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World Climate: A Role-Play Simulation of Global Climate Negotiations

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Abstract

Global negotiations to reduce greenhouse gas (GHG) emissions under the United Nations Framework Convention on Climate Change (UNFCCC) have, so far, failed to produce an agreement sufficient to avoid the most dangerous consequences of climate change. But even if the negotiations yielded a treaty with binding commitments such an agreement could not be ratified or implemented in many nations due to inadequate public support. The scientific consensus on the reality and risks of anthropogenic climate change has never been stronger, yet public support for action has fallen. Educators, the media, civic and business leaders, and citizens need tools to understand, for themselves, the dynamics of climate change and its geopolitical implications. The *World Climate* simulation provides an interactive role-play environment through which participants can explore these issues using a scientifically sound simulation model of the climate to show the consequences of proposed emissions paths. Participants play the roles of major GHG emitting nations and negotiate proposals to reduce emissions. Participants then receive immediate feedback on the implications of their proposals for atmospheric GHG concentrations, global mean surface temperature, sea level rise and other impacts with the C-ROADS climate policy simulation model now being used by negotiators and policymakers. The role-play enables participants to explore the dynamics of the climate and impacts of proposed policies in a way that is consistent with the best available peer-reviewed science but that does not prescribe what should be done. *World Climate* has been used successfully with diverse groups, including students, business executives and political leaders. Here we describe protocols for the role-play and the resources available to run it, including the C-ROADS model, briefing memoranda, facilitator guide, debriefing slides and videos of sessions, all of which are freely available at climateinteractive.org.

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The Climate Change Communication Challenge

In 1992 the nations of the world created the United Nations Framework Convention on Climate Change (UNFCCC) to negotiate binding international agreements to address the risks of climate change. The 194 signatories—nearly every nation on earth—commit themselves to limiting greenhouse gas (GHG) emissions to prevent "dangerous anthropogenic interference in the climate system,"[1] which is generally accepted to mean limiting the increase in mean global surface temperature to no more than 1.5 - 2°C above preindustrial levels.[2] High hopes were dashed at the Copenhagen climate conference in December 2009, when face-to-face negotiations among dozens of heads of state broke down. No agreement was reached; rather each nation was encouraged to make unilateral pledges to reduce its emissions. To date, those pledges fall significantly short of what is needed (UNEP 2010, 2011), while global GHG emissions have risen to record levels despite the great recession that began in 2008.

Negotiations have failed even though scientific understanding of climate change and the risks it poses have never been stronger. In 2007 the Intergovernmental Panel on Climate Change (IPCC) concluded, in its Fourth Assessment Report (AR4) that "Warming of the climate system is unequivocal" and "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations" (IPCC 2007, AR4 *Summary for Policymakers*, 2, 5; emphasis in the original).

Policies to manage complex natural and technical systems should be based on the best available scientific knowledge. In the context of climate change such knowledge is provided by the IPCC and other scientific organizations. But, while necessary, scientific knowledge is not sufficient. In democracies, at least, the ratification of international agreements and passage of legislation to limit GHG emissions requires grass-roots political support. The failure of global negotiations can be traced to the huge gap between the strong scientific consensus on the risks of

[1] unfccc.int/essential_background/convention/background/items/1349.php

[2] The 2°C target was first articulated in the Bali Declaration (www.climate.unsw.edu.au/news/2007/Bali.html). More recent statements by the Secretariat of the UNFCCC argue for no more than 1.5°C (unfccc.int/files/press/press_releases_advisories/application/pdf/pr20110606sbs.pdf).

climate change and widespread confusion, complacency and denial among policymakers, the media and the public. For example, compared to the early 2000s, Americans are now "less worried about the threat of global warming, less convinced that its effects are already happening, and more likely to believe that scientists themselves are uncertain about its occurrence" (Gallup 2010; see also Leiserowitz *et al*. 2010). Public opinion in other key emitter nations follows similar patterns (Leiserowitz and Smith 2010).

The gap between the science and public understanding means risk communication is now a major bottleneck to the implementation of policies consistent with accepted climate science and treaty obligations (Sterman 2011). However, effective risk communication around climate change is particularly difficult because the climate is an immensely complex dynamic system. Research shows that even well-educated people with strong backgrounds in Science, Technology, Engineering and Mathematics (STEM) do not understand the basic elements of complex dynamic systems, including feedback, stocks and flows, time delays, and nonlinearities (Booth Sweeney and Sterman 2000, 2007; Sterman and Booth Sweeney 2007, Cronin *et al*. 2009, Sterman 2011). Further, in some nations, including the United States, climate change has become highly politicized. A concerted disinformation campaign seeks to undermine public understanding and acceptance of climate science (Oreskes and Conway 2010). Hoffman (2011) argues further that climate change is becoming a polarizing issue on which no compromise is possible, similar to conflicts over abortion rights and gun control.

In such settings, mere transmission of information in reports, presentations, and lectures is not sufficient to change entrenched misinformation, mental models, attitudes and behaviors (Dean 2009, Fischhoff 2007, 2009, Olson 2009, Weber and Stern 2011). Successful risk communication begins with a thorough understanding of the mental models of the affected population (Morgan *et al*. 2001, Slovic 2000). Effective learning requires change in mental models that are often deeply entrenched. To do so, Sterman (2008, 2011) argues that scientists should develop a suite of "management flight simulators" and interactive learning environments for policymakers and the public as an integral component of the risk communication process. In

many situations, experience and experiments enable people to learn, first hand, how a system operates. Simulations are not needed. That is not possible for climate change. Indeed, climate science depends on simulation models because controlled experiments are not possible. But why are simulations needed in the risk communication process? When experimentation is impossible, when the consequences of our decisions unfold over decades and centuries, and when people hold strong prior beliefs, that is, for climate change and many of the important issues we face, simulation becomes the main—perhaps the only—way we can discover *for ourselves* how complex systems work and what the impact of different policies might be.

Interactive, transparent simulations of the climate, rigorously grounded in the best available science, are now available. To enable learning, the models must give people control over assumptions and scenarios, encourage wide-ranging sensitivity analysis, and run nearly instantly. Examples range from simple models to help people develop their understanding of stocks and flows (e.g., bit.ly/atmco2, bit.ly/stockflow, Moxnes and Saysel 2009) to more comprehensive models such as the C-ROADS and C-Learn climate policy simulators (climateinteractive.org, Sterman *et al*. 2011). These simulations are being used by a variety of policymakers and in interactive workshops for business leaders, educators and the public at large.

The *World Climate* Role Play Negotiation

Here we describe *World Climate*, an interactive role-play simulation of the UNFCCC negotiations using the C-ROADS or C-Learn models. The role-play and simulations are "serious games" designed to help people grapple with a difficult real-world problem of great complexity, while still fulfilling Mayer's (2009) criteria for effective games.[3] Useful in groups as small as 6 and as large as 60, participants play the role of negotiators for various nations. The participants must consider their national interests and domestic politics as they negotiate a global agreement to mitigate climate change. As in traditional role-play simulations, participants receive briefings to help them understand the national interests and objectives of the nations they represent. They

[3] Mayer (2009) argues that effective games and models will be integrative, dynamic, interactive, transparent, flexible and reusable, fast and easy to use, communicative and educational, and authoritative.

then negotiate with one another to agree on commitments for GHG emissions reductions through 2100 and contributions to a global fund to pay for mitigation and adaptation in the less developed nations. Unlike traditional role-play negotiations, however, the participants' proposals are then entered into the C-ROADS climate policy simulation (Sterman *et al*. 2011), providing them with immediate feedback showing whether their proposals achieve their goals.

C-ROADS is a computer simulation of the global carbon cycle and climate developed under the Climate Interactive project. C-Learn is a websim version of C-ROADS with a simplified interface. Both run on ordinary desktop or laptop computers in less than one second. In the negotiation, participants specify emissions reduction commitments for their nation or bloc from the present through 2100. The simulation sums these commitments to yield global emissions and provides participants with immediate feedback on the likely consequences of their emissions reductions proposals through 2100, including per capita emissions, the carbon intensity of the economy, GHG concentrations, global average surface temperature, ocean acidification and sea level rise.[4] Sterman *et al*. 2011 describe the model, assess its fit to historical data and compare it to state-of-the-art climate models. C-ROADS and C-Learn are freely available, with full technical documentation, from climateinteractive.org.

Participants specify emissions for their nation or bloc through 2100 so that they receive feedback on the consequences of their proposals over a time horizon long enough to capture projected population growth, economic development, and important climate impacts.[5] Typically, the emissions reductions participants propose fail to limit projected warming to the accepted target of 2°C above preindustrial levels. Participants then use the results to negotiate another set

[4] So that it can run immediately on ordinary laptops, the carbon cycle and climate sectors of C-ROADS/C-Learn are globally aggregated and do estimate the likely impacts of climate change at national or regional scales (inputs for GHG emissions, deforestation and afforestation are disaggregated by nations/regions). As discussed below, model results can be integrated with other resources, such as interactive maps showing the impact of sea level rise, to provide information on local impacts.

[5] Alternatively, one could have participants specify emissions through, say, 2020, simulate the results through that year, then have participants propose emissions commitments for the next ten years, until they reach 2100 (see, e.g., Moxnes and Saysal 2009). In the time available for a typical session this would likely allow participants to reach 2100 only once. We believe the ability to specify emissions paths through 2100, immediately see the results, and rapidly carry out sensitivity analysis helps people develop a deeper understanding of the dynamics of the climate.

of proposals, again receiving feedback on likely consequences using the model.

The debrief addresses a wide range of concerns, including the biogeochemical dynamics of the climate; geopolitical, economic and cultural barriers to global agreements; managing hope and fear amidst an uncertain future; and the technological and behavioral changes that can help reduce GHG emissions and limit the damage from climate change.

We have run *World Climate* for business leaders, policymakers, oil industry executives, the US Forest Service, students at MIT and other universities, high school students, religious congregants and many others. *World Climate* helps people learn the policy-relevant science of climate change, viscerally experience the international politics, and explore realistic solutions to the challenges of building a low-carbon economy.

World Climate is not a platform for advocacy, but a way to help people learn about the science of climate change and the dynamics of an immensely complex political, economic, social, and biogeochemical system. Participants are free to propose any policies they choose, including no action, and to explore alternative assumptions about the response of the climate to GHG emissions. The role-play facilitates discussion of people's beliefs and values, without attempting to dictate values. The simulation shows participants the likely consequences of *their* choices, using a model that captures the best available scientific knowledge, but does not prescribe what should be done.

In the following we describe protocols and materials for setup, briefing, play, and debriefing. Like any complex role-play, effective delivery requires practice, but many have learned to use and run the simulation successfully from the free materials.

Overview, Roles and Setup

Table 1 lists the materials needed for the simulation. Handouts, slide decks and other materials are available for free download from climateinteractive.org. *World Climate* can be run with groups as small as 6 and as large as 60. The time required can range from a minimum of about 60 minutes for an abbreviated session to as long as a day. We recommend 3-4 hours. We

have also successfully run the simulation across multiple days in university and school settings where class sessions are 60 or 90 minutes. *World Climate* can be run by a single facilitator, even for larger groups, though additional facilitators can be helpful. Participants need not prepare anything prior to the session. If the opportunity for preparation exists, however, then it is useful to assign a short reading that covers the science of climate change, such as the IPCC (2007) Summary for Policymakers, or Schneider (2009).

Participants are divided into negotiating teams representing different nations and regions. Six nations/blocs work effectively; these are the United States, European Union, other developed nations, China, India, and other developing nations. The C-ROADS model supports the six-party mode (and also offers a 15 nation/bloc mode). For smaller groups, or if time is limited, the world can be divided into three negotiating blocs, representing the developed, rapidly developing, and less developed nations of the world. The online C-Learn model supports the three-party mode.[6] In all cases every nation on Earth is represented by one of the delegations.

The simulation is best conducted in a flat room with tables for each delegation that can be moved as needed (Figure 1). Each table should have a placard bearing the name of the delegation to be seated there. Use blackboards, flipcharts or a document camera/overhead to record delegate proposals, observations and comments from the delegates, and other data.

Participants can be assigned to teams several ways, depending on the size and composition of the group and on whether the participants are known in advance. Part of the value of the exercise lies in coming to understand the perspectives of other nations. Hence we recommend pre-assigning people to balance each delegation by nation of origin, gender, etc. If pre-assignment is not possible, assign people randomly by asking them to count off (1-3 or 1-6). Alternatively, ask people to self-identify the delegation corresponding to their own country, or

[6] In the six-party mode, the "other developed nations" include non-EU Europe, Russia and former Soviet states, Japan, Canada, South Korea, New Zealand and Australia. The "other developing nations" include South Africa, Mexico, Brazil, Indonesia, and all other developing nations in the Middle East, Latin America, Africa and Asia. In the three-party mode, the developed nations include the US, Europe, Russia and the former Soviet states, Japan, Canada, South Korea, New Zealand and Australia. The rapidly developing bloc includes China, India, South Africa, Mexico, Brazil, Indonesia, and other large developing Asian countries. The least developed bloc spans the rest of the world, including developing countries in the Middle East, Latin America, Africa, and Asia.

for which they feel affinity, and then swap them, so that participants play roles that differ from the country they favor. To enhance realism, give participants name badges with their names and delegation, similar to the credentials UNFCCC delegates wear.

To accommodate larger groups we have created other roles, including lobbyists for the fossil fuel industry and activists representing environmental NGOs or indigenous populations. Briefing memos for these groups are available online. These actors can be encouraged to lobby, stage demonstrations, lead walkouts, and employ other tactics used in the actual negotiations e.g., at COP17 in Durban, South Africa (www.youtube.com/watch?v=Xg88rf-5t4A). The workshop can also be run with groups playing the role of advocates for other species and future generations – including, where appropriate, the actual children of participants.

When the time available is short, we ask each delegation to select a "president" who is empowered to make quick decisions when needed. The facilitator asks each delegation to point at the most decisive person in their group, selecting as president the person with the most fingers pointed at her/him. Interestingly, delegations unhappy with the decisions of their president have sometimes staged a coup (a rich opportunity for discussion).

Briefing the Negotiators

To help participants understand the economic and political constraints to action we provide each delegation with a confidential Briefing Memorandum outlining the negotiating position of the nation(s) they represent. Each memo is two pages so it can be printed on a single sheet and read quickly. The first page describes the political constraints and negotiating position for their delegation; the second shows data on GHG emissions they can use to argue their case. Table 2 excerpts key text from the memos for the US and Chinese delegations; the full set is available at climateinteractive.org. Note the contrasting language and data used to support the arguments for each nation's interests. For example, the US memo cites the fact that China is now the world's largest GHG emitter, while the Chinese memo stresses the fact that the vast majority of cumulative GHG emissions were caused by the developed nations (see Table 3).

To reinforce the national interests of the delegates, the tables for the delegations representing the developed nations (the Developed bloc in the three party version; the US, EU and Other Developed Nation delegations in the six party version) should have tablecloths set with food and drinks, the more luxurious the better (Figure 2)—although doughnuts also work. The tables for the other delegations should be bare. Cover the food as participants enter the room so that it is available only to those representing the developed nations.

To further reinforce the differences in economic and political power among nations the facilitator should ask that all the delegates from the least developed nations sit on the floor, with exceptions only for those for whom doing so would be a physical hardship. There may be some resistance; the facilitator should insist. In one session, an actual head of state assigned to the least developed delegation happily complied and sat on the floor. Requiring participants representing the poorest nations to sit on the floor, while those representing the rich nations are not only seated but enjoy food and drink, is a mild intervention, but vividly demonstrates the differences in economic and political power among nations, particularly for those participants who have little or no first-hand experience of life in the developing world.

One might imagine that participants might all get together and propose emissions reductions that unrealistically ignore the national interests and domestic political realities of the countries they represent. However, the briefing memos, food and seating arrangements have proven effective in inducing the political interests of the nations each participant represents. Often, participants begin to feel grievances against the other delegations and castigate them for their alleged lack of cooperation and care for their fellows. In our experience, the participants have never proposed unrealistically large emissions reductions in the first round of negotiations.

The Secretary General Addresses the Delegates

Once the participants are seated, distribute the briefing memos and give each delegation a few minutes to read them and discuss their negotiation strategy. The facilitator, playing the role of the UN Secretary General (currently Ban Ki Moon) or Secretary of the UNFCCC (currently

Christiana Figueres), should then formally call the meeting to order.

In playing the role of Secretary General the facilitator should adopt a formal demeanor. It is helpful for the facilitator to put on more formal clothing (e.g., a suit; do this while the delegates are reviewing their briefing memos). If there are two facilitators, one can play the role of Secretary General while the other moderates the session. Additional facilitators, if available, can serve as technical advisors to the parties or scientific advisor to the Secretary General (entering proposals into the simulation model and explaining results). In the role of Secretary General, the facilitator should call the meeting to order with a gavel, speak formally, and approximate parliamentary procedure. For example, if a participant representing India wished to speak, the facilitator would say "the chair recognizes the delegate from India."

After calling the meeting to order the facilitator addresses the delegates, outlining their charge, as shown in the briefing slides available online. The slides briefly review the history of the UNFCCC and negotiation process. Most audiences are not familiar with the history, including the fact that essentially every nation on Earth is a signatory to the treaty establishing the UNFCCC, is legally obligated to reduce GHG emissions to avoid "dangerous interference in the climate system" and that doing so is now agreed to entail limiting global warming to 2°C above preindustrial levels. The briefing should also review the 1997 Kyoto protocol (unfccc.int/kyoto_protocol/items/3145.php), which came into force in 2005 after ratification by Russia. Although Kyoto constituted a milestone as the first international treaty committing signatories to mandatory cuts in GHG emissions, it has failed in several ways: first, developing nations, including China and India, were exempted from mandatory reductions; second, the United States did not ratify the treaty and formally withdrew from it in 2001 while Canada announced its intention to withdraw in 2011; and third, the overall Kyoto targets will almost certainly not be met. Global CO_2 emissions from fossil fuel use have continued to rise since Kyoto, reaching record levels in 2010. Global emissions have been growing faster than the scenarios the IPCC used in the fourth assessment report, suggesting that the IPCC projections of future climate change impacts under business as usual (BAU) are overoptimistic.

The Secretary General next shows CO_2 concentrations in the atmosphere, which stood at over 390 ppm in 2011, more than 40% above the preindustrial level of about 280 ppm, then discusses the likely consequences of BAU on climate, agriculture, ecosystems and other systems that affect human welfare. Explain that the higher the global mean temperature increase by 2100, the more severe the impacts of warming on humans and the ecosystems upon which we and all life depend will be, including declines in agricultural productivity and water availability, increases in extreme weather events including droughts and floods, more rapid extinction of species, and greater chances of crossing a tipping point that could cause climate change to become self-reinforcing, leading to large and abrupt changes in climate, changes that, on any time scale of interest to humans, will be irreversible (IPCC AR4 SPM 2007, pp. 13-14, Solomon *et al*. 2009, IPCC 2011). How much warming is projected under the BAU scenario? Recent simulations (Sokolov *et al*. 2009) yield expected temperature increase by 2100 of 5.3°C (9.5°F), with a 90% confidence interval from 3.5 to 7.4°C (6.3 to 13.3°F). Since many people are unfamiliar with the concept of confidence intervals, the first author often explains as follows:

> "There is uncertainty about the impact of emissions on the climate. The expected warming under BAU is 5.3°C (9.5°F). The 90% confidence interval means that there is a 5% chance we could be lucky—continuing on the BAU path may only cause warming of 3.5°C (6.3°F) or a little less. On the other hand, there's also a 5% change that the climate is more fragile than we think, could warm by 7.4°C (13.3°F) or more by 2100. In plain language, we are playing Russian roulette with the future, using a weapon in which 19 of 20 chambers are loaded. And the gun is not pointed at our own heads, but at the heads of our children and grandchildren."

The Secretary General's introduction and charge to the negotiators should not only to present participants with up-to-date information on GHG emissions and climate risks, but impress upon the participants that, while they are playing a game, the risks are real, the issues difficult, and the responsibility on them, as negotiators, is serious, as Ban Ki Moon stated at COP17 (unfccc.int/meetings/durban_nov_2011/statements/items/6584.php):

> "It would be difficult to overstate the gravity of this moment.
> Without exaggeration, we can say: the future of our planet is at stake.
> People's lives, the health of global economy, the very survival of some nations.
> The science is clear.
> The World Meteorological Organisation has reported that carbon emissions are at their highest in history and rising.
> The Intergovernmental Panel on Climate Change tells us, unequivocally, that greenhouse gas emissions

must be reduced by half by 2050 – if we are to keep the rise in global temperatures to 2 degrees since pre-industrial times.
According to the International Energy Agency, we are nearing the "point of no return," and we must pull back from the abyss."

The Secretary General should then introduce the C-ROADS or C-Learn model (Sterman *et al*. 2011), showing slides explaining the purpose and structure of the model, and reviewing the model's fit to historical data for GHG emissions and concentrations, global mean surface temperature, sea level and other key variables and the conclusions of the scientific review panel. These slides can be cut in shorter sessions; full model documentation and the report of the scientific review committee are available at climateinteractive.org/simulations.

Next, project the model on the screen and present the BAU scenario (Figures 3-4), starting with BAU emissions. The default BAU scenario in C-ROADS as of 2011 is the IPCC SRES A1FI scenario (www.ipcc.ch/ipccreports/sres/emission/index.htm). A1FI portrays a rapidly developing world that remains largely dependent on fossil fuels for energy.[7] Point out that BAU emissions, while growing, rise at a diminishing rate, though world population, following UN projections, is expected to rise from the current level of about 7 billion to roughly 9 billion by 2050, and world economic output is assumed to rise through 2100. That is, the BAU scenario assumes that the carbon intensity of the economy (CO_2 emissions per dollar of real economic output) will steadily decline through 2100 without any international agreements or policies to price carbon or otherwise limit emissions (show the graphs in the model of historical and projected population, economic growth, emissions per capita and the carbon intensity of the economy as you explain). In the developed nations, actual carbon intensity has fallen over the past half century roughly 1%/year, reflecting general technical progress and a shift in the composition of the economy, with much energy-intensive manufacturing moving to the less developed nations. Thus the BAU assumption that global carbon intensity will continue to fall absent any policy is likely overoptimistic. Note that C-ROADS includes many other scenarios

[7] Both C-ROADS and C-Learn include the full array of greenhouse gases besides CO_2, including CH_4, N_2O, the fluorocarbons, SF_6, black carbon, and aerosols. To keep the role-play manageable, delegates do not make separate decisions for emissions of each of these; instead, emissions of these other gases are assumed to follow emissions of CO_2. C-ROADS offers various options to set individual pathways for the non-CO_2 gases, but we recommend avoiding this complexity in the context of *World Climate* when time is limited.

you can use as the BAU case, including a user-defined option.

Next, show the likely impacts of BAU emissions, in the following sequence: atmospheric GHG concentrations (both CO_2 and CO_2e are available), global mean surface temperature anomaly, ocean pH and sea level rise. Take questions from the delegates—it is important that they understand the dynamics of and connections among these variables. You should also illustrate that the model easily enables sensitivity analysis. Although the base case represents the scientific consensus, there is uncertainty around the response of the climate to GHG emissions. C-ROADS does not require participants to accept any particular assumptions. C-ROADS includes sliders for key parameters including the rate at which CO_2 is removed from the atmosphere by the oceans and by biomass, the so-called "climate sensitivity" (the expected rise in global mean surface temperatures given a doubling of CO_2 concentrations over preindustrial levels), the expected increase in sea level per degree of warming resulting from increased melting of the Greenland and Antarctic ice sheets, increased GHG release from melting of permafrost, and others. Demonstrate how these uncertainties work, for example, showing the impact of varying climate sensitivity and ice sheet melt rates on sea level.

The final step in the set-up is to re-emphasize the goal—to achieve emissions reductions that collectively are likely to limit warming to no more than 2°C above preindustrial levels.

First Round of Negotiation

The first round of negotiation begins after the Secretary General concludes his or her charge to the delegates (see steps of play in Table 1). Inform the delegations how long they have to negotiate with their colleagues from the other delegations. A minimum of 20 minutes is recommended for the first round; larger groups require more time. Monitor the mood and progress of the group and adjust the time accordingly, though time pressure is, of course, a feature of the actual negotiations. Announce that, at the end of that time, each delegation must specify what, if any, commitment they are willing to make to change their GHG emissions. If no pledge is received, that delegation's emissions follow the BAU scenario.

Hand out the Proposal Record Sheet (Figure 5) to each delegation to record their pledges. C-ROADS offers a variety of ways to enter emissions pathways for each delegation, allowing complete control over the emissions path through 2100. We recommend a simple method in which the delegates specify future emissions with three parameters: the growth stop year (when each nation/bloc is willing to cease the growth of its GHG emissions, if they are willing to do so); the decline start year (when each nation is willing to begin a decline in their emissions, if they are willing to do so); and the decline rate (the annual rate of decline in emissions after the decline begins). These parameters are easily explained, can be entered quickly into the model, and provide a good approximation to continuous emissions paths (Figure 6).

Delegates also have the option of proposing Reductions in Emissions from Deforestation and land Degradation (so-called REDD or REDD+ policies). C-ROADS and C-Learn both include the option to reduce deforestation and to implement afforestation programs.[8]

Finally, each delegation specifies how much they are willing to commit to the creation of an international fund to help the developing nations pay the costs of mitigation and adaptation. The declaration of the parties at the 2010 COP16 meeting set the target for the fund to $100 billion per year, to be achieved by 2020 (unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf, Section IV.A.98). These goals were reaffirmed at COP17, but commitments for funding remain far below $100 billion per year. The facilitator should identify $100 Billion/year as the goal; it is up to the delegates from the developed nations to decide how much, if anything, they are willing to contribute. Heated discussion among the delegates often arises regarding whether China should contribute to the fund or maintain the position that it is still a developing nation and make no contribution. Proposals for emissions reductions, REDD, and funding can be unconditional or conditional on other delegations meeting certain targets.

Inform the delegates that after the first round of negotiations one representative from each

[8] C-Learn treats deforestation and afforestation at the global level. C-ROADS offers the global level and also allows the impacts of deforestation and afforestation to be specified at the level of each nation/bloc. We provide a spreadsheet that calculates the aggregate impact of the individual delegations' REDD+ pledges when using the global mode. The technical documentation for C-ROADS provides the data sources for REDD+ impacts.

delegation will make a two-minute plenary address to the full conference describing and arguing for their proposal. The facilitator should continue in the role of the Secretary General during these presentations, formally calling each representative to the podium to address the delegates. Strictly enforce the two-minute time limit. Record the proposals of each delegation on the blackboard using the table shown in Figure 7. We have found an effective order of presentation to be the US, EU, Other Developed Nations, China, India, and Other Developing Nations (or Developed, Rapidly Developing, and Less Developed in the three-bloc version).

As the participants negotiate, move among the delegations, answering questions that may arise. Delegates from the least developed nations (those sitting on the floor) often feel powerless and frustrated—their GHG emissions are currently very small, yet they will suffer the most from the consequences of climate change and have the least capacity to adapt. They often ask what they can do to influence the other delegations. Encourage delegates to be creative. In some sessions conducted by the first author, delegates from the developing nations have staged demonstrations, led walk outs, and taken, without permission, the food of the developed nations—including, in one case, appropriating the entire table of the US delegation. Delegates should also be encouraged to be creative in their plenary presentations. In one session conducted by the first author, two participants assigned (by chance) to the Chinese delegation were fluent in Mandarin and English. Playing the role of lead negotiator and translator they presented their address in Chinese with consecutive translation in a highly formal manner. In another, the delegate from the least developed nations gave an impassioned speech castigating the developed nations for failing to cut emissions, then led a silent walk out of the entire delegation.

After the last presentation, thank the delegates and then enter their proposals into the simulation model. Conditional proposals, such as "the US will commit to x if China commits to y," should not be entered unless the conditions have been met.

Before showing the results, ask the group how close to the 2°C goal the delegates' pledges will come. Typically, first round proposals will be relatively weak, leading to expected warming by 2100 far above the 2°C target. Show the impact of the first-round proposals on the climate,

beginning with global GHG emissions, then GHG concentrations, expected temperature increase, ocean acidification (pH), and, finally, sea level rise.

First round proposals usually cause sea level to rise only slightly less than the BAU amount (approximately 1.3 meters by 2100). To show the impact of such a large increase, take the sheet and cover the participants from the developing nations, who are still sitting on the floor (Figure 8). If there are additional facilitators, use sheets to cover up all the other delegations—every region will suffer from rising sea level. Covering the delegates demonstrates dramatically that sea level rise will have major consequences for millions of people. Next, show the impact of sea level rise on particular regions of the world, using, e.g., flood.firetree.net. Ask the group which regions they want to examine. Regions vulnerable to sea level rise in the US include the Mississippi delta and Gulf of Mexico region, the mid-Atlantic coast, and San Francisco bay area/Sacramento-San Joaquin deltas. In Europe, the Netherlands, Denmark, Venice, London and many other areas will be heavily affected. In Asia, many coastal areas will be inundated, including the deltas of the Indus, Ganges, Mekong, Yellow and Yangtze; major economic zones of China including Shenzen and Shanghai, and major coastal cities of Japan. Many islands in the Indian and Pacific oceans will be completely inundated.

Participants from regions far from the sea may remark that they won't be affected. Ask the group if that's true and have them explain, elaborating only if the delegates are not able to provide the information. First, sea level rise is only one impact of climate change; others include higher summer temperatures, loss of winter snow pack and alpine glaciers, droughts, increased wildfire risk, and declines in agricultural production (affecting all through higher food prices). Further, rising sea level is likely to affect everyone no matter where they live. Using, e.g., flood.firetree.net, focus on the Indus river delta, showing that much of this heavily populated and agriculturally important region will be inundated with even one meter of sea level rise. Ask participants to explain the likely consequences of the potential displacement of millions as climate refugees on the border of India and Pakistan, increasing the risk of conflict between these nuclear-armed nations with historic grievances against one another.

In several sessions led by the first author, the delegates from the least developed nations (those who were sitting on the floor and covered by the sheet) get up and take the seats and food of the delegates from the developed nations. As one group of refugees told the startled developed nation delegates, "We've been forced from our homeland by the climate change you caused. You tried to turn our boats away, but we are here. We are desperate. We need jobs, housing, health care and education. You must compensate us for the loss of our homes."

Bathtub Dynamics

Often the first-round proposals cause global CO_2 emissions to stabilize or even drop slightly, yet the model will show a steady rise in atmospheric CO_2 and global mean temperature. Participants often ask why concentrations and temperature continue to rise even though emissions stabilize. If not, the facilitator should ask the group. Research shows that most people, including highly educated elites with substantial training in STEM, do not understand basic principles of accumulation (stocks and flows) and often find this result surprising—they expect that stabilizing emissions should stabilize atmospheric CO_2 concentrations and halt further climate change (Sterman and Booth Sweeney 2007, Sterman 2008, Cronin, Gonzalez and Sterman 2010). C-ROADS and C-Learn are designed to help people understand the stock-and-flow structure of CO_2 accumulation in the atmosphere. The models provide graphs showing both global emissions and the net flux of CO_2 removed from the atmosphere (Figure 9). Today, emissions are roughly twice as large as the net flux of CO_2 being removed from the atmosphere as it is taken up by biomass and dissolves in the ocean. The situation is analogous to a bathtub in which the flow in from the tap is twice as large as the flow out through the drain. Even if participant proposals stabilize global emissions, CO_2 emissions into the atmosphere remain substantially above the net removal of CO_2 from the atmosphere, so the concentration of CO_2 continues to rise. Stabilizing atmospheric CO_2 requires emissions and removal to become equal. Encourage discussion on this point to make sure people understand the "bathtub dynamics" governing CO_2 concentrations (Figure 10). After this discussion, participants should understand

why stabilizing GHG concentrations in the atmosphere requires deep cuts in global emissions.

Further, the net removal of CO_2 from the atmosphere is not constant but depends on the state of the climate (Figure 9). Lowering emissions slows the rise in atmospheric CO_2, which reduces uptake by biomass and the oceans, making it harder to balance emissions and net removal. Delegates often ask why the removal flux doesn't increase in proportion to atmospheric CO_2 concentrations. Again, ask the group. The carbon sinks absorbing CO_2 from the atmosphere have finite capacity. First, the ocean's ability to take up CO_2 declines as the CO_2 concentration in the surface layer of the ocean increases. Second, although higher CO_2 levels stimulate photosynthesis, the increase is less than proportional as other required nutrients constrain growth. Additionally, plants, whether plankton or trees, eventually die or shed their leaves; that organic matter is then consumed by bacteria and fungi, releasing CO_2 and methane back into the atmosphere. These feedbacks grow stronger as the climate warms, further reducing net CO_2 uptake. Figure 11 shows two examples: the balancing (negative) feedback of CO_2 fertilization, and the reinforcing (positive) feedback whereby warming stimulates bacterial respiration, releasing more CO_2 and methane into the atmosphere and leading to still more warming, e.g., via permafrost melt (Schurr *et al*. 2011).

Tipping Points and the Burning Candle Demonstration

Permafrost melt, the ice-albedo effect, and other reinforcing (positive) feedbacks might dramatically accelerate climate change and create the possibility of irreversible regime shifts. Causal diagrams can illustrate these self-reinforcing processes, but presentation alone is not sufficient to help people understand how such nonlinear regime shifts arise. The "burning candle" demonstration developed by the first author provides an effective demonstration of these concepts. Begin by lighting a candle. Be sure to have permission, if needed, water and/or a fire extinguisher at hand; making a show of being concerned about fire or triggering the alarm heightens the drama. Explain that many people believe that we can "wait and see" whether climate change will turn out to be more damaging to human welfare than it has been so far – if

not, then we avoid the cost of mitigation; if so, then we can take action.

Wait-and-see is a useful strategy when there are short lags between the detection of a problem, the implementation of corrective policies, and the impact of those actions. "For example, consider this candle; let the position of my hand represent the climate. As I lower my hand over the flame, it starts to get a bit warmer. Eventually, it becomes so hot that my hand will jerk away to avoid being burned" [do this as you explain. You will find that your hand can get quite close to the flame before you need to remove it]. "Unfortunately, there are long time delays in the climate. Let's simulate these delays by repeating the experiment, but now adding a ten second lag between when I feel the heat and when I can remove my hand." Start lowering your hand, then ask, "do you mind if I use a piece of paper instead of my hand?" Before starting, say "To ensure that there is a time delay, I'll now hand out these cards" and distribute seven numbered sheets of paper, folded over, to participants in the front of the room. The sheets say "1. Study the Issue", "2. Call for Emissions Reductions", "3. Negotiate an International Agreement", "4. Pass enabling legislation", "5 Increase Research and Development", "6. Deploy New Technologies", "7 Begin to Reduce Emissions." Ask people to open and read their sheets out loud, in sequence. As they do, gradually lower a piece of paper to the flame, so that it catches fire before they finish reading the last card. At that point, start to raise the paper, saying "I'm cutting emissions. Emissions are now falling." Of course, the paper remains ablaze. Once your arm is fully extended, extinguish the fire in a cup of water. Explain that the delays in the response of the political and economic system, and in the response of the climate to emissions reductions, mean a wait-and-see policy guarantees that action, if needed, will come too late. The climate passed a tipping point, so that even after emissions started to fall, warming and climate change continued. The candle exercise makes a powerful demonstration of the impact of time delays and reinforcing feedbacks, two concepts that research shows people have great difficulty understanding (Sterman 2011), and typically generates heated discussion among the delegates. A video of the candle demonstration by the first author in testimony before the City Council of Cambridge, Massachusetts is available at www.youtube.com/watch?v=Pn-Sn2nWa_o.

Second and Third Rounds of Negotiation

First round results typically yield proposals from each delegation that are collectively insufficient to stabilize atmospheric GHG concentrations or limit expected warming to 2°C. Delegates commonly assert that while they are willing to make some reductions compared to BAU, the other parties must make larger cuts (this dynamic is particularly strong between the US and other developed nations on the one hand and China and India on the other). The developed nations argue that China is now the world's largest emitter and must commit to large reductions, while China and India argue that the developed nations caused the problem and must bear the largest share of emissions reductions to pay for the harm they have caused and to allow the poor nations to develop their economies. Point out that these positions are similar to those taken in actual negotiations, as illustrated by Table 3, an excerpt from the transcript of the private head of state meeting during COP15 in Copenhagen. Secretly recorded and leaked to the media, the transcript reveals a highly charged atmosphere with the developed and developing nations blaming each other for the problem and demanding that the other make larger cuts. The arguments used by the delegates in the first round of *World Climate* are often strikingly similar.

The Secretary General should then send the delegates back for another round of negotiation, charging them to find an agreement that collectively reduces global emissions enough to limit expected warming to 2°C.

The second round ends with another set of plenary addresses in which each delegation presents their new proposal. Enter these into C-ROADS and show their simulated impacts, beginning with global emissions, then moving through GHG concentrations, the "bathtub" view of emissions and removal, expected temperature increase, ocean pH, and sea level rise. Global emissions after the second round are typically lower than in the first, but still fail to limit expected warming to 2°C. After discussion, the Secretary General should then send the delegates back for a third round of negotiation. The Secretary General may depart from protocol at this point and moderate a negotiation among the group as a whole, similar to the last-minute, all night talks at COP17.

Enter the new proposals into C-ROADS and show the results. In our experience, delegates often begin the role-play in a distributive, zero-sum mode, blaming other nations for the problem and seeking to avoid (what they fear will be) free riding by others in a global common pool resource system. After several rounds, the negotiating posture of the delegates sometimes shifts from a largely distributive, blame-oriented frame to a more integrative frame emphasizing the common interests of all parties in limiting the risks of climate change. The facilitators may promote this shift in frame by asking individual delegations how inaction will hurt their own nations, and challenging them to help the other delegations understand that they also face serious risks if there is no agreement. Although C-ROADS does not estimate impacts at the national or regional level, the local effects of sea level rise (discussed above) provide delegates with information about the specific risks to their nations. Facilitators can also provide downscaled information about local risks related to water availability, extreme weather, and other impacts using reports from the IPCC (e.g., IPCC 2011), the US Global Change Research Program (www.globalchange.gov) and other current literature. For example, delegates representing the less-developed nations recognize that they will suffer the most from sea level rise, droughts, and other climate impacts, while simultaneously being least able to adapt to these changes, while those representing the developed nations see that such impacts will create refugees, political turmoil, and conflict, posing economic and national security threats to the developed world (see Hasselman *et al*. 2012 for discussion of distributive vs. integrative approaches to climate policy). When this shift in frame occurs, the delegates often propose emissions cuts causing global emissions to peak between 2020 and 2030 and decline substantially thereafter, with significant commitments to REDD+ policies and pledges for aid from the developed nations (including China) to the $100 Billion/year fund for mitigation and adaptation.

Debriefing

As the negotiation ends, emotions among the delegates range from elation, if they reached an agreement, to skepticism, cynicism and even despair about the feasibility of reaching an

agreement in the real world, the technical feasibility of cutting emissions, or the costs of doing so. The debriefing should address these issues, cement key insights about the dynamics of the climate, and, if appropriate for the context, connect the lessons people learned to personal commitments to action. If time permits, change the seating in the room, mixing participants so they no longer sit with their delegations. Ideally, create a large circle to maximize the ability of people to see each other. The "Secretary General" can now step out of role and smile again. Begin the debrief by asking people to speak to each other in pairs about how it felt to play their role and how they feel about the outcome, then share their feelings with the group as a whole. Stress that this is not the time to evaluate the model or climate policy, but to talk about their feelings, e.g., angry, depressed, scared, glad, confused. Acknowledging their feelings helps participants look at possibilities for action, rather than becoming discouraged.

To address the question of feasibility, the present the debriefing slides available from Climate Interactive. Many participants do not know that significant reductions in emissions are technically feasible today, with off-the-shelf technology, and many of them, particularly efficiency measures, are economically attractive even at current energy prices. The slides also show the rapid cost declines for, and dramatic exponential growth of, renewable technologies such as wind and solar. Tailor the slides to the regions and examples that are most personally relevant to you and to the participants.

Participants often raise controversial issues such as geoengineering and nuclear power, issues of equity and burden sharing among the developed and developing nations, and the political difficulties of reaching an agreement. The latter point provides an opportunity to elicit participants' (often implicit) theories of social and political change. Some believe change must come from national leaders and governments; others that government should not be involved, with innovation and leadership arising from the private sector. Others argue that political and business leaders cannot act without sufficient grass-roots support, that change will come when enough people vote at the ballot box for leaders who support emissions reductions and vote with their dollars in the marketplace for businesses whose products and services are sustainable. Still

others call for mass demonstrations similar to the civil rights movement or the 2011 Occupy movement. Facilitators should not advocate for any particular theory of change but instead help participants share and discuss their beliefs about how significant change can be achieved and how they, as individuals, can contribute to it.

We stress again that *World Climate* is not a platform for advocacy. Participants are free to propose any policies they like, including no action, and have: some sessions yield strong agreements to cut emissions and fund adaptation and mitigation; others continue BAU policies. However, the role-play should not be merely an exercise, but should connect with people at the personal level, including how they may change their behavior (if at all) after the experience. Research shows that having people publicly commit to an action increases the likelihood that they will follow through (see Cialdini 2009). Ask participants how the results may have changed their thinking about the climate change challenge, including what, if anything, they are willing to change in their professional and personal lives. Participants in our sessions have committed to insulating their homes, buying efficient lighting, bicycling instead of driving, and action at the local, state and/or national levels including promoting energy efficiency and renewables in their own community, joining activist organizations—and learning how to run *World Climate* and offering it for members of their community, religious congregation, school, or university.

Finally, after formally closing the session, thanking event hosts and sponsors, other facilitators, and the participants, ask the participants to complete an evaluation so they can comment on the experience, offer suggestions for improvement, and put down in writing what, if any, actions they will now take to reduce their emissions or get involved in the political process.

Evaluations

Formal evaluations of *World Climate* are sparse; this is an area where future research is needed. Here we offer two examples covering quite different participants and contexts.

Example 1: In 2011 author JRV taught an elective course entitled "Climate Change: Science, Communication, and Solutions" at the University of Massachusetts, Lowell. Students

(N=25, 13 undergraduate and 12 graduate students; ages 19-26) completed various exercises, including writing an op-ed article on climate change science or policy, creating a public service announcement video on climate change, exploring climate models and climate science, and *World Climate*, using C-ROADS and the 6-party mode. The course was formally assessed at the end of the semester by an independent external evaluator as a requirement of a NASA Global Climate Change Education grant, which funded curriculum development. The assessment included a survey and focus group with the students. The evaluator reported, "When asked about which assignments to keep and which to eliminate, all respondents wanted to keep the World Climate exercise and the video script assignment." *World Climate* was cited as among the course activities "promoting the most learning." A video of students describing their experience is available at climateinteractive.org/simulations/world-climate/media/videos.

After the course, 72% of respondents rated their depth of understanding of the UNFCCC negotiation process as "High" or "Very high," with all but one indicating that their depth of understanding "was influenced by the World Climate role playing exercise." Asked how, written comments from the participants included:

- More understanding of the countries I represent
- Experience → Learning
- Everything just seemed to become real. Science didn't seem to make a difference though
- Better understanding of the views of other countries
- I just got a better feel for what happens during these summits
- I understood what was involved in negotiations
- Made me realize why getting this solved is hard globally
- Participating made me understand better than the lecture.
- It increased. Let me stress, I love this exercise
- The ability to participate in world climate made me realize the challenges involved in agreeing to reduce emissions

Students' written comments on World Climate included:

> "Although this was just a simulation, I think everyone did a good job getting into their roles and holding true to the nation(s) they were assigned to. This made it all the more shocking. We all knew that after class, no matter what happened, we would be able to walk away and our outcome wouldn't matter. But what if it was real? I can see now why little gets done in negotiations, because there is so much at stake…."

> "The mock negotiation provided us with a great deal of insight into climate negotiations, and the methods used to reach decisions. The hands-on experience in class left a much deeper impression than simply reading or attending a lecture on the subject, and I am glad we performed this exercise in class."

After meeting with students in a focus group the evaluator reported:

> "The World Climate Exercise was also seen as a powerful experience, and no one had any negative things to say about it. They particularly appreciated the experience of approaching the issue from a point of view other than their own."

Example 2: in June 2010, the first author facilitated *World Climate* for approximately 100 mid-career executive MBA students at the MIT Sloan School of Management as part of the orientation program during their first week on campus. Two sessions of about 50 people each were run, using C-ROADS with six negotiating parties. In contrast to example 1, the participants were much older (approximately 35-45), with extensive business and management experience. At the end of their program roughly a year later, the participants were asked to complete a survey on sustainability issues, including their *World Climate* experience. Participants responded on a 5-point scale (with anchors "1. Not important," "3. Indifferent," "5. Extremely important"). Asked "Do you think it is important to discuss sustainability and climate change" as part of the required curriculum, a total of 88% chose Extremely important (74%) or somewhat important (14%), while a total of 7% chose Not Important (2%) or Somewhat unimportant (5%).

Asked whether the *World Climate* exercise should be required in their curriculum, a total of 69% selected Extremely important (48%) or Important (21%), while a total of 20% selected Not important (15%) or Somewhat unimportant (5%). The written comments show that some who rated the exercise Not important believe it should have been optional, not required. Others had strong reactions to the intensity of the interactive format:

> "It can be a bit shocking and might challenge the views of many as well as what they might consider to be an appropriate way to communicate a message. But it is a very important exercise to shake people up and get them thinking about important issues…that they often never think about because they are too busy…. Need more time for discussion after the simulation to give participants ideas about what they can do."

> "I think this was a very powerful exercise. Even if it made some people uncomfortable, it is important."

The strongly positive evaluations from the executive MBA participants are particularly noteworthy because these executives were not admitted to the program based on any pre-existing interest in climate change or environmental issues and were required to participate in *World*

Climate, ruling out selection bias as an explanation for positive evaluations.

Although these examples provide some confidence that the role-play can be effective with diverse audiences, further evaluation work is needed due to the heterogeneous nature of the participants in *World Climate*, from high school students to business leaders and policymakers.

Summary

World Climate is an interactive role-play simulation of global climate negotiations designed to help people learn about the science of climate change and the economic, social and political challenges in reaching agreements to limit the risks of anthropogenic climate change. The role-play combines a highly interactive face-to-face negotiation format with the C-ROADS climate policy simulation to provide participants with immediate feedback on the implications of their proposals on likely changes in the climate. *World Climate* enables participants to explore the dynamics of the climate and impact of proposed policies in a way that is consistent with the best available peer-reviewed science but that does not prescribe what should be done—participants are free to try any policies they desire and can examine a wide range of assumptions about the processes governing climate change. The combination of the role-play with a simulation model rigorously grounded in the best available science enables participants to learn, for themselves, about the structure and dynamics of the climate, and the ecological, economic and geopolitical issues involved in climate policy. *World Climate* has been used successfully with a wide range of participants, including students, business executives and political leaders.

All the materials needed to learn and run *World Climate*, including the C-ROADS and C-Learn simulation models, are freely available from climateinteractive.org.

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Materials

Briefing Memos for each delegation (1 per participant)
Nametags/credentials for delegates (1 per participant)
Placards with delegation name for tables (1 per delegation)
Proposal Record Sheets (several per delegation)
1 table for each delegation with sufficient chairs for each participant
Food/drinks for delegates representing developed nations
Computer with internet connection and/or access to C- ROADS/C-Learn model
Projector for computer output
Blackboard/Whiteboard/Flip Chart to record proposals, notes
Large sheet or tarpaulin to demonstrate impact of sea level rise
Candle, matches, large cup of water and/or fire extinguisher

Optional: Background readings (e.g., IPCC AR4 Summary for Policymakers)

Sequence of play

1. Welcome and introductions
2. Participants assigned to roles, take seats & read briefing memos
3. Secretary General calls the Conference of the Parties to order and addresses the delegates
4. Negotiation Round 1
    a. Negotiations among parties
    b. Two-minute plenary address by representative of each delegation outlining their proposal
    c. Proposals entered into C-ROADS or C-Learn model
    d. Results shown and discussed
    e. Sea level rise illustrated with sheet and website
    f. Bathtub dynamics discussed,
    g. Burning Candle demonstration
5. Negotiation Round 2 (steps a-d)
6. Negotiation Round 3 (steps a-d)
7. Secretary General brings negotiation to close
8. Debriefing
    a. Participant reactions, comments, feelings; shifts (if any) in negotiating positions across rounds noted and discussed.
    b. Implementation: can emissions be cut? Costs and barriers to implementation of participant proposals
    c. How can we catalyze change (participants' theories of change)
    d. Wrap-up: Personal aspirations and commitments to action
9. Thank yous; participant evaluations and feedback

Table 1. *World Climate* materials and sequence of play. Briefing memos and slides available at climateinteractive.org.

CONFIDENTIAL
Briefing for Upcoming Climate Negotiation
TO: ***United States*** Negotiators at UN conference on Climate Change
SUBJECT: Our negotiating goals

You head the United States delegation at the upcoming negotiations on climate change.

The best available science shows the risks of climate change are real and serious. The United States seeks to negotiate a global agreement to reduce greenhouse gas (GHG) emissions that achieves the best outcome for our economy and vital national interests, as well as for the world. The public in our country generally believes climate change is real, and that human activity contributes significantly to it. Most support agreements to address the climate change issue. However, most oppose higher taxes on energy or other actions that will raise the cost of living. Climate change ranks near the bottom of most people's priorities, far below jobs, the economy, two wars, and terrorism.

Most importantly, the public is strongly opposed to any agreement that does not require mandatory commitments by the developing nations, particularly China and India. With unemployment still high people fear that actions to limit emissions will harm US competitiveness, hurting both businesses and workers as profits and jobs move offshore even faster than they are now. Any agreement that puts the greatest economic burden of limiting climate change on the US is not politically acceptable. After the Kyoto Accord was signed the US senate passed a resolution opposing any agreement limiting US GHG emissions unless there were also mandatory limits for China, India and other developing nations. The resolution passed 95-0.… The Bush administration then formally withdrew from Kyoto. The Obama administration proposed limits on US GHG emissions, but any treaty must be ratified by the US Senate. Cap and trade legislation designed to reduce US emissions died in 2010 without coming up for a vote.… Legislation limiting US GHG emissions cannot be passed without significant, binding, and verifiable commitments from China, India and the rest of the world.

China is now the world's largest emitter of GHGs, and its emissions and economy are growing far faster than ours.… The US cannot agree to action unless there are significant, verifiable agreements for emissions reductions from China and the rest of the world.

CONFIDENTIAL
Briefing for Upcoming Climate Negotiation
TO: Negotiators for ***China*** at UN conference on Climate Change
SUBJECT: Our negotiating goals

You head the Chinese delegation at the upcoming negotiations on climate change.

The best available science shows the risks of climate change are real and serious. China seeks to negotiate a global agreement to reduce greenhouse gas (GHG) emissions that can limit those risks, but seeks the best outcome for our economy and vital national interests. Many people in our country believe climate change is real, though fewer support agreements to address the climate change issue.… Our economy is growing rapidly and we are emerging as a global superpower. However, our average standard of living is far less than that in the US, Europe, Japan, and other developed nations. Our top priority is economic development. Our people, like people everywhere, want to live in a healthy environment, but also want to increase their standard of living: a healthy environment includes having the means to provide for decent jobs, housing, food, healthcare, mobility and national security.

….[T]he developed nations will pressure us to reduce our emissions because we are now the world's largest GHG emitter and because our economy and GHG emissions are growing faster than theirs. However, emissions per capita in these nations are far higher than ours (US emissions per capita are roughly 5 times higher than China's and an astounding 20 times higher than India's). Any agreement that puts the greatest burden of limiting climate change on us is not acceptable.…

The developed nations of the world created the climate crisis, and must take responsibility for their past actions. Nearly 80% of the total CO_2 released by burning fossil fuels since the start of the industrial revolution came from the developed nations. These nations used that energy to build their economies and enrich their populations, often by exploiting our natural resources. The developed nations will demand that we cut our emissions before our people have the chance to reach even the level of economic development they now enjoy, and while many of our people continue to live in poverty. We are prepared to do our share, but the rich nations of the world must agree to significant action, commensurate with their past contribution to the problem. We will not pay the price for their past emissions.

Table 2. Excerpts from briefing memoranda for the United States and China.

German Chancellor Angela Merkel (addressing the Chinese representative): "Let us suppose 100 percent reduction, that is, no CO_2 [emissions] in the developed countries anymore. Even then, with the [target of] two degrees, you have to reduce carbon emissions in the developing countries. That is the truth."

Chinese deputy foreign minister He Yafei: "People tend to forget where it is from. In the past 200 years of industrialization developed countries contributed more than 80 percent of emissions. Whoever created this problem is responsible for the catastrophe we are facing."

US President Barack Obama: "If there is no sense of mutuality in this process, it is going to be difficult for us to ever move forward in a significant way."

French President Nikolas Sarkozy: "I say this with all due respect and in all friendship….With all due respect to China…[The developed countries have pledged to reduce greenhouse gas emissions by 80 percent.] And in return, China, which will soon be the biggest economic power in the world, says to the world: 'Commitments apply to you, but not to us.' This is utterly unacceptable! This is about the essentials, and one has to react to this hypocrisy!"

Chinese deputy foreign minister He Yafei: "Thank you for all these suggestions. We have said very clearly that we must not accept the 50 percent reductions. We cannot accept it."

Table 3. Excerpts from transcript of private heads of state meeting, Copenhagen Climate Conference, December 2009. Source: Der Spiegel, www.spiegel.de/international/world/0,1518,692861,00.html.

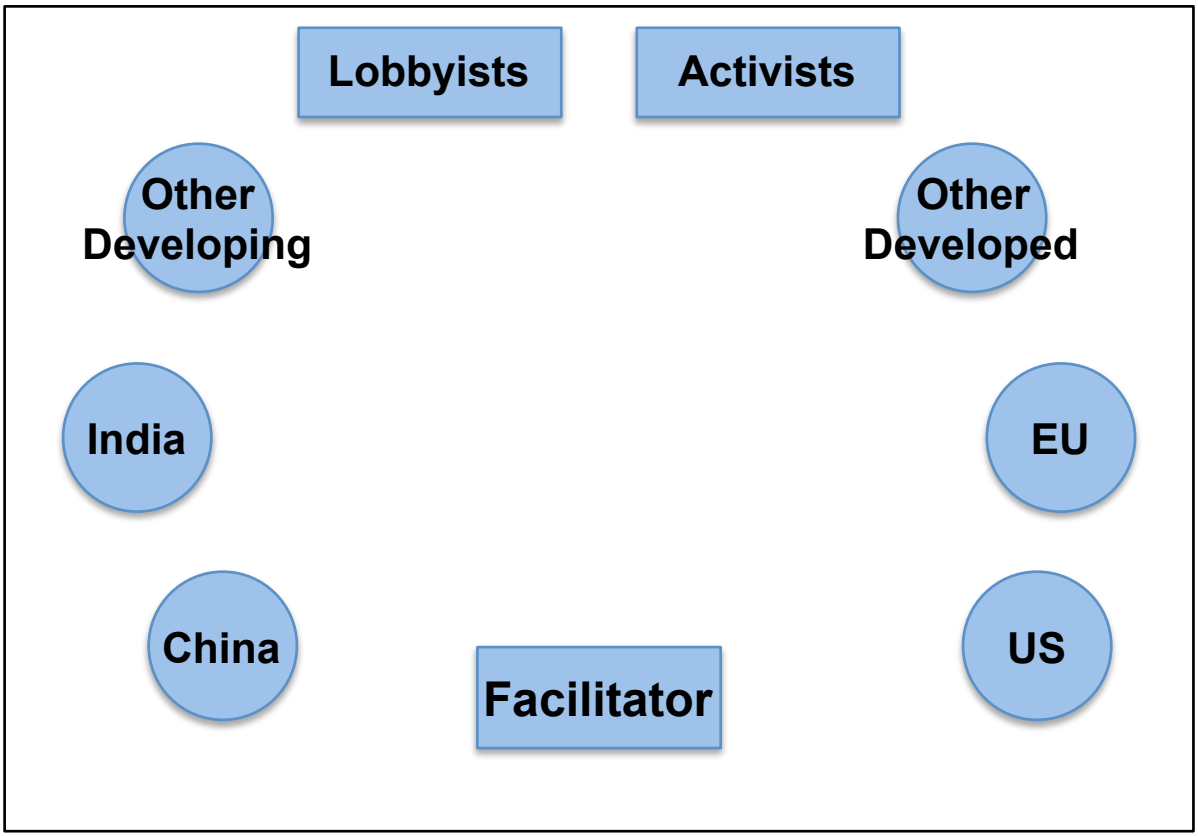
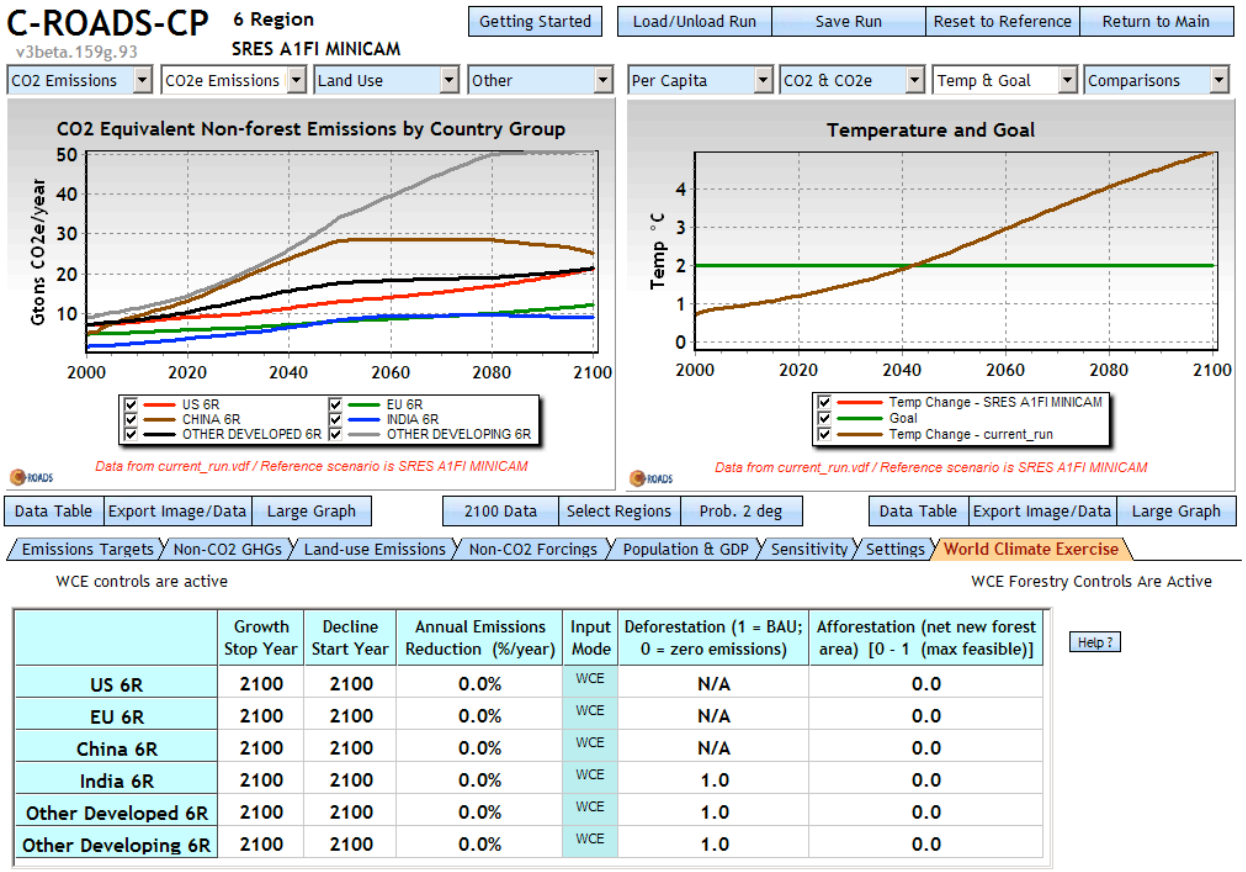


Figure 1. Typical room layout, for six-party mode with optional fossil fuel industry lobbyists and environmental activists. The large open space in the middle will be where the delegates representing the Other Developing Nations will be seated on the floor, and where delegates can meet to negotiate. The tables for the developed nations (US, EU, Other Developed) should have food and drink, while those of the developing nations (China, India, Other Developing) should be bare (Figure 2).



Figure 2. To create a visceral impression of the disparity in wealth and power among nations, delegates from the developed nations are seated at tables laden with food, while those from China and India have no food at their tables and those representing the least developed nations sit on the floor.



	Growth Stop Year	Decline Start Year	Annual Emissions Reduction (%/year)	Input Mode	Deforestation (1 = BAU; 0 = zero emissions)	Afforestation (net new forest area) [0 - 1 (max feasible)]
US 6R	2100	2100	0.0%	WCE	N/A	0.0
EU 6R	2100	2100	0.0%	WCE	N/A	0.0
China 6R	2100	2100	0.0%	WCE	N/A	0.0
India 6R	2100	2100	0.0%	WCE	1.0	0.0
Other Developed 6R	2100	2100	0.0%	WCE	1.0	0.0
Other Developing 6R	2100	2100	0.0%	WCE	1.0	0.0

Figure 3. C-ROADS main screen, showing the emissions for each of the six nations/blocs (left graph) with projected future global mean surface temperature (right graph). This view shows the Table Entry format for *World Climate* through which facilitators can enter delegate decisions. More advanced modes of entering emissions pathways, and for sensitivity analysis, are available through the other tabs. C-ROADS is freely available for download from climateinteractive.org.

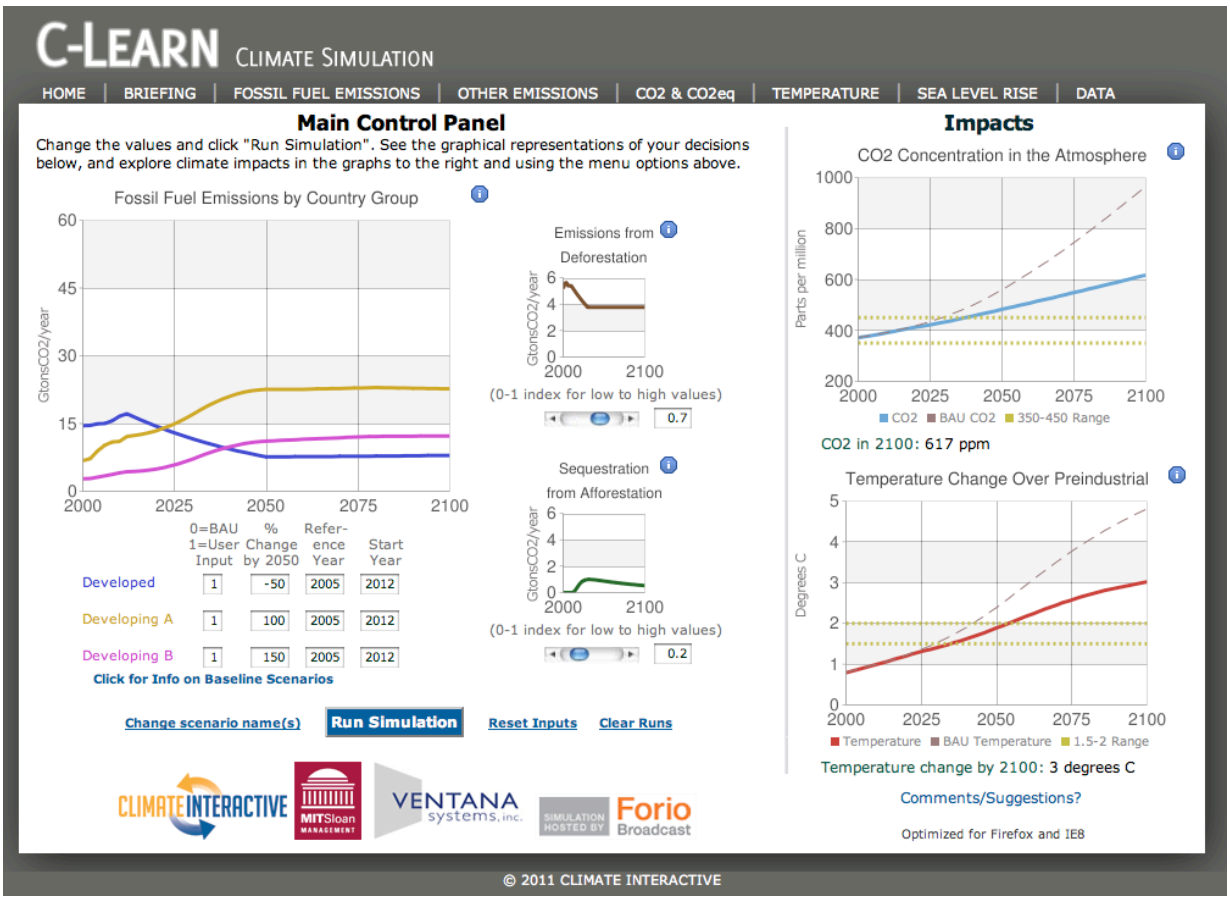


Figure 4. C-Learn main screen, showing a hypothetical set of policies for emissions for each of the three blocs of nations (left graph), and impacts on the climate (right graphs). Tabs at the top provide instructions, documentation and detailed output. C-Learn runs over the internet and is freely available online at climateinteractive.org.

Proposal Form

- **Region:** _____
- **CO_2 Emissions growth stop year:** _____
- **CO_2 Emissions decline start year:** _____
- **Fractional rate of decline (%/year):** _____
- **REDD+ (Reduction in Emissions from Deforestation and land Degradation)**_____
  India, Other Developed, Other Developing only:
  (1 = no reduction from BAU; 0 = max reduction)
- **Afforestation (net new forest area)** _____
  All nations/regions: (0 = no new afforestation area; 1 = maximum feasible)
- **Your region's contribution to fund for mitigation and adaptation ($B/year):** _____

Figure 5. Proposal form for each delegation (6 delegation version).

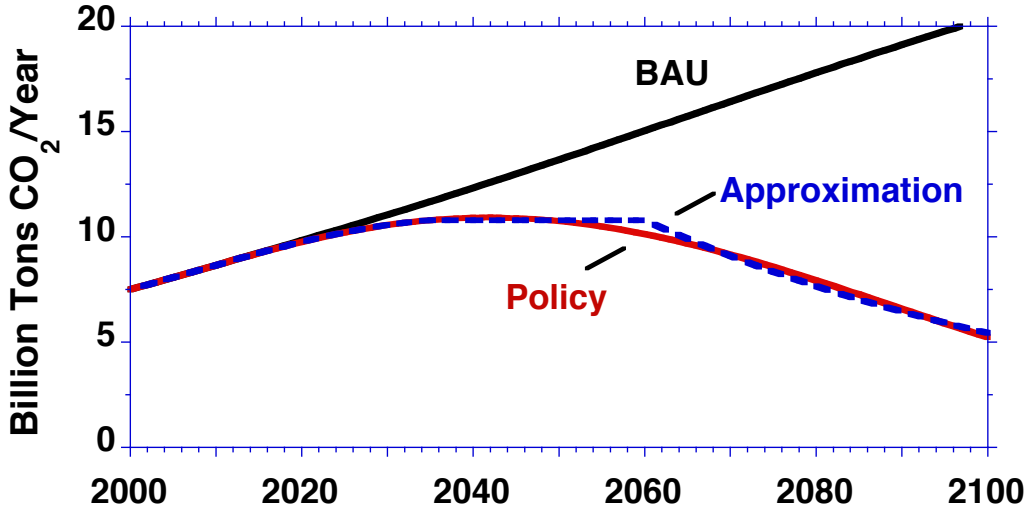


Figure 6. Hypothetical emissions path for the US, illustrating how specifying an emissions growth stop year, emissions decline start year and decline rate provide a good approximation to smooth projections of emissions under reductions policies. In the example, the growth rate in US CO_2 emissions under the hypothetical policy declines linearly from the BAU rate of 1.3%/year in 2012 to –2.5%/year in 2100, causing emissions to peak in 2042. The smooth Policy pathway is closely approximated by a growth stop year of 2035, a decline start year of 2060, and a fractional decline rate of 1.7%/year.

Proposal Summary

	Emissions Growth Stop Year	Emissions Reduction Start Year	Annual Emissions Reduction (%/year)	REDD (1 = BAU; 0 = zero emissions)	New Afforestation Area (0-1 [max feasible])	Contribution to (or Draw on) Fund ($ Billion/yr)
United States				**NA**		
European Union				**NA**		
Other Developed						
China				**NA**		
India						
Other Developing						
Example	*2075*	*2085*	*1.0%/year*	*0.8*	*0.1*	*$10 B/yr*

Figure 7. Summary table of delegate proposals to be projected or written on the blackboard as each delegation presents their proposals during their plenary presentations.



Figure 8. Often, the first round proposals lead to small emissions reductions and a large increase in sea level. To show the impact of sea level rise on their populations, the facilitator covers the delegates representing the developing nations (those sitting on the floor) with a large sheet. In some sessions, those covered by the sheet spontaneously become climate refugees, taking the seats of the other delegations, a highly effective illustration of the destabilizing impact of sea level rise.

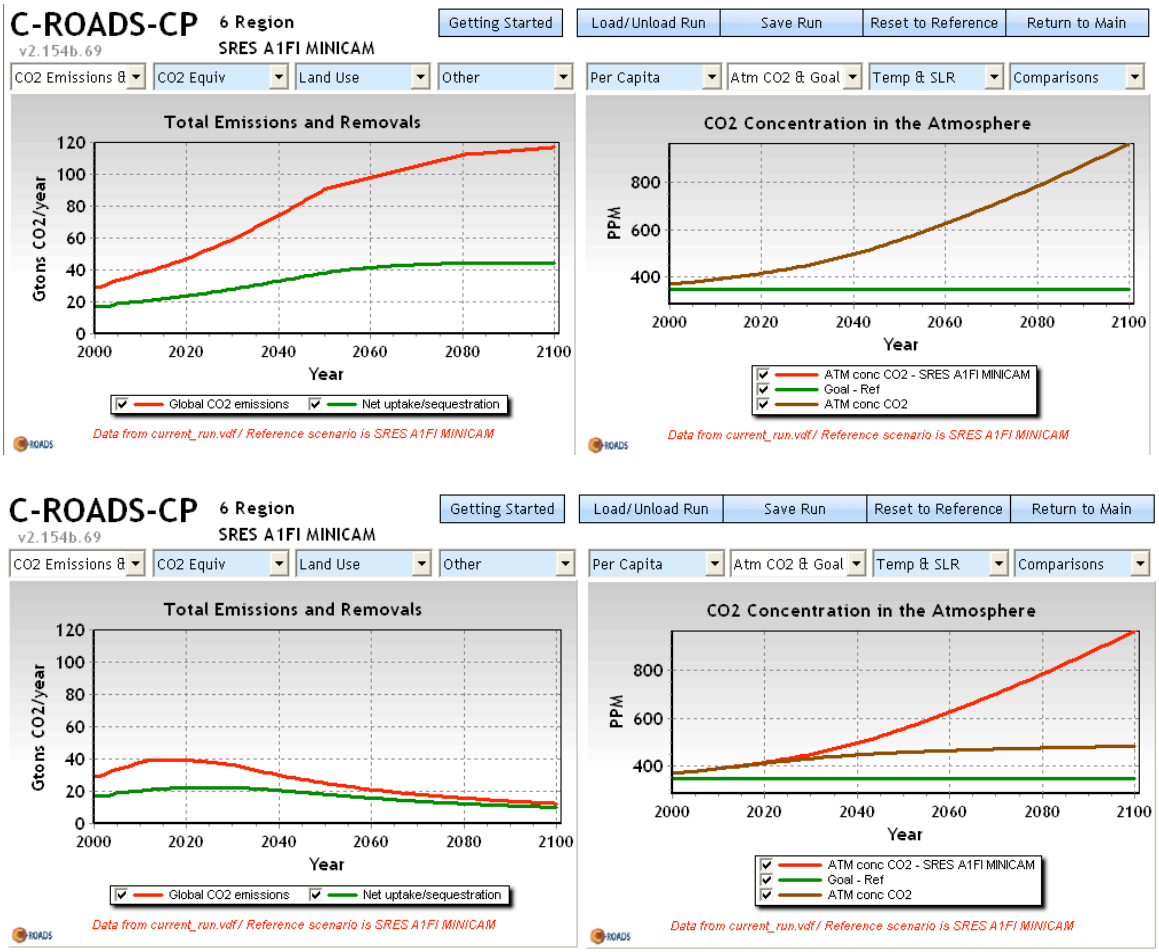


Figure 9. Carbon mass balance or "bathtub dynamics" illustrated by C-ROADS. Top: The graph on the left shows the inflow to the stock of atmospheric CO_2 (global CO_2 emissions; red line) and the outflow of CO_2 from the stock in the atmosphere (net CO_2 removal as it is taken up by biomass and dissolves in the ocean; green line). The inflow always exceeds the outflow, so the level of CO_2 in the atmosphere rises continuously. Further, the gap between inflow and outflow increases over time, so concentrations rise at an increasing rate, reaching 965 ppm by 2100. To stabilize atmospheric CO_2 concentrations, emissions must fall to net removal. Bottom: A scenario in which global emissions peak around 2020 and fall to roughly a third of the 2005 flux by 2100, by which time emissions and net removal are nearly in balance, so that CO_2 concentrations nearly stabilize (in this scenario, at about 485 ppm). Note that net emissions fall in the stabilization scenario: lower atmospheric CO_2 concentrations reduce net uptake of CO_2 by biomass and the oceans.

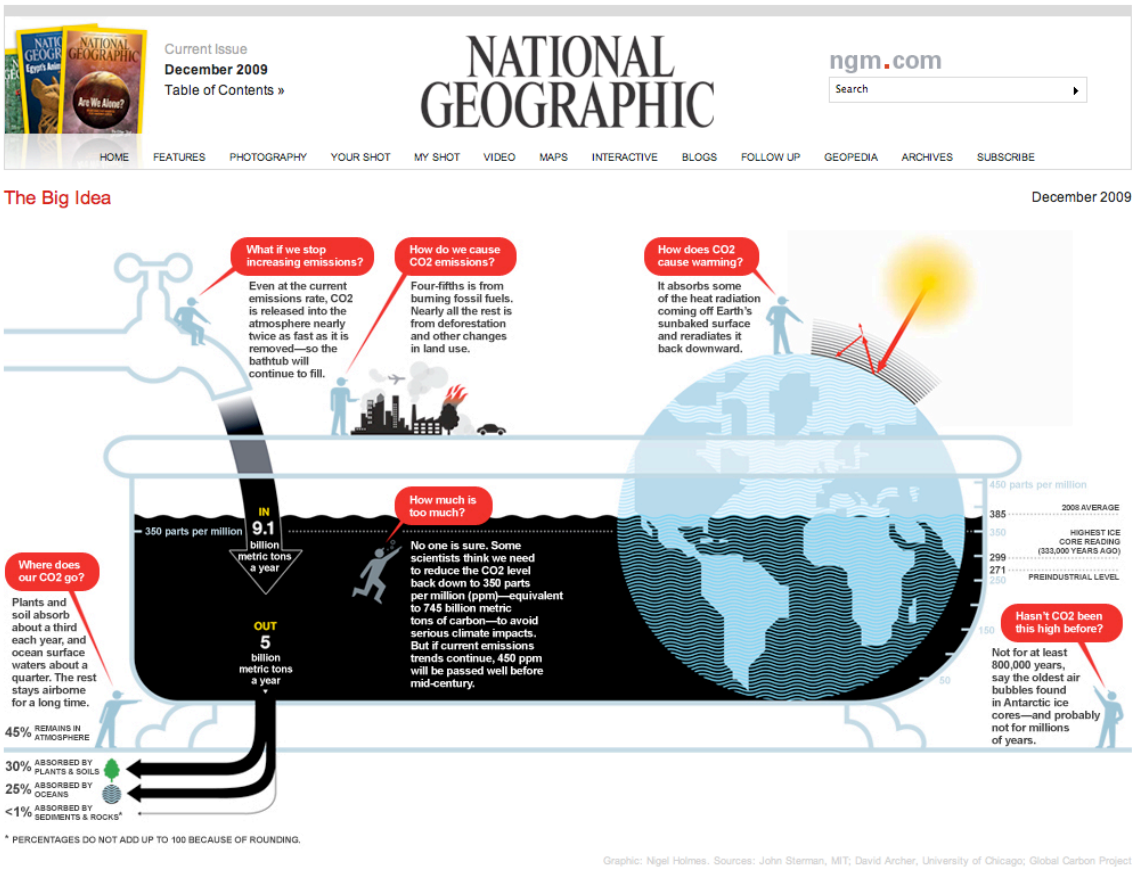


Figure 10. The Carbon Bathtub: The stock of CO_2 in the atmosphere is analogous to the level of water in a bathtub. Like any stock, atmospheric CO_2 rises only when the inflow to the tub (emissions) exceeds the outflow (net removal, primarily due to net CO_2 taken up by biomass and dissolving in the oceans), is unchanging only when inflow equals outflow, and falls only when outflow exceeds inflow.

Source: *National Geographic*, December 2009. Available at ngm.nationalgeographic.com/big-idea/05/carbon-bath.

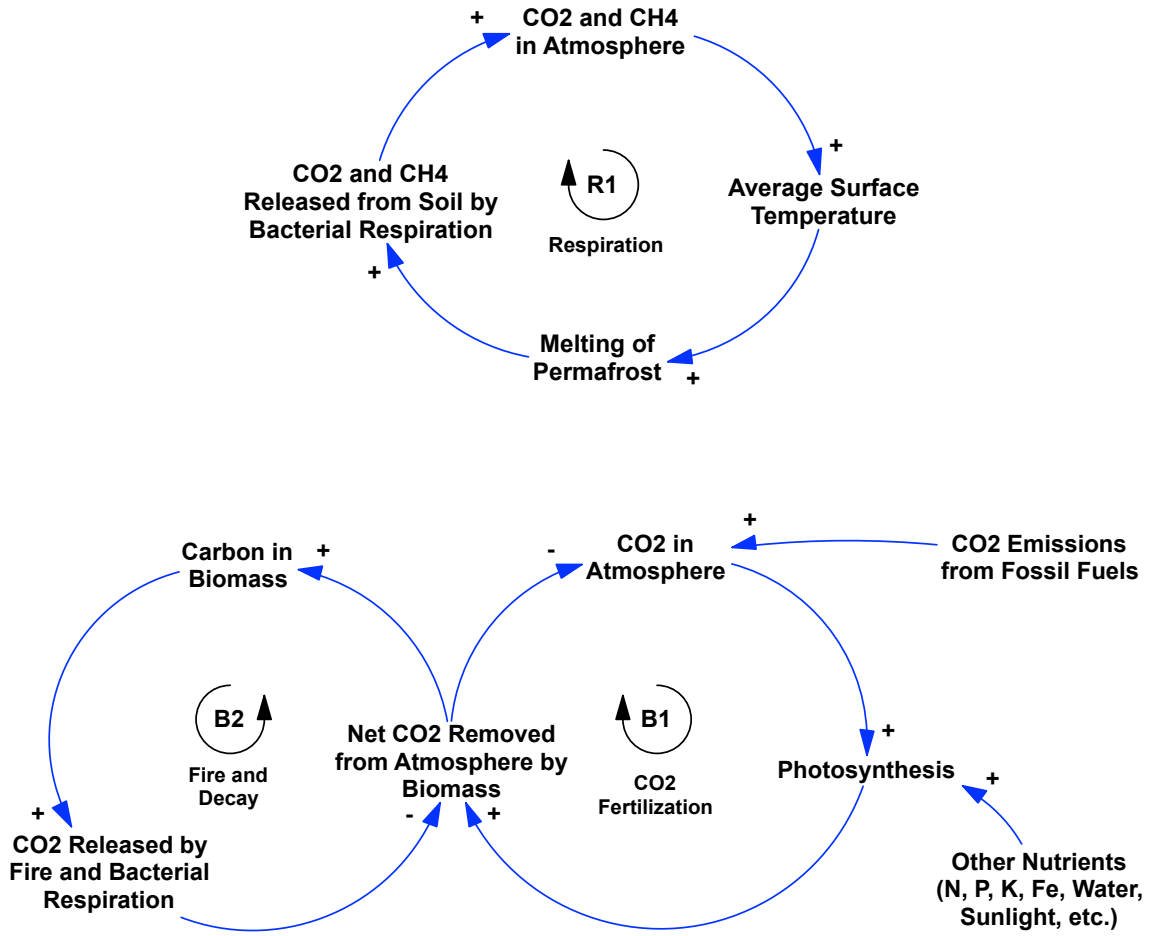


Figure 11. Causal diagrams illustrating feedback processes that affect net removal of GHGs from the atmosphere. Arrows indicate causal influence; arrow polarity, e.g., $x \xrightarrow{+} y$, indicates an increase in x raises y above what it would have been otherwise; $x \xrightarrow{-} y$ indicates an increase in x lowers y below what it would have been otherwise (Sterman 2000, ch. 5 provides formal definitions and examples). Top: Reinforcing (positive) ice-albedo feedback. For clarity, the diagram shows a single loop. Bottom: Balancing (negative) feedbacks around CO_2 fertilization. Diagram shows two loops to illustrate constraints on net CO_2 uptake by biomass as the biomass eventuall burns or dies and is metabolized by bacteria and fungi, releasing CO_2 into the atmosphere. Limits on the availability of other macro and micro nutrients also constrain plant growth even as CO_2 concentrations rise.