

Science, Technology & Innovation Studies
Vol. 6, No. 2, December 2010

ISSN: 1861-3675

STI
Studies

www.sti-studies.de

Post-Carbon Ambivalences

The New Climate Change Discourse and the Risks of Climate Science

Fritz Reusswig (Potsdam Institute for Climate Impact Research, fritz@pik-potsdam.de)

Wiebke Lass (Potsdam Institute for Climate Impact Research, wiebke.lass@pik-potsdam.de)

Abstract

The publication of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) can be seen as a starting point for a new climate change discourse. The paper reconstructs the two ideal types of 'old' and 'new' climate change discourse and pays special attention to the new role of scientific expertise in it. In analyzing the recent credibility crisis of the IPCC, the paper tries to assess the choices to be made at the science-policy interface. We conclude by sketching some of the ambivalences of the possibly emerging post-carbon society, and the challenges for a non-expertocratic science.

1 Introduction

In most developed countries, climate change has evolved as the major environmental concern, and climate science has gained both public attention and policy relevance. Climate science today transcends the boundaries of a single discipline, such as meteorology, and encompasses others like atmospheric physics and chemistry, oceanography, plant biology, ecology, physical and human geography, (climate) economics, (environmental) sociology, political science, and is also supported by scientific tools such as modeling or integrated assessment. Yet, climate science is less a well-defined area of various scientific (sub-)disciplines but more an evolving field of partly heterogeneous domains of research in a highly political context. *If* the scientific evidence supports the idea that humans change the climate, and *if* society declares this a real problem, *then* the results of climate science are highly relevant for the future path of the world society.

For this very reason, climate science is a contested science. And the more aspects it does encompass, the higher the risk of dissenting voices, arguing for different interpretations or valuations of the complex universe of 'climate facts'. A major reason for this polyphonic choir lies in the fact that global warming does *not* result from some insignificant human activities that can easily be changed. Quite the contrary: The immediate causes of anthropogenic climate change are intricately linked to all kinds of important human activities (such as growing food and raising cattle, cooking meals, heating homes, driving cars, flying to other places, using the internet etc.). They are thus not only deeply rooted in everyday routines, they do also relate to all kinds of economic and political structures and related interests. Climate science, initially a rather marginal branch of meteorology, today cannot avoid being political. This is why uncertainties, ambivalences and

controversies exceed the scope of merely scientific debates. They are expressions of and at the same time causal factors within the 'social fabric' that defines the future pathway of human development.

In this paper, we would like to focus on the recent evolutions of climate science, understood as a social endeavor. It will be argued that the dominant climate change discourse has changed recently, and some of the characteristics of that change will be given in section (2), where we analyze this change as a transition from analytical understanding of the climate system to a decision-oriented understanding of the Earth system, a 'hybrid object' composed of natural and social entities, mainly driven by human agency, and subject to all kinds of interventions. This change was brought about by the combined effect of the broadening of the social discourse base, the cognitive closure with respect to prior uncertainties, and the ability to influence the policy cycle. An important test case for the hypothesis of a changing climate discourse is the recent crisis of the public perception of climate science, especially the credibility of the Intergovernmental Panel on Climate Change (IPCC). Section (3) will briefly touch upon this most recent development of the climate change debate. Although it has been argued in the previous section that the public climate change discourse has reached a new quality, there is no reason to believe that the new discourse will be free of ambiguities and conflicts. On the contrary, it will be argued in section (4) that we are facing new uncertainties and conflicts, and some of them will be characterized. We will argue that these conflicts mainly arise from the ambiguities that have become explicit in the new climate change discourse, especially from the side-effects of 'climate solutions' and their evaluation. The final section (5) concludes by defining some future challenges and tasks of (climate) science as we see

them today, and it especially addresses the responsibility of the social sciences that have become much more important in the new climate change discourse. By arguing in favor of a 'reflexive interventionism', we propose that social scientists should transcend their chosen role as 'pure observers'. Only by reflexive interventionism, we argue, can the social sciences adequately perform their tasks in the new climate change discourse.

2 The Old and the New Climate Change Discourse

Climate change is a highly scientifically mediated issue. Other than, say, air or water pollution, average everyday actors can hardly detect changes in the central parameters of the Earth's climate (Yearley 1994). One of the reasons for this is the 'ontological' distinction between weather and climate: While 'weather' refers to the concrete state of a set of parameters of the lower atmosphere, such as air temperature, humidity or sunshine, 'climate' is a theoretically more ambitious construct, referring to statistically significant patterns of weather over time (about 30+ years), linked to basic mechanisms of the physical Earth system (such as the solar constant or the global carbon or water cycles). As weather encompasses many stochastic processes, it cannot be precisely predicted. Climate, on the other hand, is characterized by a high share of deterministic processes, resulting in the counterintuitive fact that we can 'predict' the climate of 2100 more precisely than the weather of next week.

This is not to say that lay persons are completely unable to notice changing climate patterns. People with high stakes in the economic use of climate sensitive natural resources, such as farmers or fishermen, have developed their own methods of monitoring weather patterns in order to cope with adverse effects, especially in developing countries (cf. Broad and Orlove

2007, Orlove 2005, Patt 2001, Semenza et al. 2008). Nevertheless, *global* climate changes can only be detected by systematic instrumental records, statistical methods, the analysis of historical data sets, and computer models (Edwards 2001; Rahmstorf and Schellnhuber 2007), which are beyond the scope of non-scientific observers. This is why the history of the climate *discourse* (see below for a definition) is for long almost exclusively – and even today to a substantial degree – a history of climate *science* (or its predecessors) (Fleming 1998; Weart 2003). Measured global warming until today adds up to no more than an increase of 0.8° C of Global Mean Temperature (GMT) since the 19th century (IPCC 2007). GMT is a statistical construct that integrates across all geographical regions, seasonal differences as well as day/night-differences – the very fabric of everyday experience. Usually perceived and relevant daily temperature changes by far exceed this figure. The scientifically mediated character of climate change especially holds when it comes to the attribution problem: who or what is responsible? Climate (other than weather) refers to long-term patterns and processes of the atmosphere as embedded into other bio-geochemical cycles, influenced by the oceans, the biosphere, human activities, and natural factors, such as volcanic eruptions or the sun's activity. Causal analysis and attribution in such complex and non-linear systems is extremely difficult – one of the reasons for various uncertainties in climate science statements, and a major driver behind the increasingly interdisciplinary character of climate science.

And it is not only interdisciplinary natural science that is needed to assess whether or not (and how strong) there is anthropogenic climate change. One also needs to know about system feedbacks and their time asymmetry in order to assess if, how and how quickly societies could 'stop' global warming. This requires a thorough

understanding of the Earth's energy and urban systems, again with inclusion of the major feedbacks of natural systems (e.g. the buffering capacities of the oceans or the fertilization effect of CO₂). Indispensable part of this understanding is an assessment of how difficult a transition of this energy system towards less carbon-intensive fuels (low-emission society) would be and how fast it could be achieved.

Sociologists and other social scientists have repeatedly and correctly pointed out how the scientifically mediated character of climate change anchors it in society and in societal debates. Climate science is part of a social discourse on climate. Human reasoning and practice is constitutively relying on discourses, i.e. on the structured flow of exchanging arguments in order to give reasons for statements and actions – not only for enabling the (public) communication of arguments, but also for the very process of generating reasons in a originally shared world of human action (Brandom 1994; McDowell 1996). Beyond this very fundamental interdependency of discourse and human reasoning, any actual social use of scientific reasoning can be reconstructed as a social discourse, and discourse analysis has developed into a powerful tool of analyzing science-society interactions. It has also been applied to climate change.¹

¹ Keller (2005) offers an enlightening discussion of the sociological and philosophical backgrounds of modern discourse analysis, and gives some applications to debates about environmental risks. Ereaut and Segnit (2006) have analyzed the recent British CCD in an interesting manner, but narrowed down 'discourse' to mass media coverage. Viehöver (2003a; 2003b) has also looked at the ('old') climate discourse, but as a contested narration of reflexive modernity. Discourse analysis can highlight the embedded and contextual nature of global environmental issues, and the constitutive role of discourses in shaping identities, attitudes, and controversies (Macnaghten/Urry 1998).

A *Climate Change Discourse* (CCD) is a thematically focused and (more or less) coupled sequence of publicly visible arguments in various contexts (or framings) that different social actors are engaged in, in order to influence (1) one another, (2) specific boundary conditions of social action (such as politics), and (3) the general public so, that the resource endowments, interests and worldviews of the speaking actors have a higher chance to prevail in the social interpretation and individual or collective decision making processes. It is worth noting that this definition on the one hand draws from discourse analysis in the Foucault tradition, but combines it with sociological theories that focus on actors, action, and structures (Giddens 1984; Oswick et al. 2007). And it links power and truth, i.e. the realm of argumentative justification of (scientific) claims (Habermas 1981). Discourse analysis can be seen as a contemporary realization of a famous dictum of Max Weber's:

"Not ideas, but material and ideal interests, directly govern men's conduct. Yet very frequently the 'world images' that have been created by 'ideas' have, like switchmen, determined the tracks along which action has been pushed by the dynamic of interest." (Weber 1946: 280)

Would one concentrate on 'ideas' exclusively, one would, for example, be able to follow the changes in narratives about carbon dioxide, but risks to ignore the economic and political interests involved (Blaikie 1996). Talking about these interests by neglecting the sphere of 'ideas' would, on the other hand, miss the interpretation (framing) of interests, and thus their relevance to social action. Discourses are the social 'locations' for creating and processing ideas and worldviews (Weber: 'world images'), as well as social spaces that are shaped by interests. 'Ideas' and 'interests' in their *interplay*, not as *isolated* from each other make up a social discourse.

The distinction between 'old' and 'new' CCD creates two ideal types,

thus stylizing facts in a manner that enables the generation of hypotheses and further discussion.² One can summarize the changing CCD with the following table:

worldwide (Besio and Pronzini 2010; Boyce and Lewis 2009; Boykoff 2007).³ Second, in qualitative terms, the character of mass media reporting has changed, and one important indicator

Table 1: Old and New Climate Change Discourse

Analytical Dimension	Old Climate Change Discourse	New Climate Change Discourse
Master Frame	Climate System Analysis, Attribution	Earth System Management, Decision
Leading Sciences	Physics, climatology, other natural sciences (IPCC Working Group I).	Economics, engineering, other social sciences (IPCC Working Groups II & III)
Main Risks	Climate Risks	Socio-Climatic Risks
Main Uncertainties	Climate System Uncertainties	Hybrid Earth System Ambiguities
Core Questions	Is there (anthropogenic) climate change? How certain can we be about it? How and when will natural and social systems be affected?	What is dangerous climate change? How can a cost effective and fair stabilization of the climate system be achieved? What is an optimal degree of adaptation, and how can it be financed?
Main Actors	Natural sciences, environmental politics, environmental movement	Trans-disciplinary science, politics in general, business sector, environmental movement, critical consumers & citizens
Core Public Debates	Nature versus society Alarmism versus skepticism Mitigation versus adaptation	Hybrid scenario preferences Normality of climate change Optimal mix of mitigation/adaptation

Well aware of the difficulty to exactly date the beginning of the 'new' CCD, we suggest the years 2006/07 as its inception phase. There are some indicators that support this hypothesis. A first indicator is the significant increase in mass media coverage of climate change – not only in Europe, but

here is that especially in the U.S. the 'balanced' view (presenting climate supporters and skeptics as two equally legitimate scientific positions, see Boykoff/Boykoff 2004) has given way to an unequivocal statement that climate change is real, that its causes are

² Weingart et al. (2000; 2002) and Carvalho and Burgess (2005) have proposed other, partly more fine-grained subdivisions of the CCD. None of these authors has yet looked at the most recent period which is addressed here. As we refer to ideal types in a hypothetical distinction, we usually use quotation marks when speaking of old and new CCDs.

³ There are substantial differences in the quantitative and qualitative coverage of climate change, not only between countries (coverage is less marked in developing and transition countries, quality is lower), but also between individual media. Nevertheless, compared against their relative historical backgrounds, 2006/07 has been a historical threshold in *all* countries and *most* individual mass media.

anthropogenic, and that something should be done to prevent (further) climate change (Boykoff 2008; Cottle 2009). Several agenda-setting studies show that press coverage does influence public attention to climate change issues (Hester/Gonzenbach 1997; Trumbo 1996). And it is not only the frequency of coverage, but also the character and framing of that coverage that help to draw public attention to environmental issues, e.g. the narratives told and the storylines presented (McComas/Shannahan 1999).

Some additional stimulating events of the emerging 'new' climate discourse have to be mentioned, which helped to bring about the new master-frame of decision making:

- The publication of the 'Stern Review' (2007) in late 2006, where a number of distinguished climate economists have argued that (a) the consequences of (unmitigated) climate change would be substantial in monetary terms, and not marginal as often previously thought; and that (b) climate policies would be much less costly than often assumed (only about 1-2% of the world GDP). This helped the business community and policy makers to justify otherwise too risky investments and regulations.
- The publication of the IPCC's Fourth Assessment Report (2007), showing that climate change is happening more rapidly than previously thought, and settling the debate about whether or not human activities can be attributed as drivers. IPCC's Working Group III basically confirmed the results of the Stern Review, and underlined the urgency of action.
- The Nobel Peace Award for both the IPCC and Al Gore, who in his movie 'An Inconvenient Truth' (2006) had demonstrated the serious consequences of climate change to a wider public worldwide. Among other things, Al Gore in 2007 became portrayed together with (other) Holly-

wood celebrities in a 'green' cover story of *Vanity Fair*. Al Gore organized a worldwide series of music festivals in early 2008 in order to highlight the necessity to act against climate change. The issue thus had become part of popular culture.

The most important question for the 'old' CCD, which we would date from the founding of the IPCC in 1988 to the first years of the 21st century, was to find out if and to what degree human activities did cause observed recent climate change. In order to do so, massive climate change research programs had been launched, including data gathering, modeling work, and systematic analysis (Conrad 2008; Fleming 1998; Miller/Edwards 2001; Maslin 2004; Weart 2003). Our understanding of the climate system did grow substantially during this first phase, and it ended by more or less unequivocally answering the attribution problem: 'Yes, the climate is changing, and, yes, human activities (such as burning fossil fuels or clearing forests) are responsible for the majority of the observed changes'. The natural sciences – such as physics, meteorology, atmospheric chemistry, biology – did take the lead in that early phase, given the enormous complexity of the climate system and its links to important bio-geophysical cycles (like carbon, water or nitrogen). All kinds of uncertainties did occur and had to be tackled, not only with respect to missing data, but also with respect to imprecise or contested scientific models, and to the complexity of a mainly mechanistic, but partly stochastic and, above all, non-linear system.

In the 'new' CCD, after the closure of the attribution debate, the new master frame is Earth System Management, explicitly taking into account the human contribution to a changing atmosphere, as well as the widely recognized necessity to take decisions in view of adverse impacts of climate change, either by mitigating against its causes, or by adapting to a changing

environment. Instead of being a distinct and purely natural object, the Earth's climate is now fully recognized as being an integral part of human-nature interactions at various levels. Climate transformed from a natural to a 'hybrid object' (Latour 1993), including human activities as well as the reflexive reaction upon our knowledge about climate change.⁴ The leading question now no longer is whether or not there is anthropogenic climate change, but rather what to do about it. More precisely: How can a cost effective and fair stabilization of the climate system be achieved? In this global management perspective climate risks have become dependent upon societal decisions, so that socio-climatic risks are at stake. Not only in the sense that climate change has become visible as a side-effect of intentional human action (such as heating a home or driving a car), but also in the sense that – in the face of that knowledge – we now have to confront the risks and costs of climate *inaction* with the risks and costs of climate *action*. The dominant uncertainties of our climate knowledge now mainly originate from human decision making processes, no longer from, say, the stochastic component of the climate system. The latter adds to the former, but the former defines the new quality of risk. As decisions at various levels have to be looked at in order to 'predict' the future climate, climate science is confronted with the inherently ambivalent character of human choices, bringing additional uncertain-

⁴ There is a 'very old' climate discourse, dating back to the ancient Greeks, mainly stating that the Earth's various climates more or less determine—via the human body—the way people think and behave, and thus also influence culture and politics. Elements of this early form of climate determinism can also be found in later periods, such as in Montesquieu (18th century) or Huntington (20th century) (Stehr/Storch 2000). The 'old' climate discourse is inspired by a scientific hypothesis of the 19th century, that humans can in fact modify not only local climate conditions, but the climate of the whole planet.

ties to climate projections. A multitude of preferences and alternative choices (opportunity costs) now have to be taken into account.⁵ We have to choose among different socio-climatic (thus termed hybrid) scenarios, and our choices depend not only upon our knowledge about the Earth system (including its uncertainties), but also upon our preferences and values, which are often inconsistent, conflicting, and subject to historical change. We would like to use the term ambiguity in order to characterize this type of risk coming up in the 'new' CCD.

While climate change in the old discourse was mainly debated by natural scientists, environmental NGOs (ENGOs) and environmental politics, today we observe a substantial broadening of the actor base:

- Many more sciences engage with climate research, and new sub-disciplines such as 'climate economics' have emerged. Governments have launched various interdisciplinary climate research programs, and as a result new research capacities, institutions and communities have been built. They in turn generate new questions, ask for additional funds, and offer new solutions (Halfmann/Schützenmeister 2009).
- *Climate policy* during the 'old' discourse was more or less confined to the environmental ministries and their administrative extensions (like environmental protection agencies). The 'new' discourse is characterized by (a) a substantial broadening of

⁵ Some scholars even doubt whether it is both possible and feasible to build climate policy on the search for coherent and consistent social preferences (Jaeger/Jaeger 2010). But even if one assumes that an optimal social choice is possible, it inevitably comes with the opportunity costs of foregone options—and these are the 'stuff' that political debates are made of. Every 'optimal' social choice in point t_1 can be questioned in t_2 , based on new facts, new preferences of old players, or old or new preferences of new players.

- political agencies that deal with climate change, and (b) by an upgrading of climate policy in the agenda of the political system as a whole. Today, climate issues are dealt with in all branches of the administration, such as economic policy (e.g. when it comes to the subsidizing of renewable energy), education and research policies, infrastructure and traffic planning, foreign policy etc. In recent times, leading political figures such as Barack Obama (USA), Tony Blair (UK), Angela Merkel (Germany) or Manmohan Singh (India) have given climate change top priority – at least for some time. Climate change has evolved from a marginal issue to a complex political theme that might even play a role in general elections.
- The 'old' CCD saw the *business sector* mainly as opposing the claims for combating global warming. Industry was mainly perceived as 'the enemy', a view that many environmental NGOs did hold at that time. Today, a remarkable part of the industry makes money by selling 'green' products or services, such as wind or solar power plants, bio-fuels, green electricity, building insulation materials, carbon offsets etc. Millions of jobs depend upon these 'green industries' (Lehr et al. 2008). And even traditional, carbon-intensive industries, such as car manufacturing or oil production, have developed green branches or product lines, broadening both their economic portfolios as well as their political lobby interests. The recent boom of organizational changes such as the introduction of Corporate Social Responsibility (CSR) or of Sustainability Reporting has supported and reinforced this trend (Epstein 2008; Laszlo 2008; Schaltegger/Wagner 2006).
 - In the 'new' CCD, *critical consumer organizations* and *concerned citizens* do play an important role. They assume responsibility for themselves, but also advocate climate friendly policies and green business models. Lifestyles of Health and Sustainabil-

ity (LOHAS) are both detected and promoted, and many civil society watchdogs have taken on the issue of climate change as a good opportunity to promote their agendas. Technological changes, most importantly the rise of the internet, have substantially reinforced this more active role of the civil society in the new CCD. Web blogs for example help both to create virtual communities and to influence the mass media and political decision makers. The new CCD is a significant driver of a possibly emerging 'moral economy' (Stehr 2007), linking questions of private consumption and lifestyle choices to outcomes in terms of the carbon footprint of individuals, communities and countries (Leggewie 2010; Leggewie/Welzer 2009).

One thus can observe a *broadening* of the set of actors that participate in the social discourse on climate, which at the same time has *intensified* – measurable in terms of more mass media coverage, or more political debates and decisions related to climate. *Ceteris paribus*, that is under the conditions of the 'old' CCD, this might have led to an intensification of 'old' controversies, such as the oscillation between alarmism and skepticism. But this has not happened. Instead, climate change has become a reality, part of the normal world view, and the mass media as well as the mass media consumers take it for granted that upcoming extreme weather events are part of that normality. From 2006/07 onwards, we can observe a remarkable closure of the 'old' debate about attribution, and a significant shift of the dominant discourse frame towards decision-making problems. The *discourse closure* was mainly promoted by the scientific community (around Working Groups I and II). The *discourse shift* was mainly initiated by Working Group III scientists and a related community of climate economists.

Their argumentation to some degree resembles to what engaged scientists and environmental NGO activists had already stated in the 'old' CCD: the problem is real, and now something has to be done about it. Nevertheless, different to former times, this conclusion could now be supported by serious data analysis and computer based economic reasoning.⁶

Many NGO representatives and policy makers – not only, but foremost those who had been involved in the boundary organization IPCC and in environmental decision making – together with some business representatives basically accepted this view, trying to accommodate it to existing political programs and profiles. These agents thus added something to the climate discourse that it was lacking so far: a viable socio-economic vision of the future that at least offered the chance to find the support of social majorities, together with some degree of economic *resources* and political *power* to bring it about. The narratives of a 'Third Industrial Revolution', a 'Green New Deal', or simply the 'greening of the economy' did orchestrate this vision in different political disguises.

This discourse change can thus not be grasped by the concept of 'epistemic communities'. Haas (1992) has coined this term in order to highlight the constitutive role of scientific consensus for environmental policy making. As in the case of acid rain or ozone layer depletion, in climate science there is something like a scientific consensus about

the attribution problem (with some clearly marked remaining uncertainties), which has been forcefully communicated in and around the Fourth Assessment Report by IPCC members (above termed discourse closure). However, the main drivers behind the discourse *shift* towards (economic) solutions – the climate economists and some other integrated assessment people around WG III – do not share neither a cognitive nor a normative consensus with respect to exactly *what* the solution might look like. A majority favors technological solutions, but there is a minority opinion that behavioral changes would (also) be needed. And among those who favor technological solutions, some see nuclear power as the most important wedge, while many others argue that only renewable energy sources are the way to go. Most economists favor market solutions, while others see a more prominent role for the state. And so forth. In other words: the 'new' CCD is characterized by various discourse coalitions (Hajer 1995), not only by a single one. The visible consensus did thus only cover the notion that climate change was happening, that it would become very dangerous if business as usual was to prevail, and that massive technological and other supporting measures would rather rapidly have to be taken. It did neither include the socio-technical pathway, nor did it cover the instruments and measures by which to achieve it. This remains the task and challenge of the 'new' CCD, and this is a major reason why we think that it will be characterized by vivid debates and conflicts.

However, together with the formerly mentioned discourse closure, this discourse shift did suffice to lend everyday *credibility* to the seriousness of the climate change issue, even beyond the question whether climate science is right or if media attention cycles are supporting public perception of climate issues. If, as in the case of Germany or the European Union, encom-

⁶ The Stern conclusions did not pass uncontested by many 'mainstream' economists, questioning aspects like discount rates or damage figures (Tol 2006; Tol/Yohe 2009). More 'radical' critics asked for leaving behind some basic assumptions of standard neoclassical theory, doubting that cost-benefit analysis is a feasible tool for climate policy (Spash 2007). In our view it has been exactly this 'sticking to mainstream thinking' that enabled the conclusions of the Review to become so powerful in the scientific community and, especially, in policy making.

passing climate policy packages with ambitious goals (e.g. reducing GHG emissions by 40% until 2020), a variety of measures and instruments (from economic incentives to announced bans) are publicly discussed and brought on their way, the climate discourse has entered a new and advanced stage of the policy cycle (Jänicke et al. 1999). Scientific evidence usually plays a crucial role in early stages, especially in the phase of problem definition and agenda setting. In the 'new' CCD, a thematically broadened scientific discourse has managed to influence policy formulation, policy implementation, and to some degree even policy monitoring. The discourse, in other words, has managed to shape the boundary conditions for further decisions and their discursive embedding. And this also means that the public awareness of climate issues has started to become decoupled from the mass media and its attention cycles – at least with respect to climate science and (possibly) related natural disasters. Climate issues have made their way to 'normal' policy debates in various action arenas, and these are – other than scientific debates – object of constant mass media observation and attention.

These three tendencies – the *broadening* of the actor base, the *narrowing* of the argument base, and the *strengthening* of the policy relevance – taken together have helped to bring about the 'new' character of the social CCD. They are responsible for the new framing of the discourse, as well as for the shift in the core questions and the related scientific implications, e.g. new research questions that arise in climate science.

Before we expose our interpretation to a possible counter example in the next section, we would like to stress that *new* discourse formations do not preclude *old* arguments to be repeated or renewed by particular actors. We have characterized the 'new' CCD by a *broadening* of actively participating

actors, *not* by a *substitution* of actor set A by actor set B. This implies that participants of the 'old' CCD are still speaking today, trying to rephrase them under the new boundary conditions, or even try to reverse the change of the master frame.

In other words, there is ample reason to assume that we will be confronted with new and even intensified conflicts in a 'new' CCD. These conflicts do not arise *in spite of* a reached consensus on the attribution problem, but *because* of it. Once the 'human' factor in climate change has been firmly established, the full complexity, including ambiguities and heterogeneous interests, of modern society has become part of the climate discourse.

3 Interpreting Calamity: The recent 'credibility crisis' of IPCC and its meaning

Discourse changes are not irreversible. The stylized distinction made in the previous section could have rolled out in the years to come, with climate change remaining an uncontested scientific issue residing at the higher ranks with the agendas of policy makers, the business sector and civil society organizations.

However, things came different. In 2009/10, climate science in general and the IPCC in particular did come under heavy attack by many critical observers, questioning not only the credibility of science, but in part also the relevance of climate change as a public issue. Whether or not this recent 'credibility crisis' will inhibit the further development of the 'new' CCD remains to be seen. Before we address this question, we would first like to face and interpret some relevant facts.

- *The Economic Crisis*. In 2008 and 2009, the global economy underwent a severe crisis, initiated by the breakdown of the U.S. real estate 'bubble'. Across the globe, the economic output of most economies

- dropped, many lost their homes and savings, and many more their jobs. One climate change relevant consequence of this crisis was the drop of global CO₂ emissions of about 2.5% (GCP 2009). Another was that public concerns about climate change have been outdistanced by concerns about the economy in most countries (for the U.S. see Gallup online: www.gallup.com/poll/1615/Environment.aspx#1; for Europe see Eurobarometer 2009).
- *The Copenhagen 'Failure'*. The COP 15 meeting of UNFCCC parties in December 2009 was the largest climate policy conference ever. More than 16,000 participants, many of them from NGOs, and numerous political leaders across the globe had been attending. The media coverage was huge, and expectations high. While the conference started promising, the closer it got to decisions, the more disappointing the results turned out to be. No binding Post-Kyoto regime was established. The final document – termed ‘Copenhagen Accord’ – did accept the 2° C goal, but remained mute about concrete measures to reach it. Besides some financial transfers to poorer countries for adaptation, nothing tangible came out of Copenhagen, and all remaining work was passed on to future conferences. The COP 16 conference in Cancún (December 2010) could not resolve the issue, but helped to stabilize the UN climate regime.
 - *'Climategate'*. Immediately before Copenhagen started, internet blogs and newspapers did report about the publishing of some ‘secret’ e-mails from some climate scientists at the University of East Anglia. This ‘uncovering’ seemed to demonstrate that climate scientists did actively manipulate their results in order to push the climate policy agenda.
 - *'Glaciergate'*. At about the same time, scientists discovered an open mistake in the 2007 WG II contribution of the 4AR, maintaining the Himala-

yan glaciers to retreat until 2035. This statement was based on non-peer reviewed (so called ‘grey’) literature (in this case from a NGO report), which first was not in line with the working principles of IPCC, and second did contradict the (presumably correct) statement of glacier experts in the WG I contribution to the same report.⁷

These developments did lead the climate science community into a rather disastrous ‘mood’ at the beginning of 2010. All the credits of IPCC, the hallmark of a politically relevant community of excellent (peer-reviewed) scientists seemed to have been melting away like the famous ice caps and glaciers of the planet. The public perception of climate science had reached a low. U.S. respondents for example tended to believe that the media in general exaggerate the seriousness of global warming (2007: 35%, 2010: 48%). 36% believed that scientists were unsure about climate change, up from 29% in 2006. The loss of conviction that climate change is already happening was especially marked with those who felt best informed about climate change; those who do not understand much of the issue have remained uninfluenced by the recent debate (Gallup online: <http://www.gallup.com/poll/1615/Environment.aspx#2>).

How is this development to be interpreted? Does it not contradict the claim of a new CCD made in the previous section? Given the very recent character of these events, any interpretation seems to be preliminary. For the so-called climate ‘skeptics’ (otherwise also termed ‘contrarians’ or ‘deniers’), the interpretation is rather easy: IPCC has always been an advocacy coalition rather than a thorough scientific body,

⁷ Another mistake in the same document did quote misleading information about the size of the low-lying areas in The Netherlands, provided by a Dutch governmental organization.

and the recent events only reveal this to the wider public (Singer 2008; Idso/Singer 2009). Looking back to a long-standing history of quite successful work in 'debunking' climate science and lobbying against climate policy (Agrawala 1998a; 1998b; McCright and Dunlap 2003), the 'skeptics' community tries to seize the actual opportunity and 'kill' the whole issue.

But not all critics of IPCC are climate contrarians, and not all are on the payrolls of the coal, oil and gas industries. Some even have participated in IPCC reports. They still criticize the way the IPCC results have been generated and communicated. Pielke (2007) for example argues that many IPCC scientists have left behind the role of a 'solid broker', offering sound scientific evidence and the option space of possible choices to policymakers, taking on (often covertly) the role of an 'issue advocate', trying to sell preferred solutions to politicians. In reading the books of famous climate scientists (Hansen 2009; Schneider 2009), one can see how difficult to draw that line in reality is. And it is not a priori clear whether one has to blame the scientists or reality for this difficulty (Jasanoff 2008).

Against this background, a reform of the IPCC has been proposed by many observers and participants in 2010. Broadly speaking, the propositions made fall in two categories: While some argue in favor of re-assuming the role of the 'honest broker' (Pielke 2010) and of re-scientification even at the expense of its policy interface (Schellnhuber 2010), others resort to more explicitly dealing with values and the intrinsically political nature of climate science, e.g. by dissolving the three working groups (Hulme et al. 2010).

In interpreting the calamity in which IPCC seems to have come, one has to keep several points in mind:

- IPCC undoubtedly issued erroneous statements in its 2007 report – most

probably also in earlier ones. Every scientist or scientific organization is bound to 'getting the facts right', otherwise its credibility suffers. However, given the huge number of scientific publications that IPCC has reviewed, as well as the large number of international reviewers, failures do and will continue to happen. The contradictions between Working Groups I and II indicate that IPCC needs closer collaboration between its Working Groups, transparent rules for dealing with 'grey' literature, and possibly an independent supervising committee to control the correct application of rules. But given the overall quality of its reports, as well as the quantitative relation between errors and non-errors, IPCC is still an outstanding scientific organization. This especially holds when one takes the treatment of uncertainties into account, which many other scientific bodies treat much less transparent than IPCC, although even there improvements are possible (Edwards 1999; Edwards/Schneider 2001; Schenk/Lensink 2007). Alarmism is the wrong way if there is no reason for concern. But if climate trends provide ample reasons for concern, scientists have to be alarming (Risbey 2008).

- Attempts to re-establish IPCC as a purely scientific body in order to regain public credibility are risky both for IPCC and the UNFCCC process, given the success story of this very specific 'boundary object' (S. Beck 2009; Conrad 2010; Skodvin 1999; 2000). Climate policy has been and in large parts still is a science-driven issue. But keeping politics out (according to the original rules of the British Royal Academy in the 17th century: 'Not Meddling with Politics') of the formulation process of IPCC Reports would substantially reduce the political relevance and impact of IPCC, especially under conditions of the 'new' CCD. Political bureaucracies that, together with IPCC,

- have developed expertise and commitment would lose interest, and IPCC would share the fate of so many scientific expert committees, that usually pay the high price of political irrelevance for their presumed scientific purity. Climate science can be regarded as an example for 'post-normal science': stakes are high, and uncertainties as well (Funtowicz/Ravetz 1993). Attempts to 're-normalize' it risk to trade less impact for more purity (Ravetz 2010).
- There is no doubt that the 'Copenhagen Accord' (<http://unfccc.int/resource/docs/2009/cop15/eng/107.pdf>) has disappointed the high expectations that many climate activists and scientists did have. No binding commitments have been achieved, and the greenhouse gas reductions offered on a voluntary basis by some governments fall short from any realistic chance to achieve the 2° C goal (Rogelj et al. 2010). Nevertheless, the Accord is the first international policy document within UNFCCC to accept this goal as a valid and binding definition of Article 2 of the Convention, stating the prevention of 'dangerous anthropogenic interference in the climate system' as policy goal. May be more flexible multilateral solutions for single aspects of the climate problem will be found. In addition, the 'failure' of Copenhagen has facilitated the importance of non-state actors in (international) climate policy, namely consumers/citizens, the business sector, and local communities, especially cities. This might also give rise to new initiatives at the international level (Ostrom 2009; Sterk 2010).
 - Macroeconomic indicators as well as expectations regarding the economy point to a recovery of the world economy already in 2010, not only in India and China where two digit growth rates have come back. Parallel to this, public awareness and concern regarding climate change might also recover – in fact we have empirical evidence supporting that

view (Borgstedt/Reuswig 2010). This holds especially true if one takes into account that many weather related disasters can in principle be causally linked to global warming, as the mass media have done (sometimes erroneously) during the last decade. Forest fires in Russia and floods in China and Pakistan during summer 2010 are cases in point.

The heated and controversial public debate on IPCC and climate science in general in 2009/10 can hardly be explained as a debate about scientific accuracy. Otherwise the public would have had to blame mainstream economists much more aggressively after their failure to predict the recent economic crisis. Giddens (1990) argues that trust entails a commitment to something, rather than just a cognitive understanding. The trust crisis of IPCC is thus not merely a crisis of the cognitive credibility of climate science, but also a chance to get rid of the illusion that our commitment to climate policy was only a function of scientific discoveries. Instead, we are confronted with the inevitably political character of our climate views and choices (S. Beck 2010; Jasanoff 2010). The intensity of the debate indicates how powerful climate science has become, or is perceived to be. The coincidence of 'Climategate' with the recent economic downturn indicates another element of explanation: By shifting from 'Convinced that climate change is real' to 'We are not sure about the science', the general public can dispense itself from saying 'Yes, action would be needed, but actually we have other problems'. When people are facing an economic crisis, they may be less willing to support policies that will cost them money, but at the same time feel uncomfortable about jeopardizing the planet's future simply to fatten their bank balance. Skepticism absolves them of selfishness.

Interpreted that way, it would once more be a failure to focus on the scientific credibility issue exclusively

when considering the recent twist of the Climate Change Discourse. Instead, we do better to address a much wider scope of the science-society interface in actual CCD. This ultimately leads to the ambivalences and risks associated with the possibly emerging post-carbon society. In our interpretation, the recent debate about IPCC is less a consequence of scientific uncertainties (as it would have been under the auspices of the 'old' CCD), but rather a symptom of decision ambiguities that characterize the 'new' CCD.

4 Ambivalences of a post-carbon society

Discourses, it has been mentioned, refer to speech acts, e.g. to socially relevant narratives of looming disasters and culprit agents such as CO₂ (Viehöver 2003a; 2003b; and in this volume). Discourses, as Weber reminds us, do also refer to social actors, their interests and their actions. For discourse analysis – not only in the case of climate change – it is crucial to keep the interactions between the 'material' and the 'ideal' levels in mind. Neither is it true that ideas and worldviews simply 'reflect' pre-determined interests, nor can be stated without restrictions that actors are simply governed by 'discourse' in the narrow, idealistic sense of the word. The relation between both levels is a dialectical one: the 'ideal' sphere of worldviews – expressed in speech-acts – and the 'material' sphere of interests – expressed in dispositions, preferences and actions, anchored in positions of the socio-ecological system – are opposite aspects that are mutually dependent at the same time.

Human action, far from being 'mute' behavior, is inevitably interwoven with the logic of reasoning as set out in language. Other than by *interpreting* what we do – or what we observe others doing – the very fact of *doing* is non-existing for humans. And as a private language is impossible (Witt-

genstein), interpretation is a social process, taking place in a world shared by a multitude of actors.

Social change and/or scientific progress can thus alter the *meaning* of one and the same action. The climate discourse provides sufficient examples: While 'car driving' was an action (and a concept) that did relate to many discourse orders (such as the economy or law), it did not occur as a global environmental problem until the climate discourse identified CO₂ emissions from cars as a source of global warming.

The same holds for interests. One might think that having economic assets in fossil fuels inevitably binds the asset holder to particular interests and significantly limits the scope of possible actions. Although this is empirically often true, it is not necessarily true. Even in the empirically *true* cases fossil fuel asset holders still need to interpret their assets and evaluate them in the social space and its dynamic in order to detect profitable ways of utilizing the resource. But there are cases where this link does not hold true. Some fossil energy companies have started to seriously invest in renewable energy sources, broadening their economic portfolio, while others have remained reluctant, maintaining their fossil fuel path dependency. These cases are not exceptions from a rule ('actions follow interests, interests follow physical assets'), but arguments of another rule ('actions follow *interpreted* interests, interests follow *evaluated* physical assets'). The important point is that this latter rule holds for both cases – fossil path dependency and portfolio approach – alike. It is not (necessarily) a different physical asset base that drives company A to diversify, while company B stays its course. It is a different *interpretation* of that asset base in the economic and political landscape that leads one company to divert from the path taken by the other. These differences may arise due to a new assess-

ment of profit rates from renewable energy sources, or from expectations about new government regulations, or from changes in the public perception of the corporation etc.

The 'new' CCD has revealed that both unchecked climate change and climate protection are choices we have to make, and that both of them come with 'price tags'. It thus ultimately confronts us with questions about the way of life we want to live (Leggewie 2010). As a consequence, the 'new' CCD has to face *new types of uncertainty* and is explicitly confronted with the problem of *ambivalence*, both of which have not been (that) relevant in the 'old' one. While uncertainty in the climate system can arise from lacking data or from the impossibility of predicting the future development of very complex and/or (mainly) stochastic systems, the uncertainty of human agents and social systems arises from other sources: the freedom of human agents to decide otherwise, the double contingency inherent to interaction systems, unintended side-effects of intentional action, or of emerging macro-properties of micro-systems (Mayntz 1991).

In addition, if the climate system is explicitly perceived as part of a wider Earth system that is significantly modified (if not dominated) by human action and intervention (Turner et al. 1990), the scientific understanding of this complex and hybrid object now cannot escape to deal with the fact that human actors (individuals, organizations, states) adhere to different, sometimes even conflicting values that influence their perception of what is the case (or what is relevant), and what should be done at individual or collective levels (Kahan et al. 2011). The new CCD is characterized by this double influence of *uncertainties* from the social realm that add to climate uncertainties, and from the *ambivalences* that any decision brings about due to the (contested) values involved. One thus can, taking these elements

(uncertainties about human decision making, ambivalence of decisions) together, conceive the highly *ambiguous* nature of the 'new' CCD.

As has been stated before, climate change is a scientifically mediated, but by no means a science-dominated affair. It has been stated that the major question of the 'new' CCD is less about the attribution problem ('Is climate change anthropogenic in nature or not?'), but more about the management of adverse effects (adaptation) and of cost effective and fair solutions (mitigation). This might seem to imply degrees of coherence and consistency of measures, according to the motto 'We all know what needs to be done.' This is clearly *not* the case. A unanimous set of solutions, encompassing climate-friendly individual attitudes and behavior, organizational routines, new technologies and supporting political regulation has not emerged yet. Instead, the 'new' CCD is characterized by new controversies about climate friendly lifestyles, technologies, and policies (Giddens 2009). And we are confronted with the unintended consequences and ambivalences of 'climate solutions' – aspects which had been of minor importance during the 'old' CCD, when the solution space for the climate problem has been much less in the center of attention. In other words: The *sustainability* of a post-carbon society that vaguely becomes apparent in the new CCD is open to debate (and in fact has to be debated). One can easily imagine a fully-fledged post-carbon society that massively violates, say, other environmental goals (such as biodiversity conservation) or social goals (such as protecting smallholder farmers from exploitation). There are several aspects that can support this view:

- What looks like a 'solution' or 'wedge' to mitigate against the causes of climate change from a (natural) science point of view has to be regarded as a behavioral change and/or a different investment deci-

- sion from the standpoint of a social actor. Both behavioral changes (such as buying a hybrid car) and investment decisions (such as setting up a wind park) have to 'make sense' for the actors involved, i.e. they have to maximize utility (or whatever rationality concept one wishes to defend), or they have to be profitable, i.e. they have to generate a financial return that exceeds costs by at least average profit rates in a given period of time. Decisions come with transaction costs, and they are located in a world of limited (social) resources. This will inevitably lead to conflicts, competition, trade-offs, strategic use of (scientific) knowledge etc., especially in global capitalist market societies (Deutschmann 2008).
- Given the long lasting path-dependencies of the 'modern' energy system and infrastructures (Arthur 1989; Unruh 2000), the decarbonizing of modern society will be a long-lasting and difficult process. As in every other historical case of major socio-technical transitions (Geels 2005), the transition towards a post-carbon society will bring about structural disruptions. There will be winners and losers of climate change and climate policy (DB Research 2007; Meadowcroft 2009). Potential losers will most probably oppose the transition, e.g. by doubting the credibility and impartiality of its scientific underpinning. They will hijack some arguments, piggyback on others, or re-interpret them in 'creative' ways – just in order to utilize social trends for particular interests. Losers are usually much clearer about their losses than potential winners about potential gains, resulting in an asymmetry of their respective voices. Post-carbon ambiguities result from the creative ability of social actors to re-interpret both their interests and hegemonic ideas that might threaten them.
 - Given the complexity of the hybrid Earth system, which is heavily influenced by human action without being completely determined by it, many interventions are possible, but remain risky at the same time. Global mean temperature, the central 'driver' for all kinds of climate change impacts, cannot, as a statistical property of the system, directly be influenced by human action. Only anthropogenic emissions can, but the translation of emissions (via greenhouse gas concentrations) into temperature remains a scientific challenge. In addition, many 'variables' of the Earth system intervene in not-easy to understand ways: the oceans, terrestrial and marine biomass, global biogeochemical cycles other than the carbon cycle (e.g. water or nitrogen), the albedo of different land covers, dust in the atmosphere etc. (Rahmstorf/Schellnhuber 2007; Walker/King 2008). If, for example, the iron fertilization of the world's oceans could substantially increase their carbon uptake, costly emission reductions 'on land' are rendered unnecessary. Such 'geo-engineering' options have been arising rapidly in recent years, trying to intentionally intervene in the Earth system by technological 'fixes' on a global scale (Blackstock et al. 2009; Shepherd et al. 2009; Stephens/Keith 2008). The more difficult political attempts to limit global GHG emissions at various levels turn out to be, the more tempting it will become to think about these risky geo-engineering options (Ott 2010). Post-carbon ambiguities result from the persistent and inherent complexity of the Earth system, rendering risky reinforced attempts of deliberate global human intervention (geo-engineering).
 - The core criterion for a post-carbon society is a technical but at the same time a very minimal one: to substantially reduce the atmospheric emissions of greenhouse gases, measured in carbon dioxide equivalents. Many concrete technological and social development pathways – some of which mutually exclusive – are in-

- ternally consistent and comply to that condition, even without referring to the ‘magic bullets’ of radically new technologies (Pacala/Socolow 2004). But the proponents of a post-carbon society disagree about the basic character of the transition process. How much efficiency (e.g. increased energy productivity), how much subsistence (e.g. lifestyle changes), and how much consistency (e.g. based on zero-emission technologies) will be feasible and necessary (Huber 2004)? And what concrete technological pathways should be chosen to reach the ‘blue economy’ based on environmentally adapted technologies (Pauli 2010)? Post-carbon ambiguities result from the tension between the narrow target definition and the wide and in part conflicting pathways to reach that target.
- Environmentalists tend to believe that only the technologies of the fossil age – including nuclear power in many views – can be termed risky technologies, while ‘green’ solutions are often regarded as ‘clean’ or intrinsically unproblematic. This may be true with respect to the problem they are intended to solve – first of all to reduce GHG emissions. But this is in no way true with respect to all other kinds of risky side-effects. Biofuels are a good example: one could substitute fossil fuels by fuels from plants, thus mitigating against the causes of global warming, while at the same time reduce both food security and the biodiversity of the planet. Reforestation projects to sequester carbon can lead to more monocultures, new land conflicts, and the marginalization of local forest users, especially if they are poor and/or politically weak (Gerber 2011). Electric cars run on zero emissions during the operation phase (if electricity is generated from renewable sources), but the chemical cocktail in their storage batteries might create a new toxic waste problem. The establishment of a renewable energy system across Europe and North Africa might substantially reduce Europe’s energy related GHG emissions, but at the same time could lead to centralized economic structures with new North-South divides. And so forth. Post-carbon ambiguities result from our tendency to ignore side-effects once our ‘favorite’ problem has been solved – or, put more technically, from our reluctance to apply the principles of precautionary risk assessments to the brave new post-carbon world (Hulme 2009).
 - Even if humankind managed to reach a post-carbon society, given the historical emission and the inertia of the Earth system, additional global warming is already underway and unavoidable. Adaptation to a changed climate is necessary – and has to be funded. While both adaptation and mitigation measures are economically and politically compatible (even mutually beneficial) to some extent, given the limited financial and organizational scope of modern societies trade-offs may arise (Fankhauser 2009; de Bruin et al. 2009). It is also open to debate what adaptation priorities might be preferred, and what instruments and measures should be applied (e.g. technological, organizational, financial compensation). Post-carbon ambiguities result from the limited funding for mitigation and adaptation, as well as from the value dependency of adaptation priorities.
- The intention of this most probably not comprehensive list is not to create ‘artificial’ problems, or to debunk the post-carbon society, which we think has to come about. However, social scientists – as scientists in general – must not lose their analytical skills and duties only because – under the auspices of a ‘new’ CCD – a post-carbon society takes shape. The evidence of newly emerging conflicts and ambiguities should have removed the idea that a low- or post-carbon society would be

a 'harmonious' society. Post-carbon ambivalences do emerge, and science will be needed to deal with them. But what kind of science, and how?

5 New challenges for climate science

The master frame of the 'old' CCD was one of 'analyzing the climate system', or more precisely: explaining major observed effects by tracing them back to complex causal patterns. Although IPCC did have three Working Groups (WG) right from its beginning, Working Group I did take the lead in the 'old' CCD. WG I members typically are atmospheric scientists, climatologists, physicists, chemists, or climate modelers. The examples of Galileo, Newton or Einstein illustrate how physics did play a leading role in the evolution of modern science, and that physicists have often been endowed with a consciousness of forming the top end of scientific discovery. This is one reason why the more physics-oriented body of research reported in WG I assessments has been officially termed 'The Scientific Basis'. Due to their higher complexity and lower degrees of predictability, biological systems seem to be less able to be conceived in a unified and consistent theoretical framework, based on first principles. It seems to us that this is the reason why biologists are perceived as being a little 'less scientific' than, say, physicists. As biologists (and geographers) make up the majority of WG II members, the results of this group do not count as 'scientifically basic' as WG I results. And this despite the fact that the scope of WG II, dealing with impacts of climate change and the vulnerability of biological and social systems, covers more or less the reasons for social concern about climate change: most social actors worry about the impacts of climate change, not about climate change 'as such'. WG III finally, dealing with mitigation options and adaptation to climate change, has many members from the social sciences, as

well as some engineering and energy modeling people. Again, their work is very important if we consider that future climate change is heavily dependent upon future anthropogenic emissions and its social and technological drivers. But the scientific character of economics or sociology is disputed among 'hard core' scientists, may be even more so than the work of biologists and geographers. The least one can say is that for the core question of the 'old' CCD – is there anthropogenic climate change? – the social sciences did have little to contribute.

Under the 'new' CCD, the decision problem within the Earth system has become center stage. This discourse shift translates into a shift in the relevance of the sciences involved, giving the social sciences in general a much more prominent role. WG III is on its way to lay the new 'scientific basis' of climate science. In the days of the 'old' CCD, the social sciences did not have much to contribute to the attribution problem. Their main task was to calculate impact costs as well as adaptation and mitigation costs. Under the auspices of the 'new' CCD, these latter costs have still to be calculated, if not gained importance. However, the important point now for the social sciences is that various options (scenarios) have to be figured out, including technology choices and governance structures, as well as risk assessments for mitigation and adaptation options in the 'reflexive' mode of climate politics described above. Whether or not the climate science community in the wider sense lives up to that challenge depends upon the way it perceives itself, and to the concepts and models it applies accordingly.

Actually, climate related decisions are dominantly analyzed by economists and their cost-benefit assessment tools (Helm/Hepburn 2009; Nordhaus/Boyer 2003). The climate economics community has improved both the quality and the salience of its models by model comparison efforts

(Edenhofer et al. 2006), and some important developing country scientists have followed that exercise (CMFI 2009). More and more, the facts and models of the natural scientists in climate change research are used as ancillary input into models that economists have developed. But this gained relevance of (mainstream) economics does not suffice when it comes to adapt the science-society interface to the challenges of the 'new' CCD with a post-carbon society as a possible future, for a number of reasons:

- Mainstream economics can be seen as an attempt to de-politicize decisions by seeking neutral ground, e.g. by quantifying outcomes in terms of Gross Domestic Product (GDP). However, the conceptual framework of costs and benefits does neither capture the broad variety of (potential) climate damages, nor does it reflect the fact that it is difficult, if not impossible to deduce a consistent welfare measure (such as GDP) from heterogeneous preferences (Jaeger/Jaeger 2010; Spash 2007).
- Even if the dominant mode of cost-benefit analysis would be overcome, the scope of economics would be too narrow to cover all decision relevant questions of climate policy. Economic institutions and mechanisms find themselves embedded in social and cultural institutions, and a scientific account of what options need to be researched in favor of a viable post-carbon society needs to cover the whole range of these other social sciences as well. Climate change has become a cultural, not only an economic task (Leggewie/Welzer 2009; Welzer et al. 2010).
- The widespread self-concept of scientists as impartial and objective observers still informs their understanding of policy advice as 'speaking truth to power'. This self-understanding, reinforced by powerful institutional settings and role models, does not reflect the co-production of science and society in

knowledge-dependent issues (Jasanoff 2004), with climate change being a clear case of choice dependent nature-science interactions (Jasanoff/Wynne 1998).

- As a consequence of the indicated ambivalences of the 'new' CCD, science would also have to institutionally reflect the co-production of science and society. More participatory approaches together with a higher degree of transparency of the procedures that generate knowledge should be established, especially with respect to the nomination of IPCC scientists, the review process itself, and the process of communicating its results in policy relevant summaries (S. Beck 2010).⁸

To illustrate this point one has to look a little more carefully at a core question of the 'new' CCD: What is dangerous climate change? This question arises upfront when dealing with climate change. Nobody is affected by or interested in climate change as such, i.e. independent of the impacts on natural and social systems it might have. In addition, given both the climate change history of the planet and the adaptive skills human societies have displayed over centuries, one cannot conclude a priori that *any* change of the Earth's climate (say: + 0.1° C) is harmful or dangerous. So what exactly *is* dangerous about climate change? Fortunately, this basic question is also enshrined in the leading document of international climate policy. Article 2 of the United Nations Framework Convention on Climate

⁸ Some of the recommendations of a committee to improve IPCC's work (IAC 2010) hints to that direction (e.g. the suggestion to include non-scientists in to the Executive Committee, a new body suggested by IAC), while others try to reduce the influence of stakeholders (e.g. in preparation of the Summary for Policymakers). Instead, one could have thought about making the negotiation process public, so that the general public (and citizens of particular countries) can learn about how their governments argue in climate science.

Change (UNFCCC) specifies the purpose of the Convention by stating that humankind should prevent 'dangerous anthropogenic interference with the Earth's climate', but leaves the interpretation of 'dangerous' more or less open to further debate. Many climate scientists have tried to answer that question (Schellnhuber et al. 2006). It has emerged as a sort of scientific and political consensus that an additional warming of + 2° C against the pre-industrial level seems to be a good operational definition of 'dangerous climate change', a 'focal point' shaping our expectations and actions (Jaeger/Jaeger 2010). The 'Copenhagen Accord', as flawed as it is in many respects, confirms that goal.

However it is not possible to define from a purely scientific point of view what dangerous climate change is, and how many degrees of global warming this would entail. Scientists can say what will happen to various systems once global mean temperature reaches or exceeds two degrees. For example, coral reefs might die back over time once this threshold is taken. But why would this be dangerous? The very concept of danger lies beyond the scope of pure scientific observation. It is an expression of values: we shift from 'A influences/impacts B' to 'B is at risk from A impacting it' due to a valuation process that expresses our attachment to and/or concern about B. Coral reefs for example. They offer hotspots of biodiversity – which most of us prefer over less diverse environments – , they create economic income for fishermen and tourist agencies – which at least they will prefer over a non-income situation – , or they simply are beautiful to many people. This is why the probability of coral reefs to vanish under climate change is framed as risky or dangerous.

Usually, lay people and policy makers make value statements as a normal mode of operation. So one might wish lay people and/or policy makers to provide science with a notion of dan-

gerous climate change. As good as those actors are in making value judgments, they usually lack a deeper understanding of impact mechanisms and system thresholds. To conclude that 2° C is dangerous one needs to have *both* – an impact mechanism provided by science, *and* a valuation statement provided by social actors. The statement '2° C is dangerous climate change' thus is a hybrid statement, generated at the science-society interface, not by science alone (Luhmann 2010).

The decision making problems we are facing today do reinforce this type of co-production between science and society. It is no more sufficient to simply define what dangerous climate change is (e.g. by a temperature threshold), we also need to know how to avoid it, and we need to understand the risks of options that may help doing so. This inevitably brings the problem of evaluation to the fore, as well as the problem of future uncertainty with respect to the side-effects of new options (Carolan 2008).

Evaluation questions arise when it comes to the concrete path of socio-technical systems we should implement in order to meet specific emission paths. And as the historical emissions as well as the future-binding trajectory of particular societies vary substantially, these questions are intrinsically linked to moral and economic issues of equity and burden sharing – not only between (Grosso 2007; Narain 2010), but also within nations (Chakrawarthy 2009; Schlüns 2007). Operating closer at the science-policy interface and cooperating in a transparent manner with stakeholders does inevitably 'charge' science with social values. It is the particular task of the social sciences to rationally deal with the social values and preferences entailed in stakeholder propositions. According to Max Weber, science can only *reveal* the value orientations it is committed to. A *rational discussion* of values is impossible. Not subscribing

to the decisionist view on values Weber adheres to (Ambrus 2001; Daniel 2000), we assume that 'values' and 'facts' are richly intertwined – much closer than Weber (or Hume) and many others have thought (McDowell 1998; Putnam 2002). Other than Weber we also assume that a rational discourse on values is possible (Habermas 1981). Science cannot prescribe the values that should govern our (climate) choices, but it can discuss which consequences might flow from these choices, which social and environmental implications particular choices might have, and which moral principles are involved in particular ethical choices (Longino 1990). Scientists alone cannot come to a conclusion about moral choices, not even together with philosophers. But they can, together with stakeholders, decide whether or not real choices are compatible with the goal to avoid dangerous climate change. As beings endowed with limited, but self-reflexive and socially embedded rationality humans not only have preferences (e.g. about a particular energy system), they do also have second-order preferences, i.e. they can and often do reflect, rationalize and correct their first order preferences (Frankfurt 1971; 1988). We smoke, but we might wish to give it up. Instead of weighing future climate change induced damages higher than actual benefits from activities that contribute to climate change, we might as well wish to abandon harmful activities that we are engaged in due to our first order preferences. Rational self-constraints can arise from anticipated damages, but they can also arise from preferences for a more equitable and more beautiful world. Reconstructing these second order preferences, revealing not only the negative side effects of first order preferences, but also the internal contradiction between our first and second order preferences, and searching for viable (e.g. cost-effective and equitable) ways to translate second order into first order preferences – all these

are challenging tasks of science in the new CCD.

Given the narrow timeline when it comes to avoid a global warming of +2° C technological and social options to reduce GHG emissions can probably not wait for too long (Meinshausen et al. 2009). If a stabilization is not achieved until 2020, irreversible climate change effects may well have been triggered – most prominently sea level rise. Climate science, in becoming aware of the risks of non-action, pushes for a rapid de-carbonization of our economies. On the other hand, as has been mentioned in section (4), new risks arise from new solutions. In this situation, we would like to propose a stance of 'reflexive interventionism'. By this term we mean that (social) scientists, in the light of urgent action against dangerous climate change, should engage in activities of social actors that aim at reducing the carbon footprint of societies. In other words: we propose to actively engage in attempts to bring about a post-carbon society. We see this as a clear consequence of their social responsibility, perceiving science at least as an early warning system for society.

There clearly is a normative element in reflexive interventionism: Given the risks of unmitigated climate change, we value the climatic and other environmental conditions of human societies that have historically evolved within the 2° C temperature window (Behringer 2007) as a precious good, including the lives and livelihood conditions of many people, especially the poor and those living in low-lying coastal areas. As the continuation of the carbon-intensive pathway of modern societies threatens these and other stakes, we take it to be imperative to avoid dangerous climate change, and thus to significantly and rapidly de-carbonize modern societies. Scientists do already play a crucial role in this process, e.g. by developing low-carbon technologies or designing post-carbon urban structures and related social

organizations. As we have shown in section (2), climate policies have been brought on their way intending to achieve this goal – how fragmented and tentative ever. Pleading for interventions thus does not necessarily mean to initiate de-carbonizing processes from scratch. It rather means to actively participate in an *ongoing* process of socio-technical change (Reusswig 2010).

In the previous section we have highlighted the *risks* of climate solutions. Scientists can clearly contribute in increasing these risks, and in fact many of them already do so, as our examples from section (3) should have made clear. However, the answer to this cannot be to simply refrain from intervention and instead to take a back seat as ‘pure observers’. This position has been cultivated by the social sciences – especially, but not exclusively by sociologists following systems theory. Societies cannot be changed, just observed, and the only meaningful task of sociologists is to observe social observations. This position – a point of indifference between modesty and superiority – has been reinforced by the loss of utopian energy after 1990. However, we argue that social scientists cannot afford to stick to this attitude when it comes to such big problems as climate change (Adam/Groves 2007; Lever-Tracy 2008). Instead, we see the role of (social) scientists in critically reflecting the interventions they – together with others – engage in. This would, for example, require to actively put on the floor the critical voices that oppose a particular option. Given the technological bias of many geo-engineering options, it would be crucial to be critical here, as many proponents of geo-engineering are not only driven by concerns about global warming, but also by the perceived difficulty (or even: the perceived danger) to change social institutions and power structures. It seems easier to technologically ‘fix’ the atmosphere – and keep the carbon intensive modern

society untouched – than to address the underlying causes of power structures, interests, institutions, cash flows, and the like. The suspicion seems realistic to us that many scientists engaging in such experiments (e.g. the iron fertilization of oceans, which is ongoing, but hardly perceived by the public: Wiertz and Reichwein 2010) play around with the ecology of the globe – risk seekers – because they shy away – risk averse – from its sociological realities.

Here, as in any other case (e.g. personal trading schemes of household emissions, or changes in the urban form), the new CCD requires a critical reflection (including transparent and participatory risk assessments) of the various options is urgently needed. But it is not the role of social scientists as pure (critical) observers that enables them to participate in such deliberation processes. It is only the role of critical and scientifically skilled participants in a social discourse that both enables and entitles them to bring their expertise in.

6 References

- Adam, B., Groves, C. 2007. *Future Matters. Action, Knowledge, Ethics*. Leiden and Boston, MA: Brill.
- Agrawala, S., 1998a. Context and early origins of the IPCC. *Climatic Change* 39(4): 605-620.
- Agrawala, S. 1998b. Structural and Process History of the IPCC. *Climatic Change* 39(4): 621-642.
- Ambrus, V. 2001. Max Webers Wertfreiheitspostulat und die naturalistische Begründung von Normen. *Journal for General Philosophy of Science* 32: 209-236.
- Arthur, W.B. 1989. Competing technologies, increasing returns, and lock-in by historical events. *Economic Journal* 99: 116-131.
- Beck, S. 2009. *Das Klimaexperiment und der IPCC. Schnittstellen zwischen Wissenschaft und Politik in den internationalen Beziehungen*. Marburg: Metropolis.
- Beck, S. 2010. Vertrauen geschmolzen? Zur Glaubwürdigkeit der Klimaforschung. *Aus Politik und Zeitgeschichte*, 32-33: 15-21.

- Behringer, W. 2007. *Kulturgeschichte des Klimas: Von der Eiszeit bis zur globalen Erwärmung*. München: C.H. Beck.
- Besio, C., Pronzini, A. 2010. Unruhe und Stabilität als Form der massenmedialen Kommunikation über Klimawandel. In: Voss 2010: 283-299.
- Blackstock, J.J. et al. 2009. *Climate Engineering Responses to Climate Emergencies* (Novim, 2009), archived online at: <http://arxiv.org/pdf/0907.5140>.
- Blaikie, P.M. 1996. Post-modernism and global environmental change. *Global Environmental Change* 6(2): 81-85.
- Borgstedt, S., Reusswig, F. 2010. *Umweltbewusstsein in Deutschland 2010. Ergebnisse einer repräsentativen Bevölkerungsbefragung*. Hrsg. Bundesministerium für Umwelt, Natur- und Reaktor-schutz und dem Umweltbundesamt, Heidelberg/Potsdam.
- Boyce, T., Lewis, J. (eds.) 2009. *Climate Change and the Media*. New York: Peter Lang.
- Boykoff, M. T. 2007. *Changing Patterns in Climate Change Reporting in United States and UK Media*. Presentation at the Carbonundrums Workshop, 27 June 2007.
- Boykoff, M.T. 2008. *Media and scientific communication: a case of climate change*. Geological Society, London, Special Publications, 305: 11-18.
- Boykoff, M. T., Boykoff, J.M. 2004. Balance as bias: global warming and the US prestige press. *Global Environmental Change* 14: 125-136.
- Brandom, R.B. 1994. *Making It Explicit. Reasoning, Representing, and Discursive Commitment*. Cambridge, MA: Harvard University Press.
- Broad, K., Orlove, B. 2007. Channeling globality: The 1997-98 El Niño climate event in Peru. *American Ethnologist* 34(2): 285-302.
- Carolan, M.S. 2008. The Bright- and Blind-Spots of Science: Why Objective Knowledge is not Enough to Resolve Environmental Controversies. *Critical Sociology* 34(5): 725-740.
- Carvalho, A., Burgess, J. 2005. Cultural circuits of climate change in the UK Broadsheet press, 1985-2003. *Risk Analysis* 25: 1457-1469.
- Chakravarty, S. et al. 2009. Sharing global CO₂ emission reductions among one billion high emitters. *Proceedings of the National Academy of Sciences of the USA* (PNAS) 106(29): 11884-11888.
- CMFI (Climate Modelling Forum India). 2009. *India's GHG Emission Profile. Results of Five Climate Modelling Studies*. Supported by Ministry of Environment and Forests, Government of India. New Delhi, September 2009.
- Conrad, J. 2008. *Von Arrhenius zum IPCC: Wissenschaftliche Dynamik und disziplinäre Verankerungen der Klimaforschung*. Münster: Monsenstein und Vannerdat.
- Conrad, J. 2010. Sozialwissenschaftliche Analyse von Klimaforschung, -diskurs und -politik am Beispiel des IPCC. In: Voss, M. (ed.): *Der Klimawandel. Sozialwissenschaftliche Perspektiven*. Wiesbaden: VS Verlag für Sozialwissenschaften, 101-116.
- Cottle, S. 2009. *Global Crisis Reporting. Journalism in the Global Age*. Maidenhead: Open University Press.
- Daniel, U. 2000. Auf Gänsefüßchen unterwegs im Wertedschungel. Eine Lektüre von Webers 'Wissenschaftslehre'. *Tel Aviver Jahrbuch für deutsche Geschichte* XXIX: 183-206.
- DB Research. 2007. Klimawandel und Branchen. Manche mögen's heiß! *Aktuelle Themen* 388, Frankfurt am Main, 4. Juni 2007.
- De Bruin, K., Dellink, R., Agrawala, S. 2009. *Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits*. Paris: OECD Environment Working Paper No. 6.
- Deutschmann, C. 2008. *Kapitalistische Dynamik: Eine gesellschaftstheoretische Perspektive*. Wiesbaden: Verlag für Sozialwissenschaften.
- Edenhofer, O., Lessmann, K., Kemfert, C., Grubb M., Koehler J. 2006: Technological Change: Exploring its Implications for the Economics of Atmospheric Stabilization. *The Energy Journal Special Issue, Endogenous Technological Change and the Economics of Atmospheric Stabilization*.
- Edwards, P.N. 1999. Global Climate Science, Uncertainty and Politics: Data-Laden Models, Model Filtered Data. *Science as Culture* 8 (12): 437-472.
- Edwards, P.N. 2001. Representing the Global Atmosphere: Computer Models, Data, and Knowledge about Climate Change. In: Miller/Edwards 2001: 31-65.
- Edwards, P.N., Schneider, S.H. 2001. Self-Governance and Peer Review in Science-For-Policy: The Case of the IPCC Second Assessment Report. In: Miller/Edwards 2001: 219-246.
- Epstein, M. J. 2008. *Making Sustainability Work. Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts*. Sheffield, San Francisco, CA: Greenleaf Publishing Ltd.
- Ereaut, G., Segnit, N. 2006. *Warm Words. How are we telling the climate story and can we tell it better?* Institute for Public

- Policy Research (IPPR), August 2006: London.
- Eurobarometer 2009. *Europeans' attitudes towards climate change*. Special Report Eurobarometer 313 / Wave 71.1 – TNS Opinion & Social. Strasbourg/Brussels: European Parliament and European Commission.
- Fankhauser, S. 2009. *The costs of adaptation*. Leeds and London: Centre for Climate Change Economics and Policy, Working Paper No. 8.
- Fleming, J.R. 1998. *Historical Perspectives on Climate Change*. New York: Oxford University Press.
- Frankfurt, H. 1971. Freedom of Will and the Concept of a Person. *Journal of Philosophy* 68: 5–20.
- Frankfurt, H. 1988. *The Importance of What We Care About*. Cambridge: Cambridge University Press.
- Funtowicz, S.O., Ravetz, J.R. 1993. Science for the post-normal age. *Futures* 25(7): 739–755.
- Geels, F.W. 2005. *System Innovation and the Transition to Sustainability. Theory, Evidence and Policy*. Cheltenham: Edward Elgar.
- Gerber, J.-F. 2011. Conflicts over industrial tree plantations in the South: Who, how and why? *Global Environmental Change* 21(1): 165–176.
- GCP (The Global Carbon Project) 2009. *The Carbon Budget 2008*. www.globalcarbonproject.org/carbonbudget/08/presentation.htm.
- Giddens, A. 1984. *The Constitution of Society: Outline of a Theory of Structuration*. Cambridge: Polity Press.
- Giddens A. 1990. *The Consequences of Modernity*. Stanford, CA: Stanford University Press.
- Giddens, A. 2009. *The Politics of Climate Change*. Cambridge, Malden, MA: Polity Press.
- Grosso, M. 2007. A normative ethical framework in climate change. *Climatic Change* 81: 223–246.
- Haas, P.M. 1992. Introduction: Epistemic Communities and International Policy Coordination. *International Organization* 46(1): 1–35.
- Habermas, J. 1981. *Theorie des kommunikativen Handelns*. 2 Bände. Frankfurt am Main: Suhrkamp.
- Hajer, M. 1995. *The Politics of Ecological Modernization*. Oxford: Clarendon Press.
- Halfmann, J., Schützenmeister, F. (eds.) 2009. *Organisationen der Forschung. Der Fall der Atmosphärenwissenschaften*. Wiesbaden: VS Verlag für Sozialwissenschaften.
- Hansen, J. 2009. *Storms of My Grandchildren: The Truth About the Coming Climate Catastrophe and Our Last Chance to Save Humanity*. London: Bloomsbury.
- Helm, D., Hepburn, C. (eds.) 2009. *The Economics and Politics of Climate Change*. Oxford: Oxford University Press.
- Hester, J., Gonzenbach, W. 1997. The environment: TV news, real world cues, and public opinion over time. *Mass Communication Review* 22(1/2): 5–20.
- Huber, J. 2004. *New Technologies and Environmental Innovation*. Cheltenham: Edward Elgar.
- Hulme, M. 2009. *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge: Cambridge University Press.
- Hulme, M. et al. 2010. IPCC: cherish it, tweak it or scrap it? *Nature* 463: 730–732.
- Idso, C., Singer, S.F. (eds.) 2009. *Climate Change Reconsidered: 2009 Report of the Nongovernmental Panel on Climate Change (NIPCC)*. Chicago, IL: The Heartland Institute.
- IAC (InterAcademy Council) 2010. *Climate Change Assessments. Review of the Processes and Procedures of the IPCC*. Washington, DC: IAC.
- IPCC (Intergovernmental Panel on Climate Change) 2007. *Climate Change 2007: Synthesis Report*. Geneva: IPCC.
- Jaeger, C.C., Jaeger, J. 2010. Warum zwei Grad? *Aus Politik und Zeitgeschichte* 32–33: 7–15.
- Jänicke, M., Kunig, P., Stitzel, M. 1999. *Lern- und Arbeitsbuch Umweltpolitik*. Bonn: Dietz.
- Jasanoff, S. 2004. *States of Knowledge. The Co-production of Science and Social Order*. London: Routledge.
- Jasanoff, S. 2008. Speaking Honestly to Power. *American Scientist* 96(3): 240–243.
- Jasanoff, S. 2010. Testing Time for Climate Science. *Science* 328(5979): 695–696.
- Jasanoff, S., Wynne, B. 1998. Science and Decisionmaking. In: S. Rayner and E. Malone (eds.): *Human Choice and Climate Change. Vol. 1: The Societal Framework*. Columbus/Ohio: 1–87.
- Kahan, D.A., Jenkins-Smith, H., Braman, D. 2011. Cultural cognition of scientific consensus. *Journal of Risk Research* 14(2): 147–174.
- Keller, R. 2005. *Wissenssoziologische Diskursanalyse. Grundlegung eines Forschungsprogramms*. Wiesbaden: Verlag für Sozialwissenschaften.
- Laszlo, C. 2008. *Sustainable Value. How the World's Leading Companies Are Doing Well by Doing Good*. Stanford, CA: Stanford University Press.
- Latour, B. 1993: *We have never been modern*. Cambridge, MA: Harvard University Press.

- Leggewie, C. 2010. Futur Zwei. Klimawandel als Gesellschaftswandel. *Aus Politik und Zeitgeschichte*, 32-33: 40-46.
- Leggewie, C., Welzer, H. 2009. *Das Ende der Welt, wie wir sie kannten. Klima, Zukunft und die Chancen der Demokratie*. Frankfurt am Main: S. Fischer.
- Lehr, U. et al. 2008. Renewable energy and employment in Germany. *Energy Policy* 36: 108-117.
- Lever-Tracy, C. 2008. Global Warming and Sociology. *Current Sociology* 56(3): 445-466.
- Longino, H. 1990. *Science as Social Knowledge*. Princeton, NJ: Princeton University Press.
- Luhmann, H.-J. 2010. Auf welche Wissenschaft beruft sich die Politik beim Zwei-Grad-Ziel? In: *Gaia* 19(3): 175-177.
- Macnaghten, P., Urry, J. 1998. *Contested Nature*. London: Sage Publications.
- Maslin, M. 2004. *Global Warming: A Very Short Introduction*. Oxford: Oxford University Press.
- Mayntz, R. 1991: Naturwissenschaftliche Modelle, soziologische Theorie und das Mikro-Makro-Problem. In: W. Zapf (ed.): *Die Modernisierung moderner Gesellschaften*. Frankfurt am Main: Campus: 55-68.
- McComas, K., Shanahan, J. 1999. Telling Stories About Global Climate Change. Measuring the Impact of Narratives on Issue Cycles. *Communication Research* 26(1): 30-57.
- McCright, A. M., Dunlap, R.E. 2003. Defeating Kyoto: The Conservative Movement's Impact on U.S. Climate Change Policy. *Social Problems* 50(3): 348-373.
- McDowell, J.H. 1996. *Mind and World*. Cambridge, MA: Harvard University Press.
- McDowell, J.H. 1998. *Mind, Value, and Reality*. Cambridge, MA: Harvard University Press.
- Meadowcroft, J. 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. *Political Sciences* 42(4): 323-340.
- Meinshausen, M., et al. 2009. Greenhouse-gas emission targets for limiting global warming to 2° C. *Nature* 458: 1158-1163.
- Miller, C.A., Edwards, P.N. 2001. The Globalization of Climate Science and Climate Politics. In: Miller/Edwards (eds.) 2001: 1-29.
- Miller, C.A., Edwards, P.N. (eds.). 2001: *Changing the Atmosphere. Expert Knowledge and Environmental Governance*. Cambridge, MA, London: The MIT Press.
- Narain, S. 2010. Klimawandel: Keine gemeinsame Teilhabe an der Welt. *Aus Politik und Zeitgeschichte* 32-33: 3-7.
- Nordhaus, W.D., Boyer, J. 2003. *Warming the World: Economic Models of Global Warming*. Cambridge, MA, London: The MIT Press.
- Orlove, B. 2005. Human adaptation to climate change: a review of three historical cases and some general perspectives. *Environmental Science & Policy* 8: 589-600.
- Ostrom, E. 2009. *A Polycentric Approach for Coping with Climate Change*. The World Bank, Development Economics. Office of the Senior Vice President and Chief Economist, Washington, D.C., October 2009.
- Oswick, C., Keenoy, T., Beverungen, A., Ellis, N., Sabelis, I., Ybema, S. 2007. Discourse, practice, policy and organizing: some opening comments. *International Journal of Sociology and Social Policy*, 27(11/12): 429 - 432.
- Ott, K. 2010. Argumente für und wider 'Climate Engineering'. *Technikfolgenabschätzung - Theorie und Praxis*, 19(2): 32-41.
- Pacala, S., Socolow, R. 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years With Current Technologies. *Science* 305(5686): 968-972.
- Patt, A.G., 2001. Understanding uncertainty: forecasting seasonal climate for farmers in Zimbabwe. *Risk, Decision and Policy* 6: 105-119.
- Pauli, G. 2010. *The Blue Economy. 10 Years, 100 Innovations, 100 Million Jobs*. Tale, NM: Paradigm Publications.
- Pielke, Jr., R.A. 2007. *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge, UK: Cambridge University Press.
- Pielke, Jr., R.A. 2010. Major change is needed if the IPCC hopes to survive. *The Guardian* 4. 3. 2010 (www.guardian.co.uk/environment/2010/mar/04/ipcc-major-change-needed).
- Putnam, H. 2002. *The Collapse of the Fact/Value Dichotomy. And other Essays*. Cambridge, MA: Harvard University Press.
- Rahmstorf, S., Schellnhuber, H.-J. 2007. *Der Klimawandel*. München: C.H. Beck.
- Ravetz, J. 2010. *Climategate: Plausibility and the blogosphere in the post-normal age*. <http://wattsupwiththat.com/2010/02/09/climategate-plausibility-and-the-blogosphere-in-the-post-normal-age/>.
- Reusswig, F. 2010. Sustainability Transitions Through the Lens of Lifestyle Dynamics. In: L. Lebel, S. Lorek, R. Daniel (eds.): *Sustainable Production and Consumption Systems. Knowledge, Engagement and Practice*. Dordrecht, Heidelberg, London, New York, Berlin: Springer, 39-60.

- Risbey, J.S. 2008. The new climate discourse: Alarmist or alarming? *Global Environmental Change* 18(1): 26–37.
- Rogelj, J. et al. 2010. Copenhagen Accord pledges are paltry. *Nature* 464: 1126–1128.
- Schaltegger, S., Wagner, M. (eds.) 2006. *Managing the Business Case for Sustainability. The Integration of Social, Environmental and Economic Performance*. Sheffield: Greenleaf Publishing Ltd.
- Schellnhuber, H.-J. 2010. "Die Politik soll sich raushalten". Interview in der *Süddeutschen Zeitung* vom 12.2.2010.
- Schellnhuber, H. J. et al. (eds.) 2006. *Avoiding Dangerous Climate Change*. Cambridge University Press, Cambridge, UK.
- Schenk, N.J., Lensink, S.M. 2007. Communicating uncertainty in the IPCC's greenhouse gas emissions scenarios. *Climatic Change* 82: 293–308.
- Schlüns, J. 2007. Umweltbezogene Gerechtigkeit in Deutschland. *Aus Politik und Zeitgeschichte* 24: 25–30.
- Schneider, S.H. 2009. *Science as a Contact Sport: Inside the Battle to Save Earth's Climate*. Washington, D.C.: National Geographic.
- Semenza, J.C. et al. 2008. Public perception and behavior change in relationship to hot weather and air pollution. *Environmental Research* 107: 401–411.
- Shepherd, J. et al. 2009. *Geoengineering the Climate: Science, Governance and Uncertainty*. London: The Royal Society.
- Singer, S.F. (ed.) 2008. *Nature, Not Human Activity, Rules the Climate*. Summary for Policymakers of the Report of the Non-governmental International Panel on Climate Change. Chicago, IL: The Heartland Institute.
- Skodvin, T. 1999. *Science-policy interaction in the global greenhouse*. Cicero Working Paper 3, Oslo: Cicero.
- Skodvin, T. 2000. *Structure and Agency in the Scientific Diplomacy of Climate Change*. Dordrecht/Boston/London: Kluwer Academic Publishers.
- Spash, C.L. 2007. The economics of climate change impacts à la Stern: Novel and nuanced or rhetorically restricted? *Ecological Economics* 63(4): 706–713.
- Stehr, N. 2007. *Die Moralisierung der Märkte. Eine Gesellschaftstheorie*. Frankfurt am Main: Suhrkamp.
- Stehr, N., von Storch, H. (eds.) 2000. *The Sources and Consequences of Climate Change and Climate Variability in Historical Times*. Dordrecht: Kluwer.
- Stephens, J.C., Keith, D.W. 2008. Assessing geochemical carbon management. *Climatic Change* 90(3): 217–242.
- Sterk, W. 2010. Auf dem Weg zu einem neuen globalen Klimaabkommen? *Aus Politik und Zeitgeschichte* 32-33: 22–28.
- Stern, N. 2007. *The Economics of Climate Change - The Stern Review*. Cambridge: Cambridge University Press.
- Tol, R.S.J. 2006. The Stern Review of the Economics of Climate Change: A Comment. *Energy & Environment* 17(6): 977–981.
- Tol, R.S.J., Yohe, G.W. 2009. The Stern Review: A deconstruction. *Energy Policy* 37: 1032–1040.
- Trumbo, C. 1996. Constructing climate change: Claims and frames in U.S. news coverage of an environmental issue. *Public Understanding of Science* 5: 269–283.
- Turner II, B. L. et al. 1990. *The Earth As Transformed by Human Action. Global and Regional Changes in the Biosphere over the Past 300 Years*. Cambridge etc.: Cambridge University Press.
- Unruh, G., 2000. Understanding Carbon Lock-in. *Energy Policy* 28: 817–830.
- Viehöver, W. 2003a. Die Wissenschaft und die Wiederverzauberung des sublunaren Raumes. Der Klimadiskurs im Licht der narrativen Diskursanalyse. In: R. Keller, A. Hirsland, W. Schneider, W. Viehöver (Hrsg.): *Handbuch Sozialwissenschaftliche Diskursanalyse 2. Forschungspraxis*. Opladen: Leske + Budrich, 233–267.
- Viehöver, W. 2003b. Die Klimakatastrophe als ein Mythos der reflexiven Moderne. In: L. Claussen, E. Geenen, E. Macamo (Hrsg.): *Entsetzliche soziale Prozesse. Theorie und Empirie der Katastrophen*. Münster: LIT, 247–286.
- Voss, M. (Hrsg.). 2010. *Der Klimawandel. Sozialwissenschaftliche Perspektiven*. Wiesbaden: VS Verlag für Sozialwissenschaften.
- Walker, G., King, Sir D. 2008. *The Hot Topic. What We Can Do About Global Warming*. Orlando etc.: Harcourt.
- Weart, S.R. 2003. *The Discovery of Global Warming*. Cambridge, MA: Harvard University Press.
- Weber, M. 1946. The Social Psychology of the World Religions. In: H.H. Gerth and C. Wright Mills (eds.): *From Max Weber: Essays in Sociology*. New York: Oxford University Press, 267–301.
- Weingart, P., Engels, A., Pansegrau, P. 2000. Risks of communication: discourses on climate change in science, politics, and the mass media. *Public Understanding of Science* 9: 261–283.
- Weingart, P., Engels, A., Pansegrau, P. 2002. *Von der Hypothese zur Katastrophe. Der anthropogene Klimawandel im Diskurs zwischen Wissenschaft, Politik und Massenmedien*. Opladen: Leske + Budrich.
- Welzer, H., Soeffner, H.-G., Giesecke, D. (Hrsg.) 2010. *KlimaKulturen. Soziale*

- Wirklichkeiten im Klimawandel*. Frankfurt am Main: Campus.
- Wiertz, T., Reichwein, D. 2010. Climate Engineering zwischen Klimapolitik und Völkerrecht. *Technologiefolgenabschätzung – Theorie und Praxis* 19(2): 17-25.
- Yearley, S. 1994. Social movements and environmental change. In: M. Redclift, T. Benton (eds.): *Social theory and the global environment*. London, New York, NY: Routledge, 150–168.