as part of this broader trend represented 6.5% and 16.1% of such references respectively. Second, concerns regarding abrupt change imply judgments about the capacity of sociopolitical systems to adapt and respond, a point elaborated below more thoroughly.

Re-description and Conventionalization

In Russill and Nyssa's (2009) study, they pointed to examples of re-description, where previous research was referenced and re-described in newer terms. Re-description is evident in the most sophisticated elaboration of tipping terminology in the scientific literature. Lenton et al. (2008) develop their tipping point perspective in explicit contrast to the IPCC AR4 to argue for greater attention to the urgency represented by abrupt transitions and non-linear change, and to provide a formal definition for determining tipping points in model simulations used in IPCC assessment reports. John Schellnhuber, a co-author of the research and probably the longest standing booster of climate change tipping point terminology, suggests the article is "a 'mini-IPCC-report' focusing on tipping elements" (Potsdam Institute

for Climate Impact Research 2008, paragraph 16). It is a valuable and important article, yet the reference to IPCC processes indicates the desire to conventionalize tipping point warnings, as opposed to illuminating how the questioning of climate experts regarding tipping points compares to the construction of assessment reports by the IPCC.

In this case, the re-description and conventionalization is most evident in the accompanying press materials, which reference "Selected publications on tipping elements (from PIK authors)". Five papers are provided from associated Potsdam Institute for Climate Impact (PIK) scientists, yet none of these articles use tipping points or tipping elements terminology. It is hardly a matter of distortion; several articles speak of bifurcation points or a trigger point in a manner suggestive of the formulation of tipping elements and tipping points in Lenton et al. (2008) and Lenton (2009). Yet, none of the non-PIK authored research on tipping points is referenced in the press release, although it is discussed in the original article. In this respect, the press releases display the process of conventionalization through which a preferred metaphor is naturalized – given a deeper and more established intellectual trajectory and empirical base – without calling attention to the metaphorical elements of the process itself. The example also illuminates how institutional authority plays a central role in conventionalizing metaphor.

Implications

It is interesting that the ubiquity of analogy and metaphor in abrupt climate change communication is rarely noted, and that discussions of its importance are quite rare. What implications might result from better recognizing the role and scope of metaphor in climate change communication?

It is possible that familiar patterns in climate change discourse could be indexed to differences in temporal understanding. Ravetz (2003) and Lenton (2009) both suggest the preference for gradual over abrupt change has guided decisions to focus on global mean temperature or sea-level, as opposed to specific instances of non-linear impact, like sea-ice melt. Ravetz also hints that choices regarding that appropriate discount rate for economic modelling reflect such assumptions. Ideas about natural change may also influence decisions to emphasize the global importance of positive feedbacks (emphasized, for example, by Al Gore and James Hansen), or the stabilizing feature of negative feedbacks (a frequent feature in the sceptical discourse of Richard Lidzen). Hulme's (2009) idea that metaphor can amplify risk in climate change consideration is also of relevance, and he points specifically to institutional efforts to disseminate tipping point warnings (p. 203, 205).

If disputes were indexed to competing temporal assumptions, it would recast our understanding of why people disagree about climate change. Differing opinions could be explored and evaluated not simply in terms of factual content or predictive likelihood, although a wider range of perspectives might well produce new information and novel insights for regional and local impact models. Instead, these

views would be explored and elaborated in terms of possible futures, and as Ravetz (2003) suggests, the emphasis would be placed on re-imagining the relationship of climate change to citizens in these futures. It is especially important that assumptions regarding social change be defined in ethical and political terms, and not disguised in technically oriented scientific and policy discussions, or as incontestable models. A good example, in this respect, is Michael Hulme's (2009) study of disagreement in climate change discourse. Hulme uses metaphor freely in characterizing the different kinds of stories structuring climate change discourse, and he uses metaphors that indicate how western culture is strongly defined by Judeo-Christian mythology (p. 329).

A second implication of accepting the significance of analogy and metaphor in climate change communication is the possibilities opened up for public participation. The important touchstones for warnings of the danger of abrupt climate change are scientific publications. Hansen et al. (2008) made his determination of dangerous anthropogenic interference at the 350 PPM CO_2e tipping point in a standard scientific paper. Lenton et al. (2008) identified several tipping points through an expert elicitation or survey. In both papers, the technical focus of the argumentation and discussion can obscure the potential role of generative metaphor in policy solutions, especially the assumptions made regarding sociopolitical change. If, however, the emergence of tipping point warnings is described in terms of generative metaphor, then a few important features become more evident.

First of all, warnings assume possible futures, and embed claims regarding the desirability of futures, as well as the capacity of people to respond to changing circumstances that will shape these futures. Tipping point warnings propose that a different temporal structure is required in order to make the dangers of climate change intelligible. Change might come as punctuation rather than progress or increment. This is a reasonable claim. The difficulty arises in selecting thresholds, and in the effort to fit geophysical phenomena to the timescales of policy and political change. There is no agreement or fixed understanding regarding how quickly policy and politics promote social change; a warning, by definition, makes assumptions regarding the adaptive or responsive capacities of people and societal institutions. All efforts to determine human resiliency have difficulty incorporating reflexivity, or the capacity to learn and act differently given awareness of a situation. Tipping point notions of social change, for example, tend to view social systems as expressions of universal laws of dynamical systems, not as one sociopolitical perspective among many. Thus, it is not simply that differences in temporal assumption underpin the appraisal of the possibility of abrupt climate change; these assumptions influence visions of social change as well. One implication of this position is that if the warnings of Hansen et al., and Lenton et al, are viewed as alarms, it means not only that the response capacity of humans is taken into account in deciding when to sound an alarm, but that the threshold for signalling danger must be sensitive enough to accept mistakes. Warnings based on crossing thresholds must permit adequate time for human response to danger, but also permit or account for error. In each case, judgments regarding sociopolitical and economic change are implied.

Second, it is evident that debates regarding the future involve values. It is important to recognize the role of values in the expression of opinions and preferences on climate change, as the "framing" researchers claim, and to avoid reducing disagreement to truth claims or factual statements regarding geophysical phenomenon. Yet, as Robert Cox (1982) reminds, we make implicit temporal assumptions in forming judgments of value, which means "we structure our existence in relation to certain ends – in relation to purposes which are realizable *within* time" (p. 232). If Cox is right, ways of acting in the world are woven through with assumptions about the nature of time and change, and disagreements expressed in terms of geophysical facts or human values rest on prior assumptions regarding the nature of time. Gould's dichotomy of temporal metaphor helps us explore the implications of different temporal assumptions in a more reflexive manner, while suggesting the importance of culture and context.

These features of climate change warnings and the assumptions they require might be illuminated by an account organized in terms of generative metaphor, and it could open opportunities for expanding public participation in the manner of participatory sustainability perspectives. The increasing emphasis on regional and local impact modelling represents a clear opportunity to extend the participatory integrated assessment model (IAM) perspective found in Kasemir et al. (2003), Gough et al. (2003), and Ravetz (2003).

Conclusion

Climate change communication is characterized by frequent recourse to analogy and metaphor in a variety of contexts. The implications of better recognizing the role and scope of metaphor in abrupt climate change warnings were explored in terms of generative metaphor and Steven Jay Gould's claims regarding the constitutive feature of temporal assumptions for scientific study. The proliferation of tipping point warnings of climate danger was examined as an exemplary case of generative metaphor, and the opportunities for better explaining entrenched disagreements and opening climate science to public participation were suggested. It is especially important to recognize advocacy for tipping points in public opinion and social systems as metaphorical if the conflation of climatic and social phenomenon is to be avoided, and if the political nature of enshrining a preferred conception of social change is to be recognized.

There are clear limitations to the work presented here. The analysis should be extended to include visual material and the rich diagrams that often accompany abrupt change warnings. There are myriad theories of analogy and metaphor that could be brought to bear on material covered in this paper, as well as research into non-metaphorical rhetorical figures important to scientific practice (Fahnestock 1999). It is also important to include a more perspicuous understanding of media systems, including the analysis provided by Carvalho and Burgess (cf. Hulme 2009, pp. 221–222). Public discourse would also be improved if greater clarity were

gained on the paradigm of abrupt change assumed by various proponents of its possibility. At least four different theoretical frameworks have informed the recourse to abrupt change metaphors: simple physical examples (a tipped glass), the chaos and complexity theories developed from Lorenz's discussions of meteorological chaos and Thom's catastrophe theory, among other sources (one version of which informed Al Gore's *Earth in the Balance*), the "punctuation" thinking developed in Gould's work (put to good use by Frank Baumgartner), and the epidemiological model for tipping points found in Malcolm Gladwell's (2000) popular book (inspiring the visions of social change shared by a raft of experts and activists today). Finally, the weighting of temporal assumptions among other elements important for making sense of climate change needs greater attention.

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