

Chapter 9

Communicating Climate Information: Traveling Through the Decision-Making Process

Ghislain Dubois, Femke Stoverinck and Bas Amelung

Abstract Climate change forces society to adapt. Adaptation strategies are preferably based on the best available climate information. Climate projections, however, often inform adaptation strategies after being interpreted once or several times. This process affects the original message put forward by climate scientists when presenting the basic climate projections, in particular regarding uncertainties. The nature of this effect and its implications for decision-making are as yet poorly understood. This chapter explores the nature and consequences of (a) the communication tools used by scientists and experts and (b) changes in the communicated information as it travels through the decision-making process. It does so by analyzing observatories; the interpretative steps taken in a sample of 25 documents, pertaining to the field of public policies for climate change impact assessment and adaptation strategies. Five phases in the provisioning of climate information are distinguished: pre-existing knowledge (i.e., climate models and data), climate change projection, impact assessment, adaptation strategy, and adaptation plan. Between the phases, climate information is summarized and synthesized in order to be passed on. The results show that in the sample, information on uncertainty is underrepresented: e.g., studies focus on only one scenario and/or disregard probability distributions. In addition, visualization tools are often used ineffectively, leading to confusion and unintended interpretations. Several recommendations are presented. While climatologists need better training in communication issues,

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decision-makers also need training in climatology to adopt more cautious and robust adaptation strategies that account for the uncertainty inherent in climate projections.

Keywords Climate change · Communication · Uncertainty · Visualization
Climate services

9.1 Introduction

Regardless of mitigation efforts, some degree of climate change is already inevitable (Füssel and Klein 2006), due to past emissions and lag effects in the climate system. As a result, there is a growing need for adaptation strategies, based on observed and projected climate information. Climate projections tend to be technical and science-driven, with considerable emphasis on the many uncertainties involved. Publications in peer-reviewed scientific journals determine a scientist's chances for promotion and success, and there is generally little incentive for scientists to communicate their findings to anyone outside their area of expertise. On the demand side of climate information, decision-makers have little time to search for scientific information, and they often struggle with the technical jargon. Moreover, scientific information faces 'competition' from other information inputs in the decision-making process and may not hold overriding priority (Tribbia and Moser 2008). There is therefore a mismatch between the supply and the demand side of climate information. On the one hand, there is climate data in a raw and inaccessible form; on the other hand, there is demand for highly applied and localized climate information. The connection between the two sides is as yet not specified and standardized and is therefore often filled-in in ad hoc and obscure ways. Bridging this information gap is the field of research and application in climate services (Hewitt et al. 2012).

This chapter addresses the issue of how climate information is communicated from climate scientists to policy makers developing adaptation strategies. It reviews a sample of 25 documents pertaining to the field of public policies for climate change impact assessment and adaptation strategies. The objective is to assess the nature and consequences of the interpretative steps needed to translate scientific knowledge into information that is useful to policy makers. The central theme of the chapter is: How do interpretative processes along the science-policy nexus affect the representation of climate information in the adaptation literature? In addition to exploring the central role of uncertainties, the chapter pays special attention to the role of visual representation of climate information. The chapter addresses the following three key questions: (1) How does climate information flow from climate models to adaptation strategies? (2) How is uncertainty communicated? and (3) How is climate information visualized?

The chapter is structured as follows. Section 9.2 provides an overview of the literature on communicating climate information and on visualization techniques. Section 9.3 describes the data and methods. The results are presented in Sect. 9.4 and discussed in Sect. 9.5, followed by a conclusion in Sect. 9.6.

9.2 Communicating Climate Information: Uncertainties and Visualization

Worldwide, there are only a few technical guidelines and little legal framework concerning the production of climate knowledge and its application in adaptation strategies and plans. For instance, the IPCC provides some detailed guidelines on the treatment of uncertainty (Mastrandrea et al. 2010). France is an example of a country that has legislation that makes an adaptation plan mandatory for governmental authorities, yet without any guidance on what climate information to use and how to use it. Originally, climate information was generated only in national meteorological institutes, universities, and research laboratories. Due to increased public availability of climate data and a rapidly increasing demand for climate information, specialized consultancy offices, local authorities, and NGOs are gaining the ability to use climate data and present it in more user-friendly ways. Together with the lack of guidelines or a legal framework, this increasing demand has led to an uncontrolled supply of climate information (Dubois 2011).

Public and private decision-makers operating in settings that require climate information are generally struggling to assimilate the available climate information (WMO 2009; Changnon et al. 1990) because ‘raw’ climate information is too difficult to be readily understood by lay people. Providers of climate information also face challenges. They need to provide the information in such a way that it is understandable and clear for decision-makers so that it is quickly understood. However, the information also has to be scientifically rigorous. Therefore, providers of climate information are caught in a dilemma: Should scientific rigor prevail at the expense of societal usefulness, or should societal usefulness be maximized at the expense of scientific rigor? Striking a balance between these two extremes can be rewarding, but it is a delicate undertaking (Dubois 2011).

Two factors that influence this dilemma are the concepts of uncertainty and visualization. Climate information is inherently uncertain; scientists emphasize this aspect, whereas decision-makers tend to ask for ‘desired answers’ to problems (McNie 2007). Visualization of climate information can enhance communication by quickly conveying strong and memorable messages and condensing complex information. Nevertheless, visualization also has its pitfalls (Nicholson-Cole 2005) and the question as to when and how visualization improves decision-making have barely been addressed by research (Lurie and Mason 2007).

9.2.1 *Communicating Uncertainty*

A large body of the literature has developed on the communication of uncertainty inherent in long-term climate projections, which in a way makes meteorology and climatology reference disciplines on uncertainty management (Allen and Eckel 2012; Budescu et al. 2009; Dessai and Hulme 2004; Dessai et al. 2009; Joslyn and Savelli 2010; Morss et al. 2008; Dessai and Van der Sluijs 2007; Risbey and Kandlikar 2007). This echoes a broader literature on uncertainty, pertaining to various disciplines like medicine, psychology, economy dealing with uncertainty in a context of decision-making, in the present or in the future (Spiegelhalter et al. 2011).

Most people prefer words over numbers as an intuitive way to describe the likelihood (probabilities) of events (Patt and Dessai 2005). Accordingly, the IPCC developed a methodology to express probabilities by using a set of words that refer to an equivalent set of probability estimates; for example, ‘very likely’ always means >90% probability. The very specific meaning that the IPCC attaches to these words, however, differs from their meaning in everyday life. The IPCC uses the qualitative descriptions to indicate only the *likelihood* of a climatic event to occur. Yet, when people express likelihoods, estimates are influenced by the events potential magnitude. In other words, the *likelihood* of occurrence is multiplied by the events *consequence*. In addition, people have the tendency to overestimate the likelihood of low-magnitude events and underestimate the likelihood of high-magnitude events (Patt and Schrag 2003). As a result, qualitative descriptions of probabilities are subject to a wide range of interpretations (Katz 2002; Budescu et al. 2009).

Patt and Schrag (2003) state that some assessment reports fail to mention climate information that is highly uncertain or avoid quantifying the uncertainty. Gradually changing means for temperature and precipitation are reported, while more extreme and less likely scenarios are ignored. Although the resulting information is easy to understand, it is incomplete, which can have dire consequences. Arguably, changes in the occurrence and intensity of extreme weather events are likely to affect society more and faster than changes in mean climate conditions.

Uncertainty can be expressed in simple terms (e.g., mean) or in more sophisticated ones (e.g., spread and probabilities). The latter ones are more difficult to communicate (Patt and Dessai 2005) but contain valuable information for decision-making (Katz 2002). Instead of leaving the users of climate information to their own devices, scientists are encouraged to elucidate the meaning of probabilistic language and their connection to everyday life (Patt and Schrag 2003). Zehr (2000) refers to this practice as the ‘accountable representation’ of uncertainties. If lay people are informed about the complex processes that give rise to the uncertainties, they may reject information that is overly certain (Pidgeon and Fischhoff 2011).

9.2.2 *Visualizing Climate Information*

Using visualization tools is a delicate business; however, visualization can enhance all kinds of messages, both intended and unintended. A significant body of knowledge on the effects of visualization tools has been developed. Unfortunately, key insights from this knowledge field are typically not observed when communicating climate information. Common pitfalls in visualization still remain (Kelleher and Wagener 2011).

It is known that visualized information receives greater weight than its textual counterpart, resulting in an overrating of visual information and underrating of textual information (Lurie and Mason 2007). Visual representation can alter the connotation of textual messages by using color (e.g., green for a ‘good’ message and red for a ‘bad’ one), instead of presenting the information in neutral black-and-white spectrum (Lurie and Mason 2007). There are several tools to achieve visualization: a colored map, a line graph, a bar chart, or a scatter plot. Cleveland and McGill (1985) found that people can more accurately judge length (of a line or bar) than an area or color. Therefore, maps are fit to attract people, but not for making decisions (British Department of Environment, Food and Rural Affairs 2011).

There has been little investigation into how and when visualization tools affect decision-making. Decision-makers often have a risk management perspective, and they need information on uncertainty, yet visualization tools inevitably simplify or ignore the message of uncertainty (Wittenbrink et al. 1995). On the one hand, visualization may support decision-making by making patterns and outliers easier to see and by highlighting key information (Lurie and Mason 2007). On the other hand, visualization can increase bias and lower the quality of the decisions by drawing attention to a particular part of the visualization (Glazer et al. 1992; Jarvenpaa 1990; Mandel and Johnson 2002).

9.3 Methods

For this study, climate information is defined as ‘knowledge about future climates that is communicated, in written form, between scientists and any other players involved in the decision process, resulting from studies that focus on the projection, impact assessment, and/or adaptation strategy phases’ (authors’ definition). In this context, information is considered to have been communicated only if they are publicly available. Gray literature, such as internal reports and working documents, is not included in this review.

A sample of documents related to 25 climate change adaptation initiatives (see Fig. 9.1) was obtained through several sources:

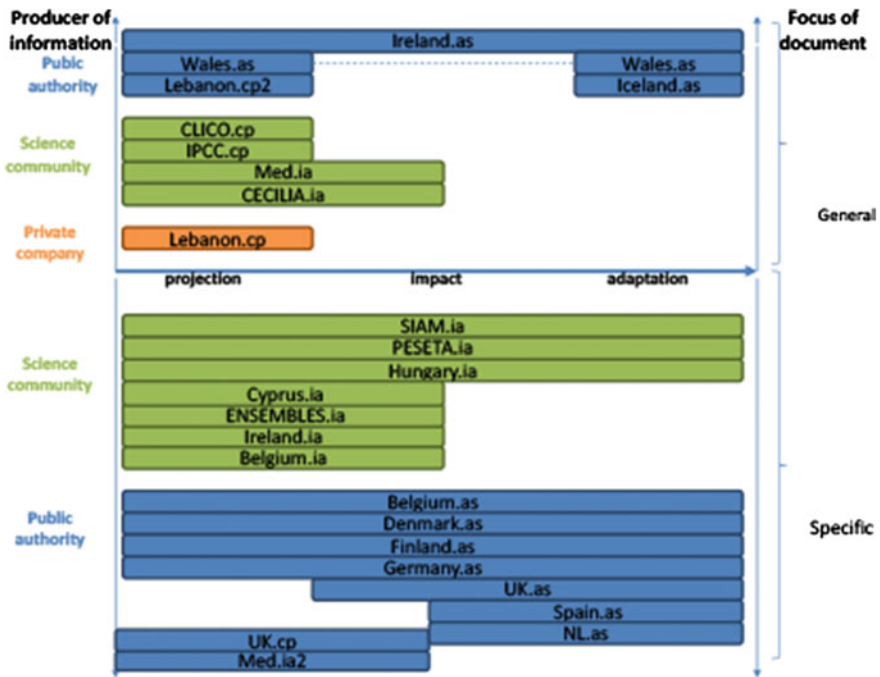


Fig. 9.1 Sample studied: authorship and place in the climate change adaptation process. [.as = adaptation strategy, .ia = impact assessment and .cp = climate projection. See Appendix for meaning of document abbreviations (detailed references)]

- from the European Environmental Agency (EEA) adaptation portal¹, designed as the main institutional entry point for European stakeholders in charge of climate change adaptation;
- through an open call to the CLIM-RUN project partners;
- and with a Web search of climate change projects on projections and impacts that had their results published by scientific institutions or governmental bodies.

The documents were subjected to content analysis. Here, since the issue was to study communication tools, and in particular visualization tools, the criteria developed pertained to maps and graphs (number of maps and graphs, type of graphs, color codes, etc.). Broadly, content analysis can refer to methods for studying and/or retrieving meaningful information from documents (Tipaldo 2014; Krippendorff 2004). While content analysis has clear merits in that it supports a systematic comparison of documents, some limitations are notable. The exercise is

¹<http://www.eea.europa.eu/themes/climate/national-adaptation-strategies> Now replaced by the Climate-ADAPT portal <http://climate-adapt.eea.europa.eu/>.

limited to the content of the document. It does not consider the production process of the document nor does it consider the consequences of communication. Since there are no legal guidelines for the content and structure of climate projections and adaptation strategies, the documents of the sample varied greatly in length and scope, which hampered the exercise of comparison.

To classify the documents and to provide inferences, three dimensions were used that relate back to the study's three core questions: general criteria, uncertainty criteria, and aspects of visualization.

9.3.1 General Criteria

General criteria notably concern the flow of climate information between its creation by climatologists and its application in adaptation strategies by policy makers. By identifying if a climate scientist was (co-) author of a document, it becomes clear whether the communicator is in the realm of science or of that of society. This sheds light on potential differences in communication between the two. Between the creation of climate information and its application, there are several distinctive phases: projection, impact assessment, and adaptation strategy. By identifying what is communicated in the documents, it becomes clear whether climate information is present at all, which relative importance it is given and what the content is of this climate information (e.g., temperature, precipitation, extremes, short-term, or long-term projections). In addition, it is assessed whether climate information is present in one or several phases of the process, and how it evolves from one phase to another.

9.3.2 Uncertainty Criteria

The first criterion in this dimension is whether uncertainty is mentioned or not. As a follow-up, the documents for which the answer was 'yes' were assessed against five more detailed criteria:

- **Coverage of the cascade of uncertainty.** Uncertainties cascade to each other as the climate information flows from a projection to an impact assessment. In the study, it was determined which part of this cascade is mentioned and whether this is adapted to the objective of the document.
- **Use of models and scenarios.** According to current quality standards, a report on the future climate should include several climate models that are run for several socio-scenarios. This provides a full span of probabilities and therefore a more complete message on uncertainty. In the documents, even though it was not always clear how many models were used, the number of scenarios included could be derived.

- **Acknowledgment of the role of the time horizon used.** The magnitude of different sources of uncertainties depends on the time horizon used. Until around 2050, most uncertainty results from the inter-model spread. After 2050, the scenarios cause most uncertainty (Hawkins and Sutton 2009).
- **Ways to express uncertainty.** Uncertainty can be expressed in simple terms (e.g., mean) or in more sophisticated ones (e.g., spread and probabilities). The latter ones are more informative for decision-making.
- **Inclusion of extreme events.** Projections of climate extremes differ from extreme climate projections: They concern the provision of information on potential extreme events (for example, hurricanes and floods).

9.3.3 *Aspects of Visualization*

The content analysis helps to answer the question whether climate information is visualized, and if so, how it supports the textual information, if at all? As a follow-up, the documents for which the answer was ‘yes’ were assessed according to which visualization tool was used. In addition, the choice of color or other graphical details (width of lines for instance) was analyzed since they can influence the message that is communicated. During this analysis, it was concluded whether or not the visualization (tool and color) supported the textual message.

9.4 Results

9.4.1 *Climate Information Flow in the Policy Process*

Information on climate has spread beyond its initial scientific boundaries and infiltrated in all layers of society, in particular due to rising concerns about climate change. This study found that climate information encompasses a certain process when crossing scientific boundaries into society. Conceptualizing this process helps indicating more precisely where, by whom and how climate information is communicated.

The process by which information travels roughly consists of five phases (see Fig. 9.2). In the pre-existing knowledge, phase actors are mainly occupied with studying and understanding the relationships between compartments of the natural climate system, generating data from observations and building climate models. Projections, in the next phase, can be ‘off-the-shelf’, resulting from models and data that already exist (pre-existing knowledge) or they can be customized, being

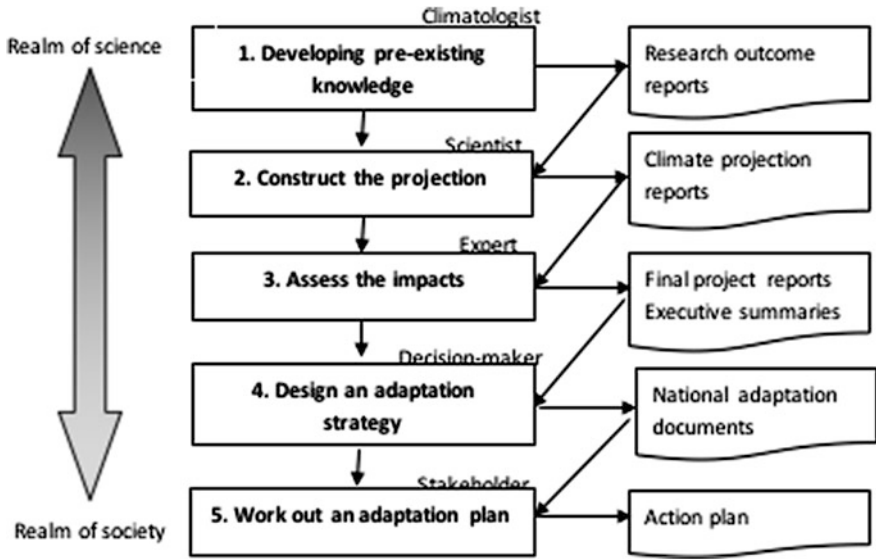


Fig. 9.2 Framework of phases in the process chain

derived from models and data that are developed in the projection phase. Based on the climate projections, the following phase determines a range of impacts for specific sectors. In the adaptation strategy phase, public and private decision-makers design adaptation strategies to address the assessed impacts. The last phase consists of an adaptation plan, a detailed action plan associated with a set of indicators allowing performance evaluation.

Ideally, climate information flows through the process chain from pre-existing knowledge all the way down to adaptation plan. However, in practice this is not always the case (Dubois 2011). The chain starts with a dominant role for the natural sciences, halfway through the social sciences increase their influence and it ends with a dominant role for actors in society. After the release by climatologists, climate information is summarized and synthesized in order to pass it on to the next phase and actor. This causes a dilemma because, due to summarizing and synthesizing, the richness and completeness of the information are reduced. If not, the information transfer between phases is too big (Dubois 2011).

The objective of this study is to understand the transfer of climate information from the scientific world to the decision-makers. Supply and demand of climate information meet in the phases of projection, impact assessment, and adaptation strategy. In the sample, three out of the 25 initiatives do not contain any climate information and all three are adaptation strategy documents. This sample shows that documents that do not represent climate information are positioned toward the end of the process chain.

Two documents showed that summarizing and synthesizing cause great reduction of the message of uncertainty. As a result, the users of the adaptation strategy documents are not provided with this information, the so-called broken telephone phenomenon. A case study of Ireland is presented below. Ireland can serve as a case study where the projection/impact document (Environmental Protection Agency 2003, 22) and the adaptation strategy document (Irish Department of the Environment, Heritage and Local Government 2007, 44), that follow each other, differ in their message. The language in the second document indicates less uncertainty, and the figure on projected temperature change is different.

9.4.2 Underrepresented Uncertainty

Five out of 25 initiatives do not contain a message on uncertainty, neither as a general message nor in the outcomes of a projection or impact assessment. However, during the content analysis it became clear that even if the uncertainty is mentioned, it is still not always clear what the reader is looking at; the median, a 90% probability, or an average.

Uncertainties from the projection phase and impact assessment phase pile up and turn into a cascade. This study found that nearly half of the documents do not address all uncertainties that are applicable to them; uncertainties resulting from impact assessments turn out to be largely forgotten.

When focusing on the performance of climatologists on this topic, from this study it becomes clear that some documents produced by them also fail to mention the appropriate part of the uncertainty cascade. Of the nine documents produced by teams that had a climatologist on board, seven included a projection as well as an impact assessment. Therefore, they should discuss uncertainty for both phases, which only two of the seven actually did.

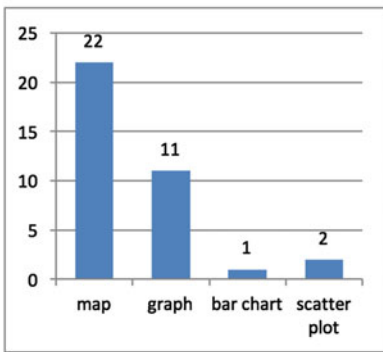
Half of the sampled documents (11 out of 22) represent only one socioeconomic scenario. For two of the eleven documents, single scenario use is less of a problem because the timeline is below or around 2050. Before 2050 most uncertainty stems from models, whereas after 2050 the scenarios cause most uncertainty. However, the other nine documents include projections for the period 2050 to 2100. In these nine cases, uncertainty is underrepresented.

When focusing on the nine documents coproduced by climatologists, three of them discuss only one scenario. However, their focus on only one scenario is not problematic because their aim was not to provide a projection but improving technical aspects (for example, models) or the timeline was below 2050. Thus, this study discloses that teams including a climatologist provided appropriate information in this respect.

Another aspect of uncertainty is the spread of possibilities that a projection can provide. Almost half of the documents represent only the mean estimate of all

possibilities. Given that the ensembles of projections do not have a statistical distribution and cannot be used for full probabilistic analysis, nothing says that this mean estimate is more probable than others, and the use of mean is not scientifically very significant. The mean estimate should at least be accompanied by information on the spread of projections. For instance, the wettest projections of a given ensemble enjoy least probability; however, they potentially cause most damage and are therefore important information for decision-makers. Most documents in the sample paid attention to these extremes.

To visualise a projection (n=36)



To communicate the message on uncertainty (n=13)

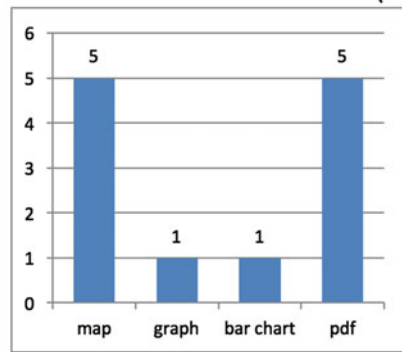


Fig. 9.3 Distribution of visualization tools according to their purpose. (pdf = probably distribution function)

Table 9.1 Frequency of colors used for a decrease or increase of *temperature* and *precipitation*

Color for decrease of <i>temperature</i>	Frequency	Color for increase of <i>temperature</i>	Frequency
Green	1	Red	7
Blue	1	Blue	2
		Yellow ranging till red	1
		White ranging till red	1
Blue (increase + decrease)	3	Blue (increase + decrease)	3
Color for decrease of <i>precipitation</i>	Frequency	Color for increase of <i>precipitation</i>	Frequency
Red	4	Blue	3
Blue	1	Green	2
Yellow/red	1	Red	1
Brown	1	Blue/green	1

9.4.3 *Non-Facilitating Visualization*

During the content analysis, it became clear that visualization of climate information can serve two purposes: to present a projection or to communicate the general message of uncertainty. This latter one can help the user understand the topic of uncertainty.

In the sampled initiatives, 49 examples of visualization were found. Colored maps are the most frequently used visualization tool (27 out of 49 visualizations), followed by the line graphs (12 out of 49 visualizations). Figure 9.3 shows these results, broken down into the purpose of visualization. Focusing on images made by climatologists, this study shows that the same preference for maps is visible.

There is no consensus on the use of color in maps for both temperature and precipitation projections (see Table 9.1). In maps that visualize *temperature* projections, green and blue are used for a decrease. Red is most frequently used to indicate a warmer temperature, but examples were also found in which blue was used for this. To complicate matters further, there were also maps that used different colors of blue to indicate both an increase and decrease. In one case, the scale range only indicated an increase of temperature, starting with a white color, while recent best practice literature suggests to use white to indicate no change/neutral (Kelleher and Wagener 2011). Also for projections of *precipitation*, there is no homogenous application of colors. Most frequent in this sample is the ‘reverse’ use of colors used for the temperature scale. For this application, red indicates a decrease and blue an increase.

In the maps from documents coauthored by one or more climatologists, colors are applied less inconsistently, but there is still no full consistency in color use. The range of colors used is smaller, but a color can still have several meanings (increase as well as decrease).

This analysis sheds light on the fact that the red–blue color scale is most frequently used for maps of temperature projections as well as maps that present precipitation projections. This dominant red–blue color scale could lead to confusion. When taking the IPCC as a benchmark, red and blue colors are used for temperature, and green and brown for precipitation (IPCC 2010). This is easy for people to relate to, since in our daily lives red and blue indicate warm and cold, think about water taps. And green and brown can easily be related to greenery (which require precipitation) and desert or dry soil (where no greenery exists due to lack of precipitation).

9.5 Discussion

This quantitative description of the sample opens a more critical discussion, with the most adequate options to communicate climate information. The human brain places more importance on visualized information than textual information.

Therefore, the basic decision to visualize or not will determine the amount of emphasis being placed on the various elements communicated.

9.5.1 *Maps or Graphs?*

Maps do not necessarily provide information fit for decision-making. For example, maps included in the German Adaptation Strategy to Climate Change (2008) illustrate the frequent contradiction between the way information is communicated and the way it is perceived intuitively. These maps show the trend of future climate change. However, a more obvious detection is the message that the individual models have different outcomes. The reader is probably able to detect the generally increasing trend in temperature in Germany. However, by how many degrees it is not easy to discern: It requires the reader to calculate the average of all the grids. In addition, to detect the level of uncertainty, all of the maps need to be studied in more detail for their differences. In comparison, maps included in the Finnish adaptation strategy reveal a far clearer message: Their visualization shows at once the magnitude of the different trends and the uncertainty between the scenarios.

This misuse, and frequent overuse (see Fig. 9.3), of maps by climatologists might be due to several factors including the influence of geography perhaps and also the power of the technical tools they use. Software like netCDF, frequently used to process climate data, makes it quick to create maps, while producing graphs may require some second-order processing (e.g., extracting data, averaging it, representing it on a graph).

9.5.2 *Readability Issue*

Results also highlight the need to finalize ‘prototypes’ of graphs for a better communication. Small details might deeply affect the efficient communication: The presence of scales, the presence of city names to allow readers to locate a map, the font size, the presence of full legend rather than acronyms understood only by climatologists (for instance, ‘Winter’ instead of ‘DJF’) are details that count for a sound information transfer.

Another example is the use of graphic software that allows for adding explanation to a technical graph. For instance, when scientists and assessors elucidate on the probability information, a probability density function (PDF) may serve as a good tool (see Folland et al. 2001, Fig. 2.32). It provides probabilistic information, and words, arrows, and colors are used to assist in the interpretation of information.

This is a good example of how visualization techniques can help to reconcile scientific rigor and societal usefulness.

In the same vein, some documents present from the sample the message of uncertainty in ways that are easier for the user to relate to or to understand than other documents. These examples do this by linking the message of uncertainty to an example of uncertainty in everyday life (for example, planning a picnic according to possible weather conditions), clearly stating that the projection is one plausible outcome, explaining what the reader is looking at (i.e., the 50% or central estimate) and what this represents, or indicating the factors that constitute the uncertainty.

9.6 Conclusion and Recommendations

The transfer of climate information from science to society is a vital but complex process. The initial sender and final receiver of climate information are often far apart in terms of the contexts they operate in. This study focuses on the chain of events that take place between the production of climate information and its final destination. It conceptualizes this chain as consisting of a number of steps and assesses the representation of climate information in each of them. Climate information flows through five different phases: pre-existing knowledge, projection, impact assessment, adaptation strategy, and adaptation plan. Each phase is dominated by different actors who reuse the initial information, create new information, and summarize and synthesize this information. In this process, information is unavoidably lost, sometimes including vital information on uncertainty. This goes at the expense of societal usefulness of the climate information.

The study focuses not only on what is communicated but also on how that is done. In particular, it focuses on visualization techniques, concluding that these techniques are not always effective when the images disrupt an easy interpretation of the visualized information. These results are of importance for adaptation policies, given that climate information is the foundation of adaptation: The choice of projections, of time horizons, the presence or absence of a message on uncertainty can deeply influence the form of response to climate change decided by stakeholders.

Several recommendations can be drawn. Firstly, for the elaboration of adaptation strategies, it is current practice that the flow of information is cut up and divided over the phases of the process chain, but it could be beneficial to try to maintain the flow by making the different actors work in parallel instead of sequentially. This would reduce the necessity to summarize and synthesize information. Some more participative approaches are required for this; for example, stakeholders should have a say in methodological choices. The choice of a reference time horizon for

adaptation for instance, or the decision to cover x% of potential climate futures through the choice of an ensemble of projections, are not neutral, and should not be scientists’ choice only. Moreover, the uncertainty is largely underrepresented or represented in heterogeneous ways and visualization does not always facilitate an easy uptake of information, as shown by our research. Development of best practice guidelines on these aspects for national, local, or sector-specific communication of climate information could help adaptation specialists better responding to this issue. This could be the task of institutional climate change portals, such as the European Environment Agency Climate-ADAPT portal, for instance (<http://climate-adapt.eea.europa.eu>).

Additionally, in the fields of training and awareness raising, climatologists are now caught in a dilemma between scientific rigor and societal usefulness. Informed lay people might reject climate information that is overly certain. Therefore, training the end user in the basics of climatology and defining what a decision-maker can and cannot do with climate information might reduce the need to choose between scientific rigor and societal usefulness. Conversely, training climatologists to understand users’ needs and communicate better could help bridging the gap. Introducing communication courses in climate curricula or associating communication specialists with climate projection exercises might help.

Further research could focus on users’ perception of uncertainty messages and more generally of visualized information. This could provide insights whether visualization is helpful or not, and in which occasions it facilitates communication. Guidelines are needed to help communicators decide which visualization tools facilitate accurate and easy uptake of information.

Appendix 1

Table of sampled documents

Doc	Code	Full title
1	Belgium.as	Belgian National Climate Commission, 2010. Belgian national climate change adaptation strategy
2	Danmark.as	The Danish government, 2008. Danish strategy for adaptation to a changing climate
3	Finland.as	Ministry of Agriculture and Forestry of Finland 2005. Finland’s national strategy for adaptation to climate change
4	Germany.as	The Federal Government 2008. German strategy for adaptation to climate change
5	Iceland.as	Iceland’s ministry for the environment, 2007. Iceland’s climate change strategy
6	Ireland.as	Department of the Environment, Heritage and Local Government, 2007. Ireland national climate change strategy 2007–2012
7	Spain.as	

(continued)

(continued)

Doc	Code	Full title
		Spanish ministry of Environment and Rural and Marine Affairs, 2008. The Spanish national climate change adaptation plan
8	Wales.as	Welsh Ministry of Environment, 2010. Climate change strategy for Wales
9	NL.as	Ministeries van VROM, V&W, LNV, EZ, IPO, VNG, Unie van Waterschappen, 2007. Maak ruimte voor klimaat! National adaptatiestrategie – de beleidsnotitie
10	UK.as	British Department for Environment Food and Rural Affairs, 2010. Defra's climate change plan
11	Lebanon.cp	Earth Link and Advanced Resources Development S.A.R.L. (ELARD), 2010. Climate risks, vulnerability and adaptation assessment
12	Lebanon.cp2	Lebanese Ministry of Environment, 2011. Lebanon's Second National Communication, Chap. 4 Climate risks, vulnerability and adaptation assessment
13	Med.ia	Giannakopoulos, C., et al. 2005. Climate change impacts in the Mediterranean resulting from a 2 °C global temperature rise
14	Cyprus.ia	Bruggeman, A., et al. 2011. Effect of climate variability and climate change on crop production and water resources in Cyprus
15	CLICO.cp	CLICO, 2010. Climate outlooks for CLICO case study sites
16	Med.ia2	Plan Blue, 2010. The foreseeable impacts of climate change on the water resources of four major Mediterranean catchment basins
17	CECILIA.ia	CECILIA, 2010. CECILIA- Central and Eastern Europe climate change impact and vulnerability assessment
18	ENSEMBLES.ia	ENSEMBLES, 2009. Climate change and its impacts at seasonal, decadal and centennial timescales
19	Ireland.ia	Environmental Protection Agency 2003. Climate change—scenarios & impacts for Ireland
20	PESETA.ia	European Commission Joint Research Centre, 2009. Climate change impact in Europe—Final report of the PESETA research project
21	SIAM.ia	Santos, F.D., Forbes, K. And Moita, R., 2001. SIAM- Climate change in Portugal
22	IPCC.cp	IPCC, 2007. Chapter 11—Regional climate projections
23	UK.cp	British Department for Environment Food and Rural Affairs, 2009. Adapting to climate change—UK Climate projections
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