The Climate CoLab:
Large scale model-based collaborative planning

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ABSTRACT

The Climate CoLab is a system to help thousands of people around the world collectively develop plans for what humans should do about global climate change. This paper shows how the system combines three design elements (model-based planning, on-line debates, and electronic voting) in a synergistic way. The paper also reports early usage experience showing that: (a) the system is attracting a continuing stream of new and returning visitors from all over the world, and (b) the nascent community can use the platform to generate interesting and high quality plans to address climate change. These initial results indicate significant progress towards an important goal in developing a collective intelligence system – the formation of a large and diverse community collectively engaged in solving a single problem.

KEYWORDS: Collective intelligence, collaborative planning, climate change

1. INTRODUCTION

Many important decision-making problems in the real world are so-called "wicked problems"—problems for which no single computational formulation of the problem is sufficient, for which different stakeholders do not even agree on what the problem really is, and for which there are no right or wrong answers, only answers that are better or worse from different points of view (see, e.g., [1][2][3]). For example, most social problems (including the environment, health care, poverty, education, and crime) are wicked in this sense, as are many problems in management (including strategic decision-making and product design).

The problem of global climate change is a wicked problem, in this sense. In fact, many people would say it

has some characteristics that make it especially challenging (or "super-wicked" [4]): Time is running out, there is no central authority that can implement a solution, and it is truly universal: it affects every one of us and is affected by all of our actions.

Left to their own devices, scientists, journalists, politicians, businesses, and consumers will certainly do something about this problem. But the inefficiencies, delays, and distortions of traditional mass media, political decision-making, markets, and scientific publication mean that the results will almost certainly not be as good as we might hope.

Fortunately, however, in just the last decade or so, a new way of solving global problems has become possible. Examples like Wikipedia and Linux illustrate how it's now possible to combine the work of thousands of people in ways that would have been impossible only a few years ago.

Inspired by systems like these, we are developing a global, on-line forum—called the Climate CoLab[1]—in which we hope thousands of people around the world will eventually create, analyze, and ultimately select detailed plans for what we humans can do about global climate change. With thousands of people working together constructively in this way, we hope that the solutions they ultimately develop will be better than any we would otherwise have found.

To build the technology platform at the center of the CoLab, many design questions need to be answered. But for our technology to have any real impact, thousands of volunteers must form a community around the platform, and this community must exhibit dynamics that are compatible with the overall goal of solving global climate

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[1] Until August 2010, the system was called the "Climate Collaboratorium."

change. This is an important hurdle for a project like the CoLab to overcome.

In this paper, we describe the core technical design features of the CoLab and report on early usage experience that demonstrates substantial progress with this hurdle. While there is still much work to be done to fulfill our long-term goals, we believe the work we present here can serve as a road map for others that seek to build similar systems.

2. BACKGROUND

When people involved in making group decisions can only use communication tools like face-to-face meetings, telephones, and paper-based communications, it is very difficult to have more than a few people deeply engaged in analysis and decision-making. Even with modestly sized groups of people, groups may experience a range of inefficiencies and process losses [5]. Group decision support systems (GDSS) have sought to grapple with such problems [6]. But the size, complexity and open-endedness of decision-making for large-scale social problems such as global climate change far outstrips the capabilities of traditional technological solutions.

A new generation of social-computational systems (like Wikipedia, Linux, and InnoCentive) may be able to pick up where existing decision support technologies have left off. These systems leverage the combined efforts of very large groups of people to solve complex problems and create large-scale products. Enabled by cheap, fast access to the Internet, these systems are often referred to as "collective intelligence" systems [7].

Developing a collective intelligence platform to support large-scale collaborative planning for problems like global climate change presents a variety of specific design issues. In our initial design, we have focused primarily on three of these core technical challenges.

The first challenge is how to help community members predict what will happen if a plan is implemented. In the climate change world, computer simulations that make such predictions have served as the cornerstone of policy discussions, but access to these models is mediated by the experts who run them and interpret their results. This arrangement puts a bottleneck between stakeholders and the results they require to make decisions. For example, this bottleneck makes it much more difficult for a group to explore a diverse set of planning possibilities without active participation of the modeling experts at each step of the way.

Other fields in which modeling and simulation are heavily used for policy making have begun to develop systems to eliminate this bottleneck. For example, a growing number of systems within environmental policy-making combine live access to models with stakeholder decision support tools ([8]), and similar systems have been developed within the field of urban planning (e.g. [9] [10]).

A second core design challenge concerns how to deal with the wide differences of opinion that are common in wicked problems like climate change. How can we address the divisiveness and polarization that threaten productive discourse? Computer-supported argument mapping tools have been explored for decades as a technique for precisely this kind of problem ([11][3][12]). Such systems have been shown, for instance, to have cognitive benefits such as improving comprehension and retention (e.g. [13][14]), and Iandoli, Klein, and Zollo [15] have recently shown how argument mapping might scale to large groups of users with the addition of moderators.

A third core design challenge concerns how to focus a group's attention on the most promising plans being explored and, ultimately, how to select a single plan to be implemented. The simplest way of doing this is with various forms of on-line voting and rating (e.g., Reddit, Amazon, Netflix). More sophisticated possibilities include pairwise voting [16], preferential voting [17], and range voting [18].

3. DESIGN APPROACH

We have designed the Climate CoLab around three core technologies to address the challenges described in the previous section: model-based planning, structured on-line debates, and electronic voting. We have also incorporated a number of features to help coordinate work and support awareness. In the following sections we describe each of these design elements in more detail.

3.1. Model-Based Planning

Plans are based on *simulation models* that use as inputs a set of *actions* humans can take and produce as outputs the predicted *impacts* of those actions (see Figure 1). For instance, with the current models, the actions in a plan include reducing greenhouse gas emissions by various amounts in different regions of the world, and the impacts include factors such as temperature change, sea level rise, and economic costs.

Each plan, therefore, includes a specific "run" of a simulation model with a particular set of inputs and outputs. Plans also include free-form descriptions, generated by the plan creators, which can contain any amount of text, graphics, links, or other web content. For instance, this content can include more details about why
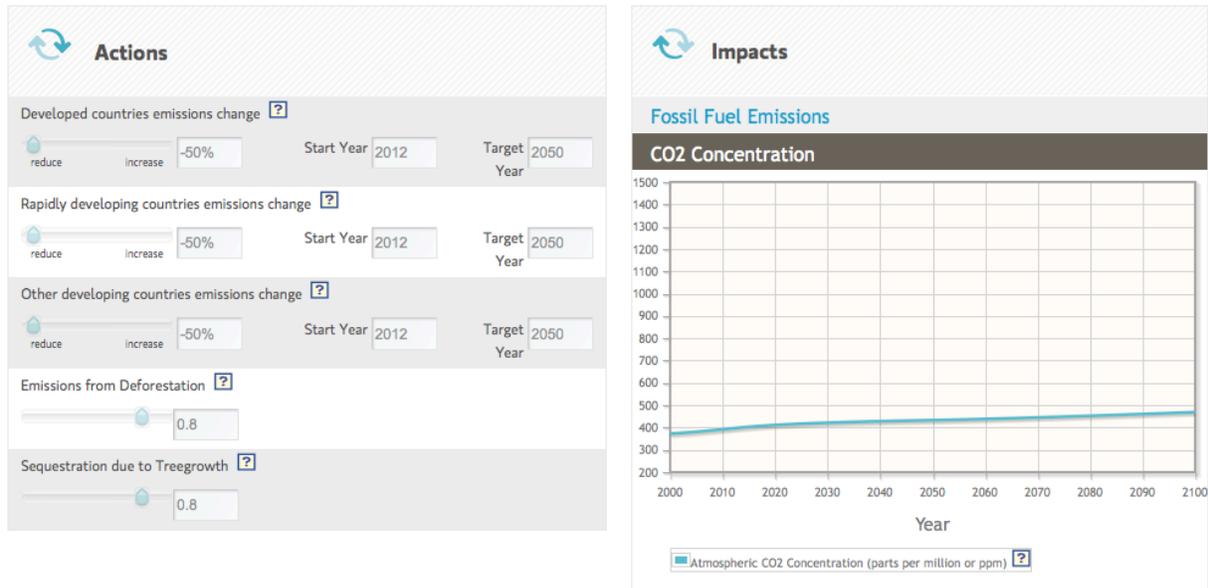
Figure 1: The CoLab Modeling Interface

the plan is feasible, why it is desirable, and how it is different from other plans. We will even encourage users to include artistic representations (such as images, short stories, or videos) about what the world would be like if this plan is adopted.

In addition, each plan includes: a link to the simulation model upon which it is based, a discussion forum in which users can comment on the plan, and links to the key

debate positions the plan embodies (see the description of debates below). Key data about all plans in the system are summarized in a table that can be filtered and sorted (see Figure 2).

In the current version of the system, plans can be "open" or "closed," and the initial plan creator controls this setting. Any registered user can modify an open plan, but only team members can modify a closed plan. The plan

Figure 2: The Climate CoLab Plan Index

creator and other administrators chosen by the creator manage team membership. We expect to experiment with different choices for these policies in future versions of the system.

Like in a wiki, all edits to a plan are logged, and users can revert to a previous version of any plan element at any time. This allows large groups of users to edit plans much more freely, knowing that undesirable changes can always be easily undone.

3.1.1. Models

All plans in the current version of the system are based on a single composite model that combines multiple smaller models. At the heart of this composite model is the C-LEARN model, a web-based version of C-ROADS [19]. C-LEARN was chosen because it reproduces the behavior of much larger climate models with sufficient precision for policy makers, but unlike larger models runs quickly enough to use in a dynamic web environment. C-LEARN takes as input a set of regional commitments to emission reductions, and produces as outputs projections of atmospheric carbon concentration, temperature change, and sea level rise.

The outputs of C-LEARN are used to drive eleven additional models that predict the anticipated economic costs and qualitative impacts to human and physical systems such as agriculture, water and health. The economics models are implemented as *response surfaces* [20], which approximate the range of the much larger, computationally intensive models upon which they are based. More information about the specific models used can be found on the Climate CoLab web site [21].

3.2. On-Line Debates

For controversial topics like climate change (and other wicked problems), any large scale planning tool must somehow take into account the fact that different people have significantly different points of view about many important issues. To deal with this problem, the Climate CoLab includes *on-line debates* for key issues related to climate change.

These debates are designed to summarize the key points of view about an issue in a way that is easy to understand and reduces the amount of redundant and ungrounded information. Following argumentation systems like Compendium [22] and the Deliberatorium [15], these on-line debates include significantly more structure than conventional discussion forums. As shown in Figure 3, each user contribution is classified as either (1) a *question*, (2) a *position* (a possible answer to the question), (3) an *argument for* a position (or another argument), (4) an *argument against* a position (or another argument), or (5) a *comment.*

Even though this basic structure is similar to that in a number of other argumentation systems [12], the specific user interface in the CoLab has evolved through several rounds of user testing. The current version now appears to be usable by large numbers of "random" web visitors.

The interface is structured as follows. A basic "map" of the debate (questions, positions, and arguments) is always visible in outline format on the left side of the window, and when users select one of these items, more details about that item (including any references) appear in the upper right of the window. Comments appear directly beneath the detail field of each debate item, and can be added very quickly. It is also possible for any user to directly edit the argument map by adding or editing questions, positions, or arguments.

Experience has shown that structured argumentation can be difficult for the untutored end-user [22], and thus we expect that many users will prefer to express their

Figure 3: The Climate CoLab Debate Interface

opinions by adding unstructured comments. These comments can then serve as the basis for improvements to the argument, through the work of a team of moderators whose task is to "tend the garden" and modify the argument maps in response to the evolving comments.

As with plans, all changes to debates are logged, and users can easily revert to a previous version of a debate item. This allows large groups of users (and moderators) to edit more freely.

3.2.1. Linking Debates To Plans

Figure 4: Proposal interface for linking plans to debates.

Some debates in the CoLab capture arguments and information about cross cutting issues that underlie a number of different plans. For instance, the Issue entitled "What should the global emissions target be for 2050?' has a position called "Emissions should be cut substantially." The detailed description of that position is "Emissions should be reduced to about half of 2005 levels by 2050." To be consistent, a plan that adopts this position would thus need to have input emission reduction variables that would call for cuts of approximately 50 percent by 2050.

Plan creators are encouraged to specify what positions their plans take on cross cutting issues like these, and the system provides a special user interface for them to do so (Figure 4). In this way, debates about the cross cutting issues can occur once (in a place to which multiple plans link) rather than being repeated haphazardly in the discussions of many different plans.

3.3. Electronic Voting

With just the plan and debate capabilities described so far, there is a risk that users could create an endless proliferation of plans and arguments, with no convergence on the most promising solutions to the problem. To allow the CoLab community as a whole to focus on the most promising plans and positions, users can vote on the debate positions and plans they prefer.

3.3.1. Linking voting to debates and plans

In plans, voting occurs within the context of a *plan question*. For instance, the question from our most recent contest (see below) was "What international climate agreements should the world community make?" Users can vote on their favorite plan within each plan question, and they can change their votes as long as voting is underway.

In this way, voting for plans is a way for a community to select a few promising courses of action from among a large number of possibilities put forward by its members.

Within debates, any user can vote for one position per debate question and can remove or change their vote at any point. Thus, votes on debates are a running estimate of the user community's positions about a variety of climate related questions.

3.4. Contests

The three core elements described above are brought together in the CoLab to create contests, which serve as the primary organizing principle for activity on the site. Each contest is associated with a set of debate issues and models that are used to construct plans.

Contest have a beginning and an end, and are organized into phases (as described in more detail below).

3.5. Community Support

The CoLab also provides a number of features that allow users to stay aware of site activity and identify others with whom they'd like to communicate. Many of these features use an activity tracking system that logs all significant changes on the site, such as changing a plan description, adding a comment in a debate, or voting for a plan. For instance, users can subscribe to any area of the site where activity occurs, such as a plan, a debate, or a discussion board, and receive email notifications whenever other users make changes in that area.

The site also has a community page, which contains the site blog, a historical record of all logged activities, and a public directory of all registered users. The public directory includes the number of logged activities for each user and a link to each user's public profile page. The user's public profile page includes a short bio, a picture, and a list of the activities that user has done.

3.6. Implementation status

The Climate CoLab has been operational on a public website (http://climatecolab.org) since late November 2009. All the software for both the CoLab and the

modeling services is available under an open source license [23]. We invite and welcome others who would like to contribute to this effort.

4. COMMUNITY DESIGN APPROACH

We believe that the organizational design of the community that uses the Climate CoLab will be critical to its success. As a step in that direction, we have, so far, recruited two specialized types of users: moderators and experts.

4.1. Moderators

A team of volunteer moderators is responsible for monitoring the site and facilitating community interaction and content creation. For instance, moderators are responsible for deleting spam and deliberately inflammatory or offensive material. As noted above, they also monitor debate discussions and modify argument maps according to a set of mapping guidelines. In order to carry out these functions, moderators have certain editing privileges not available to ordinary users.

So far, these moderators are mostly graduate students from different universities who are interested in energy and climate-related topics, but the moderator group also includes volunteers from several other climate-related organizations.

4.2. Experts

In order to be sure that the best expert knowledge about climate change is reflected in the Climate CoLab, we have recruited an Expert Advisory Board and a broader Expert Council. These groups include some of the most respected climate change researchers in the world (for a list of current members, see [24]). Their role is to provide general advice about the project and especially to review specific content on the site. For instance, the Expert Council has already formally evaluated the scientific credibility of the climate model (C-LEARN) currently included in the CoLab and plans to review the economic and climate impact models in the future.

5. USAGE EXPERIENCE

We have been collecting standard web analytics data via Google Analytics since 12/07/09. As of Jan 1, 2011, the CoLab had 13,155 unique visitors. Of these, 1,537 (11.7%) have registered for the site. Visitors have come from 129 countries, with over 400 visits each from the US, Canada, China, India, Australia, and several European countries. Table 4 shows a summary of some more detailed indicators of site usage.

Table 4: General site traffic statistics

Measure	New visitors	Return visitors
Average visits per day	34	32
Average time on site	03:16	08:47
Bounce Rate (% of visitors who looked at one page and left)	47%	36%
Average page views	5.31	10.21

These early results illustrate that the CoLab is at least usable and interesting enough to sustain a relatively steady flow of new traffic, and that there is enough engaging content to keep a subset of members in our nascent community coming back and spending a significant amount of time on the site.

In addition to web analytics, the activities logged by the CoLab provide a fairly detailed summary of the types and quantities of activity on the site. The activities that are logged include all of the different ways people may contribute content, including voting, creating or editing plans, and commenting. Roughly 35% of all users who are not part of the CoLab core team have performed at least one of these activities, and 8% of these users have performed ten or more.

5.1. CoLab Contests

Since the site has been live, we have run two contests to develop plans for a global agreement on climate change, coinciding with the 2009 and 2010 United Nations Framework Convention on Climate Change (UNFCCC) meetings.

The first contest began with the official launch of the Climate CoLab in November 2009. This contest had a single phase and there was no expert involvement. By the end of the contest on December 9, 2009, 162 users had registered on the site, and 58 had voted on a plan. Twenty plans were submitted, and four of these garnered 85% of the votes. These four plans were presented in a white paper that was sent to the UNFCCC meeting in Copenhagen [25].

One notable result of this contest was that the plan receiving the most votes specified emissions reductions in all regions of the world by 99% by the year 2050. All the experts we have talked to say that it would be essentially impossible to make these reductions this fast, and yet the majority of our voters voted for it. As a result of this outcome, we introduced a multi-round contest in our second contest.

The second contest ran from October 1 – November 26, 2010 and included three phases: a plan creation phase, an expert evaluation phase, and a voting phase. Only those plans deemed feasible by expert judges in the expert evaluation phase were chosen as finalists and advanced to the voting phase where all users could vote for their first choice plan. This multi-round design with expert evaluation in the middle essentially eliminated the possibility of having a winning plan be one that experts thought was infeasible.

In this case, 29 plans were submitted, and 4 were chosen by the judges as finalists. A total of 403 votes were cast, and the popular choice winner received 174.

The results of the second contest were presented at briefings held at the United Nations and the U.S. Congress. As a prize for winning the contest, the winners had their expenses paid for trips to both of these briefings, and they described their own plans in both the briefings.
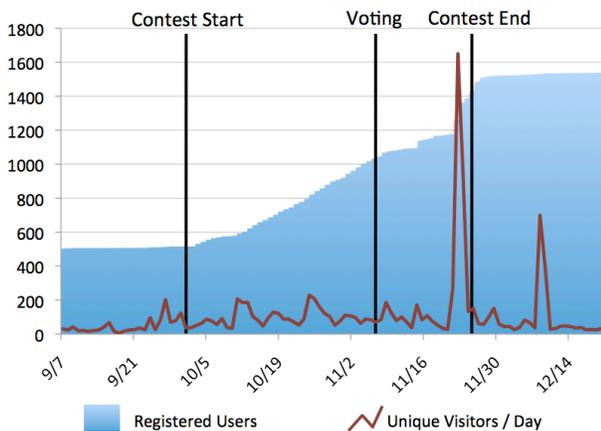

Figure 5: Number of registered users (blue) and daily unique visitors (red) during the second contest. Contest start (10/01), beginning of voting (11/07), and contest end (11/27) are indicated.

As shown in Figure 5, this contest generated substantial traffic and the community of registered users almost tripled in size during this time period. Two significant spikes in traffic occurred (on 11/23 and 12/9) when one of the winning plan submitters posted about the contest on a very widely read social media site.

Plans in the second contest were in general substantially more comprehensive and of higher quality than those in the first contest. For example, in the first contest, the popular choice plan contained no information about how the proposed emissions commitments might be achieved. In contrast, the popular choice plan from the second

contest contained ten times as many words and provided both rationale and a range of suggested actions for implementing the plan.

6. CONCLUSIONS

The Climate CoLab is a novel collective intelligence system designed to help thousands of people around the world solve the "super-wicked" problem of global climate change. It combines three previously unrelated technologies in a clean and synergistic way: model-based planning, online debates, and electronic voting.

Our initial results have been very encouraging. The Climate CoLab has attracted a continuing stream of web visitors from around the world. During our second contest, members of our community undertook great effort and created comprehensive plans of high quality and substantial novelty. These results are evidence that we are on our way to overcoming a key hurdle in the creation of a collective intelligence platform – the formation of a large and diverse community collectively engaged in solving a single problem.

In addition to its value as a tool to help construct solutions to climate change, the CoLab also serves as an example of a new scientific paradigm, which Shneiderman referred to as "Science 2.0" [26]. Just as in traditional science, "Science 2.0" requires a laboratory within which to test theories, but unlike traditional science, this laboratory is situated in the real world at scales not possible in controlled settings. This paper is one of very few that documents the intentional creation of just such a laboratory.

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REFERENCES

[1]   C. W. Churchman, "Guest Editorial: Wicked Problems," *Management Science*, vol. 14, no. 4, pp. B141-B142, Dec. 1967.

[2] H. W. J. Rittel and M. M. Webber, "Dilemmas in a general theory of planning," *Policy Sciences*, vol. 4, no. 2, pp. 155-169, Jun. 1973.

[3] J. Conklin, *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. John Wiley & Sons, Inc., 2005.

[4] K. Levin, B. Cashore, S. Bernstein, G. Auld, and D. Student, "Playing it Forward: Path Dependency, Progressive Incrementalism, and the "Super Wicked" Problem of Global Climate Change," in *International Studies Association 48th Annual Convention, February*, vol. 28, 2007.

[5] J. F. Nunamaker, A. R. Dennis, J. S. Valacich, D. Vogel, and J. F. George, "Electronic meeting systems," *Communications of the ACM*, vol. 34, no. 7, pp. 40–61, 1991.

[6] G. DeSanctis and R. B. Gallupe, "A Foundation for the Study of Group Decision Support Systems," *Management Science*, vol. 33, no. 5, pp. 589-609, May. 1987.

[7] T. W. Malone, R. Laubacher, and C. Dellarocas, "The Collective Intelligence Genome," *Sloan Management Review*, vol. 51, no. 3, pp. 21-31, Spring. 2010.

[8] M. Matthies, C. Giupponi, and B. Ostendorf, "Environmental decision support systems: Current issues, methods and tools," *Environmental Modelling & Software*, vol. 22, no. 2, pp. 123-127, Feb. 2007.

[9] I. S. Mayer, E. Van Bueren, P. Bots, H. van der Voort, and R. Seijdel, "Collaborative decisionmaking for sustainable urban renewal projects: a simulation-gaming approach," *Environment and Planning B: planning and design*, vol. 32, no. 3, pp. 403–423, 2005.

[10] B. Friedman et al., "Laying the foundations for public participation and value advocacy: interaction design for a large scale urban simulation," in *Proceedings of the 2008 international conference on Digital government research*, pp. 305-314, 2008.

[11] J. Conklin and M. L. Begeman, "gIBIS: a hypertext tool for exploratory policy discussion," *ACM Transactions on Information Systems (TOIS)*, vol. 6, no. 4, p. 331, 1988.

[12] P. A. Kirschner, S. J. B. Shum, and C. S. Carr, *Visualizing argumentation: software tools for collaborative and educational sense-making*. Springer, 2003.

[13] D. D. Suthers, R. Vatrapu, R. Medina, S. Joseph, and N. Dwyer, "Beyond threaded discussion: Representational guidance in asynchronous collaborative learning environments," *Computers & Education*, vol. 50, no. 4, pp. 1103–1127, 2008.

[14] T. Van Gelder, "The rationale for RationaleTM," *Law, probability and risk*, vol. 6, no. 1, pp. 23-42, 2007.

[15] L. Iandoli, M. Klein, and G. Zollo, "Enabling on-line deliberation and collective decision-making through large-scale argumentation: A new approach to the design of an internet-based mass collaboration platform," *International Journal of Decision Support System Technology*, vol. 1, no. 1, 2009.

[16] M. J. Salganik, P. S. Dodds, and D. J. Watts, "Experimental Study of Inequality and Unpredictability in an Artificial Cultural Market," *Science*, vol. 311, no. 5762, pp. 854-856, Feb. 2006.

[17] J. Toplak, "Preferential Voting: Definition and Classification," in *Annual Meeting of the Midwest Political Science Assication 67th Annual National Conference*, 2010.

[18] W. D. Smith, "Range Voting," Dec-2000.

[19] "C-ROADS — Climate Interactive." [Online]. Available: http://climateinteractive.org/simulations/C-ROADS/overview. [Accessed: 04-Aug-2010].

[20] G. E. P. Box and K. B. Wilson, "On the experimental attainment of optimum conditions," *Journal of the Royal Statistical Society. Series B (Methodological)*, vol. 13, no. 1, pp. 1–45, 1951.

[21] "Climate CoLab model help," 10-Aug-2010. [Online]. Available: http://www.climatecolab.org/web/guest/resources/-/wiki/Main/Models+Help. [Accessed: 04-Aug-2010].

[22] J. Conklin, "Dialog mapping: Reflections on an industrial strength case study," *Visualizing argumentation: software tools for collaborative and educational sense-making*, pp. 117–136, 2003.

[23] "Collaboratorium Open Source Code Site," 10-Jul-2010. [Online]. Available: http://code.google.com/p/climatecollaboratorium.

[24] "Climate CoLab Credits," 03-Aug-2010. [Online]. Available: http://www.climatecolab.org/web/guest/resources/-/wiki/Main/Credits. [Accessed: 04-Aug-2010].

[25] R. Laubacher, L. Pierpoint, J. Introne, and T. Malone,, *Harnessing collective intelligence to address climate change: The Climate Collaboratorium Copenhagen Challenge*. MIT Center for Collective Intelligence: , 2009.

[26] B. Shneiderman, "Science 2.0," *Science*, vol. 319, no. 5868, pp. 1349 -1350, Mar. 2008.