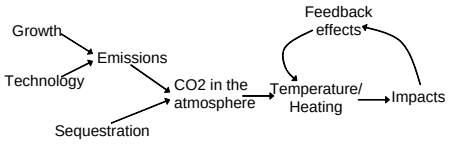

The Climate Sims: Interactive Online Models to Support Learning

Sustainability Institute

Project Team
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Overview

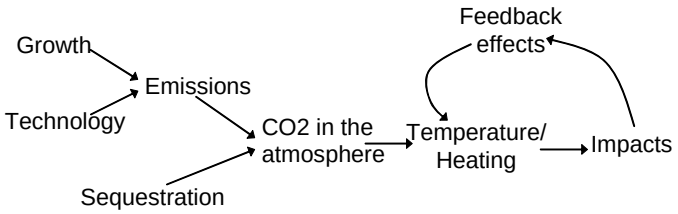
It is becoming increasingly clear that society is going to need to reduce CO_2 emissions on the order of 75% over the next decades in order to avert the most significant damages from climate change. How to engage people to take the needed action?

Experimental studies by Sterman and Sweeney have shown that most people misunderstand the core dynamics of the complex carbon-climate-economic-social system and that these misunderstandings may lead to inaction. (See their recent paper in *Climatic Change*.)

Therefore, we are proposing to develop a broadly-accessible on-line experience that can lead large numbers of people to better understand the dynamics of this important system and, thus, understand what sort of action would be needed.

Our proposed mechanism is a suite of online simulation experiences that help learners, at a deep, visceral level, to understand the dynamics of the climate system.

The insights the learners gain will help them become more effective advocates for and implementers of significant responses to climate change.



The Overall System

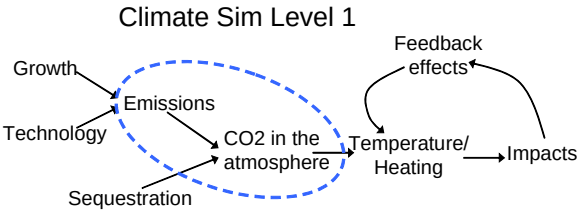
For people to advocate for change at the scale that is needed to address climate change, they need to understand the dynamics of a complex physical, social, and economic system.

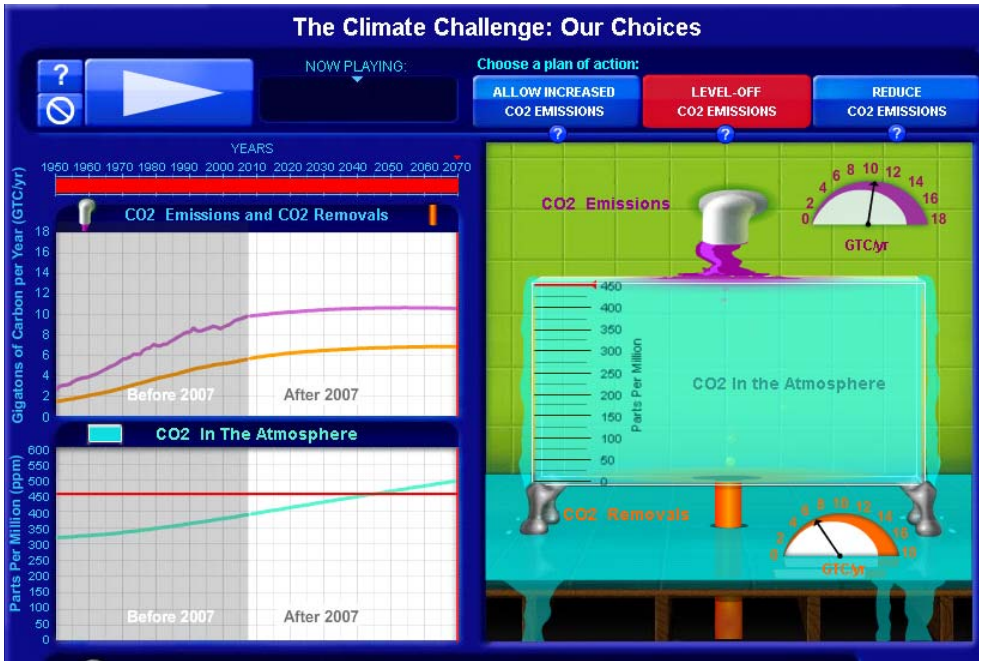
Progress To Date

We have completed a draft of a prototype simulator that explores the relationship between emissions and atmospheric CO_2. Designed with 12-18 year-olds in mind and situated on SEED/Schlumberger's science education website (SEED also holds the copyright for this level 1 Sim), the Climate Bathtub Simulator creates an engaging experience for understanding a simple but powerful principle regarding facing climate change: it will be insufficient to level-off CO_2 emissions at recent levels. Deep cuts are needed.

As the system map shows, the Sim addresses one part of the overall system.

The Sim will also be useful for businesspeople, government leaders, and adult citizens. Peter Senge is planning to present it to international leaders and heads of state at the June Tallberg Forum. We are currently exploring other venues to use the Sim or an adapted version of it.





Proposed Sims

We are proposing to develop a suite of several other integrated and mutually supporting Sims to address different aspects of the "climate challenge" question.

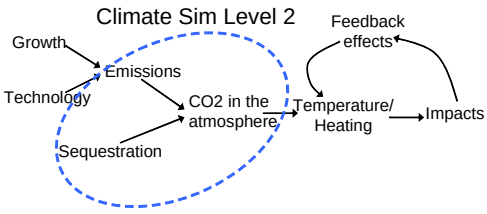
These Sims include:

1. The effect of emissions futures on atmospheric CO_2 (underway)

2. Contribution of carbon sequestration
3. What it will take to reduce emissions – growth and technology
4. The effects of CO2 on global temperature
5. Feedback effects - the potential for climate change to feed on itself.
6. What instrument will work – the dynamics of carbon trading and taxes

Level 2: Contribution of carbon sequestration and emissions

The Level 1 simulator helps a learner conclude that we will need significant reductions in CO_2 emissions in order to keep atmospheric CO_2 below a goal such as 450 ppm. However, one might ask, how much of a contribution to reducing atmospheric CO2 can carbon sequestration make, and over what time frame? And how will a combination of sequestration and emissions reduction interact to produce the results we would like to see? In particular, what will happen with emissions reductions that fall in-between the three scenarios in the "Level 1" simulator?

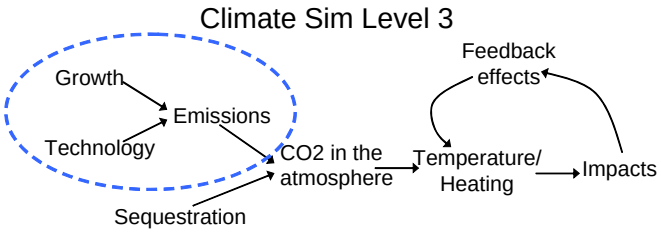


The Level 2 simulator will allow the learner to experiment with different actions such as pumping CO2 into deep wells and increasing the growing of trees at the same time as they reduce emissions as much as they would like – 20%, 38%, 82%, etc.

Level 3: What it will take to reduce emissions – growth and technology

As we noted in the last section, the Level 1 simulator helps a learner conclude that we will need significant reductions in CO_2 emissions in order to keep atmospheric CO_2 below a goal such as 450 ppm. The next questions we'd want a learner to explore are: What will it take? Can we wait to act? How much action is necessary?

More specifically, we intend to give the learner a challenge (e.g., "Try to reduce emissions 80% by 2080!) and allow the learner to manipulate sliders or click buttons in the Sim to choose different future paths for economic growth and the adoption of new technologies such as efficient cars, buildings, factories etc. The learner will see their results on a graph and in a graphic analogous to the bathtub in Level 1.

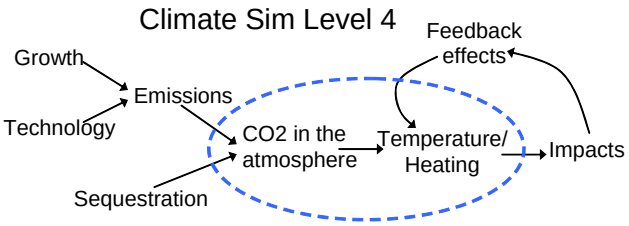


It is widely acknowledge that addressing climate change will require wide-spread change. This aspect of the simulation will help learners grapple with just how fundamental that change must be, reaching in to the dynamics of economic growth and technology implementation.

Level 4: The effects of CO_2 on global temperature

Given various futures for CO_2 in the atmosphere, what will be the effects on global temperature? The connection in one sense is quite simple – rising CO_2 levels increase temperature. But the extent and the timing of the effects are actually quite complex. For example, few understand that the symptoms of climate change we experience today are the result of emissions from three decades in the past, or that falling CO_2 levels could still

lead to increasing temperatures, if levels of CO_2 are high enough to trap more heat each year than is released into space . Further, experiments by Sterman and Sweeney show that even quite mathematically proficient people misunderstand these dynamics, leading to serious policy implications.

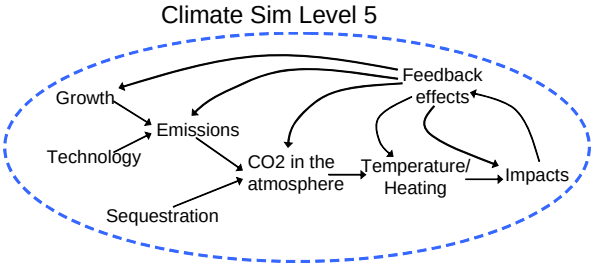


These long lag times between emissions and temperature effects provide additional motivation for immediate action on climate change, and learners who have internalized this aspect of the dynamics will make better advocates for immediate action. Thus, this Sim will help the learner experiment with in the relation between emissions choices and temperature consequences in a graphically engaging simulation.

Level 5: Feedback effects from impacts

The carbon/climate system is non-linear – small changes can yield large impacts. The non-linearity is due to the multiple feedback effects in the system. Higher temperatures could reduce reflective ice and increase heat-absorbing land, thereby increasing temperatures, for example.

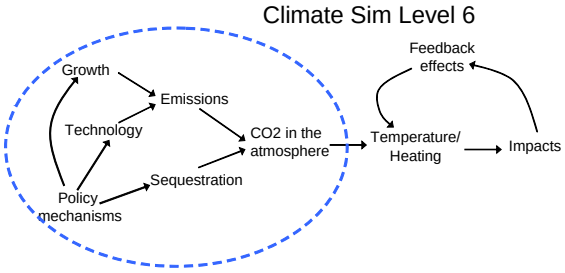
Level 5 will help the learner understand the various feedback effects through the use of an interactive causal loop diagram that spells out the various causes and effects and supports them with data. This Sim will not include a running computer model, like the others.



This aspect of the Sim will emphasize and explain the narrow window of opportunity we have to act – the very short period, perhaps one decade, before these positive feedback loops grow strong enough to be unstoppable by human intervention.

Level 6: What instrument will work – the dynamics of carbon trading and taxes

Through the other Sims, it will clear to the learner that emissions reductions will be necessary. But how to create the incentives to reduce emissions?



This Sim will explore the dynamics of "Cap and Trade" programs with carbon markets and approaches such as a Carbon Tax.

We envision this Sim as part of this suite of Sims, but it is not part of the budget below.

The Team

We envision pulling together a team to create the Sim. Current members include:

Drew Jones, SI

Drew is serving at the project director for this effort. His expertise is creating learning experiences that help System Dynamics simulation models to generate action.

Peter Senge. SoL

Peter hopes to use the Sim in multiple settings, including a session at the June Tallberg Forum with global leaders and in many other settings.

John Sterman, MIT

John provides scientific depth both in dynamic modeling and climate science. His paper on learning about climate with Linda Booth Sweeney (which, in part, motivated the need for these Sims) was recently published in Climatic Change.

Tom Fiddaman, SI

Tom is a highly experienced climate modeler who received his PHD from MIT with a system dynamics model of climate-economy issues. As he did for the Level 1 Sim, he will be creating the models behind the graphics. He will be working as an individual contractor through SI. His model website is http://www.sd3.info/ .

Linda Booth Sweeney, SoL

Linda is an expert in learning about complex systems such as climate change. She will be contributing to the learning plans and the Sim designs. Her paper on this topic was recently published in Climatic Change.

Michael Tempel, SEED

Michael contributes to the educational design with a strong grounding in the Sciences. The lead for the other SEED animated simulations on science and climate science, he will help manage the creation of the Sims, particularly the relationship with designers such as Mama Media.

http://www.seed.slb.com/en/scictr/watch/climate_change/index.htm

Elizabeth Sawin, SI

Beth is the founder of "Our Climate Ourselves" a Sustainability Institute effort funded by the Morgan Foundation to build support for action on climate change. An expert both in climate science and how to engage people at a deep level in taking action, she will help with Sim design and written support.

http://www.sustainabilityinstitute.org/oco/index.html

Nathan Senge, SEED

Nate is a researcher working on parameter estimation, documentation of model assumptions, and basic climate research.

Sustainability Institute

Sustainability Institute [www.sustainabilityinstitute.org] is the convening organization for this proposal.

The Sustainability Institute (SI), founded by the late Donella (Dana) Meadows, is committed to helping society move toward sustainability through its systems analysis, multi-stakeholder convenings, writing, teaching and mentoring. Applying the principles of organizational learning and system dynamics, SI works with individuals as well as public and private entities to identify key leverage points, shift mindsets, restructure systems, and help build the capacity necessary to manage, learn from, and adapt to complex environmental, social, and economic systems. Projects currently underway include:

- Convening diverse groups of stakeholders to shift unsustainable global food systems;
- Inspiring and empowering action on climate change;
- Building leadership capacities in sustainability professionals;
- Supporting public health leaders to prevent chronic disease; and
- Sharing training, games, and publications on sustainability issues.

SI has a staff of twelve, an active board and an annual operating budget of approximately $2 million. Current sources of funding include foundation grants, individual contributions and fee for service consulting. A 501c3 organization, SI operates out of our renovated 1950s farmhouse in Hartland, Vermont.