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 urgency of the problem. The divide in the discourse 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', and 'worse than previously thought'. Though all these terms are imprecise and may convey a range of meaning, they are consistent with the science. Factors which divide climatologists on this discourse are also reviewed. The divide over a sense of urgency relates to a paradigm split 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.

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. 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 our 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. 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. Thus, a further goal is to present some of the reasons for that case.

According to the New York Times (Revkin, 2007), the view of climate change portrayed in documentaries like “An Inconvenient Truth” 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.

In that opinion piece, 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 fear-mongering 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 and portrayals 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 isn’t much point in being over-precise 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. The paper then concludes with an assessment of who stands either side of the divide in the discourse, and what it is that divides them. First, we address the claim that climate change is ‘catastrophic’.

2 Is it catastrophic?

As Hulme 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 ice sheet. This is of concern because it represents a large sea level rise (about 7m) and is considered to be potentially unstable to relatively small temperature increases [perhaps as low as 2 or 3°C globally (Gregory et al., 2004; Hansen, 2005)]. The 7m of sea level rise from Greenland would be liberated over a period spanning a count in hundreds 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. By any reasonable definition of the term, these impacts would be 'catastrophic'.

3 Is it rapid?

To assess whether climate changes are 'rapid' or not, we need to measure them against relevant time scales for responding to the changes. If the time scales 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 $\tau_{res} \geq \tau_{cc}$. 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; Risbey et al., 2007)]. In that case, the changes could be rapid, even on the time scales of agricultural adaptation. Such changes would also be abrupt from the perspective of water resources, where shifts in supply infrastructure and demand management take longer to implement (multiple decades). For many species, the changes in temperature are too rapid for 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.

4 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 time scales 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.

The relevance of the 'commitment time' in this definition might be clearer with a simple example. Suppose that we are piloting a ship through the fog that may be on a collision course with an object and must stop to prevent the collision. Further suppose that the ship is a supertanker that requires fifteen minutes to stop. The decision to stop the tanker becomes urgent, not as it approaches the point of impact, but as it approaches the committment point that is 15 minutes from the impact. Beyond this point, the decision to stop the tanker is now moot (beyond urgent) as the impact can no longer be avoided.

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 concerns. We accept for the sake of argument that we need to keep the global warming below about 2°C 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 time scales for changing our energy 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 inertia in the system. The operative time scale 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 time scales for the ice sheet melt problem are depicted schematically in figure 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 ice sheet (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; Hansen et al., 2007). This period of time is not long compared to the time scales for policital coordination and action needed to institute major carbon cuts and initiate a real shift toward a non-carbon energy system. The time available to make the decision before the impact (melting Greenland) 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 ice sheet 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., 2007), and so the estimates of time scales 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 wouldn't be experienced for some few to many centuries, the point at which we may be 'locking in' these impacts is almost upon us.

5 Is it irreversible?

The answer to this question depends on the phenomenon we are looking at and the time scale over which we look. 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. Compared to the normal time scales on which our societies plan and conceive events and reproduce, this time scale is effectively irreversible.

Focusing again on the Greenland ice sheet, 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., 2007). 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 and the climate system. Similarly, the notion of a 'tipping point' is quite consistent with the view that the Greenland ice sheet may be 'locked in' to disintegrate once a certain level of committed warming has been reached.

6 Is it worse than we thought?

Whether climate change is worse than we 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, 2005). 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).

Alternatively, we can measure the problem by the pace of change of the climate system (warming and sea level rise) and impacts on ecosystems. 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 worrying. Sea level rise has been increasing at the very top of the range of projections, so it is worse than our (IPCC) best guess expectations (Overpeck et al., 2006; Rahmstorf et al., 2007).

Changes in our view of ecosystem impacts are harder to discern as we need to account for the increasing number of such studies with time.

That increase alone could give the perception that species are more vulnerable than we thought, though that does seem to be the perception. Recent studies have highlighted uncertainties in earlier estimates (Akçakaya et al., 2006), and the vast scale of extinctions caused by human factors more generally (Meyer, 2004). This particular metric is clearly quite complicated, and we defer from offering an assessment on this one.

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 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., 2007). 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., modeling 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., 2007). 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. 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, 2006).

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 we 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 1990's. 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 2ppm/year, which is a "significant increase from earlier trends" (UNESCO-SCOPE, 2006), 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 650ppm". There is a growing realization that the slow start to emissions reductions and the inertia of the system make CO_2 concentration targets that once seemed prudent harder to reach.

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; perhaps much worse! In addition, recent rates of increase of carbon emissions are also worse than previously thought. Taken together, it is not overstating the case to say that the problem is worse than we thought it was just a few years ago.

7 Is it chaotic?

In the strict technical sense in which this term is used in science, the climate system is thought to behave chaotically. That is, modellers view the climate system as a nonlinear system that exhibits sensitive dependence on initial conditions and regime-like behaviour. 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 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. Slow changes in ice volume (on millennial scales) are associated with slow changes in orbital forcing. However, greenhouse climate change is warming the planet on much faster decadal and century time scales. Thus, it is quite possible that changes in sea level could be more rapid and on the higher end of projections (Hansen et al., 2007).

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 1m/century for the last deglaciation ($\sim 10,000$ years ago) and perhaps 2m/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 5m/century. These empirical rates are an order of magnitude faster than IPCC projections. The temperature during these interglacials was only moderately warmer than at the present time (Hansen et al., 2007). 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 won't.

In practice, although the sea level rise will 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 will 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 don't 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 probable feature of climate change.

8 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.

If the scientific community is not able to use such terms when describing the impacts of certain significant phenomena, then we wouldn't be able to communicate information about the degree of threat or changes in our understanding of the threat. Surely the issue is not whether we can use such terms, 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 whether to use the terms or not, but that does not render the use of such terms 'unscientific'.

9 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. Many of them have been working for decades to get this information into the public domain and to promote sustainable energy pathways and systems. 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 'truth' about the threat is not best described by the terms discussed here. The message is credible and the green groups are, on the whole, clearer about what is at stake and what can be done about it than other segments of society.

10 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 attempted to show that the terms are justified by the science. However, there are clearly some reputable climatologists (Revkin, 2007's "invisible middle") who don't think these terms are consistent with the science. It seems therefore that the primary divide is amongst climatologists themselves, not between climatologists and green groups.

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 wouldn't. 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 doesn't 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, don't 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 emission 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 putting the necessary pieces together to appreciate the full problem.

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 time scales (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 time scales 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. 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). Early IPCC reports were overly optimistic in their view of when key uncertainties would be reduced (Risbey and Stone, 1996). 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 uncertainty acts as a form of bias against theories which imply much faster rates of sea level rise than previous estimates.

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., 2007). 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. Second, limiting the time scale to 2100 is convenient for analysis and seems to be a long enough range view that it takes key impacts and human planning time scales 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 doesn't 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 100ppm of CO_2 concentration (Hansen et al., 2007). To put this amount in perspective, Archer, 2006 notes that we would need to keep total anthropogenic carbon emissions below about 570Gton, and have already released about 300Gton. Because of the inertia in the energy system, carbon reductions, efficiency gains, 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.

While this is not a difficult concept to understand, it doesn't 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, til 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 isn't 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 meltdown 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. 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 don't 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 wouldn't threaten ice sheet breakdown. The logic of 'little effect' is self-defeating, and increasingly flawed when distant impacts can not be decoupled from present actions.

11 Conclusions

The climate discourse has changed to reflect more grave assessments of the problem in recent years. Some think that shift is concordant with community understanding of the nature of the problem, and some think that the shift is rhetorical and inconsistent with the science. 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 reasonable and consistent with it. Nevertheless, a divide exists, and that divide is reflected 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 ice sheet is inevitable, implying about 7m of eventual sea level rise. Opinion is divided over whether this will be a relatively slow process spanning millenia or a relatively quick process spanning centuries. Recently published paleoclimate evidence on ice sheet disintegration seems to support the latter view. However, 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.

Regardless of which view of the relevant time scale of ice sheet breakdown is correct, the amount of warming required to initiate irreversible breakdown of Greenland is thought to be only a moderate few 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.

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 isn't 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 act early and often.

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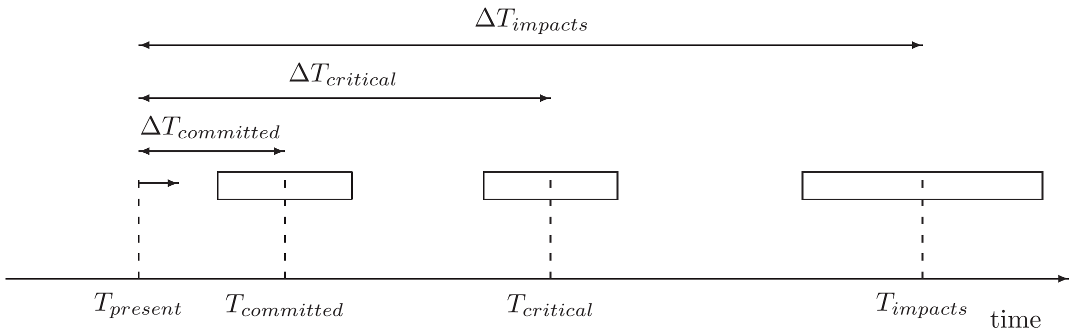

Figure 1: Schematic diagram (not to scale) indicating key times in the process of producing a warming that melts the Greenland ice sheet. The times shown are the present time, $T_{present}$; the time at which our energy system is effectively committed to producing a warming which is large enough to melt the ice sheet, $T_{committed}$; the time at which the critical global warming large enough to the melt the ice sheet 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.

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