EarthAgora: A collaborative knowledge management tool

White Paper describing a possible EarthCube design, Oct 2011

Michael Hoffmann, School of Public Policy (m.hoffmann@gatech.edu),
Judith Curry, School of Earth and Atmospheric Sciences,
Calton Pu, College of Computing,
Georgia Institute of Technology

This white paper is about the management of *knowledge* in the philosophical sense of the term: knowledge as "justified true belief." This paper focuses on the *user* of data, and the problem of organizing knowledge without having initially a clear understanding of the problem for which knowledge might be relevant.

0. The problem

A crucial problem of knowledge management is that the relevance of knowledge and how it should be organized depends on the *problem* that drives the search for knowledge. Context and purpose determine what is relevant. This problem is further aggravated when we are facing ill-structured problems or what Rittel and Webber (1973) called "wicked problems." In pluralist societies, they write, in which a multitude of world views and values compete, the determination and formulation of a problem itself is often controversial. Based on differing belief and value systems, problems can be "framed" in a variety of ways, and there is no one who could legitimately claim an authoritative position to decide who is right and who is wrong.

Framing and problem-formulation pose problems not only for pluralist societies, but also for scientific communication and collaboration, especially in interdisciplinary settings and in rapidly changing constellations of scientific cooperation. Interdisciplinary collaboration figures centrally in frontier research in geo- and related sciences. Any disciplinary approach to a certain problem space conceptualizes the problems within this space differently and organizes knowledge accordingly. Disciplines often use different strategies to identify problems, and they develop specific terminologies and schemes to structure problems and knowledge. Any set of problems, concepts, models, and theories can be organized in conflicting hierarchies and structures in addressing a particular problem.

The wickedness of problems in the sense of Rittel and Webber becomes the central challenge at the borderline between science and politics. The fundamental problem of how to deal with the "monster of uncertainty" in climate modeling, for example, can be framed as the challenge to pursue a broad international consensus in the scientific community with high confidence levels and strong appeals to the authority of the consensus relative to opposing viewpoints (IPCC, 2007). But it can also be framed as an important opportunity to emphasize an open and honest acknowledgement of doubts, open questions, and the limits of knowledge, data, and information (Curry & Webster, 2011). At the same time it is easy to see how the "merchants of doubt" frame uncertainty as part of an argument for doing nothing on the political level.

The openness of wicked problems implies that they should be approached "based on a model of planning as an argumentative process in the course of which an image of the problem and of the

solution emerges gradually among the participants, as a product of incessant judgment, subjected to critical argument" (Rittel & Webber, 1973, p. 162).

1. A Vision for EarthCube: What is envisioned as the scope of EarthCube? How will it transform geosciences research? What functionality will EarthCube provide to the Geosciences community?

Using *arguments* to foster the understanding of problems and to manage access to knowledge is the basic idea of the interactive and web-based argument visualization software "AGORA-net" (http://agora.gatech.edu/). AGORA-net provides a cyberinfrastructure in which everybody can propose arguments for positions, recommendations, or theses, or can contribute to debates with further arguments or counterarguments. The results are graphically organized argument maps in which knowledge is presented in a network of justifications. This way, knowledge becomes visible in the graphical structure of arguments and more complex argumentations that together support one main claim. The reasons of these argumentations can then be linked with existing infrastructure and data bases.

Since the way people formulate their main claim and justify it in a network of arguments is dependent on their respective perspective, it is possible that different stakeholders, interest groups, and scientific disciplines and traditions construct very different, but nevertheless related, argument maps. And it is possible that the same information is linked with different, even opposing, argumentations.

We propose to further develop AGORA-net to EarthAgora as a component of an overarching EarthCube design—that is, as a "knowledge management system and infrastructure that integrates all geosciences data in an open, transparent and inclusive manner" (http://www.nsf.gov/pubs/2011/nsf11085/nsf11085.pdf). This system could provide the following functionality to the Geosciences community. EarthAgora should allow

1. the presentation of knowledge according to user perspectives
2. the refinement and development of user perspectives and arguments based on collaboration and debate
3. the "reshuffling" of entire chunks of knowledge, or justified claims, to address newly arising problems and user perspectives

EarthAgora is not an automated system. Argument maps are created by human beings and users collaborate on their refinement and development. Although everyone can create argument maps that present and organize knowledge, it is desirable to establish an organizational structure that offers argument mapping as a service, performed in collaboration with potential users and expert communities. At least in the initial phase of an AGORA-based EarthCube, a library of problem-specific argument maps that are designed according to specific user perspectives should be build up. Such a service provider—in form of a center—should be established as an institutional link between the users of geoscientific knowledge—politicians and administrations on the federal, local, and global level; the public; other scientific disciplines; corporations; education; media; and geoscientists themselves—and the growing variety of geoscientific expert communities.

The software AGORA-net offers a simple and unified standard for the presentation of knowledge. The logic that is used to construct graphical argument maps is always the same—whatever the perspective presented may be—so that reading an argument map allows much faster access to the knowledge presented than reading publications as we know them. EarthAgora would provide access to knowledge that is already structured. And this structure itself evolves based on collaboration and feedback. This way, the loop between publishing, reading, and reacting is much tighter; it can be closed within hours.

2. The Conceptual CI Architecture: The architecture necessary to provide the services of EarthCube, to integrate advanced information technologies that facilitate access to distributed resources such as computational tools and services, instruments, data, and people

The software AGORA-net is still in development but it can already be used for synchronous and asynchronous online collaboration on arguments and argumentations. Everybody can register, and every registered user has access to all argument maps and can contribute to them.

For its final version, we envision an EarthAgora that is built as a three-level structure. The visitor enters first the AGORA WORLD, an open, three-dimensional space like the one in Ancient Greek cities where citizens gathered for all kinds of public purposes. On this *agora*, the visitor will find all the topics for which argumentations exist in the form of claims, organized by domains, and of course a search engine. By clicking on a claim she or he gets access to the argument for this claim (or a debate about this claim) on the second level. This level is called the LAM WORLD since all maps are constructed as "Logical Argument Maps" (references).

Each argumentation in the LAM WORLD consists of a main argument and connected sub-arguments, including counterarguments, counter-counterarguments, as well as questions, comments, definitions, friendly amendments, and so on. The reasons, questions, and comments in a LAM map can be connected to elements of the DATA WORLD—the third level of EarthAgora—which is accessible by clicking on icons attached to these elements of the LAM WORLD. The DATA WORLD will not only store information and all sorts of resources users might upload, but also links to other resources, services, instruments, people on the web, and to available computational tools. It will be possible to switch between these three levels at any time, and to contribute on each level.

This three-level architecture of EarthAgora allows the management and the collaborative creation of knowledge in a dynamic system. *Knowledge* as "justified belief" is primarily presented in the form of argument maps, whereas data, models, simulation software, etc. are stored in, or accessible through, the DATA WORLD. The system is dynamic in three ways:

1. EarthAgora is designed to encourage reflection and the revision of both formulations and structures of arguments. This is achieved, first, by guiding the user through the construction of logically valid arguments. Logical validity guarantees an easily accessible standard to assess the completeness of arguments. The software automatically creates an additional premise to every user-generated argument that transforms it into a logically valid argument. A reflection on the acceptability of this additional premise challenges the user to add further reasons, or

to modify the formulations of claim and/or reasons, as long as it takes to formulate a convincing argument. Second, since anybody can add objections, comments, questions, and friendly amendments to any statement of a publicly available map, everybody is challenged to modify arguments to cope with the issues raised by others.

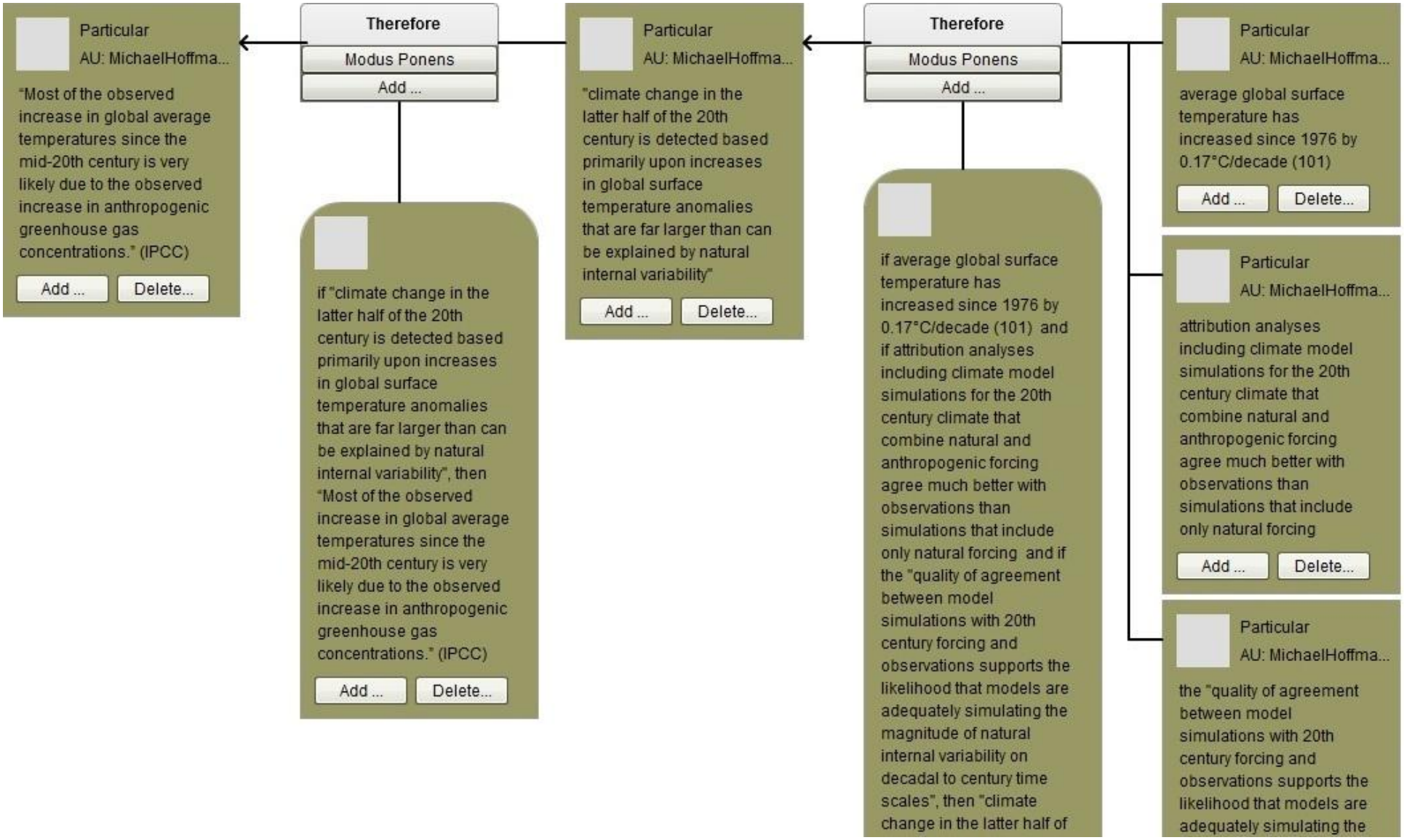
2. Criticizing a given argument should motivate users to create their own arguments to justify their positions and perspectives. Since these counterarguments can spread off from a given argument map within the LAM WORLD, knowledge can be created not only within maps, but also across maps.

3. Whole chunks of argumentations can be copied into other argument maps, and information can be linked to arguments at will, so that an ongoing revision of the structure of entire knowledge domains is possible.

The figure on the next page shows, as an example, a central argument of the IPCC's AR4 as it might be presented in the LAM WORLD of EarthAgora. While the first reason on top on the right side could be linked to corresponding data in the DATA WORLD, the second reason could be the subject of an objection that criticizes that the models used for assessing "natural internal variability" cannot rule out the possibility that substantial warming resulted from other causes such as solar forcing and internal multi-decadal ocean oscillations. The third argument again could be criticized by pointing out that this agreement between forced climate model simulations and observations for the 20th century is questionable since it depends heavily on inverse modeling, whereby forcing data sets and/or model parameters are selected based upon the agreement between models and the time series of 20th century observations—clearly a circular argument (Curry & Webster, 2011). Objections such as these would probably lead to interesting and important debates in the course of which new research questions would be raised and a revision of the entire knowledge domain became possible. (Examples for those large-scale debates are available at Hoffmann, 2009, 2010a, 2010c. The theoretical background and further applications of the AGORA approach are discussed in Hoffmann, 2004, 2005, 2010b, 2011a, 2011b).

3. A Community-Based Governance model: The community structures necessary to acquire current and future user input/requirements, to respond to changing data and science needs, to adapt and adopt new technologies, to coordinate components and facilities, to foster partnerships and community participation

While we are starting both with an existing software prototype and with a clear target—the problem of varying user and stakeholder perspectives that makes a dynamical and user-driven approach to knowledge management necessary—the process of designing the overall EarthCube architecture needs to be open to the needs of the intended user communities. Procedures and governance models for managing user input and the further development of EarthCube should be developed in a manner that is transparent, open, and inclusive. Based on our experience with AGORA-net as a global communication infrastructure we are ready to participate in this process, but we are well aware that the necessary EarthCube governance structures need to be developed by the involved communities themselves. The future development of EarthAgora can be adapted to a wide range of user needs and interests.


Particular
AU: MichaelHoffma...
"Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." (IPCC)
Add ...
Delete...
Therefore
Modus Ponens
Add ...
if "climate change in the latter half of the 20th century is detected based primarily upon increases in global surface temperature anomalies that are far larger than can be explained by natural internal variability", then "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." (IPCC)
Add ...
Delete...
Particular
AU: MichaelHoffma...
"climate change in the latter half of the 20th century is detected based primarily upon increases in global surface temperature anomalies that are far larger than can be explained by natural internal variability"
Add ...
Delete...
Therefore
Modus Ponens
Add ...
if average global surface temperature has increased since 1976 by 0.17°C/decade (101) and if attribution analyses including climate model simulations for the 20th century climate that combine natural and anthropogenic forcing agree much better with observations than simulations that include only natural forcing and if the "quality of agreement between model simulations with 20th century forcing and observations supports the likelihood that models are adequately simulating the magnitude of natural internal variability on decadal to century time scales", then "climate change in the latter half of
Particular
AU: MichaelHoffma...
average global surface temperature has increased since 1976 by 0.17°C/decade (101)
Add ...
Delete...
Particular
AU: MichaelHoffma...
attribution analyses including climate model simulations for the 20th century climate that combine natural and anthropogenic forcing agree much better with observations than simulations that include only natural forcing
Add ...
Delete...
Particular
AU: MichaelHoffma...
the "quality of agreement between model simulations with 20th century forcing and observations supports the likelihood that models are adequately simulating the

4. The Design Process: User requirement-driven design methodology, identification of design team members, qualifications of development team, time-line for design demonstration and scale-up, design tools and practices that create robust, sustainable, well-documented and open source infrastructure

The development of the AGORA software is currently funded through a FIPSE grant from the US Department of Education (Fund for the Improvement of Postsecondary Education, Grant P116S100006). In this context, the software is used as a tool to guide and structure collaboration of small groups of students who are autonomously working on projects in which they develop justifications for stakeholder positions. This grant aims at developing a new approach to engineering ethics education. It is performed in a collaboration of the Georgia Institute of Technology (GT) and Bauman Moscow State Technical University (BMSTU). The AGORA software is published under the Affero GPL v3 Open Source License and can therefore be adapted to other purposes—as long as the (usual) license conditions are respected (http://www.gnu.org/licenses/agpl.html).

Based on the requirements that are typical in educational contexts, the software employs a highly sophisticated user-support infrastructure and full guidance for all user activities.

While the next steps of completing the AGORA-net functionality that we envision are clear, its future design development will depend on target definitions by the entire EarthCube community.

A. Current team members

Dr. Michael Hoffmann is Associate Professor in the School of Public Policy and Director of the Philosophy Program at the Georgia Institute of Technology. Dr. Hoffmann is trained in philosophy and political science. His research focuses on argument visualization, theory of argumentation, diagrammatic reasoning and the cognitive role of external representations for learning processes and for the visualization of framing processes in conflict management. Hoffmann developed the ontology, rules, and conventions of Logical Argument Mapping (LAM), the representation system that forms the core of AGORA's interactive web architecture. He is also the head of the Georgia Tech team that developed the first running version of the AGORA-net software.

Dr. Judith Curry is Professor and Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology and President (co-owner) of Climate Forecast Applications Network (CFAN). Dr. Curry received a Ph.D. in atmospheric science from the University of Chicago in 1982. Dr. Curry's research interests span a variety of topics in climate research. A recent area of research is reasoning about climate uncertainty and the propagation of uncertainty in complex reasoning. Dr. Curry is proprietor of the blog Climate Etc. at judithcurry.com. Dr. Curry currently serves on the NASA Advisory Council Earth Science Subcommittee and the DOE Biological and Environmental Research Advisory Committee and has recently served on the National Academies Climate Research Committee and the Space Studies Board, and the NOAA Climate Working Group.

Dr. Calton Pu is Professor and John P. Imlay, Jr. Chair in Software in the College of Computing at Georgia Tech and Co-Director, Center for Experimental Research in Computer Systems (CERCS). Dr. Calton's research interests are in the areas of distributed computing, Internet data management, and

operating systems. In distributed systems, his focus is on extended transaction processing, system survivability, and Internet applications. In operating systems, he is applying the idea of specialization. Comparing with usual centralized systems, distributed and parallel systems softwares display unique characteristics in distance, complexity, extensibility, concurrency and availability. Making software handle these problems in a reliable and efficient way is the emphasis of Calton Pu's work. In the Infosphere project, he is developing concepts and software for Internet-scale applications driven by information flow such as real-time decision support, digital libraries, and electronic commerce. The sponsors for Calton Pu's research include both government funding agencies such as DARPA, NSF, and companies from industry such as IBM, Intel, and HP. He is an affiliated faculty of Center for Experimental Research in Computer Systems (CERCS), Georgia Tech Information Security Center (GTISC), and Tennenbaum Institute.

B. Timeline

The basic functionality of EarthAgora can already be demonstrated, and its complete functionality—including the challenging design of a user-friendly entrance area in which all the necessary orientation for a broad range of user populations needs to be provided—should be available and tested within a year.

We would use this first year for the following activities:

- Forming an EarthAgora advisory board that represents a broad spectrum of those involved in the EarthCube design and governance
- Defining a list of targets, in collaboration with the advisory board, for an EarthAgora design that is fully integrated in the overall EarthCube architecture with all its other components
- Developing a library of exemplary, knowledge representing argument maps for a variety of user-defined purposes. This project component will be used as a test-bed for different purposes: generating user feedback on software functionality and interface; designing mechanism and procedures for efficient interaction with users on the one hand and varying, problem-dependent networks of experts in the geosciences on the other; specifying technical, organizational, and administrative requirements for the optimal integration of the AGORA component into the overall EarthCube architecture
- Defining the organizational outlines for a possible “Center for Knowledge Transformation (CeKTra)”
- Designing dissemination mechanisms and training opportunities for a growing and sustainable EarthAgora user community

5. An Operations and Sustainability Model: Operational aspects of a community-wide enterprise need to address such activities as: centralized functions, coordination of services, user services including training, etc. What will it take to sustain an infrastructure that can viable over a long periods of time and who will carry out those functions?

Using the AGORA approach as an overarching *knowledge* management structure in contrast to embedded *information* management systems will be the more beneficial the more knowledge is presented in this form. Although EarthAgora can even be used for the creation and publication of knowledge—not only for its management—it is clear that there is a long way to go before either knowledge management can be provided or knowledge creation can happen on a large scale within an AGORA-based EarthCube. To guarantee sustainable effects of investments into this approach it is recommended to establish a "Center for Knowledge Transformation (CeKTra)" that provides the organizational and administrative core for a long-term development into this direction, as already mentioned in Sections 2 and 4 above. Such a center would provide argument-based knowledge representation as a service for interested user communities: politicians and administrations on the federal, local, and global level; the public; other scientific disciplines; corporations; education; media; and geoscientists themselves. And it would provide training for both user and expert communities.

References

Curry, J. A., & Webster, P. J. (2011). Climate Science and the Uncertainty Monster. *Bulletin of the American Meteorological Society, Early online release*. Retrieved from http://journals.ametsoc.org/doi/pdf/10.1175/2011BAMS3139.1. doi:10.1175/2011BAMS3139.1

Hoffmann, M. H. G. (2004). How to Get It. Diagrammatic Reasoning as a Tool of Knowledge Development and its Pragmatic Dimension. *Foundations of Science, 9*(3), 285-305.

Hoffmann, M. H. G. (2005). Logical argument mapping: A method for overcoming cognitive problems of conflict management. *International Journal of Conflict Management, 16*(4), 304-334.

Hoffmann, M. H. G. (2009). Argument Visualization in the Political Arena: The Debate on Global Climate Engineering. Argument Map. Retrieved from http://works.bepress.com/michael_hoffmann/2

Hoffmann, M. H. G. (2010a). The Debate about the Stern-Review and the Economics of Climate Change. Argument Map. Retrieved from http://works.bepress.com/michael_hoffmann/3

Hoffmann, M. H. G. (2010b). Diagrams as Scaffolds for Creativity. *AAAI Workshops, North America*. Retrieved from http://aaai.org/ocs/index.php/WS/AAAIW10/paper/view/2027

Hoffmann, M. H. G. (2010c). LAM map of Nagel's core argument in "The Problem of Global Justice" (2005). Argument Map.

Hoffmann, M. H. G. (2011a). Analyzing Framing Processes in Conflicts and Communication by Means of Logical Argument Mapping. In W. A. Donohue, R. G. Rogan & S. Kaufman (Eds.), *Framing Matters: Perspectives on Negotiation Research and Practice in Communication* (pp. 136-164). New York, NY: Peter Lang.

Hoffmann, M. H. G. (2011b). Climate Ethics: Structuring Deliberation by means of Logical Argument Mapping. *Journal of Speculative Philosophy, 25*(1), 64-97.

IPCC (2007). Climate Change 2007. Fourth Assessment Report (AR4). Retrieved from http://www.ipcc.ch/

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155-169.