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This is an electronic version of an article published in:

Victoria Wibeck , Enhancing learning, communication and public engagement about climate change – some lessons from recent literature, 2013, Environmental Education Research. Environmental Education Research is available online at informaworldTM:
http://dx.doi.org/10.1080/13504622.2013.812720

Enhancing learning, communication and public engagement about climate change – some lessons from recent literature

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Acknowledgements

This paper was made possible by a grant from the Swedish Research Council for the project Making sense of climate change – a study of the formation and maintenance of social representations (project no. 2008-1723). The author wishes to thank anonymous reviewers for their valuable comments on earlier drafts of the paper.

Enhancing learning, communication and public engagement about climate change – some lessons from recent literature

This paper aims to provide environmental educators with insight into the fields of climate change communication and public understanding of climate change. These fields are of relevance to environmental education theory and practice since they can shed light on issues such as how learners of climate science understand messages on climate change, what the communicative context for education on climate change is like, what barriers that can be found to public engagement in climate change, and how these barriers could be addressed.

The paper is a literature review of 92 peer-reviewed studies of climate change communication and public understanding of climate change. It analyzes the goals and strategies of climate change communication, discusses barriers to public engagement in climate change and considers ways of addressing these barriers in climate change communication and education, with focus on a) the content of climate change communication; b) visualizations; c) framing; d) audience segmentation. The paper concludes that climate change communication and education need to address barriers to public engagement on several levels simultaneously.

Keywords: climate change; communication; public understanding; public engagement; learning; non-formal education

1.Introduction

Today, it is widely recognized that climate change is one of the greatest challenges facing humanity (Schneider, 2011). Since climate change is expected to have severe consequences for many citizens around the globe, considerable money and effort have been initiated in educating the public of the causes and effects of climate change and of

how laypeople should behave to mitigate and adapt to a changing climate.[1] For over a decade, social scientists have studied the public understanding of climate change, analyzing, for example, whether laypeople understand or misunderstand climate science (e.g., Etkin & Ho, 2007; Seacrest et al., 2000; Sterman & Sweeney, 2002, 2007), laypeople's attitudes to various action strategies (e.g., Ohe & Ikeda, 2005) and barriers to public engagement in climate change (e.g. Lorenzoni et al., 2007a). Knowledge gained from such studies has been used to inform research into science communication and environmental education as well as climate information/communication campaigns organized by, for example, state agencies, NGOs, and the European Union.[2]

This paper is intended to provide environmental educators with insight into the fields of climate change communication (CCC) and public understanding of climate change. These fields are of relevance to environmental education theory and practice since they provide insight into how learners of climate science understand climate-related issues, how climate change is framed in media discourse, what barriers that can be found to public engagement in climate change, and how these barriers could be addressed. Hence, the history and future of climate change communication could influence the design of environmental education, primarily in non-formal settings where lay people become learners outside the formal school context. The focus on non-formal

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[1] For examples of non-formal climate education activities, see e.g. the World Bank Climate Change Portal (http://sdwebx.worldbank.org/climate portal/) or the climate courses for sustainable agriculture in Australia discussed by George et al. (2007, 2009).

2 Examples of such campaigns include the EU's Climate Action campaign (http://ec.europa.eu/climateaction/index_en.htm) and the Swedish Environmental Protection Agency's climate campaign, which included TV and newspaper advertisements as well as posters displayed in public places across Sweden in 2002–2003 (SEPA, 2004).

education is motivated by the fact that the studies reviewed as a basis for this paper primarily focus on the views of adults, not enrolled in formal environmental education.

This paper reviews climate change communication research, and discusses recurrent themes in the literature as well as possible futures for climate change communication and education.[3] In particular, the paper addresses the following questions:

- What is the communicative context[4] for climate change communication?
- What are the goals of climate change communication to lay audiences, as identified in scholarly papers?
- What are the barriers to public engagement in climate change and how could they be addressed?
- What key messages from the CCC literature could be relevant for the field of non-formal education on climate change?

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[3] A previous, comprehensive synthesis paper on climate change communication was written by Moser in 2010. Moser's paper builds on knowledge from the broader field of communication studies to inform theory and practice of climate change communication. The present paper complements Moser's findings in that it takes it point of departure in the growing field of climate change communication literature rather than in communication theory in general. Moreover, in contrast to Moser's paper, the present paper is explicitly directed to an audience of environmental education scholars.

4 "Communicative context" here refers to factors that influence how climate change communication is understood and received by the audience, e.g. how media framings of climate-related issues or the public's pre-existing perceptions on causes, impacts and responses to climate change.

2. Material included in the review

This paper builds on a literature review of the scholarly literature on the public understanding of climate change and public communication of climate change. These themes are interrelated in that I assume that it is necessary to gain knowledge of public perceptions of climate change to properly address the issue of how climate change messages should be communicated to different audiences. For the purpose of this paper I have chosen to treat the public understanding of climate change literature as a sub-category to the broader field of CCC literature. This means that papers which primarily aim to analyze public perceptions are included in the body of CCC literature reviewed here.

The literature review encompasses peer reviewed articles (i.e. empirically based research papers and literature reviews) published between the years 2000 and 2011 and listed in the Academic Search Premier and Scopus databases. The search included the following search terms: climate change, global warming, communication, public, public understanding and public engagement. These terms were searched for in papers' titles, abstracts, and key words. Only papers published in English were included in the search. A full list of the material included in the review is available in the reference list.

In all, a total of 109 papers were identified from the data base searches. Of these, 17 were considered as falling out of the scope of the review, which left me with a total of 92 articles. These papers were read in their entirety and thematically analyzed with focus on the main arguments of the paper, rationales for studying the public understanding of climate change/ the goal of climate change communication, and what was seen as affecting the perceptions of the public and public engagement.

All data-base driven reviews of course suffer from limitations. One obvious limitation here is related to the selection of a particular time period (2000-2011). When scanning the CCC literature, some of these papers make reference to a few studies published in the 1990s. The vast bulk of research, however, has been conducted in the 2000s, which is why the present review started in the year 2000. Moreover, in a paper published in 2000, Bulkeley argued that at that time much attention was being paid to public responses to environmental issues in general, but studies focusing on climate change were rare. Due to the fact that the data base search was performed in early 2012, the year 2011 was considered a natural end point and papers published until the end of 2011 were included in the sample. Another limitation is that not all potentially relevant journals might be indexed in the selected databases, and that the data base search only includes journal articles. To avoid overlooking central strands of CCC literature, I have consulted the reference lists of the papers included in the review to check for frequently referred works not included in my sample. As a result, the review was complemented with a few books and reports (Carvalho, 2008; Eurobarometer, 2011; Hulme, 2009; Leiserowitz et al., 2011 a, b). Moreover, it is worth noting that the numerous studies examining media coverage of climate change have not actively been included in the sample (except where they have an explicit reception focus, analyzing public understanding of media messages of climate change). This is motivated by the focus of the review on the role of the public as an audience for climate change communication, how the public understands and interprets climate change and the barriers to public engagement. However, I have used some of the most frequently cited studies which examine media coverage of climate change as background material to contextualize the literature review. Last but not least, there may well be studies published in languages other than English, which thus were not found in the data base searches.

Climate change communication is a relatively young research field, driven by a relatively small group of prominent scholars. However, the interest in studying public understanding of climate change and how climate change has been and should be communicated is rapidly increasing. The distribution over time of the articles included in this review is illustrated in Figure 1.

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The papers included in the review focus on climate change perceptions and communication in a few developed countries. With only a few exceptions, the studies take their point of departure in the contexts of the United States or Britain. Only a few case studies are undertaken elsewhere, in Norway (Ryghaug et al., 2011), Sweden (Olausson, 2011; Sundblad et al., 2008; Uggla, 2008), Malta (Akerlof et al,. 2010), Canada (Akerlof et al., 2010), Japan (Ohe & Ikeda, 2005; Sampei & Aoyagi-Usui, 2009) and Australia (Bulkeley, 2000; Herriman et al., 2011). The reviewed sample of papers include some cross-country comparisons (Akerlof et al., 2010; Lorenzoni & Pidgeon, 2006; Wolf & Moser, 2011) as exceptions to the strong one-country-at-a–time focus in the sample as a whole. A notable exception to the overwhelming focus on perspectives from developed countries is a review by Wolf and Moser (2011), which cites a few qualitative studies in developing parts of the world, e.g. Ethiopia, Tuvalu and Tibet.

Many contemporary scholars of learning take on a constructivist view of learning and emphasize the importance of the context in which learning is situated (Dillon, 2003; Whitmarsh et al., 2011). For climate change educators inspired by constructivist and situated theories of learning, the overwhelming focus on the US and

UK contexts constitutes an obvious limitation of the climate change communication literature. However, this shortcoming is well recognized in the literature (e.g. Wolf & Moser, 2011), which gives hope for future broadening of the scope of CCC research to other parts of the world.

3.Public understanding of science vs. public engagement in science

When analyzing how the public relates to climate change, a central distinction is that between public understanding and public engagement. This distinction has been much discussed in the general science communication literature, which has argued for a transition from a public understanding of science to a public engagement in science approach. This implies a shift of focus from deficits in lay peoples' scientific literacy to a contextual, dialogue model which acknowledges the situatedness of public understanding of science, and the legitimacy of other knowledge domains in science and policy processes (Schäfer, 2009; Sturgis & Allum, 2004; Wynne & Felt, 2007). This trend has not only been noted for climate change, but can be seen for other issues of science, technology and policy as well (Trench, 2008), for instance when it comes to biotechnology (Chopyak & Levesque, 2002) or nanotechnology (Rogers-Hayden & Pidgeon, 2007; Delgado et al., 2011). Although in practice the public understanding and the public engagement approaches are not easily separated and tend to coexist (Trench, 2008), the public understanding of science paradigm still informs many science communication initiatives, which departure from the "premise that deficits in public knowledge are the central culprit driving societal conflict over science" (Nisbet & Scheufele, 2009:1767).

While studies of public understanding of climate change tend to rest on

the so called “information deficit model”, which treats basic science education as remedy for public distrust and lack of interest in climate change (Brossard & Lewenstein, 2009; Lewenstein & Brossard, 2006; Nisbet & Scheufele, 2009), studies endorsing the public engagement in science perspective emphasize that increased scientific literacy is not a sufficient goal for climate change communication. Instead of being mere receivers of climate change messages, public engagement means that the public needs to actively take part in learning and action on climate change; engagement involves “minds, hearts and hands” (Wolf & Moser, 2011, p. 550).

Public engagement in climate change could be of two types. First, public engagement could be equaled with public participation in climate science and policy processes (e.g. Few et al., 2007). This is a particular type of engagement which presupposes ”a degree of active involvement in taking decisions” (ibid.:49). Such public participation activities often have as their explicit or implicit goal to empower public groups to engage in science as part of an agenda to “democratize” science (Lewenstein & Brossard, 2006). Second, it has been argued that public engagement in climate change should be seen as “a personal state of connection with the issue of climate change [...] concurrently comprising cognitive, affective and behavioural aspects” (Lorenzoni et al., 2007a:446, emphasis in original). For people to be engaged in climate change, they need to care about the issue, feel motivated and have the ability to take action (Lorenzoni et al., 2007a; Wolf & Moser, 2011). In this view, people can be engaged in climate change without necessarily taking part in processes of public participation in policy making (ibid.).

In sum, this section has briefly outlined the general trend in science communication from information transfer informed by the information deficit model to dialogical or participatory modes of communication aimed at enhancing public

engagement. Regardless of the model chosen for science communication, however, such communication does not take place in a vacuum. In the following, we will turn to contextual factors such as media coverage and framings, or preexisting frames of interpretation among the public which influence how different publics respond to science-based information and communication.

4.The communicative context: climate change, media, and the public

Dillon (2003) argues that a large number of educational researchers endorse constructivist theories of learning. A constructivist perspective on learning emphasizes that "we build (construct) knowledge through social interactions—so that through dialogue, we become more knowledgeable" (Dillon 2003:218). As noted by Whitmarsh et al. (2011:59), "/i/n recent years, there has been a shift away from seeing scientific literacy as defined by knowledge of abstract scientific 'facts', towards investigating the contextual meanings of science applied in everyday life." Nonetheless, Dillon argues that "t/here is [. .] some debate about how much the context in which learning takes place actually matters and about the variety of ways in which we can make sense of the world, *based on what we already understand*." (ibid., emphasis in original). In other words, there is a need for anyone looking to facilitate learning to consider the communicative context for climate change education, but also to explore learners' already existing perceptions of climate change. This section strives to contextualize public climate change communication and education, by giving a brief overview of media coverage of climate change as well as summarizing findings of earlier studies about the public's understandings of climate change.

Media coverage of climate change

The mass media are seen as important actors in influencing public awareness and opinion on climate change (e.g., Nisbet, 2009; O'Neill & Nicholson-Cole, 2009; Whitmarsh, 2008). Many studies have highlighted the decisive role of news media such as television, newspapers, and the Internet in shaping public understanding of scientific issues by acting as bridges between scientists and the lay public (e.g., Kahlor & Rosenthal, 2009; Olausson, 2011; Ryghaug et al., 2011; Zhao et al., 2011). Others have analyzed the impact of popular culture representations of climate change, such as the Hollywood movie The Day after Tomorrow, on public awareness of climate change (Balmford et al., 2004; Leiserowitz, 2004; Lowe et al., 2006). Some researchers have noted that the tendency in the mass media towards sensationalism and alarmism may be counter-productive for public engagement in climate change (e.g. Hulme, 2007). In other words, how the mass media frame the issue of climate change strongly influences how the public will understand and interpret it (Boykoff, 2007; Nisbet, 2009). In framing climate change, the media highlight what could be seen as the core of the issue, suggest linkages between events, propose which actors should be seen as responsible and suggest how problems should be handled (Gamson & Modigliani, 1987; Koteyko et al., 2010; Nisbet, 2009).

Analyses of news media framings of climate change have demonstrated differences in how climate change is described in different national contexts. For instance, in Sweden (Olausson, 2009), France (Brossard et al., 2004), and Germany (Weingart et al., 2000) studies have identified a "frame of certainty," assuming that "human-induced global warming is a direct cause of climate change, bringing with it dramatic consequences already at hand" (Olausson, 2009, p. 429). In the US context, in contrast, the frame of "scientific uncertainty" has been widely used by climate skeptics to undermine public concern about climate change (Nisbet & Scheufele, 2009). In

addition, the journalistic practice of giving equal weight to both sides in a debate has contributed to give the false impression that climate skeptics are as numerous and as influential as the scientists who acknowledge the human-induced causes of climate change (Boykoff & Boykoff, 2004). This type of "balanced reporting" on climate change contributed to "a period of uncertainty among policy makers and the public" in the USA in the 2000s (Schweitzer et al., 2009, p. 269). In recent years, however, the "scientific uncertainty framing" in the US mass media is observed to be less frequent (Boykoff, 2007; Zhao et al., 2011).

Public perceptions of climate change

In light of the complexity and uncertainty involved in the issue of climate change, how is it understood by laypeople? Recent research indicates that although awareness of climate change is now high in many countries (Whitmarsh, 2011), the last couple of years have seen a decline in public concern about climate change, at least in United States and to some extent in the UK (Leiserowitz et al., 2011a; Poortinga et al., 2011; Whitmarsh, 2011). In the US, the number of respondents to the survey "Climate change in the American mind" who were very worried or somewhat worried about global warming declined from 63% to 52% between November 2008 and May 2011 (Leiserowitz et al., 2011a). Other US surveys show similar results (Maibach et al., 2010), and there are signs of a certain "issue fatigue" at least within some segments of the American public (Maibach et al., 2010). For the UK, the picture is mixed. A survey reported by Reser et al. (2012) found 71% of UK respondents to still be very or fairly concerned about climate change. Other studies have shown that a growing number of people believe that claims about climate change, and in particular its impacts, have been exaggerated (Poortinga et al., 2011; Whitmarsh, 2011). However, going outside the United States and the UK, the picture is a bit different. A recent Eurobarometer survey

showed that in the year 2011, 68% of the respondents within the European Union saw climate change as a serious problem, which is an increase from 64% in 2009 (Eurobarometer, 2011). An Australian survey identified 66% of the respondents to be very or fairly concerned about climate change (Reser et al., 2012).

In a review of fifteen years of climate change perceptions research in Europe and the USA, Lorenzoni and Pidgeon (2006) found some recurrent results. The informants in the various studies were widely aware of the issue of climate change, but their understanding of the causes of and solutions to climate change was incomplete. Climate change was regarded as a serious risk, but participants in the studies perceived it as distant in space as well as time. Hence, the informants conceived of climate change as less important than other personal or social risks. As regards informants' preparedness to address the threats they still perceived in relation to climate change, they saw governments as the main responsible bodies, although they generally expressed some willingness to act in response to climate change-induced threats. Lorenzoni and Pidgeon (2006) conclude that earlier studies demonstrate the ambivalence of lay people's attitudes towards climate change. The public needs to balance the problems of everyday life with awareness of the social problems that climate change may give rise to. In a later review, Wolf and Moser (2011) draw similar conclusions about how the public in developed countries perceive and understand climate change.

In sum, earlier research suggests that although climate change is now firmly put on the public agenda, the communicative context of climate change, at least in Europe and North America, is characterized by ongoing debate, uncertainty and controversies of various kinds (e.g. Campbell, 2011; Donner, 2011; Featherstone et al., 2009). Many voices are blended in public discourse on climate change, representing

different positions and standpoints towards how laypeople could best contribute to mitigating and adapting to climate change effects. It has been argued that 'for many members of the public, climate change is likely to be the ultimate ambiguous situation given its complexity and perceived uncertainty' (Nisbet 2009:16). Still, the public is faced with expectations, not least from governments across the world, to assume responsibility for responding to climate change in various ways (Ockwell et al., 2009). This brings us to the issues of the goal of climate change communication and barriers to public engagement in climate change, which will be discussed in the following.

5. Goals and rationales for climate change communication

For climate change educators in non-formal settings key questions could include: What is the role of climate change education to the lay person? What would constitute an appropriate learning outcome? How much could be expected from the public in terms of responses to climate change? Similar questions are at stake in the CCC literature. Although the literature rarely discusses these questions in depth, analysis of the papers included in the review reveals different rationales for climate change communication.

In the reviewed CCC literature, the ultimate goal for climate change communication appears to be the same, i.e., to identify communication strategies that efficiently support sustainable development and reduce climate impact. The papers start from the assumption that laypeople have important roles to play in mitigating and adapting to climate change. In the reviewed papers, it is often argued that the public must be engaged individually and collectively in responding to climate change. How to attain the overarching goal of reducing climate impact through public communication, however, is conceptualized in various ways. The studied papers identify three ways in

which the public could respond to climate change: *lifestyle change, political influence*, and *participation in climate science and policy dialogue*.

When it comes to the issue of lifestyle change in response to the challenges of climate change, Maibach et al. (2008) point to four areas in which mitigation action could be taken on an individual level: reduction of household energy use, recycling, surface transportation behavior, and "green" consumerism. According to Moser (2006), individuals acting collectively play two critical roles in climate mitigation: 1) they can exert influence via consumption patterns as consumers of environmental resources, material goods, and energy, and 2) they can exert political influence by supporting climate-friendly policies. These two points were also made in several other studied papers as well. The need to foster climate-friendly lifestyles has been emphasized by many scholars.[5] As regards the role of the public in supporting climate-friendly policies, it has been argued, for example, that public misunderstanding of climate change will obstruct efficient policy making (Lowe et al., 2006; Moser, 2006). Likewise, individual efforts to respond to climate change will be less powerful if not coordinated and guided by well-functioning policy. It is worth noting, however, that lifestyle change and political influence are often presented in the CCC literature as complementary rather than separate responses.

An increasing number of studies point to the need for public participation in climate science and policy matters (e.g., Featherstone et al., 2009; Kahlor & Rosenthal, 2009; Maibach & Hornig Priest, 2009; Nisbet & Scheufele, 2009; Stamm et al., 2000; Whitmarsh, 2008). In other words, this strand of literature deals with the first of the two

[5] See, for example, Kahlor and Rosenthal (2009), Kim and Neff (2009), Moser and Dilling (2004), Nicholson-Cole (2005), Ockwell et al. (2009), O'Neill and Nicholson-Cole (2009), Sterman (2008), Sundblad et al. (2008), and White and Wall (2008).

types of public engagement discussed in Section 3. Such engagement can take the form of participation in, for example, consensus conferences, town meetings, and deliberative forums (Nisbet & Scheufele, 2009). Calls for increased public participation in decision-making have been motivated by the insight that climate change management is based on "value-driven decisions made in the face of risk and uncertainty" (Lorenzoni et al., 2007b, p. 66), which calls for the involvement of a multitude of stakeholders in a so called "extended peer community" (Lorenzoni et al., 2007b; cf. Funtowizc & Ravetz, 1993; Nowotny et al., 2001). Lorenzoni et al. (2007b, p. 67) argue that decisions on climate change must involve "decentralized public-sphere politics and multilayered democratic participation. This should enable diverse knowledge and perspectives to contribute, fostering mutual learning and reflexivity, evaluation of trade-offs, uncertainties, and their distribution."

The CCC literature cites a few examples of public participation exercises (Few et al., 2007; Herriman et al., 2011), ranging from small-scale deliberations involving local stake-holders and community members in Christchurch Bay and the Orkney Islands, UK, in decisions on coastal management in the face of climate change (Few et al., 2007) to a large international attempt to engage the public in deliberations on climate change through the WorldWideViews of Global Warming project (Herriman et al., 2011).The latter project employed workshops taking place at the same date in 38 countries across the world, and aimed to give lay people a voice in the 2009 UN Climate summit (COP15) in Copenhagen. The results of the workshops were disseminated to COP15 negotiators in the form of a list that included the following recommendations resulting from the participants in the WorldWideViews project: "Make a deal at COP15; Keep the temperature increase below 2 degrees; Annex 1 countries should reduce emissions with 25-40 or more by 2020; Fast-growing

economies should also reduce emisions by 2020; Low-income developing countries should limit emissions; Give high priority to an international financial mechanism; Punish non-complying countries; Make technology availabe to everyone; Strengthen or supplement international institutions" (Bedsted & Klüwer, 2009: 4).

According to Herriman et al. (2011), the WorldWideViews project was successful in arranging and conducting participatory events in a number of countries simultaneously. Through the use of the Internet, the participants were able to see and compare results from different countries while the deliberative event was unfolding. It should be noted, however, that there was no centralized evaluation strategy linked to the WorldWideViews project, which means that it is hard to assess the quality of the participatory process or its political impact (ibid.). In terms of public engagement, it seems that those lay people who participated in the WorldWideViews were engaged in the issue of climate change and took active part in generating the outcomes of the workshops. However, more or less the same number of participants (about 100) was recruited in each participating country, regardless whether the country had a large or small population (ibid.). It is difficult to evaluate whether the level of engagement demonstrated by the participants in the WorldWideViews workshops is in any way representative of the participating countries' populations at large.

From a learning perspective public participation exercises like the coastal management deliberations or the WorldWideViews on global warming workshops are in stark contrast to top-down climate change communication aiming to foster climate-friendly lifestyles and consumption behavior, or to influence the public to support climate-friendly policies. Public participation in climate science and policy implies mutual learning between lay people, decision makers and scientists in deliberating on appropriate responses to climate change. Exercises which engage the public in

deliberating on climate-related issues could also take advantage of peer-to-peer learning, which has been suggested as a fruitful way of overcoming problems related to more top-down models of communication, such as a lack of trust in the institutions communicating climate change (Corner & Randall, 2011). However, further research is needed into how public participation could be inclusive, meaningful and secure broad-based public engagement (Few et al., 2007). For participatory exercises to be successful, people need to be willing to contribute with their time and their ideas. Since public participation events are often set up to include only a limited group of participants, there is a risk that only special interest or elite groups opt to take part (Few et al., 2007; Irvin & Stansbury, 2004). Herriman et al. (2011:27) note that "people who are extremely poor, displaced or otherwise vulnerable are likely to be unable or unwilling to participate in any global deliberative process. In countries where a large proportion of the population struggles simply to survive each day, those who do end up participating are therefore less likely to be representative of the general population".

When scrutinizing the CCC literature chronologically from 2000 and onward, a shift in focus over time from *public understanding* of climate change to *public engagement* in climate change was observed. This goes both for engagement as defined as "a personal state of connection with the issue of climate change" (Lorenzoni et al., 2007:446; cf. e.g. Whitmarsh et al., 2011; Wolf & Moser, 2011) and engagement defined as public participation in climate policy deliberations (e.g. Few et al., 2007; Herriman et al., 2011). The trend from public understanding to public engagement has also been noted by e.g. Nerlich et al. (2009), and is similar to the trend from public understanding to public engagement noted in the broader science communication literature (see Section 3). There are, however, often barriers to public engagement in climate-related issues (Lorenzoni et al., 2007; Whitmarsh et al., 2011; Wolf & Moser,

2011). We will now turn to the issue of how such barriers could be understood and addressed, which is the topic of many CCC studies.

6.Barriers to public engagement in climate change – and some potential solutions

The CCC literature finds that engaging the public in combating climate change presents a range of challenges (e.g. Lorenzoni et al., 2007). Practical experience indicates that public education and communication strategies have often failed (Moser & Dilling, 2004; Ockwell et al., 2009). This could be due to "the creeping nature of climate change, its complexity and uncertainty, system lags, human perception limits, and communication failures on the part of scientists" (Moser & Dilling, 2004:34). Nevertheless, the CCC literature also presents a number of potential solutions to address the barriers to public engagement and positively encourage public engagement in climate change. For climate change educators in non-formal contexts, this literature offers understanding of why lay people may hesitate to engage in learning activities on climate change and how such learning could be encouraged. This section will first identify barriers to public engagement found in the CCC literature (see also Table 1) and thereafter discuss potential strategies for addressing some of them.

Barriers to public engagement

One barrier that was commonly discussed not least in the beginning of the studied period refers to scientific illiteracy, more specifically, to the inability of laypeople to understand the complexities of climate science. For example, Seacrest et al. (2000) argue that laypeople tend to misunderstand the fundamental physical processes contributing to climate change. Etkin and Ho (2007), in summarizing the findings of

earlier research, discuss, among other matters, laypeople's difficulties in thinking probabilistically. For instance, it has been claimed that "people tend to overestimate the probability of relatively infrequent events […] and underestimate the probability of relatively frequent events […]" (Patt & Schrag, 2003, p. 18). Moreover, Sterman and Sweeney (2007) argue, based on an experimental study, that laypeople have difficulties understanding the system dynamics underlying climate change. Ungar (2000) found that lay people tended to conflate global warming with other, more conspicuous environmental problems, such as ozone depletion. In line with these results, it has been argued that people's behavior is governed by their mental models. A mental model can be defined as people's "beliefs about the networks of causes and effects that describe how a system operates, along with the boundary of the model ... and the time horizon considered relevant" (Sterman & Sweeney, 2002, p. 215). The claim is that lay mental models are less specific than expert mental models and thus less suited to understanding the complexities of climate change (Lazo et al., 2000). Sterman (2011, p. 813) argues that "/w/here the dynamics of complex systems are conditioned by multiple feedbacks, time delays, accumulations and nonlinearities, mental models […] often fail to account for these elements of dynamic complexity". According to Sterman (ibid.), it is crucial to identify ways to improve science communication of complex concepts to media, to foster action based on "the best scientific understanding".

A contrasting explanation concerns the *socio–cultural preconditions for public engagement in climate change.* In response to the mental models approach and the deficit model for science communication, it has been argued that even though climate change science has now been publicly communicated for over 30 years, and the level of public awareness and knowledge of the causes and effects of climate change has increased in many countries, we have not witnessed much change in the public's

behavior and lifestyles (e.g. Whitmarsh et al., 2011). This is known in the social science literature as the "value-action gap" or the "attitude-behavior divide" (Grob, 1995; Kollmuss & Agyeman, 2002; Nicholson-Cole, 2005) and it can be observed not only for climate change, but also for other so called "bigger-than-self problems" which may not be in people's immediate self-interest to contribute to solving (Corner & Randall, 2011). Hence, rather than focusing on lay people's individual cognitive abilities, the literature which discusses the socio-cultural preconditions for lay understanding of climate change refers to social norms, ideologies and values as important factors influencing public engagement with climate change (Etkin & Ho, 2007; Featherstone et al., 2009; Hulme, 2009; Moser, 2006; Ockwell et al., 2009; White & Wall, 2008; Zia & Todd, 2010). Etkin and Ho (2007) claim, based on a study by McComas and Shanahan (1999), that there is "a lack of cultural narratives within which the debate can be placed" (Etkin & Ho, 2007, p. 632). Cultural narratives, or stories, which render climate change meaningful to lay people are seen as important for sustaining engagement and motivating interest, even if the public overall may lack deeper knowledge of the details of climate science (Wolf & Moser, 2011). Lorenzoni et al. (2007a) list a range of individual and social barriers to engagement, pointing e.g. to social norms saying that consumption leads to higher status. Other studies point to the importance of *political orientation, worldviews* and *religious views* in influencing the level of public engagement (Donner, 2011; McCright, 2011; Whitmarsh, 2011; Wolf & Moser, 2011). Furthermore, a sense of agency is a key factor in determining whether people will engage in pro-environmental behavior. Unless people believe that "they *can* do something about the problem, and that it is *worth* doing something", it will be difficult to encourage engagement (Howell 2011: 178).

In the CCC literature there is a substantial body of knowledge about ways of positively encouraging public engagement in climate change. In the following I will discuss the role of a) the content of climate change communication; b) visualizations; c) framing; d) audience segmentation. These four areas where chosen for further discussion since they are recurrently mentioned in the CCC literature. They were also chosen as broad areas, each integrating several particular solutions brought up in the literature. It is worth noting, however, that the four types of solutions discussed below complement each other and should not be viewed as separate solutions.

INSERT TABLE 1 ABOUT HERE

Solutions

The content of climate change communication

As regards the *content of climate change communication*, the CCC literature repeatedly highlights the shortcomings of fear-based communication on climate change. It has been demonstrated that although alarmist "doomsday" messages and visualizations can increase public awareness of severe impacts of climate change, such narratives and images are likely to engender feelings of hopelessness and apathy in the audience (Feinberg & Willer, 2011; Moser & Dilling, 2004; Nicholson-Cole, 2005; O'Neill & Nicholson-Cole, 2009). By contrast, it is crucial to communicate awareness-raising messages that still hold the potential to empower people to take action. To achieve this, studies have identified the potential of communicating local impacts and responses to climate change, and of highlighting concrete action strategies (Nicholson-Cole, 2005; O'Neill & Nicholson-Cole, 2009). Norton et al. (2011:306) argue: "Messages about climate change issues would likely be more effective if they target issues salient to local

actors […] Climate change matters because of its impacts on various, specific regions".

Focusing climate change communication on solutions rather than on problems is also suggested as a strategy for enhancing public engagement (Cooney, 2010; Maibach et al., 2010). Positive stories of how 'ordinary people' (i.e. not 'environmentalists') take action on climate change is seen as a promising road for climate change communication, since such stories take advantage of the power of constructive social norms (Howell, 2011:186). There are also examples of web-based movements that aim to inspire lay people to engage in community-based projects centered around e.g. communal gardens or bicycle commuting. In terms of fostering public engagement, such locally based projects offer a positive outlook on the future and promotes a sense of agency and control for lay people (Cooney, 2010). Furthermore, it has been argued that positive feedback on individual action to mitigate climate change could be effective for increasing public engagement (Cooney, 2010; Howell, 2011, Whitmarsh et al., 2011). Such feedback could for instance take the form of financial payback to homeowners who take measures to reduce emissions and decrease energy use (Cooney, 2010). Feedback on individual action could also be given through online tools such as carbon calculators, where individuals can calculate their 'carbon footprint' and compare the "relative contribution of different activities and how their lifestyles compare to others locally, nationally and globally" (Whitmarsh et al., p. 58). However, it is worth noting that in case individuals are not motivated to change, carbon calculators and similar tools will probably not motivate behavior change (ibid.). On the other hand, according to Whitmarsh et al. (2011), exploratory research suggests that carbon calculators may be successful in making climate change more relevant to the individual who calculates his or her carbon footprint, and therefore could be useful in spurring engagement.

Visualizations

Another problem of making climate change salient in public communication lies in its unseen and intangible character (Moser & Dilling, 2004). Climate change is often perceived by the public as a spatially and temporally remote risk (Poortinga et al., 2011:1016). To make climate change visible, the role of *visualizations* in climate change communication – through linguistic means such as metaphors, or through images – has been emphasized (Brönnimann, 2002; Manzo, 2010; Nicholson-Cole, 2005; O'Neill & Hulme, 2009; O'Neill & Nicholson-Cole, 2009). Along these lines, Hamblyn (2009) demonstrates the importance of what he calls "canaries" in the climate change rhetoric, i.e. "individualized instances of warning signs or wake-up calls, that alert us to the presence of wider perils, analogous to the caged birds that were taken into British coal pits until the closures of the mid-1980s. In the context of climate change concern such canaries have usually been glaciers or icecaps, seen either in retreat or in dramatic fragmentation" (Hamblyn, 2009:230). The role of climate change canaries, Hamblyn (2009:231) argues, is to "render global warming visible". However, images such as melting ice caps, polar bears, floods or dried river beds, which are commonly used in climate change communication (Hamblyn, 2009; Manzo, 2010), frame climate change as a far-away issue, the consequences of which are remote in time and space, and thereby difficult for individual laypeople to influence through everyday behaviour. Doyle (2007: 142) claims that "such images produce a distancing effect, relegating climate change impacts to a remote and inaccessible place, where animals and habitats are affected rather than humans." By contrast, it has been suggested that climate change images should be nonthreatening and link to people's everyday concerns and emotions (O'Neill & Nicholson-Cole, 2009). Focusing on concrete, locally relevant impacts and responses to climate change could be seen as a way of encouraging experiential learning

(Kolb & Kolb, 2009), which starts from concrete concepts and experience as a basis for reflecting, thinking and acting. In two studies of audience reactions to climate change images, O'Neill and Nicholson-Cole (2009, p. 374) found that "the images that stimulated the greatest feelings of personal efficacy were those clearly showing what people can do personally". The interviewees in the O'Neill and Nicholson-Cole studies stated that local impact images and action images conveyed a sense of empowerment. When looking at such images, the interviewees saw the local relevance of climate change and felt that they could make a difference.

It has been argued that "visualisation has great potential to be used more extensively as a means to communicate and stimulate public willingness to engage with the issue" (Nicholson-Cole, 2005:258). To facilitate communication and learning through visualization, new techniques and technologies are continuously being developed. The field of information and communication technology (ICT) offers potentials not least when it comes to ICT-based visualization of climate change. Immersive dome environments, interactive ICT-based decision arenas and 3D landscape visualization are but a few examples of how climate-related issues are visualized and thereby made tangible and concrete to lay audiences (Neset et al., 2009; Neset et al., 2010; Niepold et al., 2008; Sheppard, 2005). In addition to common forms of data visualization through maps, charts and diagrams, Sheppard (2005) argues for landscape visualisation through which actual places can be represented in highly realistic 3D perspective views. According to Sheppard (2005: 637-638), such visualizations "may substantially enhance awareness-building on various complexities and implications of climate change, and may help motivate behavioural change at the individual to societal levels." Along similar lines, Nicholson-Cole (2005) argues that computer visualizations might help people reflect upon future impacts of climate change in relation to present

activities, since such visualizations might project local landscapes under different climate change conditions. However, since the field of ICT-based visualization is under rapid development, there is need for further testing of the effects of ICT-based visualization (Sheppard, 2005).

Framing

Much of the recent CCC literature highlight the importance of framing climate change in ways that make sense to lay audiences for influencing public engagement (e.g. Corner & Randall, 2011; Hart, 2011; Maibach et al., 2010; Nisbet, 2009; Nisbet & Mooney, 2007; Patchen, 2010). Corner and Randall (2011:1011) argue that "deep framing", which refers to "the connections that are forged between a particular communicating strategy or public policy and a set of deeper values or principles" offers "one method of linking climate change engagement strategies with values that are more conducive to solving bigger-than-self problems". It has been argued that reframing of climate change could be one way of encouraging engagement among segments of the public which do not usually engage in environmental issues. [6] For instance, leaving the traditional framing of climate change as an environmental problem and reframing it to better resonate with the framings of the target audiences has been suggested as way of encouraging public engagement. Alternatives include framing climate change as *a public health issue*, emphasizing potential health benefits of emissions reductions, less use of car transportation, altered dietary habits etc. (Maibach et al., 2010); *a security issue*, emphasizing risks to personal security posed by drastic climate change, and highlighting links between energy supply and security concerns (Zia & Todd, 2010); *a*

[6] For further discussion on how changes in framings of climate predictions influences decision making, see Nicholls (1999).

religious or moral issue, emphasizing "a moral obligation to protect the Earth and God's living things" (ibid.: 757); and/or *an economic issue*, linking climate change with the economic crisis and "framing energy efficiency as a cost-cutting and waste-saving measure" (ibid.: 758). The health frame has proved particularly beneficial in inspiring hope and encouraging public support for mitigation and adaptation measures, at least among segments of the U.S. public (Myers et al., 2012).

Audience segmentation

The CCC literature repeatedly states that "the public is not homogeneous; there are many different publics" (e.g. Featherstone et al., 2009, p. 214; cf. Akerlof et al., 2011; Kim & Neff, 2009; Lowe et al., 2006; Moser, 2006; Maibach et al., 2008; O'Neill & Hulme, 2009; Schweitzer et al., 2009). By *segmenting the audience* into target groups, climate change communication can be elaborated to resonate with the different interpretative frames of different target groups, and thereby make more sense to the public (Akerlof et al., 2011; Lowe et al., 2006; Maibach et al., 2008; Moser, 2006). The studied papers discuss various ways of doing such segmentation. The traditional approach to audience segmentation has been to divide subpopulations according to demographic traits such as gender, age, or socioeconomic background (Maibach et al., 2008). However, this is arguably not a satisfactory way of organizing climate change communication activities. It has been claimed that demographics alone cannot efficiently predict attitudes and practices related to climate change; an alternative strategy would be to base segmentation on a variety of psychosocial variables (Maibach et al., 2008). For example, audience segmentation could be based on research into different "interpretive communities of risk" defined by climate change risk perceptions, values, beliefs, media use, and policy preferences (Maibach et al., 2008). An

interpretive community could be defined as a subpopulation whose members "share similar perceptions, understandings, concerns, and emotional responses to global warming" (Moser, 2006, p. 5). Some of the studied papers identify various interpretive communities. For example, audiences could be segmented along an opinion spectrum ranging from complete denial of climate change ("naysayers") to extreme concern ("alarmists") (Moser, 2006, p. 5). In between, there may be a group that doubts the anthropogenic causes of climate change and an uninterested group that believes in human contribution to climate change, but does not regard the climate issue as important (Lorenzoni, 2003; quoted in Lowe et al., 2006). A similar approach to audience segmentation is taken in the repeated studies called The Global Warming's Six Americas. These studies have been ongoing since 2008 and identify six target audiences for climate change communication, ranging from the dismissive (10% of the 981 respondents in May 2011), which is the least concerned and least motivated group with the lowest belief in climate change , via the doubtful (15%), the disengaged (10%), the cautious (25%) and the concerned (27%), to the alarmed (12%), which have the highest belief in global warming and who are most concerned and motivated (Leiserowitz et al., 2011b). The results from the Six Americas studies have been useful in designing further studies e.g. of how different segments of the U.S. public responds to different framings of climate change (Myers et al., 2012) and to develop communication strategies targeted to different segments of the public e.g. visiting national parks (Akerlof et al., 2011).

Audience segmentation may suggest a top-down perspective on communication, where the communicator decides what to communicate to which target group, which may seem at odds with a view of learning as dependent on interaction and dialogue. However, I would argue that the key idea of audience segmentation – that it is important to consider that different target audiences interpret climate change

communication differently – is relevant for environmental educators, who could benefit from knowledge on the learner's interpretative frames when designing non-formal climate change education. It has been noted that "/e/ffective environmental education and interpretation relies explicitly on understanding the audiences' values, attitudes, and beliefs, particularly towards a specific issue or a site-specific resource" (Brownlee et al. 2012:2).

In sum, in line with the shifting focus in the the CCC literature from public understanding to public engagement in climate change, there is also increasing focus on ways of communicating climate change that take into account the need for audience segmentation and involving different publics in dialogue and deliberation on causes, impacts and responses to climate change. To enhance engagement, the literature stresses the importance of positive feedback on individual actions, locally and personally relevant framings of climate change, visibility and concretization of climate change-related issues and a focus on solutions rather than on catastrophic consequences of climate change. In the following we will turn to the implications of lessons learnt from the CCC literature for non-formal education on climate change.

7.Discussion

This paper set out to review climate change communication research, and discuss recurrent themes in the literature as well as possible futures for climate change communication and non-formal education. By identifying differences and commonalities in how lay people in different contexts and sub-segments of populations perceive and react to climate change, learning events could be designed in ways that make sense to different groups of learners. Although, admittedly, some of the

communication literature employs a top-down perspective on communication and rests on an information-deficit model which treats information as neutral and objective, while ignoring the context-dependency of public understanding of climate change (Bulkeley, 2000; Potter & Oster, 2008), there is an increasing focus in the CCC literature on public engagement in climate change as well as on "the constructivist nature of learning and individual variation in information processing and impact" (Whitmarsh, 2011:691).

The review of the CCC literature points to at least three areas of particular importance for non-formal education. First, the trend in the literature to focus less on public understanding and more on public engagement actualizes the question of how to overcome the value-action gap in public behavior. It has been suggested that increased knowledge and awareness on climate change among the public will not automatically lead to lifestyle changes (Kollmuss & Agyeman, 2002; Whitmarsh et al., 2011). Although lack of knowledge is among the barriers to public engagement discussed in the literature, this barrier interacts with others such as social norms, worldviews, ideologies and lack of agency (Lorenzoni et al., 2007; Wolf & Moser, 2011). This means that there is no single solution to how to overcome the value-action gap, but climate change communication and education need to address barriers to public engagement on several levels simultaneously. In terms of solutions to the barriers to public engagement, the CCC literature identifies a wide range of possible communicative approaches, including careful rethinking of climate change messages, use of images, metaphors and computer technology to visualize and thereby make complex science-based messages on climate change tangible and more concrete to lay people, audience segmentation whereby communication will be undertaken in ways that resonate with the interpretative frames and previous understandings of different audiences, and rethinking how the issue of climate change is framed to resonate with

different publics. Linking these different types of solutions and considering how to frame climate change for different groups of learners, how to use visualizations, metaphors and examples of climate change causes and impacts, how to focus on solutions and not only problems and how to give feedback on an individual level should be important for climate change educators.

Second, recent studies indicate that world media coverage of climate change is decreasing (http://sciencepolicy.colorado.edu/media_coverage/) and there are signs of climate "fatigue" (e.g. Maibach et al., 2010) and information overload which could make the public less inclined to learn more about climate change. In the light of this, reframing climate change from an environmental issue into e.g. an issue of public health (Maibach et al., 2010), an economic issue, a security issue or a moral issue (Zia & Todd, 2010) could be one way of overcoming barriers to engagement caused by issue fatigue. Moreover, I argue that in non-formal education on climate change, encouraging learners to explore linkages between climate change and the broader notion of sustainable development could be helpful in opening up discussions on climate change to explicitly include not only environmental dimensions but also aspects of social and economic sustainability.

Third, I argue that for climate change communicators and educators alike, it is important to rethink the roles of the lay people in mitigation and adaption strategies. Key questions would include: In what ways should lay people respond to the challenges of climate change? Could they be expected to take responsibility for mitigating emissions and/or adapting to the effects of climate change? In the CCC literature, the ultimate goal of climate change communication was the support of sustainable development and the reduction of climate change impact by engaging the public. This could, according to the papers, be manifested through lifestyle change, support for

climate-friendly policies, and/or participation in climate science or policy dialogues. However, even though the overarching goal may be clear and shared among those involved in organising and facilitating climate change communication and/or public learning, there are several possible ways of attaining this goal, each involving different ways of conceptualising the roles and responsibilities of the public. Here, there is need for further research. For instance, the question of whether the public is primarily seen as citizens or as consumers was rarely explicitly discussed in the studied CCC papers (but see e.g. Patchen, 2010; Spoel et al., 2008 and Whitmarsh, 2011 for notable exceptions), but should be taken into account since it affects what could be expected as a learning outcome of public climate change communication and education. The idea of educating individuals to facilitate changes of consumption patterns positions the lay person as a rational economic actor operating through market-based solutions. The idea of encouraging lay people to exert political influence by supporting climate-friendly policies rather positions the lay person as a citizen acting within a representative democracy, without necessarily making individual economic gain from his/her actions. The idea of involving citizens in climate science and policy dialogues, on the other hand, invokes ideals of deliberative democracy (cf. Lövbrand et al 2011) and presumes the citizen to become a lay expert devoting his/her time and everyday expertise to improving climate science and policy. Moreover, it was rarely explicitly discussed in the papers what level of responsibility should be expected from the individual citizens as compared to other societal actors. The studied papers started from the assumption that the individual level is important in combating climate change, but not much was said about the role of the individual as compared to e.g. policies and measures and state responsibilities, which for instance are emphasized in the 2007 IPCC report on mitigation options (IPCC 2007), nor about the extent and limits of individual agency.

Nevertheless, a recent focus group study among Swedish lay people (Wibeck, forthc.; Wibeck & Linnér, 2012) identified this as a crucial issue for the public. The participants in this study stated that they felt responsible as citizens for taking action to mitigate climate change. However, they also expressed frustration due to a sense of limited agency, in that their actions were perceived as having little actual impact. I argue that for future climate change communication and education to be perceived as legitimate by lay people, communicators and educators need to explicitly discuss the role of individual lay people's contributions in relation to responsibilities of other actors and discuss the need for lifestyle changes in relation to other mitigation options.

As the area of CCC is rapidly expanding and as new studies of public communication and public engagement are undertaken in more national contexts and local sub-segments of the audience, the CCC field will probably continue to be relevant for climate change educators across the world. Likewise, I believe that climate change communicators could learn a lot from professionals experienced in environmental education. Hence, there is large potential for further interaction between the fields of climate change communication and environmental education in the years to come.

8.Conclusions

In reviewing scholarly literature on climate change communication (CCC) published between 2000 and 2011 it was found that:

- Climate change is now firmly put on the public agenda. However, world media coverage of climate change is decreasing and in some countries there are signs of climate "fatigue" which could make the public less inclined to learn more about climate change. This calls for new modes of communication and

innovative forms of non-formal education.

- The CCC literature points out that the ultimate goal of climate change communication is to support sustainable development and reduce climate change impact through public engagement. However, there are several possible ways of attaining this goal, each involving different ways of conceptualising the roles and responsibilities of the public. More research is needed into analyzing the possible roles for lay people in mitigation and adaptation strategies, as compared to the roles and responsibilities attributed to other social actors, in order to explore potentials for non-formal learning activities which are perceived as legitimate and relevant by the public.
- Most CCC literature has focused on climate change perceptions and communication in a few developed countries, in particular the US and the UK. More research into how publics in developing countries and more cross-country comparisons would make a valuable contribution to our knowledge on how sociocultural factors affect public engagement in climate change. Different types of barriers to public engagement in climate change are often intertwined. For instance, lack of scientific knowledge among the public may interact with others such as social norms, worldviews, ideologies and lack of agency. Hence, climate change communication and non-formal education need to address barriers to public engagement on several levels simultaneously.

- To overcome barriers to public engagement in climate change, the CCC literature points to the potentials of enabling positive feedback on individual actions, focusing on solutions rather than on catastrophic consequences of climate change, making complex science-based messages on climate change tangible and more concrete to lay people by means of images, metaphors and

ICT-based visualizations, taking the interpretative frames and previous understandings of different audiences into account, and rethinking how the issue of climate change is framed to resonate with different publics.

Acknowledgements

To be completed after peer review.

References

Papers included in the literature review:

Akerlof, K., Bruff, G. & Witte, J. 2011. Audience segmentation as a tool for communicating climate change. *Park Science* 28.

Akerlof, K., Debono, R., Berry, P., Leiserowitz, A., Roser-Renouf, C., Clarke, K., Rogaeva, A., Nisbet, M., Weathers, M. & Maibach, E. 2010. Public perceptions of climate change as a human health risk: Surveys of the United States, Canada and Malta. *International Journal of Environmental Research and Public Health* 7:2559-2606.

Balmford, A., Manica, A., Airey, L., Birkin, L., Oliver, A. & Schleicher, J. 2004. Hollywood, climate change, and the public. *Science* 305:1713.

Binder, A. 2010. Routes to attention or shortcuts to apathy? Exploring domain-specific communication pathways and their implications for public perceptions of controversial science. *Science Communication* 32:383-411.

Bowman, T., Maibach, E., Mann, M., Somerville, R., Seltser, B., Fischhoff, B., Gardiner, S., Gould, R., Leiserowitz, A. & Yohe, G. 2010. Time to take action on climate communication. *Science* 330:1044.

Brulle, R. 2010. From environmental campaigns to advancing the public dialog: environmental communication for civic engagement. *Environmental Communication* 4:82-98.

Brönniman, S. 2002. Picturing climate change. *Climate Research* 22.87-95.

Budescu, D., Broomell, S. & Por, H. 2009. Improving communication of uncertainty in the reports of the Intergovernmental Panel on Climate Change. *Psychological Science* 20:299–308.

Bulkeley, H. 2000. Common knowledge? Public understanding of climate change in Newcastle, Australia. *Public Understanding of Science* 9:313-333.

Campbell, P. 2011. Understanding the receivers and the reception of science's uncertain messages. *Philosophical Transactions of the Royal Society A* 369:4891-4912.

Carvalho, A (ed.). 2008. *Communicating climate change: discourses, mediations and perceptions.* Braga: Universidade do Minho.

Cooney, C. 2010. The perception factor. Climate change gets personal. *Environmental Health Perspectives* 118:A485-A488.

Cooper, C. 2011. Media literacy as a key strategy toward improving public acceptance of climate change science. *BioScience* 61:231-237.

Corbett, J. & Durfee, J. 2004. Testing public (un)certainty of science: media representations of global warming. *Science Communication* 26:129-151.

Corner, A. & Randall, A. 2011. Selling climate change? The limitations of social marketing as a strategy for climate change public engagement. *Global Environmental Change* 21:1005-1014.

Cox, R. 2010. Beyond frames: Recovering the strategic in climate communication. *Environmental Communication* 4:122-133.

Donner, S. 2011. Making the climate a part of the human world. *Bulletin of the American Meterological Society* 92:1297-1302.

Etkin, D. & Ho, E. 2007. Climate change: perceptions and discourses of risk. *Journal of risk research* 10:623–641.

Eurobarometer. 2011. *Europeans' attitudes towards climate change. Special Eurobarometer 372: Climate change.* URL: http://ec.europa.eu/public_opinion/archives/ebs/ebs_372_en.pdf. Retrieved Dec 20, 2011.

Featherstone, H., Weitkamp, E., Ling, K. & Burnet, F. 2009. Defining issue-based publics for public engagement: climate change as a case study. *Public Understanding of Science* 18:214–228.

Feinberg, M. & Willer, R. 2011. Apocalypse soon?: Dire messages reduce belief in global warming by contradicting just-world beliefs. *Psychological Science* 22:34-38.

Few, R., Brown, K. & Tompkins, E. 2011. Public participation and climate change adaptation: avoiding the illusion of inclusion. *Climate Policy* 7:46-59.

Fischhoff, B. 2007. Nonpersuasive communication about matters of greatest urgency: climate change. *Environmental Science and Technology* 41:7204-7208.

Fischhoff, B. 2011. Applying the science of communication to the communication science. *Climatic Change* 108:701-705.

Fortner, R., Lee, J., Corney, J., Romanello, S., Bonnell, J., Luthy, B., Figuerido, C. & Ntsiko, N. 2000. Public understanding of climate change: certainty and willingness to act. *Environmental Education Research* 6:127–141.

Frumkin, H. & McMichael, A. 2008. Climate change and public health. Thinking, communicating, acting. *American Journal of Preventive Medicine* 35:403-410.

Hamblyn, R. 2009.The whistleblower and the canary: Rhetorical constructions of climate change. *Journal of Historical Geography* 35:223-236.

Hart, P. 2011. One or many? The influence of episodic and thematic climate change frames on policy preferences and individual behaviour change. *Science Communication* 33:28-51.

Hassol, S. 2008. Improving how scientists communicate about climate change. *Eos Trans. AGU* 89:106.

Herriman, J., Atherton, A. & Vecellio, L. 2011. The Australian experience of World wide views on global warming: The first global deliberation process. *Journal of Public Deliberation* 7:art no. 3.

Howell, R. 2011. Lights, camera... action? Altered attitudes and behaviour in response to the climate change film The age of stupid. *Global Environmental Change* 21:177-187.

Hulme, M. 2009. *Why we disagree about climate change: understanding controversy, inaction and opportunity*. Cambridge, UK: Cambridge University Press.

Kahlor, L. and Rosenthal, S. 2009. 'If we seek, do we learn? Predicting knowledge on global warming'. *Science Communication* 30:380–414.

Kim, B. & Neff, R. 2009. Measurement and communication of greenhouse gas emissions from U.S. food consumption via carbon calculators. *Ecological Economics* 69:186–196.

Kim, K. 2011. Public understanding of the politics of global warming in the news media: the hostile media approach. *Public Understanding of Science* 20:690-705.

Krosnick, J., Holbrook, A., Lowe, L. & Visser, P. 2006. The origins and consequences of democratic citizens' policy agendas: a study of popular concern about global warming. *Climatic Change* 77:7-43.

Lazo, J., Kinnell, J. & Fischer, A. 2000. Expert and layperson perceptions of ecosystem risk. *Risk Analysis* 20:179–194.

Leiserowitz, A. 2004. Before and after The day after tomorrow. A U.S. Study of climate change risk perception. *Environment* 46:22-37.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Smith, N. 2011a. *Climate change in the American Mind: Americans' global warming beliefs and attitudes in May 2011.* Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Leiserowitz , A., Maibach, E., Roser-Renouf, C. & Smith, N. 2011b. *Global warming's six Americas, May 2011.* Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Lorenzoni, I. & Pidgeon, N. 2006. Public views on climate change: European and USA perspectives. *Climatic Change,* 77:73–95.

Lorenzoni, I., Nicholson-Cole, S. & Whitmarsh, L. 2007a. Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change* 17:445-459.

Lowe, T., Brown, K. & Dessai, S. 2006. Does tomorrow ever come? Disaster narratives and public perceptions of climate change. *Public Understanding of Science* 15:435–457.

Lubell, M., Zahran, S. & Vedlitz, A. 2007. Collective action and citizen responses to global warming. *Political Behaviour* 29:391-413.

Maibach, E. & Hornig Priest, S. 2009. No more 'business as usual': addressing climate change through constructive engagement. *Science Communication* 30:299–304.

Maibach, E., Leiserowitz, A., Roser-Renouf, C. & Mertz, C. 2011. Identifying like-minded audiences for global warming public engagement campaigns: an audience segmentation analysis and tool development. *PLoS One* 6:e17571.

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K. & Diao, G. 2010. Reframing climate change as a public health issue: an exploratory study of public reactions. *BMC Public Health* 10:299-309.

Maibach, E., Roser-Renouf, C. & Leiserowitz, A. 2008. Communication and marketing as climate change-intervention assets. A public health perspective. *American Journal of Preventive Medicine* 35:488–500.

Manzo, K. 2010. Beyond polar bears? Re-envisioning climate change. *Meterological Applications* 17:196-208.

McCright, A. 2011. Political orientation moderates Americans' beliefs and concern about climate change. *Climatic Change* 204:243-253.

McKie, D. & Galloway, C. 2007. Climate change after denial: global reach, global responsibilities, and public relations. *Public Relations Review 33:*368-376.

Moxnes, E. & Saysel, A. 2009. Misperceptions of global climate change. *Climatic Change* 93:15–37.

Moser, S. 2006. Talk of the city: engaging urbanites on climate change. *Environmental Research Letters* 1:1–10.

Moser, S. & Dilling, L. 2004. Making climate hot: Communicating the urgency and challenge of global climate change. *Environment* 46:32–46.

Newell, B. & Pitman, A. 2010. The psychology of global warming. Improving the fit between the science and the message. *Bulletin of the American Meterological Society* 91:1003-1014.

Nicholson-Cole, S. 2005. Representing climate change futures: a critique on the use of images for visual communication. *Computers, Environment and Urban Systems* 29: 255–273.

Niepold, F., Herring, D. & McConville, D. 2008. The role of narrative and geospatial visualization in fostering climate literate citizens. *Physical Geography* 29:529-544.

Nisbet, M. 2009. Communicating climate change: Why frames matter for public engagement. *Environment* 51:12–23.

Nisbet , M. & Mooney, C. 2007. Framing science. *Science* 316:56.

Nisbet. M. & Myers, T. 2007. The polls – trends. Twenty years of public opinion about global warming. *Public Opinion Quarterly* 71:444-470.

Nisbet, M. & Scheufele, D. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany* 96: 1767–1778.

Norton, T., Sias, P. & Brown, S. 2011. Experiencing and managing uncertainty about climate change. *Journal of Applied Communication Research* 39:290-309.

Ockwell, D., Whitmarsh, L. & O'Neill, S. 2009. Reorienting climate change communication for effective mitigation: forcing people to be green or fostering grass-roots engagement? *Science Communication* 30:305–327.

Ohe, M. & Ikeda, S. 2005. Global warming: Risk perception and risk-mitigation behaviour in Japan. *Mitigation and Adaptation strategies for global change* 10:221–236.

Olausson, U. 2011. "We're the ones to blame": Citizens' representations of climate change and the role of the media. *Environmental Communication* 5:281-299.

O'Neill, S. & Hulme, M. 2009. An iconic approach for representing climate change. *Global Environmental Change* 19:402–410.

O'Neill, S. & Nicholson-Cole, S. 2009. 'Fear won't do it': Promoting positive engagement with climate change through visual and iconic representations. *Science Communication* 30:355–379.

Patchen, M. 2010. What shapes public reactions to climate change? Overview of research and policy implications. *Analyses of Social Issues and Public Policy* 10:47-68.

Poortinga, W., Spence, A., Whitmarsh, L., Capstick, S. & Pidgeon, N. 2011. Uncertain climate: An investigation into public scepticism about anthropogenic climate change. *Global Environmental Change* 21:1015-1024.

Potter, E. & Oster, C. 2008. Communicating climate change: Public responsiveness and matters of concern. *Media International Australia* 127:116-126.

Russill, C. 2010. Stephen Schneider and the 'double ethical bind' of climate change communication. *Bulletin of Science Technology & Society* 30:60-69.

Ryan, B. & Toohey-Morales, J. 2007. Communicating global climate change to the public and clients. *Bulletin of the American Meteorological Society* 88*:*1164.

Ryghaug, M., Sorensen, K. & Naess, R. 2011. Making sense of global warming: Norwegians appropriating knowledge of anthropogenic climate change. *Public Understanding of Science* 20:778-795.

Sampei, Y. & Aoyagi-Usui. M. 2009. Mass-media coverage, its influence on public awareness of climate change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. *Global environmental change* 19:203–212.

Schenk, N. & Lensink, S. 2007. Communicating uncertainty in the IPCC's greenhouse gas emissions scenarios . *Climatic Change* 82:293-308.

Schmidt, C. 2009. Communication gap. *Environmental Health Perspectives* 117:548-551.

Schweitzer, S., Thompson, J., Teel, T. & Bruyere, B. 2009. Strategies for communication about climate change impacts on public lands. *Science Communication* 31:266–274.

Seacrest, S., Kuzelka, R. and Leonard, R. 2000. Global climate change and public perception: the challenge of translation'. *Journal of the American Water Resources Association 36:*253–263.

Sheppard, S. 2005. Landscape visualisation and climate change. *Environmental Science & Policy 8:*637-654.

Spoel, P., Goforth, D., Cheu, H. & Pearson, D. 2008. Public communication of climate change science: engaging citizens through apocalyptic narrative explanation. *Technical Communication Quarterly* 18:49-81.

Stamm, K., Clark, F. & Reynolds Eblacas, P. 2000. Mass communication and public understanding of environmental problems: the case of global warming. *Public understanding of science* 9:219–237.

Sterman, J. 2011. Communicating climate change risks in a skeptical world. *Climatic Change* 108:811-826.

Sterman, J. 2008. Risk communication on climate: mental models and mass balance. *Science 322:*532–533.

Sterman, J. & Sweeney, L.B. 2002. Cloudy skies: assessing public understanding of global warming. *System Dynamics Review* 18:207–240.

Sterman, J. & Sweeney, L.B. 2007. Understanding public complacency about climate change. *Climatic Change* 80:213–238.

Sundblad, E., Biel, A. & Gärling, T. 2008. Knowledge and confidence in knowledge about climate change among experts, journalists, politicians, and laypersons. *Environment and behaviour* 41:281–302.

Uggla, Y. 2008. Strategies to create risk awareness and legitimacy: the Swedish climate campaign. *Journal of Risk Research* 11:719-734.

Ungar, S. 2000. Knowledge, ignorance and the popular culture: climate change versus the ozone hole. *Public Understanding of Science* 9:297-312.

Ward, R. 2008. Good and bad practice in the communication of uncertainties associated with the relationship between climate change and weather-related natural disasters. *Geological Society Special Publication* 305:19-37.

Weber, E. & Stern, P. 2011. Public understanding of climate change in the United States. *American Psychologist* 66:315-328.

White, T. & Wall, R. 2008. National, regional and local attitudes towards climate change: identifying appropriate target audiences for communications. *Local Environment* 13:589–607.

Whitmarsh, L. 2008. What's in a name? Commonalities and differences in public understanding of 'climate change' and'global warming'. *Public Understanding of Science* 18:401–420.

Whitmarsh, L. 2011. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change* 21:690-700.

Whitmarsh, L., Seyfang, G. & O'Neill, S. 2011. Public engagement with carbon and climate change: To what extent is the public 'carbon capable'? *Global Environmental Change* 21:56-65.

Wolf, J. & Moser, S. 2011. Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change* 2:547-569.

Zhao, X., Leiserowitz, A., Maibach, E. & Roser-Renouf, C. 2011. Attention to science/environment news positively predicts and attention to political news negatively predicts global warming risk perceptions and policy support. *Journal of Communication* 61:713-731.

Zia, A. & Todd, A. 2010. Evaluating the effects of ideology on public understanding of climate change science: How to improve communication across ideological divides? *Public Understanding of Science* 19:743-761.

Additional references:

Bedsted, B. & Klüver, L., eds. 2009. *World wide views on global warming. From the world's citizens to the climate policy makers.* Policy report. Danish Board of Technology. URL: http://www.wwviews.org/files/AUDIO/WWViews%20Policy%20Report%20FINAL%20-%20Web%20version.pdf.

Boykoff, M. 2007. From convergence to contention: United States mass media presentations of anthropogenic climate change science. *Transactions of the Institute of British Geographers* 32:477–489.

Boykoff, M. & Boykoff, J. 2004. Bias as balance: global warming and the US prestige press. *Global Environmental Change* 142:125–136.

Brossard, D. & Lewenstein, B. 2009. A critical appraisal of models of public understanding of science: Using practice to inform theory. In *Communicating science: New agendas in communication*, eds. L. Kahlor & P. Stout. New York: Routledge.

Brossard, D., Shanahan, J. & McComas, K. 2004. Are issue-cycles culturally constructed? A comparison of French and American coverage of global climate change. *Mass Communication and Society* 7:359–377.

Brownlee, M., Powell, R. & Hallo, J. 2012. A review of the foundational processes that influence beliefs in climate change: opportunities for environmental education research. *Environmental Education Research* DOI:10.1080/13504622.2012.683389.

Chopyak, J. & Levesque, P. 2002. Public participation in science and technology decision making: trends for the future. *Technology in Society* 24:155-166.

Delgado, A., Kjolberg, K. & Wickson, F. 2011. Public engagement coming of age: From theory to practice in STS encounters with nanotechnology. *Public Understanding of Science* 20:826-845.

Dillon, J. 2003. On learners and learning in environmental education: missing theories, ignored communities. *Environmental Education Research* 9:125-226.

Doyle, J. 2007. Picturing the clima(c)tic: Greenpeace and the representational politics of climate change communication. *Science as Culture* 16: 129–150.Funtowicz, S. & Ravetz, J. 1993. Science for the post-normal age. *Futures* 25:739–755.

Gamson, W. & Modigliani, A. 1987. The changing culture of affirmative action. In: *Research in political sociology, vol 3*, eds. R. Braungart & M. Braungart. Greenwich, CT: JAI Press.

George, D., Clewett, J., Wright, A., Birch, C., & Allen, W. 2007, Improving farmer knowledge and skills to better manage climate variability and climate change. *Journal of International Agricultural and Extension Education* 14:5-19.

George, D., Clewett, J., Birch, C., Wright A. & Allen, W. 2009, A professional development climate course for sustainable agriculture in Australia. *Journal of Environmental Education Research*.15: 417-441.

Grob, A. 1995. A structural model of environmental attitudes and behaviour. *Journal of Environmental Psychology* 15:209–220.

Hulme, M. 2007. Newspaper scare headlines can be counter-productive. *Nature* 445:818.

Irvin, R. & Stansbury, J. 2004. Citizen participation in decision making: Is it worth the effort? *Public Administration Review* 64:55-65.

Kolb, A. & Kolb, D. 2009. The Learning Way. Meta-cognitive Aspects of Experiential Learning. *Simulation & Gaming* 40: 297-327.

Kollmuss, A. & Agyeman, J. 2002. Mind the gap: why people act environmentally and what are are the barriers to pro-environmental behaviour? *Environmental Education Research* 8:239–261.

Koteyko, N., Thelwall, M. & Nerlich, B. 2010. From carbon markets to carbon morality: creative compounds as framing devices in online discourses on climate change mitigation. *Science Communication* 32:25–54.

Lewenstein, B. & Brossard, D. 2006. *Assessing models of public understanding in ELSI outreach materials: Final report.* Ithaca, NY: Cornell University.

Lorenzoni, I. 2003. *Present choices, future climates: A cross-cultural study of perceptions in Italy and in the UK*. Doctoral Thesis, School of Environmental Sciences, University of East Anglia, UK.

Lorenzoni, I., Jones. M. & Turnpenny, J. 2007b. Climate change, human genetics, and post-normality in the UK. *Futures* 39:65-82.

Lövbrand, E., Pielke, R. & Beck. S. 2011. A democracy paradox in studies of science and technology. *Science Technology and Human Values* 36: 474-496.

McComas, K. & Shanahan, J. 1999. Telling stories about global climate change: measuring the impact of narratives on issue cycles. *Communication Research* 26:30–57.

Moser ,S. 2010. Communicating climate change: History, challenges, process and future directions. *Wileys Interdisciplinary Review: Climate Change* 1: 31–53.

Myers, T., Nisbet, M., Maibach, E. & Leiserowitz. A. 2012. A public health frame arouses hopeful emotions about climate change. *Climatic Change* 113: 1105-1112.

Nerlich, B., Koteyko, N. & Brown, B. 2010. Theory and language of climate change communication. *Wileys Interdisciplinary Review: Climate Change* 1:97-110-

Neset, T., Johansson, J. and Linnér, B. (eds.) 2009. *State of climate visualization.* CSPR report 2009:4. Linköping: Linköping University.

Neset, T., Wibeck, V., Uhrqvist, O., Johansson, J. 2010. Visualizing climate change: the potential of dome presentations as a tool for climate communication. *Computer Graphics Forum* 12/2009.

Nicholls, N. 1999. Cognitive illusions, heuristics, and climate prediction. *Bulletin of the Americal Meteorological Society* 80:1385-1398.

Nowotny, H., Scott, P., & Gibbons, M. 2001. *Re-thinking science: knowledge and the public in an age of uncertainty.* Cambridge: Polity Press.

Olausson, U. 2009. Global warming—global responsibility? Media frames of collective action and scientific certainty. *Public Understanding of Science* 18:421–436.

Patt, A.& Schrag, D. 2003. Using specific language to describe risk and probability. *Climatic Change* 61:17-30.

Reser, J., Bradley, G., Glendon, A., Ellul, M. & Callaghan, R. (2012). *Public Risk Perceptions, Understandings, and Responses to Climate Change and Natural Disasters in Australia and Great Britain*, Gold Coast, Australia: National Climate Change Adaptation Research Facility.

Rogers-Hayden, T. & Pidgeon, N. 2007. Moving engagement "upstream"? Nanotechnologies and the Royal Society and Royal Academy of Engineering's inquiry. *Public Understanding of Science* 16: 345–364.

IPCC. 2007. *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.* Geneva: IPCC.

Schneider, R. O. 2011. Climate change: an emergency management perspective. *Disaster Prevention and Management* 20:53-62.

Schäfer, M. 2009. From Public Understanding to Public Engagement. An Empirical Assessment of Changes in Science Coverage. *Science Communication 30:475-505.*

SEPA. 2004. *The Swedish climate campaign—part of Sweden's climate strategy.* Stockholm: Swedish Environmental Protection Agency.

Sturgis, P. & Allum, N. 2004. Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science* 13:55-74.

Trench, B., 2008. Towards an analytical framework of science communication models. In: *Communicating science in social contexts,* eds. D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele and S. Chi. New York: Springer.

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* 9:261–83.

Wibeck, V. forthc. Social representations of climate change in Swedish lay focus groups: local or distant, gradual or catastrophic? *Public understanding of science* DOI:10.1177/0963662512462787.

Wibeck, V. & Linnér, B. 2012. Public understanding of uncertainties in climate science and policy. In: *Global Change Management: knowledge gaps, blindspots and unknowables*, eds. P. Ibisch, F. Cybulla & L. Geiger. Baden-Baden: Nomos Verlagsgesellschaft.

Wynne, B. & Felt, U. 2007. *Taking European Knowledge Society Seriously,* Chair and Rapporteur, Expert Group on Science and Governance, Brussels, European Commission D-G Research, Science Economy and Society Directorate. EUR 22700.