TJHSST Computer Systems Lab Senior Research Project
A System Dynamics Approach to Global Warming
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Abstract

Predicting the effects of increased amount of CO2 in the atmosphere is the key to understanding the long term effects of global warming. This project intends to do just that utilizing Netlogos System Dynamics Modeler. First part of the project is devoted to building a convincing model of Earths Ecosystem, including a carbon cycle and various other variables, and second part of the project is devoted to making the model relevant to the real world, by calibrating and validating results from the model. With two parts combined together, this project will be able to help people determine what consequences (if any) that increase amount of CO2 in the air can have on living creatures on earth.

Keywords: system dynamics, global warming, netlogo, stella, carbon dioxide, CO2

1 Introduction - Elaboration on the problem statement, purpose, and project scope

The issue of Global Warming has been one of the most talked about topics in recent years, as well as being one of the most controversial. What is the issue? One of the main problems that most people seem to have with the idea of Global Warming is the fact that recent changes in global climate may not be man-induced: some charge that current increase in global temperature is part of a bigger Earth temperature cycle, while some ignore the recent temperature increases altogether. By building a convincing Global Warming model using System Dynamics, the results of this project will hopefully convince the detractors of how serious the problem is. This project will also serve to raise awareness of the dangers of global warming, by demonstrating that most actions taken by current government needs to be intensified significantly. It is of great importance that we must be able to act before negative effects of global warming becomes clearer.

1.1 Scope of Study

The scope of the project is to estimate, to a certain degree, the effects that increasing amount of Carbon Dioxide gas will have on the Earth's atmosphere. The "effects" currently include, but is not limited to, global temperatures, frequency of hurricanes, methane release, and other consequences that may affect the global temperature in a long-term period. The project can be divided into two parts: for the first part, I explore the effects that natural/artifical carbon movements in the carbon cycle will have on the earth in a long term period. This model is referred to as the "primary model," given its importance in determining global temperature, both in real life and in the simulation. The secondary model, consisted of other variables that can affect the global temperature in a long term period, such as Earth's albedo or methane concentration in the ocean, assists the first model in determining the temperature changes.

1.2 Type of research

This research is a pure applied research that is meant to inform others of the effects that increased amounts of Greenhouse Gases will have on the envi-

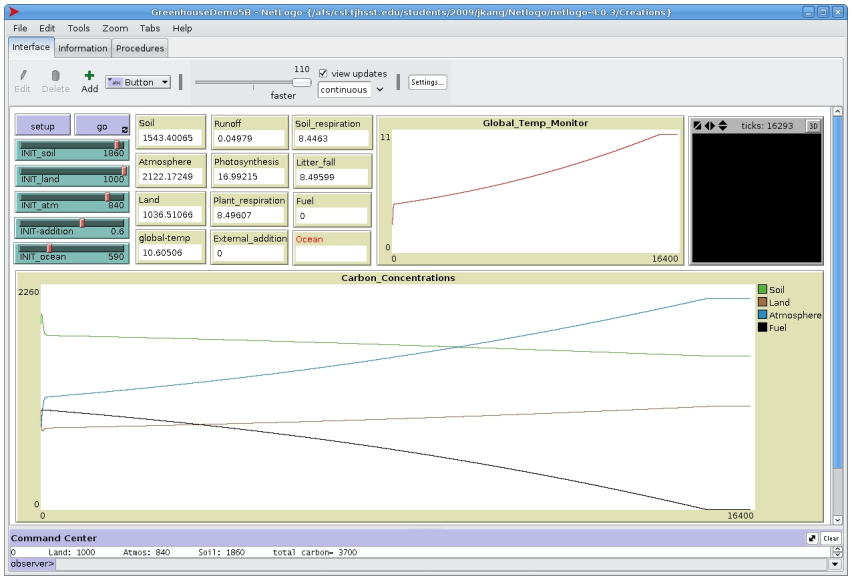
ronment, utilizing other studies done on Geosystems and Complex Systems Modeling.

2 Background and Review of Current Literature and Research

Global Warming has been studied continuously over the years by scientists with various fields of expertise, but no one has been able to come up with a comprehensive model of effects that Global Warming will have one earth. The reasons for this can be attributed to the complex nature of the problem. Although global warming problem is simple in that all of our data indicate that both our atmospheric CO2 concentration and our temperature has increased drastically over the years (at similar rate of increase), when it comes to actually trying to prove a relationship between these variables, things become more difficult. Although the relationship may appear clear to an observant observer, it takes more than just observation to prove a cause-and-effect relationship.

3 Procedures and Methodology

The main software being used in this project is Netlogo's System Dynamics Modeler. STELLA (by isee systems) is also used in conjunction to validate results obtained from Netlogo. GUI that I have built for this purpose and results I have updated are shown below:



System Dynamics models use a number of Stocks, Variables and Flows to run an user-defined simulation in which it can collect data sets and output them into graphs and output files. Two graphs are used with the project, a Temperature tracker and Carbon Concentration tracter, which tracts the concentration of carbon inside Land Biota, Soil, Ocean and Atmosphere. The Concentration of Carbon in Land Biota, Soil, Ocean and Atmosphere are also stored inside the System Dynamics model as Stocks, with flows such as Photosynthesis and Soil Respiration moving Carbon around among them. Once the simulation begins, the Model starts to move Carbon around among the stocks according to set of user-defined equations, stored in Flows. Few variables, storing important constants and variables used for the simulation, are stored inside Variables. Errors do not normally occur in Netlogo System Dynamics models and even if they do occur, they can generally be ignored. However, if irrecoverable errors occur (such as missing files or variable going out of bounds) from which the simulation cannot recover, the simulation will simply shut itself down automatically. Almost no knowledge of programming languages are required in this simulation, except a working knowledge of LOGO language, which is a crucial part of Netlogo. Another program used both to validate and provide another perspective to the data, STELLA, is entirely System Dynamics based and requires no knowledge of programming language. The model runs in a Netlogo environment, but a fully compiled version (saved as Java Applet) will run on any computer that has current

version of Java environment installed.

4 Expected Results

I expectect to see, as is supported by the real life environmental data, that Earth's global temperature is directly related to the increase in Atmospheric Carbon Dioxide. Human industrial advancements of late may have accelrated growth and gave us a better quality of life, but all that improvements came at Earth's expense. The results of this study will hopefully help people see that we need to be working on reducing the impact that we have on the environment soon. Developments in the second quarter revealed a rather alarming fact about continuous effects of global warming: because of some of the secondary effects of global warming, like increase in global Ocean Temperature, (which could result in large amounts of methane gas being released in the near future) could trigger other effects of global warming, like methane gas release and ice melting in this case, which could only serve to speed up the process of global warming. Melting ice and warming ocean only serves to reduce albedo (reflectance of Earth) and release methane gas respectively, contributing on further increase of global temperature, which, in turn, will worsen the process. A research done on public perception of Global Warming, by John Sterman and Linda Booth Sweeny, suggests that majority of Americans acknowledge global warming to be a problem, but a gradual one.(Surveys show most Americans believe global warming is real. But many advocate delaying action until there is more evidence that warming is harmful) The fact that global warming is actually an accelerating process which accelerates even further as it goes on suggests that this public perception needs to be changed: it will be too late to act on global warming by the time most people are considerably affected by the effects of global warming. In other words, waiting until there is more evidence that global warming is actually harmful could end with disastrous consequences.

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