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The new climate discourse: Alarmist or alarming?

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Abstract

The discourse on climate change is in part divided between a sense of alarm and a sense of alarmism in assessments of the magnitude and urgency of the problem. The divide in the discourse among climatologists relates to tensions in the use of key phrases to describe climate change. This article reviews evidence to support claims that climate change can be viewed as 'catastrophic', 'rapid', 'urgent', 'irreversible', 'chaotic', and 'worse than previously thought'. Each of these terms are imprecise and may convey a range of meaning. The method used here is to assess whether the conventional understandings of these terms are broadly consistent or inconsistent with the science, or else ambiguous. On balance, these terms are judged to be consistent with the science. Factors which divide climatologists on this discourse are also reviewed. The divide over a sense of urgency relates to disagreement on the manner and rate at which ice sheets breakdown in response to sustained warming. Whether this rate is fast or slow, the amount of time available to reduce emissions sufficient to prevent ice sheet breakdown is relatively short, given the moderate levels of warming required and the inertia of the climate and energy systems. A new discourse is emerging which underscores the scope of the problem and the scope and feasibility of solutions. This discourse differentiates itself from existing discourses which view the magnitudes of the problem or of solutions as prohibitive.

Keywords: Climate; Climate change; Discourse

1. Introduction

As the evidence for anthropogenically driven climate change continues to mount, arguments about its consequences and implications remain a focus of public discussion. The climate change discourse has shifted character in a qualitative sense in the last few years, underscored by an increasing sense of urgency (Ereaut and Segnit, 2006). This change in the discourse is observable in some segments of science, government, industry, and among some NGOs. The significance of this shift in discourse is contested. Some believe it reflects a real and alarming change in the climate community's assessment of the problem, and some think it is largely a rhetorical shift promoted by alarmist scientists and communicators. The distinction is an important one, as it implies that we are either on the verge of committing ourselves to serious climate change, or else we are in danger of fooling ourselves that we are. The goal of this article is to articulate some of the points of difference of these two positions and to try to understand some of the reasons for the differences. The focus is on the positions held on this issue by members of the climate science community.

According to the New York Times (Revkin, 2007), the view of climate change portrayed in documentaries like "An Inconvenient Truth" (Guggenheim, 2006) is alarmist. Revkin (2007) notes that a "usually staid" group of "climate scientists in the usually invisible middle are speaking up" against this type of alarmism. If a silent "middle" is opposed to some contemporary portrayals of climate change, then we ought to know about it and seek to understand what differentiates them and their colleagues. Revkin (2007) notes that the position of the "invisible middle" has been "most publicly laid out in an opinion article on the BBC Web site in November by Mike Hulme" (Hulme, 2006). Because that article contains a clear critique of the shift in climate discourse, it provides a good vehicle for outlining and understanding the difference between the two positions. To be sure, Hulme is not the only

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climatologist to speak out on this issue and there clearly are a significant group of climatologists who think this way. In the UK, this includes members of the Royal Meteorological Society (Ghosh, 2007), Oxford University (Harper, 2007), and the group 'Sense about science' (Raphael and Hardaker, 2007), and is echoed by prominent colleagues in Germany (Cox and Vadon, 2006) and the United States (Broad, 2007).

Hulme (2006) argues that there is a growing divide between the language of climate scientists describing climate change and that of green groups advocating action on the issue. Hulme alleges that the carefully hedged statements of scientists are being replaced by fearmongering and alarmist language in environmental communiques. Are the green groups really out of touch as Hulme asserts? This is an important question because it relates to the necessary urgency in addressing the climate change issue. Hulme notes disapprovingly that green groups are using the term 'catastrophic' to describe climate change, along with descriptors such as 'chaotic', 'irreversible', and 'rapid' to alter the public discourse. Hulme disparages this discourse and green groups for claiming that "climate change is worse than we thought" and for speaking of "irreversible tipping in the Earth's climate". He cites as an example of alarmist language British Prime Minister Tony Blair's statement that "we have a window of only 10–15 years to take the steps we need to avoid crossing a catastrophic tipping point". Hulme also singles out the name of a British research project called 'Rapid' as being part of the language of alarmism.

Since much of the divide in the discourse is about language, we address the terms that Hulme cites as inappropriately alarmist and inconsistent with the science. In the sections that follow, we ask a set of questions (raised by Hulme) about contemporary assessments of climate change: Is it catastrophic? Is it rapid? Is it urgent? Is it irreversible? Is it worse than we thought? Is it chaotic? Is it science? Is it counterproductive? Because each of these terms has a range of meaning and understanding, there is not much point in being overprecise in the assessment of each. Rather, we ask in each case whether the term is reasonable as a descriptor of the key climate change issues and whether it is consistent with the science or not. We are not seeking definitive 'yes/no' answers to the questions and recognize that there is an element of judgement involved in each case. Science can shed light on and inform these issues, but it does not lead to definitive policies or labels (Risbey, 2006). Thus, the attempt here is not to demonstrate that climate change *is* or *is not* alarming, but to evaluate whether the features of the climate change problem seem reasonably consistent with one or other of these views.

The method employed here is to describe each term above (catastrophic, rapid, urgent, irreversible, ...) in terms that are commonly understood and to briefly summarize the relevant features of the science from the literature. We then evaluate the 'fit' of the term to these features. The fit is evaluated as 'consistent', 'inconsistent', or 'ambiguous'. This is a subjective exercise and rests on the strength of the arguments. We use common understandings of the terms rather than technical ones, since the issue is about the translation and communication of climate science to the broader community. The claim made by the "invisible middle" is that the common understandings of these terms are not consistent with the science. This claim itself is subjective and can only be evaluated in subjective terms.

Before assessing each of the above terms we first address why we think this is an important issue that goes beyond the level of mere semantics. Then we outline each term as it relates to climate change and assess the applicability of the term. The paper then concludes with an assessment of who stands either side of the divide in the discourse, what it is that divides them, and where they sit in the context of the broader public discourse on climate change.

At the outset, it is fair to declare to the reader that the writer is among those who believe that the shift in discourse *does* reflect a more alarming assessment of the problem. This does not mean that we think the science can only be interpreted in this way, nor that it can be interpreted any way one likes (Schrader-Frechette, 1984). Rather, there are a limited set of views of climate change that are consistent with the science. Personal values will shape one's view within that limited set, but do not allow one to take any arbitrary view outside that set without straining the credibility of the fit with current understandings of the science. The question addressed here is whether the view of climate change described by the terms above is a credible fit to the science or not. The claims about these terms in the discourse could also be addressed from political and cultural perspectives (Oppenheimer, 2005), though this paper confines itself to the perspective of the science.

2. Is it just semantics?

What does it matter whether the science community's view of the consequences of climate change is one of alarmist hype or an alarming prospect? These two views send very different messages to the broader community. Some of that community form their own views on the basis of what the scientists appear to be saying; thus it conditions public views of the problem. Some in the broader political community use the views of scientists for rhetorical cover or justification for pursuing or not pursuing climate change policies. Politicians can promote the viewpoints of scientists who say that the problem is exaggerated or too uncertain in order to maintain and prolong present policies. Conversely, those seeking action can promote the views of scientists who say that the problem is more urgent. On any complex issue, one can always find scientists with either view. What is different here is that significant sections of the scientific and media community are making the claim that the "invisible middle" of the science community think the problem is being exaggerated.

The message from some segments of the science community that the problem is exaggerated has been amplified in the political process in key non-Kyoto signatory countries, the US and Australia. The Australian Prime Minister and Environment Minister have both described mainstream projections of climate change as "alarmist" (Kenny, 2007). The same message has featured in the major newspapers in both countries (Mitchell, 2007; Broad, 2007; Revkin, 2007). It is difficult to measure what impact such rhetorical cover has on the development of climate change policies, but it seems reasonable to presume that it can only act to slow implementation of such policies. This is the stated intention of some pro-fossil fuel lobby groups, who use the language of uncertainty and charges of alarmism to delay policies (Luntz, 2003; Karp, 2006). Given the stakes and level of politics, the debate over the discourse transcends mere semantics.

3. Is it catastrophic?

A catastrophe is a disaster, calamity, or great misfortune. As Hulme (2006) notes, whether an event is catastrophic or not is a matter of perspective ("Catastrophic for whom, for where, and by when?"), yet he believes that the notion of catastrophic climate change does not emerge from the science. Perhaps this might seem so if the question remains an abstract one, but climate change has real impacts. In particular, it will lead to the extinction of many species (Thomas et al., 2004) and submergence of low-lying island states (McCarthy et al., 2001; Barnett and Adger, 2003). From the perspectives of the lost species or nations, it is surely a catastrophe.

A focus on whole species or nations may be considered too parochial in some science discourse to warrant the label 'catastrophic'. We therefore take a global perspective on impacts in what follows. From a global perspective, one of the impacts of major concern is the melting of the Greenland and West Antarctic ice sheets. This is of concern because it represents a large sea level rise (about 7 and 5 m, respectively) and these ice sheets are considered to be potentially vulnerable to relatively small temperature increases (perhaps as low as 2 or 3 °C globally, O'Neill and Oppenheimer, 2002; Gregory et al., 2004; Hansen, 2005). Were they to melt, the 7 m of sea level rise from Greenland and 5 m from the West Antarctic would be liberated over a period as short as hundreds of years or as long as thousands of years. Conventional ice sheet models would say many hundred to thousands, while newer theories point out that conventional models neglect critical loss processes that would imply melting over perhaps only a few hundred years (Hansen, 2005). This amount of sea level rise would inundate the land and settlements of whole nations and hundreds of millions of people, and would be devastating for many coastal cities. If the rise occurred over a few hundred years, by any reasonable definition of the term, these impacts would be 'catastrophic'. If the rise occurred more slowly over thousands of years then there would be much more time to adapt to it and the use of the term would be more ambiguous.

4. Is it rapid?

To assess whether climate changes are 'rapid' or not, we need to measure them against relevant timescales for responding to the changes. If the timescales associated with climate change are given by τ_{cc} and those associated with a response are given by τ_{res}, then the changes are rapid if $\tau_{res} \geqslant \tau_{cc}$. In that case, the system changes more quickly than our ability to adapt or respond, and the impacts will be larger. For some systems such as agriculture, adaptive measures such as crop switching and management are typically fast relative to the speed of temperature changes, and thus the changes are not rapid. However, changes in rainfall may be more abrupt where the atmosphere seemingly switches from one regime to another over a period of years rather than decades (e.g. IOCI, 2002; Timbal, 2004). In that case, the changes could be rapid, even on the timescales of agricultural adaptation. Decadal scale climate changes would be abrupt from the perspective of water resources, where shifts in supply infrastructure and demand management take longer to implement (multiple decades). Climate change is expected to exacerbate drought and lead to rainfall declines in many mid-latitude continental regions (Houghton et al., 2001; Solomon et al., 2007). Extended droughts can be ruinous for some irrigated agriculture, as is currently evident in southeast Australia, for example (Marks, 2007). Such droughts and their impacts are frequently experienced as 'rapid' events because they are usually well underway before they are recognized and responses are initiated (Sadler, 2000; Risbey et al., 2007). Similarly, for impacts on species, the changes in temperature are too rapid for many of them to adjust, and they are being driven extinct (Thomas et al., 2004).

Impacts on agriculture, water resources, and species are among the more critical concerns about climate change. In each of these contexts, there will likely be many instances where climate changes are fast relative to the characteristic response times of the system. Thus, the term 'rapid' seems appropriate in these critical contexts.

5. Is it urgent?

The concept of urgency as it applies here relates to the prevention of a particular impact. In the simplest cases, a decision is urgent if the time span between the present time and the impact is similar to the time span required to prevent the impact from occurring once a decision has been made. In systems characterized by inertia (like the climate system), the impact may be committed to occurring well in advance of the time of the impact itself. In that case, the relevant timescales in defining urgency are the time span between the present time and the point when the impact is committed to occur, and the time needed to take action that avoids committing to the impact. As the former time span approaches the latter, the decision becomes increasingly urgent.

In the climate change case, there are many different impacts, which are more and less urgent. It is convenient to select a single large impact such as the melting of Greenland with concomitant sea level rise, since that is one of the main global-level concerns. We accept for the sake of argument that we need to keep the global warming below about 2 °C (from pre-industrial temperatures) to prevent wholesale melting of Greenland's ice. That means that we need to pursue carbon emissions trajectories that keep the concentration in the atmosphere low enough to avoid more than this temperature increase. At first glance it might seem that the impacts from melting of Greenland ice are well into the future (many hundreds of years), while the timescales for changing our energy, building, and transport infrastructure and emissions are much shorter than that—on the order of multiple decades to retire existing infrastructure and introduce newer forms. That is, the time required to prevent the impact seems short relative to the time span to the impact point and there appears to be no sense of urgency.

Unfortunately, this view of the problem neglects the various sources of inertia in the system. The operative timescale is not the time to impact, but the time until which the impact becomes effectively inevitable. In the climate system, there is inertia in both the translation from carbon emissions to warming, and from warming to ice sheet melting. The thermal inertia of the oceans delays the warming by multiple decades after emissions occur (Meehl et al., 2005). Once warming does occur, sea level rise due to ice melt is delayed by further centuries depending on assumptions about the melt processes. At any given point in time there is some amount of unrealized warming due to the thermal inertia of the oceans (converting current emissions to warming) and the inertia of the energy system in switching to non-carbon sources (converting future unavoidable carbon emissions to warming). This unrealized warming needs to be added to the present warming in order to arrive at the total warming already committed due to the human CO_2 emissions pulse. The inertias of the ocean and energy systems mean that we will be committed to a particular total warming well in advance of the point at which we observe it.

The relevant timescales for the ice sheet melt problem are depicted schematically in Fig. 1. The time span between the present time, $T_{present}$, and major sea level rise impacts from ice sheet melt is depicted as $\Delta T_{impacts}$. The time point at which the global scale warming is large enough to imply melting of the Greenland ice sheet is $T_{critical}$, and the point at which that critical warming is already committed to occur because of the inertia in the climate and energy systems is $T_{committed}$.

The relevant question is when will we reach the point ($T_{committed}$) that the committed warming is large enough to destabilize the Greenland and West Antarctic ice sheets (setting off irreversible melting)? The time at which we will be committed to a total warming of 2 °C varies depending on how sensitive the climate is, on how much inertia is in the climate (ocean) and energy systems, and on the emissions trajectory. Given the uncertainties (about all these quantities), the answer to this question can only be given in probabilistic terms. Some recent studies suggest that the likelihood of exceeding 2 °C increases rapidly over the next several decades, such that there will be low likelihood of staying below this value if major emissions reductions and transformation of the energy system and use do not commence within as little as a decade or so (Baer and Mastrandrea, 2006; Harvey, 2006; Hansen et al., 2007a). This period of time is not long compared to the timescales for political coordination and action needed to institute major carbon cuts and initiate a real shift toward a low-carbon energy system. The time available to make the decision before the impact (melting Greenland or the West Antarctic) is effectively inevitable is now comparable to the time needed to implement the decision. Thus, the decision is urgent.

In practice, the warming required to melt the Greenland and West Antarctic ice sheets may be larger than 2 °C. If it is much larger than 2 °C, then the available time to reduce emissions would be longer and the urgency would be diminished somewhat. However, paleoclimate evidence suggests that the value is not much larger (Hansen et al.,

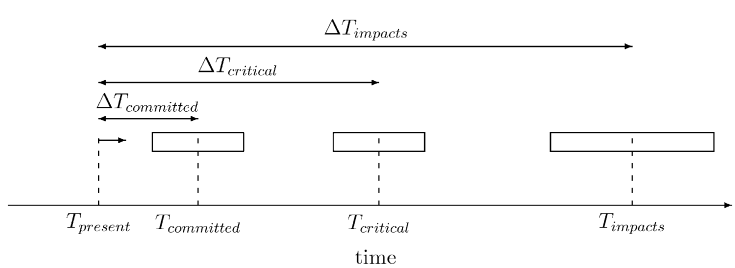

Fig. 1. Schematic diagram (not to scale) indicating key times in the process of producing a warming that melts the Greenland and/or West Antarctic ice sheets. The times shown are the present time, $T_{present}$; the time at which our energy system is effectively committed to producing a warming which is large enough to melt the ice sheet, $T_{committed}$; the time at which the critical global warming large enough to commit the ice sheet to melting is reached, $T_{critical}$; and the time at which the ice sheet has undergone significant melting to produce enough sea level rise to generate large impacts, $T_{impacts}$. The times, $T_{committed}$ and $T_{critical}$ are shown as boxes to denote the uncertainty about when they will occur. The time $T_{impacts}$ is shown as a box to denote uncertainty about when significant melt impacts will occur and to denote the fact that the impacts will extend through time.

2007a, b), and so the estimates of timescales given above are probably not too far off. In summary, though the major sea level rise impacts associated with a melting of the Greenland ice sheet would not be experienced for some few to many centuries, the point at which we may be 'locking in' these impacts is almost upon us.

6. Is it irreversible?

The answer to this question depends on the phenomenon we are looking at and the timescale over which we look. Some of the most salient features of the problem are the warming and sea level rise. The global-scale warming will persist for thousands of years, depending on how much CO_2 is ultimately emitted and on assumptions about the carbon cycle (Kasting, 1998). The sea level rise associated with the warming will persist even longer (Houghton et al., 2001). Compared to the normal timescales on which our societies plan and conceive events and reproduce, this timescale is effectively irreversible.

Focusing again on the Greenland and West Antarctic ice sheets, the melt process is thought to be reversible for moderate warmings, but irreversible once a given warming is reached (Gregory et al., 2004). Though there is argument about the precise point at which this would occur, that point is almost certainly within the realm of the projected 21st century warmings, given the response of ice sheets to periods of enhanced warmth in Earth history (Hansen et al., 2007a). Once the Greenland ice sheet is committed to melting, it could not be reconstituted for many thousands of years (Gregory et al., 2004). It is thus relevant and appropriate to refer to potentially irreversible changes in the Greenland ice sheet, sea level, and the climate system. Similarly, the notion of a 'tipping point' is quite consistent with the view that the Greenland and West Antarctic ice sheets may be 'locked in' to disintegrate once a certain level of committed warming has been reached.

7. Is it worse than we thought?

Whether climate change is worse than 'we' (the climate community) thought all depends on what we measure and what we thought. One basic measure of the problem has been the value of climate sensitivity, which is how much temperature increases for a doubling of CO_2 concentration. The prevailing estimates of this value have been stable for arguably a century since Arrhenius, with little change in the modern era of understanding (Handel and Risbey, 1992). While there may be a variety of reasons why this value has been stable (van der Sluijs et al., 1998), by this measure the problem is not worse than we thought. To be sure, recent studies have focused on the uncertainties of this quantity and some have pointed out that the upper bound may be higher than we thought (Andronova and Schlesinger, 2001; Piani et al., 2005; Torn and Harte, 2006). Others point to constraints from the paleoclimate record which limit the upper bound (Annan et al., 2005), though studies of the distant past also provide an indication of possible high climate sensitivity (Pagani et al., 2006).

Another key measure of the climate change problem is the pace of change of the climate system as indicated by warming and sea level rise rates. Temperatures have increased more or less in line with model predictions and expectations; however, they are toward the upper end of IPCC projections (Rahmstorf et al., 2007). The trend for sea level rise is more dramatic however. Sea level rise has been increasing at the very top of the range of projections, so it is 'worse' (higher) than our (IPCC) best guess expectations (Overpeck et al., 2006; Rahmstorf et al., 2007).

While observed rates of sea level rise are 'worse' than expected, what about projected rates of sea level rise? For this issue, we need to look again to ice sheet melt, particularly as the projections go further out in time. Views of the potential rate at which the Greenland and West Antarctic ice sheets could melt have become 'worse' with time (Zwally et al., 2002; Alley et al., 2005; Hansen, 2005; Overpeck et al., 2006; Hansen et al., 2007a). Traditional ice sheet models "generally do not incorporate all the physics that may be critical for the wet process of ice sheet disintegration, e.g. modelling of the ice streams that channel flow of continental crevasses and moulins, removal of ice shelves by the warming ocean, and dynamical propagation inland of the thinning and retreat of coastal ice" (Hansen et al., 2007a). As attention has shifted to these processes, and as more has been learned about sea level changes and ice sheets from the paleoclimate record, concern has risen that the timescales for ice sheet melt may be much shorter than previously thought (Alley et al., 2005).

Heightened concerns that dynamical processes could drive much more rapid breakdown of the ice sheets than simple surface melting are bolstered by recent observations. Luthcke et al. (2006) present results to suggest that loss processes associated with glacier acceleration and melting of Greenland's ice now exceed the gains due to increased snowfall over the interior. Though this result is not unexpected, it was not expected this early in the warming process (Alley et al., 2005). Similarly, paleo-research on sea level rises associated with past warming periods shows some rates of change that are much faster than current projections (Overpeck et al., 2006). Finally, projections of sea level rise based on empirical sea-level/temperature relationships also project faster rates of rise for the 21st century than IPCC estimates (Rahmstorf, 2007).

Another key dimension of the climate change problem is the rate at which carbon emissions and CO_2 concentrations are increasing. These variables indicate how fast we are forcing the climate system. Here too, recent results show that the problem may be worse than previously thought. UNESCO-SCOPE (2006) report that the growth rate of carbon emissions has surpassed 2.5%/year in recent years, whereas it was less than 1%/year in the 1990s. Current carbon emissions are now on or exceeding the most extreme emissions scenario set out in the 2001 IPCC report (Nakicenovic et al., 2000). Similarly, the rate at which CO_2 concentrations are growing is now above 2 ppm/year, which is a "significant increase from earlier trends" (UNESCO-SCOPE, 2006; Raupach et al., 2007), though only just above the range of IPCC projections (Rahmstorf et al., 2007). UNESCO-SCOPE (2006) note that "current emissions are growing much faster than rates required for stabilization at either 450 or 650 ppm". The slow start to emissions reductions and the inertia of the system make CO_2 concentration targets that once seemed prudent harder to reach (Baer and Mastrandrea, 2006).

Emissions of greenhouse gases may also increase as a result of the warming itself. There have long been concerns that the warming would liberate methane (and carbon dioxide) from methane hydrates in ocean sediments and some high latitude land areas (Schmidt and Shindell, 2003). The amount of climate forcing from hydrate release may be large, though the actual amount of forcing and processes related to timing are still very uncertain. Recent research indicates that hydrate deposits are perhaps at shallower levels of the ocean sediment than previously thought, and thus potentially more unstable than once thought (Witze, 2006).

While views of whether climate change is 'worse than we thought' are invariably mixed, for the key indicators of sea level rise measurements and projected rates of change of sea level, there are reasonable grounds for saying that the problem is indeed 'worse' than we thought. In addition, recent rates of increase of carbon emissions are also higher than expected. Taken together, it is not overstating the case to say that the problem is worse than the community thought it was just a few years ago.

8. Is it chaotic?

In the popular vernacular, the term 'chaos' implies creation of confusion and uncertainty about rules and norms governing societal interactions. Would the impacts from climate change be severe enough to create this kind of confusion and uncertainty? Projections of sea level rise over the next few centuries will be more or less severe depending on the climate sensitivity, the amount of carbon emitted, and the response of the Greenland and West Antarctic ice sheets. If the rise is on the low and slow end of projections (a few millimetres a year (fractions of a metre/century) as projected in IPCC's 2001 assessment), then one hopes there will be sufficient time to adapt to many of the impacts. However, it is quite possible that changes in sea level could be more rapid and on the higher end of projections (Hansen et al., 2007a).

The paleoclimate record indicates periods in Earth's history during interglacials when warming-induced ice sheet melting drove rapid sea level rises. Overpeck et al. (2006) cite rates of 1 m/century for the last deglaciation ($\sim$10, 000 years ago) and perhaps 2 m/century for the previous interglacial ($\sim$120, 000 years ago), while Weaver et al. (2003) note a multi-century meltwater pulse during the last deglaciation of 5 m/century. These empirical rates are an order of magnitude faster than IPCC projections. They obtained during periods of larger continental ice mass, but smaller climate forcing than present conditions, which could make them over or underestimates. The temperature during these interglacials was only moderately warmer than at the present time (Hansen et al., 2007a). These rates of sea level rise would result in displacement of hundreds of millions of people. It is possible that the displacement and resettlement of people could be achieved in an orderly manner (Byravan and Rajan, 2006), but the track record of refugee displacement and resettlement suggests that it will not.

In practice, although the sea level rise would be more or less steady, the worst impacts often come in sudden storm surge events when not expected. The ensuing calamity would create conditions of shock, confusion, and uncertainty about the future in the regions where such events occur and beyond (e.g. Homer-Dixon, 1994). Should coastal dwellers return to their lands after storm surges recede? Will they be supported by the State when they do so? Will they return anyway? Will they migrate into neighbouring areas or countries? What will their legal status be? How will they be accepted? What impacts will they have on the resources and culture of regions in which they arrive in large numbers? Will States be able to provide minimal health requirements for displaced peoples? These questions illustrate the manner in which sudden large-scale displacements of populations could create confusion and uncertainty. Further, climate change-induced displacements will often occur in regions where existing support systems are already stressed due to environmental and social deprivation and degradation, thereby increasing the impacts.

While we do not know for sure whether sea level will rise as rapidly as the above cited rates or not, there are very good reasons to be concerned that it may (the current higher than expected rate of rise and the evidence for very high rates of rise during past periods of ice sheet collapse). It thus seems reasonable to speak of 'chaos' as a plausible feature of climate change, though the uncertainty about rates of sea level rise means that it is still somewhat ambiguous.

9. Is it science?

Hulme (2006) says that the "language of catastrophe is not the language of science" and that to "state that climate change will be 'catastrophic' hides a cascade of value-laden assumptions which do not emerge from empirical or theoretical science". Yet the terms that he associates with this discourse: 'catastrophic', 'rapid', 'urgent', 'irreversible', 'worse than we thought', and 'chaotic' all seem to be fairly consistent and reasonable descriptors of the phenomenon of climate change and some of its key impacts. Empirical and theoretical science does contain these terms to describe climate change. A search of any of the standard science databases yields thousands of 'hits' for these terms when combined with 'climate change'. Of course, this is a crude counting metric, but the point stands that the scientific discourse is no stranger to these terms to describe climate change. The use of terms like the above in the modern climate literature begins at least from the first papers describing possible melt of the West Antarctic ice sheet as a "threat of disaster" (Mercer, 1978) and continues through contemporary assessments describing the kinds of "non-linear climate responses" outlined here as potentially "catastrophic" (Mitchell et al., 2006).

If the scientific community is not able to use terms such as 'catastrophic', 'rapid', 'urgent', 'irreversible', and 'worse than thought' when describing the impacts of significant phenomena, then we would not be able to communicate accurate information about the degree of threat, the rapidity and imminence of the threat, on whether and when the threat can be ameliorated, or on changes in our understanding of the threat. Scientific communication stripped of terms that describe these features of a problem might be less value-laden, but it would fall short in conveying some of the fundamental information needed to make informed judgements about the threat. There is a tendency among scientists to criticize terms describing the degree of a threat as value-laden only when the terms describe severe impacts ('catastrophic', 'rapid', 'irreversible'), and not when the terms convey moderate impacts. One rarely sees complaints about scientists being value-loaded for describing impacts as 'mild' for example. This asymmetry in use of the charge of 'value-loading' is a form of scientific reticence (Hansen, 2007) and weakens scientific communication in the face of actual threats to the public.

Surely the issue is not whether the climate community can use such terms as those above, but whether they are reasonable descriptors according to our understanding of the science and the nature and context of the impacts. There must be an element of judgement in deciding precisely which term to use, but that does not render the use of such terms 'unscientific'. If it does, then for consistency, terms describing moderate impacts must also be rendered 'unscientific', and there is no scope for communication.

10. Is it counterproductive?

In some circumstances it may be counterproductive to describe a threat in accurate terms. Hulme charges that the language of contemporary climate discourse, "fear and terror", operates "as an ever-weakening vehicle for effective communication or inducement to behavioural change". He notes that fear has been shown to be a poor motivator of behavioural change in the public health arena. This is true up to a point. Fear on its own is a poor motivator for change. If people are exhorted on the basis of fear, but are given no alternatives, then they tend not to respond. The key is whether alternative courses of action are provided that are accessible to people and can serve as effective means to reduce the threat (Moser and Dilling, 2007). When people are given full and open information about a threat and are included in the processes of defining and reacting to it, they are more likely to engage than if given partial information or limited roles and responsibility (Jasanoff and Wynne, 1998). The critical factor is not the threat itself (fear), but whether it is conveyed in a credible and trustworthy way, along with credible, effective, and fair means of redress.

In the climate change case there are many practical and accessible actions which people, institutions, industry, and states can take to reduce the threat. Many green groups are well aware of this and have been careful to provide positive 'greenhouse' alternatives for home and work and at local and national levels (Australian Greenhouse Office, 2007). Many of them have been working for decades to get this information into the public domain and to promote sustainable energy pathways and systems (Gough and Shackley, 2001). They have adopted the approach that we need to take an honest reckoning of the threat and pursue the appropriate means to diminish it. While there are always some who exaggerate the threat (and some who underplay it), that does not mean that the scientific measure of the threat is not appropriately described by the terms discussed here. Providing an honest reckoning of the problem and solutions presents hard choices and challenges, but it can and is being done by some in a way that provides credible, fair, and effective paths forward.

11. Who and what divides the discourse?

In this section we take up the questions of who stands either side of the divide in climate discourse and what it is that divides them. As Hulme (2006) sees it, the divide in the discourse is between reasoned science and alarmism, with climate scientists on one side and green 'climate alarmists' on the other. The green 'alarmists' are characterized as seeking to "amplify climate change risks" in order to influence climate policy. This particular divide would be meaningful if those brandishing the terms of the new discourse ('catastrophic', 'rapid', 'irreversible', 'urgent', 'worse than we thought', 'chaotic') were departing from the science. This review has shown that the terms are broadly consistent with the science. However, there are clearly some reputable climatologists (Revkin's, 2007 "invisible middle") who do not think these terms are consistent with the science. It seems therefore that at least part of the divide is amongst climatologists themselves.

Since climatologists have a range of views about the severity of climate change, it is natural that some would embrace the terms above and some would not. There is broad agreement among practicing climatologists of the reality of the problem (Oreskes, 2004), but the usual heterogeneity in any population sample leads to differences in emphasis and orientation. That heterogeneity underlies the divide in the discourse, but it does not explain it.

In order to explain it, we need to ask whether there are structural factors about the way the research is carried out, or paradigmatic features of it, that lead some to adopt one stance, and some another.

One possible structural reason for the divide is that climatologists, by and large, do not work on the whole problem of climate change. In order to appreciate the urgency of the current predicament, one must work the problem from end to end. This entails an understanding of the climate response to greenhouse forcing, the dynamics of ice sheet responses to warming and past climate changes, the technical and social nature of the energy system and its response to political and economic forces and instruments, and an understanding of the carbon cycle and its response to future energy emissions scenarios. While there are many who do work to put the various pieces together, most climatologists are working in only one subdomain of this cycle. This is not a criticism of climatologists. If everyone worked on the whole problem, there would presumably be little progress in each of the detailed subdomains. However, it is a feature of the division of labour within the community, and that division may, by way of focus, hinder some from seeing how the relevant timescales of the problem interact to create a sense of urgency.

The paradigmatic reasons for the divide are harder to discern, but there seem to be a couple of different factors that are particularly relevant to this issue. The first one is a classic paradigm split in the sense described by Kuhn (1996) between 'old' and 'new' paradigms of ice sheet disintegration. When the IPCC wrote their 2001 report (Church et al., 2001), the prevailing expectation was that ice sheet breakdown would occur on millenial timescales (the 'old' paradigm). That view is now being challenged by the view put forward by Hansen (2005), Overpeck et al. (2006), and others, that the appropriate timescales for wet melt breakdown of the Greenland and West Antarctic ice sheets in response to sustained greenhouse forcing may be on the order of only a few centuries. Since the different paradigms of ice sheet melt imply different degrees of urgency, this split alone could account for much of the divide among climatologists.

Paradigm splits are rarely cleanly resolved. However, the weight of support for one or other paradigm tends to shift through time (Kuhn, 1996). While it is healthy to be skeptical of any new theory (Lakatos, 1977), we might expect the IPCC to be relatively slow to accept the implications of the rapid ice sheet breakdown paradigm. The IPCC are an authoritative institution, and as such, are naturally cautious in adopting any new or revised theory (Hansen, 2007). The authority and size of the IPCC as an institution mean that it has its own time constant for 'digesting' the science, which may span a publication cycle (5 years) or two. Furthermore, the IPCC is a quintessential 'expert' authority. Experts tend to display overconfidence in their predictions and projections of change. Because they are overconfident, experts tend to underestimate uncertainties, whether the issue is laboratory science (Henrion and Fischhoff, 1986) or energy projections (Keepin, 1986). The 2001 IPCC report underestimates uncertainties associated with trends in key climate variables: temperature, sea level (Rahmstorf et al., 2007), and carbon emissions (UNESCO-SCOPE, 2006). The tendency to underestimate uncertainties can 'cut both ways' in that the 'true' result may be more or less extreme than the overconfident estimate. In this case, however, the uncertainties are asymmetric in that they would mostly act to make sea level rise rates much faster than the IPCC estimates. That is, the inclusion of the uncertain dynamical processes can only accelerate sea level rise relative to the IPCC projections (Church et al., 2001; Solomon et al., 2007), which are based on surface melt rates only.

The second paradigm issue relates to the time frame over which people tend to implicitly view the climate change problem. Through a series of three major reports (Houghton et al., 1990; Houghton et al., 1996; Houghton et al., 2001), the IPCC has tended to frame the climate change problem about the time interval out to the year 2100. Most IPCC projections and analyses extend to the year 2100 and then stop. This practice has inadvertently promoted a '2100ism' paradigm in which other studies have adopted the same time frame, and views of climate impacts have been shaped by the expectations over this period. Note for example that Hulme (2006) cites IPCC projections of warming out to the year 2100 to describe the greenhouse problem.

The reasons why the IPCC might have chosen to limit much of their analysis to the period up to the year 2100 seem sensible enough. First, past about 2100 the warmings simulated in the climate models start to become very large for the standard emissions scenarios (Nakicenovic et al., 2000)—many standard deviations outside current variability (Hansen et al., 2007a). That is such a large change that it constitutes effectively a different climate system, whereas the models have been developed to study mostly small changes about the present climate state (as is implicit with the process of 'tuning'). Second, limiting the timescale to 2100 is convenient for analysis and seems to be a long enough range view that it takes key impacts and human planning timescales into account. Combining '2100ism' with the traditional ice sheet melt view, significant melting and sea level rise is a millennium off and has little import for the decisions made in the next few decades.

In practice, warming and sea level rise will continue well beyond 2100. And even the warming quoted at 2100 is the transient warming only, and so does not include the committed, but unrealized, warming to that point. However, the largest shortcoming of '2100ism' is that it obscures the connection between impacts beyond 2100 and policy actions in the present period. If the Greenland and West Antarctic ice sheets are subject to significant melt for temperature increases of as little as a couple of degrees, then there is only a relatively small additional carbon allotment to the atmosphere that would likely keep temperature increases below that level. That allotment is less than the equivalent of another 100 ppm of CO_2 concentration (Hansen et al., 2007a). To put this amount in perspective, Archer (2006) notes that we would need to keep total anthropogenic carbon emissions below about 570 Gton, and have already released about 300 Gton. Because of the inertia in the energy system, carbon reductions, efficiency improvements, and shifts away from the coal-intensive energy infrastructure need to commence in the near term if the remaining carbon allotment is not to be exceeded. Thus, present actions are key determinants of long term impacts.

While this is not a difficult concept to understand, it does not fit well within the '2100ism' view that has tended to assume implicitly that the changes will be slow, 'linear', and effectively reversible. Of course, this is not to say that the IPCC promotes the view that climate change is slow and linear and that impacts beyond 2100 are not related to near term energy infrastructure decisions. Rather, the IPCC has adopted a framework of viewing the problem, by and large, till 2100, and that view in turn has not directed attention to the kinds of issues and analysis that show the problem in a more serious light.

While '2100ism' does not connect present emissions and present emissions policy with distant impacts, there is another school of thought which does explicitly do this. The argument, which we might call 'little effect', takes on various forms, but goes back at least to Schlesinger and Jiang (1991). They note that a small delay in the time at which emissions reductions commence leads to only a very small change in global temperature or sea level rises at points in the distant future relative to the case where the reductions commence now. A contemporary variant of this argument is put forward by Pielke (2006), who notes that "a relatively small percentage reduction in global emissions will not lead to detectable real world outcomes with respect to sea level rise". While these statements are more or less true (because, generally speaking, large reductions are necessary to make a difference), they also create the misleading impression (or at least rhetorical cover for those who claim) that there is not much point to small emissions reductions or to reducing emissions now.

While this logic might once have been sound, it begins to break down as we approach the point where we have only a finite amount of carbon left to emit to avoid ice sheet melt down and only a finite amount of time to shift the energy system in a manner that will avoid emitting that amount of carbon. If the timescale required to shift the energy system is as short as decades, then we no longer have the luxury of waiting to institute reductions. A delay may make the difference between reaching or not reaching the critical temperature increase for irreversible ice sheet melting. Further, any large shift in the energy system will necessarily be composed of numerous and diverse initiatives, any one of which will be small on their own in terms of carbon reduction. If we do not make the changes because the net affect of any one of them is small, then we would have no hope of limiting the warming to levels that would not threaten ice sheet breakdown. The logic of 'little effect' is self-defeating, and increasingly flawed when distant impacts cannot be decoupled from present actions.

12. Discussion

The contemporary public climate discourse now contains a number of distinct threads representing different views of the seriousness of the problem. Ereaut and Segnit (2006) have identified three such threads in the discourse in the UK. They call these threads "alarmism", "settlerdom", and "small actions". They characterize "alarmism" as a discourse where climate change is immense and beyond our control. "Settlerdom" is a discourse that dismisses climate change as a serious issue. Settlerdom downplays the science and sees policy responses as economically burdensome. The "small actions" discourse promotes the notion that small, easy to implement changes can be effective in solving the problem. Ereaut and Segnit (2006) question the efficacy of any of these discourses to effectively address the climate change problem, since each, in their own way, foster inaction (through fear, dismissal, or by trivializing the issue, respectively). The recent articles by Hulme (2006) and others are directed at the "alarmist" strand of Ereaut and Segnit's (2006) discourses. Significantly though, these articles do not differentiate between an alarmist and alarming discourse, and, like Ereaut and Segnit (2006), see all descriptions of climate change that depict impacts in severe terms as alarmist.

By arguing that the scientific view of climate change can legitimately be seen as alarming, rather than alarmist, we see the need for, and emergence of, a fourth thread in the discourse. The emergence of the fourth thread can be seen in the writings of Hansen (2005), Baer and Mastrandrea (2006), Hansen (2006), Harvey (2006, 2007), Bierbaum et al. (2007), Hansen et al. (2007a, b), and Monbiot (2007) for example. The fourth thread sees climate change as alarming if action is not taken soon. In this view, climate change looms large, but there is still time to take actions to avert larger changes. However, the large reductions in carbon emissions required to avert those changes will entail comprehensive responses, small and large. This entails a fundamental restructure in the way we generate and use energy. This discourse thus differs from "alarmism" in that the problem is not viewed as out of control or inevitable, and it differs from "small actions" in that responses must be comprehensive. This discourse recognizes both the possibility of large climate change and the means of preventing it. The discourse is "alarming" in that it sounds an alarm to alert the public to the need to change course.

13. Conclusions

The climate discourse is changing to reflect more grave assessments of the problem in recent years. Some climatologists think that shift is concordant with science community understanding of the nature of the problem ('alarming'), and some think that the shift is rhetorical and inconsistent with the science ('alarmist'). This review of the language of the new discourse has focused on terms selected by a critic of the discourse and finds that the terms used to describe the science are at least arguably reasonable and consistent with it. That is, the view of the discourse as 'alarming' is not inconsistent with the science. Nevertheless, a divide exists, and that divide is reflected in part within the community of climatologists.

Climatologists are split over the urgency of the problem. One of the principal reasons for urgency relates to the possibility that warming will reach the point that the breakdown of the Greenland and West Antarctic ice sheets is inevitable, implying large sea level rise. Opinion is divided over whether this will be a relatively slow process spanning millenia or a relatively quick process spanning centuries. Because much of the relevant dynamics of ice sheet breakdown have not been incorporated into the models yet, the timescales for rapid breakdown are not well known, but can only be faster than IPCC estimates.

Regardless of which view of the relevant timescale of ice sheet breakdown is correct, the amount of warming required to initiate irreversible breakdown of Greenland or the West Antarctic is thought to be only a moderate couple of degrees above pre-industrial global temperature levels. Because of the inertia of the climate and energy systems, we are fast approaching the point at which our energy-industrial system is committed to reaching that critical level of warming. Here again, there are considerable uncertainties, though the few studies that have looked systematically at this issue have concluded that the available window of action to shift the emissions trajectory sufficiently far downward to avoid locking in that warming is perhaps as short as a decade or two.

Taken together, the view of climate change that emerges in this review of the science and discourse on alarm indicates the emergence of a new "alarming" discourse. The salient features that characterize this discourse are as follows:

- With present forms of energy generation, built infrastructure, and transportation modes, we will soon be committed to reaching CO_2 concentrations that would yield a high probability of warming a couple of degrees above pre-industrial levels.
- That level of warming would likely bring severe climate impacts, particularly those associated with ice sheet melt and sea level rise.
- It is feasible to stabilize CO_2 concentrations below or close to that level.
- This does not require radical new technologies and can be achieved with existing technologies, but it does require large cuts and changes in the way we generate and use energy.
- Because of the inertia in the energy system and built infrastructure, the transition to more energy efficient infrastructure and phase out of carbon sources must begin very soon to achieve the required stabilization of CO_2.

The 'alarming' discourse takes a firm view in regard to both problem and solution. While climatologists may be divided about the degree of urgency that should be reflected in the climate discourse, the stakes are high. Shooting the messengers is not going to solve the problem. We need to develop as good a sense of the threat as we can get in the limited time available and choose a discourse that sets the appropriate course.

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References

Alley, R., Clark, P., Huybrechts, P., Joughin, I., 2005. Ice-sheet and sea-level changes. Science 310 (5747), 456–460.

Andronova, N., Schlesinger, M., 2001. Objective estimation of the probability distribution for climate sensitivity. Journal of Geophysical Research 106, 22,605–22,612.

Annan, J., Hargreaves, J., Ohgaito, R., Abe-Ouchi, A., Emori, S., 2005. Efficiently constraining climate sensitivity with ensembles of paleoclimate simulations. SOLA 1 (1), 181–184.

Archer, D., 2006. How much carbon dioxide emission is too much? Real Climate Blog, 6 November ⟨http://www.realclimate.org/index.php/archives/2006/11/how-much-co2-emission-is-too-much/#more-368⟩.

Australian Greenhouse Office, 2007. Cool communities. ⟨http://www.greenhouse.gov.au/local/about/index.html⟩.

Baer, P., Mastrandrea, M., 2006. High stakes: designing emissions pathways to reduce the risk of dangerous climate change. Technical Report, The Institute for Public Policy Research, London, 37pp.

Barnett, J., Adger, W.N., 2003. Climate dangers and Atoll countries. Climatic Change 61 (3), 321–337.

Bierbaum, R., Holdren, J., MacCracken, M., Moss, R., Raven, P. (Eds.), 2007. Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable. United Nations Foundation, Washington, DC, 144pp.

Broad, W., 2007. From a rapt audience, a call to cool the hype. The New York Times, 13 March.

Byravan, S., Rajan, S.C., 2006. Providing new homes for climate change exiles. Climate Policy 6 (2), 247–252.

Church, J., Gregory, J., et al., 2001. Changes in Sea level. In: Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK, pp. 639–693, (Chapter 12; 881pp).

Cox, S., Vadon, R., 2006. A load of hot air? BBC News, 20 April ⟨http://news.bbc.co.uk/2/hi/uk_news/magazine/4923504.stm⟩.

Ereaut, G., Segnit, N., 2006. Warm words: how are we telling the climate story and can we tell it better? Technical Report, Institute for Public Policy Research, London, 32pp.

Ghosh, P., 2007. Caution urged on climate 'risks'. BBC News, 17 March ⟨http://news.bbc.co.uk/2/hi/6460635.stm⟩.

Gough, C., Shackley, S., 2001. The respectable politics of climate change: the epistemic communities and NGOs. International Affairs 77 (2), 329–345.

Gregory, J., Huybrechts, P., Raper, S., 2004. Threatened loss of the Greenland ice-sheet. Nature 428, 616.

Guggenheim, D., 2006 . An inconvenient truth. Paramount Classics. Documentary Film.

Handel, M., Risbey, J., 1992. An annotated bibliography on the greenhouse effect and climate change. Climatic Change 21 (2), 91–255.
Hansen, J., 2005. A slippery slope: how much global warming constitutes 'dangerous anthropogenic interference'? An editorial essay. Climatic Change 68 (3), 269–279.
Hansen, J., 2006 . Expert report submitted to the United States District Court, District of Vermont in regard to case no. 2:05-cv-302 and 2:05-cv-304, Green Mountain Chrysler-Plymouth-Dodge-Jeep et al. v. Thomas W. Torti, Secretary of Vermont Agency of Natural Resources et al. Technical Report, District of Vermont.
Hansen, J., 2007. Scientific reticence and sea level rise. Environmental Research Letters 2, 1–6.
Hansen, J., et al., 2007a. Dangerous human-made interference with climate: a GISS model study. Atmospheric Chemistry & Physics 7, 2287–2312.
Hansen, J., Sato, M., Kharecha, P., Russell, G., Lea, D., Siddall, M., 2007b. Climate change and trace gases. Philosophical Transactions of the Royal Society A 365, 1925–1954.
Harper, T., 2007. Scientists threatened for 'climate denial'. London Telegraph, 11 March.
Harvey, L.D., 2006. Uncertainties in global warming science and near-term emission policies. Climate Policy 6 (5), 573–584.
Harvey, L.D., 2007. Cutting the fossil fuel umbilical cord. Ideas 3 (1), 6–9 U. Toronto Arts and Sciences, Toronto.
Henrion, M., Fischhoff, B., 1986. Assessing uncertainty in physical constants. American Journal of Physics 54 (9), 791–798.
Homer-Dixon, T., 1994. Environmental scarcities and violent conflict: evidence from cases. International Security 19 (1), 5–40.
Houghton, J.T., Jenkins, G., Ephraums, J. (Eds.), 1990. Climate Change: The IPCC Scientific Assessment. Cambridge University Press, Cambridge, UK, 365pp.
Houghton, J.T., et al. (Eds.), 1996. Climate Change 1995: The Science of Climate Change. Cambridge University Press, Cambridge, UK, 572pp.
Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (Eds.), 2001. Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK, 881pp.
Hulme, M., 2006. Chaotic world of climate truth. BBC News, 4 November ⟨http://news.bbc.co.uk/2/hi/science/nature/6115644.stm⟩.
IOCI, 2002. Climate variability and change in south west Western Australia. Technical Report, Indian Ocean Climate Initiative, Perth, Australia, 43pp.
Jasanoff, S., Wynne, B., 1998. Science and decisionmaking. In: Human Choice and Climate Change. vol. 1: The Societal Framework. Batelle Press, Columbus, pp. 1–87. (Chapter 1; 491pp).
Karp, M., 2006. The denial machine. ⟨http://www.cbc.ca/fifth/denialmachine/⟩. CBC-TV, Canada, 15 November.
Kasting, J., 1998. The carbon cycle, climate, and the long-term effects of fossil fuel burning. Consequences 4 (1), 15–27.
Keepin, W., 1986. Review of global energy and carbon dioxide projections. Annual Review of Energy 3 (11), 357–392.
Kenny, M., 2007. Turnbull slams 'fear campaign' on climate. The Advertiser, 8 February.
Kuhn, T., 1996. The Structure of Scientific Revolutions, third ed. University of Chicago Press, Chicago. 212pp.
Lakatos, I., 1977. The Methodology of Scientific Research Programmes: Philosophical Papers, vol. 1. Cambridge University Press, Cambridge, UK, 258pp.
Luntz, F., 2003. The environment: a cleaner, safer, healthier America. Technical Report, The Luntz Research Companies, Washington, Straight Talk, pp. 131–146.
Luthcke, S., Zwally, H., Abdalati, W., Rowlands, D., Ray, R., Nerem, R., Lemoine, F., McCarthy, J., Chinn, D., 2006. Recent Greenland ice mass loss by drainage system from satellite gravity observations. Science 314 (5803), 1286–1289.
Marks, K., 2007. Australia's epic drought: the situation is grim. The Independent, 20 April.
McCarthy, J., Canziani, O., Leary, N., Dokken, D., White, K. (Eds.), 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge, UK, 1032pp.
Meehl, G., Washington, W., Collins, W., Arblaster, J., Hu, A., Buja, L., Strand, W., Teng, H., 2005. How much more global warming and sea level rise. Science 307, 1769–1772.
Mercer, J., 1978. West Antarctic ice sheet and CO_2 greenhouse effect: a threat of disaster. Nature 271 (5643), 321–325.
Mitchell, C., 2007. Keeping the message cool on climate. The Australian, 9 February.
Mitchell, J., Lowe, J., Wood, R., Vellinga, M., 2006. Extreme events due to human-induced climate change. Philosophical Transactions of the Royal Society A 364 (1845), 2117–2133.
Monbiot, G., 2007. Heat: How to Stop the Planet from Burning. South End Press, Boston, 277pp.
Moser, S.C., Dilling, L., 2007. Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change. Cambridge University Press, Cambridge, 576pp.
Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., et al., 2000. Special Report on Emissions Scenarios: A Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 599pp.
O'Neill, B., Oppenheimer, M., 2002. Dangerous climate impacts and the Kyoto Protocol. Science 296, 1971–1972.
Oppenheimer, M., 2005. Defining dangerous anthropogenic interference: the role of science, the limits of science. Risk Analysis 25 (6), 1399–1407.
Oreskes, N., 2004. Beyond the ivory tower: the scientific consensus on climate change. Science 306 (5702), 1686.
Overpeck, J., Otto-Bliesner, B., Miller, G., Muhs, D., Alley, R., Kiehl, J., 2006. Paleoclimatic evidence for future ice-sheet instability and rapid sea-level rise. Science 311 (5768), 1747–1750.
Pagani, M., Caldeira, K., Archer, D., Zachos, J., 2006. An ancient carbon mystery. Science 314 (5805), 1556–1557.
Piani, C., Frame, D., Stainforth, D., Allen, M., 2005. Constraints on climate change from a multi-thousand member ensemble of simulations. Geophysical Research Letters 32 (23), 1–5.
Pielke, Jr., R., 2006. Quick reactions to arguments today before the Supreme Court on Mass. vs. EPA. Prometheus blog, 29 November. ⟨http://sciencepolicy.colorado.edu/prometheus/⟩.
Rahmstorf, S., 2007. A semi-empirical approach to projecting future sea-level rise. Science 315 (5810), 368–370.
Rahmstorf, S., Cazenave, A., Church, J., Hansen, J., Keeling, R., Parker, D., Somerville, R., 2007. Recent climate observations compared to projections. Science 316 (5825), 709.
Raphael, E., Hardaker, P., 2007. Making sense of the weather and climate: an introduction to forecasts and predictions of weather events and climate change. Technical Report, Sense about Science, London, 16pp.
Raupach, M., Marland, G., Ciais, P., LeQuéré, C., Canadell, J., Klepper, G., Field, C., 2007. Global and regional drivers of accelerating CO_2 emissions. Proceedings of the National Academy of Sciences, USA, pp. 1–6 (doi:10.1073/pnas.0700609104).
Revkin, A., 2007. Middle stance emerges in debate over climate. New York Times, 1st January.
Risbey, J., 2006. Some dangers of 'dangerous' climate change. Climate Policy 6 (5), 527–536.
Risbey, J., Hamza, K., Marsden, J., 2007. Use of climate scenarios to aid in decision analysis for interannual water supply planning. Water Resources Management 21 (6), 919–932.
Sadler, B., 2000. Informed adaptation to a changed climate state: is south-western Australia a national canary? Report, Indian Ocean Climate Initiative, Australia.
Schlesinger, M., Jiang, X., 1991. A phased-in approach to greenhouse-gas-induced climatic change. Eos Transactions—American Geophysical Union 72 (53), 593–596.
Schmidt, G., Shindell, D., 2003. Atmospheric composition, radiative forcing, and climate change as a consequence of a massive methane release from gas hydrates. Paleoceanography 18 (1), 1004.

Schrader-Frechette, K., 1984. Science Policy, Ethics, and Economic Methodology: Some Problems of Technology Assessment and Environmental Impact Analysis. Reidel, Dordrecht, 322pp.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., Tignor, M., Miller, H. (Eds.), 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 996pp.

Thomas, C., Cameron, A., Green, R., Bakkenes, M., Beaumont, L., Collingham, Y., Erasmus, B., Siqueira, M., Grainger, A., Hannah, L., Hughes, L., Huntley, B., Jaarsveld, A.V., Midgley, G., Miles, L., Ortega-Huerta, M., Peterson, A., Phillips, O., Williams, S., 2004. Extinction risk from climate change. Nature 427, 145–148.

Timbal, B., 2004. Southwest Australia past and future rainfall trends. Climate Research 26 (3), 233–249.

Torn, M., Harte, J., 2006. Missing feedbacks, asymmetric uncertainties, and the underestimation of future warming. Geophysical Research Letters 33 (10), doi:10.1029/2005GL025540.

UNESCO-SCOPE, 2006. The global carbon cycle. UNESCO-SCOPE Policy Briefs, vol. 2. Paris.

van der Sluijs, J., Eijndhoven, J., Shackley, S., Wynne, B., 1998. Anchoring devices in science for policy: the case of consensus around climate sensitivity. Social Studies of Science 28 (2), 291–323.

Weaver, A., Saenko, A., Clark, P., Mitrovica, J., 2003. Meltwater pulse 1A from Antarctica as a trigger of the Bølling-Allerød warm interval. Science 299 (5613), 1709–1713.

Witze, A., 2006. Shallow fuels bring bad news: buried deposits of greenhouse gases may be more unstable than thought. Published online: doi:10.1038/news061211-6 (news@nature.com).

Zwally, H., Abdalati, W., Herring, T., Larson, K., Saba, J., Steffen, K., 2002. Surface melt-induced acceleration of Greenland ice-sheet flow. Science 297 (5579), 218–222.