Climate Change and Futures Epistemologies: Tensions, Trends and Possibilities in Climate Discourses Epitomised by Three Prominent Climate Experts

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Abstract

In the early-to-mid 2000s climate change became the preeminent sustainability issue, as climate scientists and modellers spoke authoritatively on long-term futures. More recently social responses to climate change have become more muted. This narrative-based inquiry presents a description and examination of the experiences and research programs of three prominent climate experts – James Hansen, Mike Hulme, and Hans Joachim Schellnhuber – with a focus on ways of knowing climate futures and the evolving relationship between science, politics and society. The 'stories' highlight the current prediction imperative in climate science and policy, reveal important tensions in the expectations and practices of (climate) science, and inform discussion of associated emerging trends and issues. The paper also seeks to contribute a futures perspective on how tensions in the current social juncture – regarding how human societies understand and respond to changing and anticipated climates – might be better recognised and, hopefully, overcome.

Keywords: climate change, narrative inquiry, epistemological limits, science-policy interface

Introduction

Climate change is an inherently futures-oriented problem and arguably the most serious test of our capacity to exercise foresight. Long-term time horizons in planning must be adopted, and humanity must consider the complex, often delayed consequences of its actions. For example, climate lags – such as due to thermal inertia – mean we have not seen the full rise in temperatures as a result of already-emitted greenhouse gases (Holmes, 2005). These dynamics

mean almost as much warming is reportedly 'in the pipeline', as has occurred to-date (Meehl et al., 2005). It also suggests policies and action aiming to limit warming to two degrees above pre-industrial levels – the most common long-term target framing government policy – are, most likely, doomed to failure. Whilst extreme weather and other climate events highlight risks, and may disrupt the status quo, proactive responses appear to centrally require action based on robust anticipatory understandings.

Recent events suggest we have reached a major social juncture. Credible evidence of nonlinear ecosystem response to human-induced climate change is emerging (e.g., as seen in Arctic sea-ice ecosystems, glacier retreats). However, *at the same time* social responses are often hampered by conflict and decreased public engagement. Pressure for action was intense in the early to mid-2000s, which culminated in a Nobel Peace Prize being awarded to the Intergovernmental Panel on Climate Change (IPCC) and Al Gore. Some political scientists now argue climate denialists are winning key battles (e.g., Manne, 2012). Climate science communities are becoming increasingly frustrated and, in some parts of the world, there is declining public trust in the science and declining public concern (Griggs & Kestin, 2011; Hoffman, 2012).[1] Similarly, former Australian Minister for Science Barry Jones contends that in climate science everything old is new again, declaring the state of public debate deplorable (Jones, 2011) An international poll further suggest, public concern for the environment is at the lowest level in 20 years (Vaughan, 2012). This situation can be thought of as a 'social juncture' and it raises important questions: given the future-orientation of many climate problems, can futures studies theory and perspectives help to interpret issues in climate discourses and understand why climate change is such a difficult problem to comprehend and successfully tackle? Or, alternatively, should such an assessment be left to other social scientists?

Many related issues in climate science and change may be constraining policy-making and social responses. Previous research indicates the needs of decision-makers and expectations of science (Dessai et al., 2009), temporal and spatial 'distance' (Pahl & Bauer, 2011), and competing visions (Eames & McDowall, 2010) shape engagement. The purpose of this narrative-based study is to identify emerging issues in how climate science is conducted and responded to, and to provide a futures research perspective on these changes and ways forward.

The overall approach taken here is to review and discuss the evolving research programs and perspectives of three influential climate change experts: Mike Hulme, University of East Anglia; James Hansen, NASA; and Hans Joachim Schellnhuber, Potsdam Institute for Climate Impact Research and Climate Analytics. These experts were chosen for this study due to their influence (i.e., each is a high-profile, senior climate expert) *and* relevance to consideration of futures epistemologies in climate science and action. Through a thematic analysis of constructed narrative stories, based on document analysis, I will suggest these stories indicate important tensions in climate discourses and emerging trends in response to the social juncture described above. First, the narratives are outlined, followed by a discussion of the major themes. The analysis centrally draws on Inayatullah's (1990; 2005; 2006) framework of futures epistemologies – that is 'predictive-empirical', 'interpretive-cultural', 'critical-poststructural', and 'anticipatory action learning' approaches. Finally, I offer concluding thoughts linking the identified tensions in climate discourse to social tensions shaping future-minded action.

Three Climate Change Experts within Rapidly Evolving Climate Discourses

Mike Hulme: from predictive-empirical, to interpretative, to critical, to...?

Over the past three decades Mike Hulme's career has traversed the fields of geography, climate modelling, and sustainability. He is Professor of Climate Change in the School of Environmental Sciences at the University of East Anglia (UEA) and a member of the Science, Society and Sustainability Group at UEA. What follows is a description of his research and career trajectory, drawing on his research narrative (Hulme, 2011a) and publications.

Hulme's early work focussed on the collection and analysis of climate data, such as examining rainfall trends and variability. He recently described this work as showing "how its performance can be revealed through statistics" (Hulme, 2011a, p. 2). In the early 1980s, Hulme developed a 'winter severity index' for the UK and researched African climate and desertification, with a focus on Sudanese rainfall and hydrology (Hulme, 2011a). Early work in "the 1980s on African climate was firmly located in a geographer's worldview rather than in a meteorological perspective, or in the Earth system science paradigm which was emerging" (Hulme, 2011a, p. 3). During the mid-1980s he was employed as a climatologist within a geography department.

Hulme moved to UEA in the 'greenhouse summer' of 1988, joining a Climatic Research Unit (CRU). In his recent narrative Hulme (2011a, p. 4) remarks that by this time:

> …my understanding of climate and its relationship with society had already formed around a number of perspectives: the innate variability of climate; the importance of such variability for societies, whether developed or developing; the notion of societal adaptability; the importance of culture in shaping understanding and attitudes to climate; the power of statistics in revealing climate variability. These perspectives had emerged from my academic training as a geographer, my place-based research in Sudan and my interest in numbers.

A major turning point occurred at the CRU: "during these 12 years in the Climatic Research Unit [from 1988-2000] I came to see myself no longer as a geographer, but as a climate scientist" whose work centrally involved the construction and evaluation of climate models and scenarios. At CRU he was inducted into "a still forming international multi-disciplinary climate change network" (Hulme, 2011a, p. 8). Here he led and contributed to modelling work for the UK Government, European Commission, UNEP, and IPCC; the development of 'integrated assessment models' used to help decision-makers understand environment problems and assess policy options. This work – along with the compilation and analysis of observational climate datasets, especially precipitation data (Hulme, 2011a) – was firmly placed in a 'predictive-empirical' epistemology. One challenge Hulme faced was developing new methods for incorporating and representing both modelling and future emissions uncertainties (Hulme & Brown,

1998; Hulme 2011a).

Hulme then became the Founding Director (from 2000-07) of the new Tyndall Centre for Climate Change Research in the UK. This centre adopts a trans-disciplinary approach and seeks "to exert a seminal influence on the design and achievability of the long-term strategic objectives of national and international climate policy".[2] Hulme (2011, p. 9) observes that this role "meant that I had to learn and think more carefully about climate policy". During this period he published articles on related policy issues such as on the definition of 'dangerous climate change' and the Kyoto Protocol. Towards the end of this period many of his publications signalled his "growing unease about some of the ways in which (climate) science was being presented and deployed" (Hulme, 2011a, p.10). His public commentary asserting that the "rhetoric of 'climate catastrophe' … had become too pervasive" provoked "a huge amount of critical attention both inside the academy and outside" (Hulme, 2011a, p.10). In 2007 he left the Tyndall Centre to be an independent academic, which "gave me new independence to express these views in public" (Hulme, 2011a, p.10).

During this period a number of aspects stand out. He subjected his own work on climate scenarios to more rigorous critique, along with examining science-policy interfaces (e.g., via the IPCC) and how climate knowledge is generated (e.g., Hulme, 2010b; Hulme & Dessai, 2008). He has critiqued the increasing focus on providing decision-makers with accurate, precise climate predictions such as for climate adaptation (e.g., Dessai et al., 2009). Hulme has also focussed much more on the role of culture in understanding climate and human responses to it (Hulme, 2009; Hulme 2010c; Hulme, 2011a). This phase more deeply addressed issues of epistemological limits (Dessai et al., 2009) and the relationship between science and politics, and incorporated cultural analyses.

Mike Hulme's evolving perspective is well captured by this statement from his research narrative: "The world that we study – the climates that we seek to understand – is not simply out there in pure form waiting to be discovered by the impartial mind. These climates that we bring to life are partly created through our processes of enquiry" (Hulme, 2011a, p. 1) – i.e., moving beyond a positivist to an interpretative paradigm.[3] Hulme recently described these shifts as adopting more 'reflexive' stance and viewing climate change as an analyst of science-society interactions (Hulme, 2011a). He also reflected more deeply on model and data uncertainties, including how these relate to policy-making, via consideration of critical and philosophical disciplines (Hulme, 2011a).

When considering Inayatullah's framework we can see a clear pattern. A 'predictive-empirical' epistemology was initially central, which Hulme then reflected on and critiqued. An 'interpretive-cultural' epistemology – which considers "meanings we give to data" (Inayatullah, 2005, p. 147) and in which truth is seen as being, in part, relative due to the role of culture and language – has become stronger. Hulme (2011a) notes that his early career research as a geographer in Islamic African countries laid the foundation for this shift. Some critics have argued this cultural turn is too relativistic, or at least risks lapsing into extreme postmodernism (Hulme, 2011c). These critics further argued Hulme's analysis suggests public policy should not be attempted, due to the plural legitimate perceptions of climate change he acknowledges as being valid (Hulme, 2011c).

A complex mix of 'interpretive-cultural' and 'critical-poststructural'

epistemologies are adopted in much of Hulme's recent writing. Three key papers will be highlighted below.

In *'Cosmopolitan Climates'* (Hulme, 2010a) and *'Learning to Live with Recreated Climates'* (Hulme, 2010c) he emphasises cultural dimensions and tensions. "Sitting at the heart of most debates about climate change", he asserts, is a "tension between the assumed predictability of the climatic future and the necessary openness and malleability of the social future" (Hulme, 2010a, p.270). He points to the influential myth of a "lost Eden", and problems with "rational climates" i.e. positivist accounts which only view 'climate' as being an external, objective category (Hulme (2010c, p.118). Cultural aspects are argued to stimulate projects of climate 're-enchantment' (such as the desire to shift into reverse and return to an idealised past) and 'domination' (such as via geoengineering) which are expressed in visions and policy proposals (Hulme, 2010c). In this paper he controversially contends "novel climates are neither good nor bad" and must be imbued "with meaning, value and utility" (Hulme, 2010c, pp.120-1). He argues climate change is doing important social work by dissolving boundaries between culture-nature, present-future and local-global (Hulme, 2010a).

In *'Reducing the Future to Climate'* (Hulme, 2011b) he warns against climate *determinism* (where climate is elevated to dominant predictor variable and principle cause) and climate *indeterminism* (relegating climate to a footnote in human affairs). He makes the case that climate determinism became the dominant mode of analysis of environmental change, especially via climate models. He provocatively argues this shift has been enabled by the "the hegemony held by the predictive natural and biological sciences over visions of the future" (Hulme, 2011b, p. 255), and should be seen "within a wider cultural context of Western pessimism and loss of confidence about the future" (Hulme, 2011b, p. 250). He advocates more attention on processes of societal adaptation and change, and creation of less reductionist, new ways of envisioning the future (Hulme, 2011b).

As this narrative indicates, Hulme's career and research program have evolved dramatically. Studies of ecological and biophysical changes are balanced by consideration of "what the idea of climate change is doing…to our political discourses, social relationships and imaginative worlds" (Hulme, 2010c, pp. 273-4). Also significant is his view that "another IPCC assessment of scientific knowledge in four years' time is not going to make policy-making around climate change any easier" and "further policy fragmentation … is inevitable" (Hulme, 2010d).

James Hansen: from predictive-empirical to post-predictive?

James Hansen, from NASA Goddard Institute for Space Studies (GISS), is probably the worlds' best-known climate scientist. One reason is he has been far more outspoken than most of his colleagues (Ball, 2007). Hansen has worked at NASS GISS for over four decades.

Following the completion of his PhD in physics Hansen's research focussed on Venus. He contributed to the understanding that planet Venus is extremely hot (well over 400°C) and is kept this way by a thick carbon dioxide atmosphere. During this research Hansen became involved in a study aiming to calculate Earth's 'greenhouse effect' due to the observed changes in Earth's atmospheric composition.[4] This led to a shift in the mid-1970s to studying Earth's climate, including:

1) Calculating the effect of trace atmospheric gases and making related forecasts

(e.g. see Hansen et al., 1981; Lacis et al., 1981), such as of surface temperature change;
2) Developing and evaluating global climate simulations, such as the underlying model physics, and comparing model outputs (e.g., projections) with observations; and
3) Quantifying planetary 'energy imbalance' due to enhanced greenhouse effect, measuring the difference between the energy absorbed from the sun and radiated back to space (Hansen et al., 2005; Hansen et al., 2011). Improved measurements of the Earth system, especially via modern satellites, have been central to this research.

Forecasts made in the 1980s led to testimony to US Congress in 1988 during what was at the time the hottest summer on record. His testimony included NASA GISS future projections for temperature rise, given different future increases in greenhouse gases, and asserted that "global warming is now large enough that we can ascribe with a high degree of confidence a cause-and-effect relationship to the greenhouse effect." Soon afterwards Hansen retreated from public discourse as scientific discussions became entangled with fierce political debates.

In the mid-2000s Hansen decided to re-enter the public debate, including giving public talks which were critical of US government policy. He has become far more alarmed over the past decade, as the titles of recently published books and articles, including: *'Climate Catastrophe'*, *'Tipping Point'*, and *'Storms of My Grandchildren: The Truth about the Coming Climate Catastrophe and Our Last Chance to Save Humanity'*. He has recently also been arrested multiple times during protests, such as outside the White House. This contrasts with Mike Hulme's story, and provides an important example of the discourse of 'climate catastrophe' which Hulme reacted to. In this writing he has sought to draw attention to potential climate 'tipping points' and shifted towards defining public policy prescriptions such as the target for the atmospheric concentration of carbon dioxide. Hansen defined the 'safe upper level' as 350ppm of CO_2, well below the current 394ppm, which is also a 'planetary boundary' advocated by a senior group of scientists (Rockström et al., 2009).

Hansen (2008, p.7-8) recently concluded that the predominance of 'positive feedbacks' and inertia in the global climate system means that humanity doesn't recognise that it's "dangerously near a tipping point". He observes that inertias in the system (e.g., ice sheet inertia) "provide a buffer delaying full response by centuries" (Hansen et al., 2008, p.228). This, in conjunction with smooth projections of future climate and global change is feared to lead to complacency in the human response and increase the likelihood of a 'runaway' greenhouse effect.

Hansen has provocatively questioned more mainstream climate forecasts, especially those included in the IPCC assessment reports. In particular, projections of sea level rise are argued to be too conservative and influenced by reticence (Hansen, 2007). Moreover, he argued, "scientists preaching caution and downplaying the dangers of climate change [have] fared better in receipt of research funding" (Hansen, 2007). These pieces provoked fierce debates. Ball (2007) commented in *Nature* that often Hansen's views "haven't only ruffled political feathers — they have dismayed other scientists too" (Ball, 2007). It also highlights a key tension: scientists' training which "turn out researchers who speak in careful

nuances and with many caveats, in a language aimed at their peers" often leads to poor communication with publics (Mooney, 2010).

From the perspective of this article one aspect of his recent research is especially important: a partial shift in focus from use of climate models to historical and observational data. This may turn out to be a key turning point in Hansen's trajectory. One important driver of this is the poor understanding of ice sheet dynamics and other nonlinearities. Hansen and colleagues assert "in the absence of realistic models [for these dynamics], it is better to rely on information from the Earth's history" (Hansen et al., 2007, p. 1937). Consequently, they have combined historical data (such as the estimates derived from ice core samples) with recent observations in their estimation of 'climate sensitivity' to trace atmospheric gases and inform key judgements about dangerous human interference.5

In a second example published in *Science* (Rahmstorf et al., 2007) Hansen and co-authors compared observational data with model projections from the IPCC Third Assessment Report, which included scenarios and projections starting in 1990. They conclude that the data raises concerns that the climate system is responding faster to emissions than models projected. It also raised the possibility of model-error due to the more rapid warming from 1990-2006 than was projected. The projections "may in some respects even have underestimated the change" (Rahmstorf et al., 2007, p.709).

A third example focusses on the detailed empirical record of the past six decades. He asserted recently in the *Washington Post* (Hansen, 2012c) that:

> My projections about increasing global temperature have been proved true. But I failed to fully explore how quickly that average rise would drive an increase in extreme weather. In a new analysis of the past six decades of global temperatures … my colleagues and I have revealed a stunning increase in the frequency of extremely hot summers, with deeply troubling ramifications for not only our future but also for our present. This is not a climate model or a prediction but actual observations of weather events and temperatures.

This research, published in a paper called *'Perception of Climate Change'*, builds on Hansen's idea of loading the 'climate dice' (Hansen et al., 2012). This refers to the "chance of unusually warm or cool seasons", which data indicates has become "more 'loaded'" as measured by the changing probability distribution (Hansen et al., 2012, p.1). The article aims to "expose effects of human-made global warming as soon as possible" through a "purely empirical approach" that "avoid[s] any use of global climate models" and, thereby, also address key barriers to the public appreciating the significance of human-made climate change (Hansen et al., 2012, p.1).

One of Hansen's most recent paper – co-authored with other prominent scholars such as economist Jeffrey Sachs – further seeks to clarify the urgency of phasing out fossil fuel for restoring Earth's energy balance and 'stabilising' the climate, and to make a *moral* case for action (Hansen et al, 2012c). They argue climate change is centrally an urgent intergenerational justice issue: "young people, future generations, and nature, with no possibility of protecting their future well-being, will bear the

principal consequences of actions and inactions of today's adults" (Hansen et al., 2012c, p.4).

Like Mike Hulme's research trajectory, James Hanson's research has evolved, similarly in response to how climate science and knowledge is presented and deployed. Hansen has sought to balance modelling with alternative approaches. The statement in the *Washington Post* op-ed that "this is not a climate model or a prediction" is especially striking (Hansen, 2012c). Additionally, perhaps more importantly, Hansen has gradually been radicalised over the past two decades.

Hans Joachim Schellnhuber – towards better prediction and control of non-linear phenomena in climate and social systems?

Hans Joachim Schellnhuber is currently Director of the Potsdam Institute for Climate Impact Research and Climate Analytics (PIK) in Germany, a position he has held since PIK was founded in 1992. He is also Professor of Theoretical Physics at the University of Potsdam, External Professor at the Santa Fe Institute, USA, and Chair, German Advisory Council on Global Change.

Through early appointments, such as at the Institute of Theoretical Physics at the University of California, Schellnhuber was introduced to nonlinear dynamics, i.e. the emerging area of 'chaos theory' (Mossman, 2008). By the mid-1980s Schellnhuber was working exclusively on complex systems analysis and this led to applying this theory to understanding natural systems

Initial research on tidal flats led to experiments with modelling the future effects of climate change. Schellnhuber was asked to assist the West German Ministry for Science and Technology to predict the effects of climate change on coastlines. This led – following the reunification of Germany – to his appointment as the Founding Director of PIK. His rapid rise into climate assessment reflects the rise of mathematical modelling in environmental management and policy (Pilkey & Pilkey-Jarvis, 2007).

Over the past decade Schellnhuber has increasingly been an advisor to policy-makers, as both an advisor to the German Government and European Union (Mossman, 2008). This engagement with decision-makers has led to related efforts to communicate climate science. These experiences, including many failures to effectively engage policy-makers, encouraged him to focus on 'tipping points' (Mossman, 2008), and to theorise 'tipping elements' in the climate system (see Lenton et al., 2008; Schellnhuber, 2009). Through this approach Schellnhuber and co-authors seek to "shift the balance toward stronger mitigation and demand adaptation concepts beyond incremental approaches", given the scale of potential impacts (Lenton et al., 2008, p.1792). Examples of potential 'tipping elements' include the thawing of Arctic summer sea-ice, and the thawing of permafrost. This work acknowledges uncertainty but seeks to work towards establishing sophisticated 'early warning systems', based on more theorisation and monitoring the proximity to tipping points (Lenton et al., 2008).

For Schellnhuber, understanding nonlinearity is central to understanding climate risk:

> The dangerous impacts of climate change can only be discussed in terms of nonlinear behavior. If global warming just had gradual impacts— over time everything changed more or less linearly, so

> you have a little bit less wheat production but you have a little bit more pineapple production— who cares? We could easily adapt to that. (As quoted in Mossman, 2008, p. 1785)

Modelling and complex systems theory remains a strong feature of his work. This includes complex earth system modelling and constructing model-based prediction, as the Chair of the Global Analysis, Integration & Modelling Task Force of the International Geosphere-Biosphere Programme.

Additionally, in the mid-2000s he and other Earth-system scientists partly shifted focus from biophysical to social systems to consider "and our ability to steer ourselves toward a sustainable future" (Schellnhuber et al, 2005, p. 11). An important current focus here is accelerating desired innovation. For example, Schellnhuber is currently the Chairman of Climate-KIC (Knowledge and Innovation Community), which is assisting the commercialisation of climate change technologies.

As Chair of the German Advisory Council on Global Change he has most recently developed an interest in the broader dynamics of *societal* transformation. This aspect of his work has accelerated over the past three years. A major study by the Council concluded that a 2-in-3 chance of limiting global warming to 2°C – above the pre-industrial global average – requires all industrialised countries to achieve almost-complete decarbonisation by 2030, or to purchase enormous amounts of emissions permits from developing countries (Messner et al., 2010). The latest Council report, *'World in Transition: A Social Contract for Sustainability'* (Schellnhuber et al., 2011) follows logically on from this analysis to examine change imperatives. Moreover, rather than forecasting futures, the report focusses on how a "trend reversal" towards "climate-friendliness and sustainability" might be achieved (Schellnhuber et al., 2011, p.1). Schellnhuber et al. (2011) argue a "drastic change in direction" needs to be accomplished before the end of the current decade. Overall, *World in Transition* provides an interdisciplinary examination of the dynamics of and potential barriers to transformative processes, arguing for a coordinated and rapid 'Great Transformation' in contrast to more gradual, evolutionary changes they contend have tended to occurred historically.

Of particular note for the futures field, in *'World in Transition'* Schellnhuber and colleagues argue "the low-carbon transformation … [is] about 'learning from the future', and acting in accordance with the precautionary principle" (Schellnhuber et al., 2011, p.106). They highlight the emergence of new approaches for assisting decision-making they term "future laboratories".

Overall, Schellnhuber's research activities have also changed and diversified. On the one hand, early work on complexity theory – which others haved argued problematises early warning systems (Horton, 2012) – is being drawn on within a 'predictive-empirical' epistemology. On the other hand, recent theorisation and advocacy of a new field of 'transformation research' and 'trend reversals' in World in Transition incorporates some aspects of anticipatory action learning models.

Summary

Hulme's work brought him to the centre of science-policy interactions. This trajectory led him to critique the use and dominance of modelling and model-based projections. Hulme's examination of 'epistemological limits' (Dessai et al., 2009), and the emphasis he places on scientific uncertainties and complexities

about the future are central. He highlights the increasing engagement with these aspects (Hulme, 2013). Overall, we see adoption of both interpretative and critical paradigms.

Central to Hansen's story is politicisation, increasing frustration, and gradual radicalisation over the past decade. This has contributed to recent shifts towards a "purely empirical" approach (Hansen, 2012b), citizen activism, and moral argumentation. Like Hulme, Hansen has recently questioned the current modelling of some aspects of climate and Earth system.

Schellnhuber's career reflects the rise of quantitative modeling of natural processes/systems and complexity science. Sophisticated climate foresight is envisaged via 'early warning' systems, more monitoring, and improved projections. Recently Schellnhuber also championed a transdisciplinary focus on societal transformation, and climate change-oriented innovations.

Tensions and Trends in Climate Change Discourses

Thematic analysis of the above narratives indicates many important futures-orientated issues. This section identifies and expands on these tensions and associated key trends.

Key tensions

The role, perceptions and validity of modelling 'the future': Modelling is currently the dominant way of considering future climates; however, this has many important indirect impacts. These include: less attention on the underpinning science and other forms of evidence (indeed, some people are led to think that climate change science is *just* modelling); debate about what can or should be considered empirical research and associated model validation issues; and determinism associated with the aim to predict the future. Philosophers of science raise further issues: as climate models (and related Earth System models) cannot be verified, their predictive value is always inevitably open to question, and their core value is as a heuristic (Oreskes et al., 1994). The centrality of modelling also means the accuracy of these model-based projections is central to the field's social authority. The prevalence of nonlinear dynamics means this authority could be fragile.

Uncertainty and the dominant predictive-empirical orientation: On one hand, 'narrowing uncertainties' in predictions is the goal of the IPCC and many climate scientists (Hulme, 2012); on the other hand climate research is revealing *new* uncertainties and unknowns. For example, parameters that used to be known variables can become uncertain (Hallegatte, 2009). The potential for *abrupt* climate change provides an example: paleoclimate data has helped to put this onto political agendas; however, knowledge of this potential has *also* resulted in "tantalizing ignorance concerning the most worrying potential impacts of global warming" (Schellnhuber, 2009, p. 20562). This 'ignorance' is likely to remain during the next decades when major climate change policies need to be formed and implemented (Schellnhuber, 2009, p. 20562). Wilkinson (2012) usefully termed this the co-evolution of knowledge and ignorance.

Consistent with this tension, Australian public intellectual Richard Denniss argues that "the strategic error that continues to haunt the environment movement is the decision to counter the sceptics' message of 'doubt' with a message of 'certainty'"

(Denniss, 2012). Indeed, some climate experts recommend presenting the science as unfinished, acknowledging key uncertainties, and discussing internal disagreements in the climate science community (e.g., see Socolow 2011; Socolow, 2012). This also highlights the importance of responses to uncertainty, as this is often viewed as a rationale for an incremental response (i.e., wait for more evidence); for others, this prompts more careful management of risk.

Complexity, non-linearity and the desire for certainty: Nonlinear behavior in complex systems is central to climate risk. This is clearly reflected in Schellnhuber's recent rise to prominence. However, consistently accurate prediction in complex systems is inherently difficult and perhaps impossible. Together with current uncertainties this dimension problematises the expectations and uncertainty intolerance of decision-makers (Dessai et al., 2009). However, to-date the reaction of decision-makers and policy-makers to uncertainty has tended to be requests for greater certainty (Hallegatte, 2009).

Balancing predictive and non-predictive approaches: The futures field has long understood that the search for predictive accuracy can impair strategic decision-making and presents important trade-offs. "Preoccupation with what is likely to happen", notes Miller (2005), "tends to obscure things that may be unlikely but still possible and potentially more desirable". Methods that centrally draw on past patterns tend to miss future "inflection points and transformative changes" (Miller, 2005). Similarly, some argue climate science, along with fields like coral reef science, currently places too much emphasis on prediction and probabilistic model-based projections. Responses to this tension are emerging. We can see increasing emphasis on less reductionist approaches such as *resilience* in Hulme's evolving research agenda, and more focus on normative questions and moral arguments centred on what is *desirable* is now seen is Hansen and Schellnhuber's work. The latter exhibits an 'activist' stance towards the future (Wilkinson & Mangalagiu, 2012), not the 'disinterestedness' that is core to widely-held norms of science expressed as 'Mertonian' ideals (Bakar, 2012).

A related line of argument is termed the 'Giddens Paradox'. It summarises many of the reasons it is impossible to mobilise action (solely) on the basis of avoiding climate dangers:

> No matter how much we are told about the threats, it is hard to face up to them, because they feel somehow unreal – and in the meantime there is a life to be lived, with all its pleasure and pressures. The politics of climate change has to cope with what I call *Gidden's Paradox*… It states that, since the dangers posed by climate change aren't tangible, immediate or visible in the course of day-to-day life, however awesome they appear, many will sit on their hands and do nothing of a concrete nature about them. Yet waiting until they become visible and acute before being stirred into serious action will, by definition, be too late. For we know of no way of getting the greenhouse gases out again once they are there and most will be in the atmosphere for centuries (Giddens, 2011, p.2).

Giddens (2011, p.8) own response to this paradox is to argue "we must create

a positive model of a low-carbon future" which "connects with ordinary, everyday life in the present". He emphasises the related "limitations of the politics of fear and anxiety" (Giddens, 2011, p.165). This highlights the need to better balance predictive approaches with preferred futures thinking.

Moving from knowledge to action: Many knowledge communities concerned with sustainability are frustrated by the lack of behavioural or policy changes. Many climate scientists – as per Schellnhuber and Hansen's stories – try to clarify the need for change and to influence judgements on the urgency of change. However, as per the above tension, this may be necessary but insufficient condition for transformative changes to occur. Social scientists have identified a number of related assumptions such as assuming that better information leads to better decisions (Inayatullah, 1990; Meyer, 2012); and more science will equal better policy outcomes (Baranski, 2011). Hulme (2010e; 2012) argues that inadequate responses to climate change have little to do with knowledge gaps and that more climate science will *not* make policymaking any easier, pointing to the diminishing returns from IPCC reports. He sees this issue as being primarily deliberative and procedural, and further argues for a focus on new "domains of praxis" (Hulme, 2010e, p.17):

> Climate change has become a synecdoche for the troubling and endemic dilemmas facing a growing population with material aspirations making ever-greater resource demands on a physically finite planet. Facing and circumventing these dilemmas is about creating and mobilising — and negotiating among — different human visions, values and virtues. If I am right then science has little to offer on these matters, least of all purely physical science… it now demands an engagement with those human practices of argumentation, reflection and persuasion where human meaning is created and authenticated (Hulme, 2010e).

Diminishing versus enabling agency: A key issue in debates about climate change is tension between the assumed *predictability* of climate futures and, in contrast, cultural assumptions about *open* social futures (Hulme, 2010c). Prediction can also raise issues and questions about human agency. The tension here is: to what extent do we need to accept that climate change problematises assumptions about an open future, whilst being careful not to lapse into disempowering reductionism and climate determinism? Additionally how do we continue to cultivate the creativity needed to deal with climate change? Similarly, influential activist McKibben (2010, pp. 98-99) noted that obsessing over collapse-style scenarios "keeps you from considering other possibilities" and limit creativity.

Related futures-oriented issues

A related, important question posed by Giddens (2011, p.1) is "why do most people, most of the time, act as though a threat of such magnitude can be ignored?" Is it simply, as Giddens (2011, p.3) goes on to assert, that "people find it hard to give the same level of reality to the future as they do to the present"? The above discussion, and psychological research (Markowitz & Shariff, 2012), indicates moral judgements can be impaired by uncertainty, complexity and temporal and spatial distance, making climate change a particularly difficult problem.

The latest science suggests a wide range of outcomes could occur, as noted by Socolow (2012, p.1460): "neither slow nor rapid arrival of severe climate change can be ruled out" and the science does not present "distinct zones of safety and peril". Such uncertainty tends to promote optimistic biases and self-oriented behaviour (Markowitz & Shariff, 2012). These tendencies, along with barriers to long-term thinking, can prevent futures-responsiveness.

A related issue is the tendency to 'wait and see'. However, in the context of climate change such an approach carries enormous, often unacknowledged, risks. For example, if we wait and see how sea level rise develops this may result in far greater change and future risks as, by then, the atmospheric concentration of greenhouse gasses will have significantly increased. Similar risks are entailed in waiting for greater knowledge about the links between climate change and extreme weather events. How can appropriate responses be enacted in spite of this "tantalizing ignorance" (Schellnhuber, 2009, p. 20562)?

The role and use of future simulations (i.e., modelling) is particularly important in this context, as noted by both Hulme and Hansen. Hulme (2011b, p. 249) argues such models are "inappropriately elevated as universal predictors of future social performance and human destiny". Hansen contends that our poor understanding of nonlinear dynamics means projections are likely to be too conservative. Nonetheless, such models remain central to communicating climate risks and planning.

Related futures opportunities and trends

Inayatullah's (2005) argument that effective futures research demands integrative approaches drawing on multiple epistemological positions appears important for climate research and action. The changes and issues noted earlier indicate related trends are emerging.

The limits of the dominant predictive-empirical epistemology are beginning to prompt new calls to decrease the level of reliance on modelling, along with related experimentation. Two major trends can be observed. First, there are simultaneous attempts to bolster the predictive-empirical aspects of climate change science *and* to adopt other epistemological positions. We see also increasing focus on alternative futures and 'robust' decision-making (see Dessai et al., 2009; Wiseman et al., 2011). New anticipatory action learning-oriented approaches are also emerging. This is particularly the case in climate change adaptation (Mulligan et al., 2009; Tschakert & Dietrich, 2010). Second, we can also see a more traditional *present*-oriented empirical research being adopted in efforts to make the case for action. This is similar to emerging practices and perspectives in futures studies. Miller et al. (2012, p.195) contrast more constructivist perspectives on weak signals with "a predominantly deterministic view of the future-to-come" adopted when monitoring change. The latter is consistent with much of climate change science which is aiming to detect precursors events, what Miller et al. (2012, p.196) term "present manifestations of the future". Improvements in such monitoring and warning systems would benefit both adaptation and geo-engineering interventions.

There may be additional opportunities. For example, increasing experimentation with futures research methods is emerging in sustainability movements to better overcome inertia and move from knowledge to action (McGrail 2011; McGrail, 2012; Wilkinson, 2012). In this respect Hulme's (2010e) advocacy of a stronger focus on creating, mobilising and negotiating different human visions, values and

virtues suggests further roles for futures practitioners.

Social scientists provide further clues. New research points to the 'cultural processing' of complex scientific information and underlying cultural debates being provoked by environmental issues, which, in turn, can contributes to broken public discourses (Hoffman, 2012). Similarly, research indicates that climate change has rapidly become a proxy for conflict over alternative social visions (Hoffman, 2012; Hulme, 2009). Hoffman (2012) calls for new approaches for overcoming ideological filters, moving beyond data and focussing on broken mental 'frames'. The latter must address existing narratives and help to generate more effective communication. Potentially futures methods such as causal layered analysis (Inayatullah, 2005) can be used to move beyond prediction, 'unpack' worldviews, and identify new metaphors and narratives of the future that can gain more societal buy-in.[6] This would go beyond epistemological issues to consider ontology. Finally, a further opportunity is for futures practitioners to play the role of 'honest broker' (Pielke, 2007); that is, a person who can "integrate scientific knowledge with stakeholder concerns to explore alternative possible courses of action".

Conclusions, Implications and Future Research

This paper has briefly presented the experiences and evolving research programs of three influential climate experts and, via thematic analysis, identified futures-related tensions and issues in climate discourses. One of these experts (Hulme) has moved towards interpretative and critical paradigms, following greater exposure to climate modelling and policy and to issues of 'epistemological limits'. Hulme has concluded that model-based descriptions of future climates are given disproportionate power and raised concerns about the re-emergence of environmental determinism. Hansen and Schellnhuber have a 'predictive-empirical' focus, and have gradually become more frustrated and radicalised by responses to climate change.

These findings reflect the prediction imperative in climate science, which has become a dominant force shaping research agendas (Meyer, 2011). Hulme is one of the emerging voices questioning the increasing use of modelling tools, pointing to overreach, and arguing the physical sciences have "little to offer" in facing and circumventing current dilemmas (Hulme, 2010e). This repeats debates in other areas of science. A contribution made by this paper is identifying tensions problematising this prediction imperative focussed on: model validation and social authority vulnerabilities; the need to incorporate uncertainty and surprise; stimulating more transformative anticipatory action; and human agency.

Decreasing the reliance on modelling and mending broken public discourses demands new thinking and new approaches. This paper has sought to highlight these emerging issues. Futures practitioners can play roles in shaping the use of climate knowledge, and mediating science-society interactions.

Wider implications

Tensions in climate science and discourse are part of wider tensions. The first was articulated recently by Wilkinson (2012), a futures scholar who was educated as a physicist and later worked as a climate modeller and scenario-builder: the tension between 'learning *about* the future' and 'learning *with* multiple futures'. She

contends that "we now rely too heavily on model-based forecasting and prediction to justify future-minded action" and, moreover, "when this is not forthcoming, the result is to deny the need for change", and points to a societal "addiction to prediction" (Wilkinson, 2012).

This observation goes to the core of many issues identified here. It reinforces the possibility that the diminishing social authority of climate models – if this were to occur – could reduce public acceptance of mitigation. The latest climate models appear likely to project a wider range of uncertainty, which may look to the public like the scientific understanding is becoming less clear (Maslin & Austin, 2012). Similarly, 'climate sensitivity' estimates – that is, the amount of warming resulting from doubling atmospheric carbon dioxide from pre-industrial levels – are stubbornly variable, ranging range from approximately 2°C to 4°C with enormous mitigation and adaptation implications.

A second wider tension exists in the framing of major environmental issues. Within environmental movements climate change is most frequently framed as a crisis or emergency, as per Hansen, to motivate more future-minded action. The issues noted here indicate that the motivational power of fear is likely to be limited for threats like climate change. The dominant framings also have additional dangers which need to be further considered. It can lead to fatalism, i.e. passivity. It can also lead to reactive, short-termist thinking in responses (Robinson, 2010), such as rushing into risky engineering 'fixes'.

Limitations and future research

An important limitation is this analysis is based solely on a literature review. Collaboration between the researcher and individuals being discussed is normally an important part of narrative-based studies, for example to help with validating the analysis (Creswell, 2013). This, in turn, suggests ways the analysis could be expanded in future. The paper has also indicated that further experimentation and research is needed to explore the roles of futures research during the social juncture that was indentified and explored in this paper.

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Notes

1 This is most prominent in the United States. In Australia and Great Britain only a small minority of the public can be considered disbelievers or strong sceptics: 6.5% in Australia, 4% in Great Britain (Reser et al., 2012).

2 This description of the centre's purpose is taken from http://www.tyndall.ac.uk.

3 I thank Neil Houghton for clarifying my understanding of this major shift in perspective.

4 See James Hansen's TED talk given on February 2012, viewed 30th November 2012, available at: http://www.ted.com/talks/james_hansen_why_i_must_speak_out_about_climate_change.html.

5 Also see: http://www.nasa.gov/topics/earth/features/rapid-change-feature.html. At stated in this web-based article Hansen argues "the paleoclimate record reveals a more sensitive climate than thought and that, therefore, limiting human-caused warming to 2 degrees "would be a prescription for disaster". Elsewhere Hansen et al (2008) predict that "the eventual response to doubling pre-industrial atmospheric CO2 likely would be a nearly ice-free planet" and many metres of sea level rise.

6 I thank Sohail Inayatullah for stimulating feedback which led to the inclusion of this paragraph.

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