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ScienceDirect
Global Environmental Change 17 (2007) 1–3
Global Environmental Change
www.elsevier.com/locate/gloenvcha

Editorial

Editorial: On uncertainty and climate change

Climate change has emerged as one of the most multi-faceted manifestations of global change of our time. As emphasized in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001), it is virtually certain that the Earth's climate is changing, with most of the warming over the last 50 years likely to be attributable to the increase in atmospheric greenhouse gas concentrations. The Fourth Assessment Report of the IPCC due later this year will further reinforce these conclusions. There is very high confidence that further emissions of greenhouse gases and aerosols due to human activities will continue to change atmospheric composition throughout the twenty-first century. There is, however, less confidence about exactly how the climate will change in the future, and lesser confidence still about the adjustments it will induce to natural and human systems. Given the wide range of uncertainties associated with future climate change, it is not surprising that debates within the two domains of human response to climate change—adaptation and mitigation—remain deeply contentious and irresolvable.

Uncertainty, then, is pervasive in the climate change debate, but uncertainty is not unique to climate change. There is uncertainty associated with other global phenomena—the economy, geopolitics and health—whether in relation to economic crises, terrorism, or influenzas and pandemics. In fact, uncertainty is a multi-dimensional concept that is omnipresent in our society. A number of different uncertainty typologies have been proposed and used in the literature, but there is no agreement on the best uncertainty classification. For example, in the context of model-based decision support, Walker et al. (2003) classify uncertainties according to three dimensions: their 'location', where uncertainty manifests itself in the model complex; their 'level', where uncertainty manifests itself on the gradual spectrum between deterministic knowledge and total ignorance; and their 'nature', whether uncertainty primarily stems from imperfect knowledge or due to inherent variability. Mehta et al. (1999) discuss how ecological uncertainties, livelihood uncertainties and knowledge uncertainties are addressed by institutions, and they call for a more sophisticated understanding of the relationship between institutions and uncertainty. In terms of climate change, knowledge uncertainties have received the most attention, followed by ecological uncertainties and livelihood uncertainties. Nevertheless, all three types of uncertainties, and indeed many others, have implications for climate policy and for human security in the context of a changing climate.

Some have argued that climate policy needs 'robust' science (Patrinos and Bamzai, 2005)—an argument that favours more scientific research over policy action. Others have argued that uncertainty should not be used as a justification to do nothing, instead arguing that it provides a reason to take specific policy action in the near term (Yohe et al., 2004). Between these two positions, there are a range of views about the implications of uncertainties for different types of policy responses, ranging from mitigation to adaptation (Congressional Budget Office, 2005; Stern, 2006). Uncertainties about climate change not only shape international, national and local climate policy, but they also influence perceptions of and responses to climate change at the level of individuals, communities and businesses. As Heal and Kriström (2002, p. 34) emphasize, "*climate change involves uncertainties in a breathtaking number of dimensions, including, but not limited to, the fields of natural science and economics*".

The issue of uncertainty is clearly not trivial, nor are the uncertainties themselves, yet little effort has been made to systematically assess what uncertainty means for the many dimensions of climate change analysis and action. A wider understanding of uncertainty must, as a minimum, include perspectives from psychology, ethics, decision sciences and law. Although uncertainty about climate change has received growing attention in recent years, much of this has focused on the description of scientific uncertainties in the climate system (Carter et al., 1999), and to a lesser extent in climate change impact assessments (Jones, 2000). The only peer-reviewed special journal issue on the topic of climate change uncertainty was published in 2005 *in Comptes Rendus Geoscience* (edited by Michel Petit (2005)) on "*Scientific uncertainties and climate risk*". This special issue was the result of presentations made at an IPCC workshop in Ireland in 2004 on "*Describing scientific uncertainties in climate change to support analysis of risk and of options*". This mainly focused on a fairly narrowly drawn definition of uncertainty around issues of climate science and prediction. What is still missing, however, is a

0959-3780/$ - see front matter
doi:10.1016/j.gloenvcha.2006.12.001

wider examination of the many ways that uncertainty affects and how individuals, organisations and societies respond to climate change, and what this means for future sustainability.

This special issue of *Global Environmental Change* brings together a wider range of perspectives—from geography, psychology, communication science and decision making—on the way uncertainty affects possible responses to climate change. The six research papers in this special issue are developed from presentations made at a session (with the same title) at the Sixth Open Meeting of the Human Dimensions of Global Environmental Change Research Community, which took place in Bonn from 9 to 13 October 2005. Although not a comprehensive discussion of all the many dimensions of uncertainty, the papers raise some important issues about how uncertainty relates to both adaptation (e.g. indicators of adaptive capacity) and mitigation (e.g. energy scenarios), as well as to how individuals perceive (e.g. risk and uncertainty communication) and respond to (e.g. decision-making frameworks) climate change uncertainty.

We have also included two invited editorial essays on the topic of this special issue. The editorial by Moss (2007) makes an interesting observation about the asymmetry between US public concern on the issue of climate change (high) and public perception of scientific "certainties" and consensus (low). He discusses the evolution of the treatment of uncertainty in the IPCC and its importance in decision making. Moss (2007) concludes by arguing for uncertainty analyses that are decision focused, instead of being presented in a vacuum. The editorial by Ha-Duong et al. (2007) discusses the history of uncertainty management in IPCC assessments and examines why different Working Groups have used different methods to assess and communicate uncertainty. They argue that uncertainties related to human choice explain why Working Group III of the IPCC (dealing with mitigation) did not follow the IPCC "Guidance paper" on addressing uncertainties. Ha-Duong et al. (2007) make a case for a multi-dimensional approach to uncertainty communication in IPCC assessments.

In the first research paper of the special issue, Vincent (2007) examines uncertainty in the concept of adaptive capacity with a particular focus on the scale of the analysis, comparing a national level index for cross-country comparison in Africa and a household index for cross-household comparison in a village in South Africa. She shows that the development of robust indicators are complicated by the contextual nature of adaptive capacity, by considerations of timescale, and by the difficulties of validation. Nevertheless, there is some convergence among the central elements of such indices around notions of institutional collective response and access to resources.

In relation to mitigation, Mander et al. (2007) use a backcasting approach to explore the possibilities of energy pathways for meeting the UK Government's 60% carbon emissions reduction target by 2050. Their participatory scenario methodology allows for the identification of key uncertainties using a formal typology which differentiates between uncertainties due to 'limited knowledge' and those due to 'social variability'. The principal message in relation to uncertainty is that making the transition to a low carbon energy system is more securely achieved through a focus on a reduction in energy demand than on an increase in low carbon supply.

Patt (2007) and Marx et al. (2007) examine different psychological dimensions of uncertainty in climate change perception and communication. Patt (2007) conducts an experimental study to compare the effects on citizens of uncertainty that is quantified using models and uncertainty that emerges from expert disagreement. This is an area that has been overlooked by the IPCC and other assessment panels working under a standard expected utility paradigm. Although the results of the experiment were inconclusive, they were consistent with the psychological and social models of decision making in which problem framing matters and in which people are not assumed to optimize on the basis of probability estimates. Patt (2007) concludes with some recommendations for the IPCC and other assessment panels.

Using different case studies, Marx et al. (2007) examine how uncertainty about climate information can best be communicated. They focus on two ways in which people process information: analytically and experientially. They draw heavily upon two projects: one that examines the impact of vicarious, experiential information (as exemplified in the movie *The Day After Tomorrow*) on climate change risk perception and policy; and the other that looks at the comprehension of statistical information through experiential retranslation by Ugandan farmers' groups. Marx et al. (2007) conclude that in order to best communicate climate risks both analytic and experiential approaches need to be considered through participatory decision making.

The last two papers consider the place of uncertainty in decision making about adaptation to climate change. Dessai and Hulme (2007) and Groves and Lempert (2007) develop analytic frameworks to assess robust adaptation strategies under deep uncertainties. Dessai and Hulme (2007) assess the robustness of an adaptation strategy—a company's Water Resource Plan in the East of England—to a number of climate change uncertainties. They find that adaptation decisions about future water resource investments are sensitive to some uncertainties, but that the water company plan remains robust overall because of the sampling used, the adaptation options considered, and the climate model used in planning. This reveals a mixture of both planned and serendipitous factors in designing robust adaptation. Groves and Lempert (2007) apply a robust decision-making approach (Lempert et al., 2003) to identify policy relevant scenarios in the context of water resources planning in California. The resulting scenarios can communicate quantitative judgements about uncertainty, as well as support a well-defined decision

process without many of the drawbacks of approaches which take a less structured view of uncertainty.

Climate is changing in response to human perturbations of the atmosphere and future climate is uncertain—both because our scientific understanding of the workings of the climate system remains incomplete and because the evolution of future climate is (partly) contingent upon human actions. This uncertainty about the course of future climate—on all scales—and uncertainty about how societies will respond to this change in climate presents new challenges for the way individuals, organizations and societies make decisions. It also makes it difficult to design effective, equitable and efficient policies which will achieve the goals of the UN Framework Convention on Climate Change. It is our hope that, as a collection, these papers will inspire a wider debate about what uncertainty means for both mitigation and adaptation responses to climate change.

We would like to thank the contributors and reviewers of the papers of this special issue. Neil Jennings is thanked for all his help in putting together this special issue.

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Suraje Dessai
Tyndall Centre for Climate Change Research, UK and School of Environmental Sciences, University of East Anglia, Norwich, UK
E-mail address: s.dessai@uea.ac.uk

Karen O'Brien
Department of Sociology and Human Geography, University of Oslo, Norway

Mike Hulme
Tyndall Centre for Climate Change Research, UK and School of Environmental Sciences, University of East Anglia, Norwich, UK