Editorial

State of Climate Visualization – international research and practical applications

Tina-Simone S Neset, Jimmy Johansson and Björn-Ola Linnér

In a time of global change and global resource constraints the academic community is constantly seeking new ways of communicating current research to inform the public and create a basis for decision making on an individual to global scale. For climate researchers, this challenge is pertinent, given the vast amount of information regarding issues, such as emissions, scenarios, trends, risks and options for mitigation and adaptation that flows through media every day. To create a solid representation of research data and scenarios as well as what impacts of climate change could imply in different regions, climate researchers have over the past years started to collaborate with designers and researchers within the field of visualization. Applications assisting data analysis as well as geospatial and abstract visual representations bear great potential for future research and science communication. We are referring to this transdisciplinary field of research and science communication as *climate visualization.*

Visualization has for many years been used as a tool in climate system and impact research for communicating results between scientists themselves as well as to a broader public through e.g. web-based interfaces and portals and applications of Geographical Information Systems (GIS). Developments over the last ten years have put new demands on climate visualization for three reasons: 1) The enormous development of computer power and graphics can be used to convey the vast amount of information on climate processes and its effects as well as the associated complexities and uncertainties. 2) The need to analyse climate change linkages with other areas in science is increasingly recognized in the scientific community (IPCC 2007, Linnér, 2007). Further, in international negotiations and cooperation, climate change has increasingly been linked to other areas of sustainable development. Visualization will facilitate to demonstrate these linkages. 3) The interactive potential of visualization methods and techniques has increased substantially. Adapting them to the needs of climate change research may significantly assist in analysing and communicating interlinkages, complexity and scientific uncertainties. In a survey of on-going climate visualization initiatives, Nocke et al. (2008) conclude that "recent developments in interactive visualization using alternative visual metaphors are not wide-spread in the climate community. Thus, a major task for future developments is to further bridge the gap between climate and visualization expertise ".

The concept *climate visualization* refers to interactive research platforms, which use computer graphics to create visual images of causes and effects of climate change as well as mitigation and adaptation options. Major challenges are scientific visualization of complex interlinkages between numerous phenomena in nature as well as in society, interrelations across vertical scales over time, substantial uncertainty of feed back mechanisms and often massive numerical representation of scientific results.

These challenges were addressed at a conference on Climate Visualization, which was held in May 2009 at Campus Norrköping of Linköping University, as a co-operation between the

Norrköping Visualization Centre and the Centre for Climate Science and Policy Research. These are the proceedings from this conference presenting both the outline of talks and ongoing discussions in workshops. They display a wide variety of both conceptual approaches and concrete applications. The conceptual contributions show how worldviews are influenced by the visual surrounding (McConville), how visual representations in terms of graphic design are perceived by the user (Simmon) and how scales influence the areas of application of visualization tools for interdisciplinary research (Neset&Glad).

A key challenge facing environmental research and management is to widen public participation; to strengthen consultation on how problems are framed and to contextualize action alternatives as well as to improve the information dissemination process once decisions have been made. Burch and colleagues have analyzed how scientific visualization can increase public knowledge on climate change. Concrete applications of climate visualization are presented in this report by Shalini and Spadaro (Global Adaptation Atlas), Kirk and colleagues at KlimaCampus in Hamburg (Planet Simulator), Irving and Hamilton (Effects of Climate Change on Biodiversity for Public presentations), Gardiner (Sustained Programs for Climate Communication) and Sweitzer (Visualizing an Inconvenient Truth).

Climate visualization is rapidly expanding in three areas: visualization as an analytical tool, as a communication tool and on the epistemological consequences of visualization. Efforts to develop new tools for analysis include visualization techniques that are developed to support, for instance, research on climate policy implications on global land use and resources flows where the emphasis lies on a transdisciplinary approach involving researchers of the visualization and climate community as well as public stakeholders, planners and policy makers. The research focuses among others on visualization of abstract, multiparameter, time-dependant data as well as on linkages between and intra-linkages within natural systems, such as interactions between climate and the biological systems, between natural systems and policies and measures, e.g. consequences of climate policy on forestry.

Another strand of climate visualization research is the evaluation of visual representations. Through reflexive studies critical questions are raised on cognitive and power implications of visualization tools. How is the visualised phenomena selected and how do these choices effect representation of climate change and policy options? Reflexive visualization studies also entail analysis of post process data and modelling results used in secondary visualization applications. Also, interactivity is not inherent by default but needs analyses and evaluation of what is communicated and how it is perceived. User interaction is an important feature in visualization (Kosara et al 2003). Using a fully interactive system can enable flexible and task-specific analysis. For such interactive systems, limitations in human perception, such as change- and inattention-blindness, have to be considered.

The high-level declaration of the 3rd World Climate Conference held in September 2009 in Geneva called for ‘‘a Global Framework for Climate Services’’ which will “strengthen production, availability, delivery and application of science-based climate prediction and services” (WCC 2009). The overview of ongoing climate visualization research and development provided by the Norrköping conference indicate that this field is rapidly developing. By developing interactive climate visualization platforms it is possible to ensure the availability of climate services such as called for by the World Climate Conference, both in immersive environments and on desktop computers, which may provide one important contribution to climate services.

A first effort in disseminating climate visualization to decision makers and other stakeholders, as well as the general public, the Worldview network has during 2009 developed visualization presentations to be used at important political events in the US, within the EU as well as at the

Conference of Parties to the United Nations Framework Convention on Climate Change. These productions are based on existing software and represent geospatial data for emission on the basis of which principles for effort sharing in terms of historical responsibility, national and per capita emissions can be discussed with the audience in an interactive session. The presentations focus further on regional climate models, arctic sea ice level, sea level rise and future emission scenarios following a narrative of policy and IPCC scenarios.

The proceedings from the visualization conference provide examples from all of these three challenges for climate visualization. Although a few renowned colleagues did not have the possibility to attend the workshop as planned, the contributors to this publication represent several leading initiatives in this field. We hope that it will provide the reader with an overview of the development of climate visualization and that it will stimulate further discussions and new initiatives to collaborate on climate visualization.

References

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

Kosara et al (2003). *An Interaction View on Information Visualization*. Proceedings of EUROGRAPHICS 2003.

Linnér, B-O (2006), Authority Through Synergism: the Roles of Climate Change Linkages. *European Environment*, 16(5), pp. 278–289.

Nocke, T.; Sterzel, T.; Böttinger, M.; Wrobel, M. (2008). Visualisation of Climate and Climate Change Data: An Overview, in Ehlers et al. (Eds.) *Digital Earth Summit on Geoinformatics 2008: Tools for Global Change Research* (ISDE'08), Wichmann, Heidelberg , pp. 226–232.

WCC (2009). *High-level Declaration,* World Climate Conference 3. Geneva, Switzerland, 2009.