Using the Geospatial Web 2.0 to Improve Climate Model Accessibility

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Abstract

In this paper, we introduce our initiative to use the Geospatial Web 2.0 (Geoweb) to improve the accessibility of climate models developed by NASA/GISS. This initiative aims to increase the general public's literacy of climate change to promote their participation in climate change issues. Three groups of Geoweb applications that wrapped around the climate models are presented. The first is a web-based user-friendly and well-guided interface for setting up climate model simulations. The second is an OpenLayers application that enables users to create their own boundary conditions for designing simulations. The third is a group of geovisualization applications for analyzing and visualizing model outputs as well as for comparing model outputs data to observational data. Some of these applications have already been publicized. However, by the end of this project, it is necessary to wrap up all the applications and to present them to EdGCM users group for feedback.

Background and Relevance

The majority of scientists recognize that climate change is an urgent concern for society. However, the same consensus is not built among the general public. These divergences are due, in part, to the inherent complexity of climate change. It happens in a global scale and has long-term and gradual effects. Dilling et al. (2007) raised eight points to explain why climate change is not perceived as urgent and identified five common pitfalls for communicating climate change.

One obstacle for climate change communication lies in the complexity of the primary tools used for climate change research: the climate models. Climate models are simplifications of the real world with attempts to provide useful projections of future climates (IPCC Third Assessment Report 2001). Scientific predictions, for example, the extensive use of fossil fuels will induce further global warming in the 21st century, are mainly based on climate model experiments.

Until now, however, they have been little more than a "black box" to most people. Take the coupled atmosphere-ocean model (AOM) developed at NASA Goddard Institute for Space Studies (GISS) for example. The model runs on UNIX workstations and is programmed using Fortran-90 and Open-MP parallelization statements. The Fortran source code and input files for the 2004 version of the AOM are downloadable in their website (AOM, NASA/GISS 2007). However, a significant level of computer skills, scientific knowledge, and computer resources is expected to use it in a "scientifically useful manner". Another example can be drawn from PRECIS Regional Climate Modeling System. It was developed at the UK Met Office Hadley Centre to help climate

change study mainly in UNFCCC classes Annex I nations. It was ported to run on a Linux based PC, however, it takes 4.5 months to complete a 30-year simulation for a typical experiment runs on a 2.8GHz machine (PRECIS, Hadley Centre 2010). Unfortunately, this unfamiliarity and lack of access often engender public's distrust of scientific findings based on climate models (EdGCM 2010).

To increase comprehension, we propose the need to allow the public to interact with actual climate models. We argue that there is value in walking users through the same process a climate scientist would use, which includes designing and running simulations, analyzing and visualizing climate model outputs. EdGCM, the Educational Global Climate Model, was developed with the goal of helping high school students learn about climate change and climate modeling by giving them the ability to run a genuine NASA global climate model (GCM) on a desktop computer (EdGCM 2010). Although EdGCM gives users a clear view of some of the complexities involved in using a climate model, it can be daunting for the general public. Nonetheless, EdGCM sheds light on the possibility to improve public's access to climate models. Actually, we have research efforts going on to bring realistic global climate modeling experience to a broader audience (Sohl et al. 2010).

Furthermore, we propose the use of Geoweb technologies (e.g., earth browsers like Google Earth and OpenLayers) for engaging a broader audience. Earth browsers are interactive virtual templates of our planet. They enable easy and straight global research and allow users to conveniently collaborate and share their projects and results (Chen et al. 2009). Via an easy-to-use and intuitive earth browser interface, it is possible to build an attractive interaction between the public and climate models.

We are trying to answer the question: How to use Geoweb concepts, technologies for the design and development of our applications to improve climate model accessibility?

Methods

Our research is an initiative to use Geoweb technologies to improve the accessibility of climate models. We plan to use the Geoweb in three ways, to 1) develop a web-based interface for setting up climate simulations, 2) develop Geoweb applications for designing and controlling simulations, and 3) develop geovisualization applications for analyzing and visualizing climate data (model output data and observational data).

The web-based interface for setting up simulations allows users to choose the initial conditions and input files for GCM runs. We look to build a graphical user interface (GUI) that is user-friendly and well-guided for setting up simulations. It could be one webpage containing different components and forms (similar to EdGCM setup simulations interface) or several webpages that guide the users to set up simulations step-by-step. The web-based interface will have an advantage over the EdGCM by enabling the users to perform GCM controls across a network.

The Geoweb applications for designing and controlling simulations will be an OpenLayers application that allows users to create/modify boundary conditions (e.g.,

vegetation file). By taking advantage of the panning and zooming abilities of OpenLayers, the application could offer attractive and efficient ways for users to design simulations. EdGCM didn't include the components for modifying boundary conditions, however, several other applications (e.g., MapProjector) could be used as scientific reference to make sure the modified boundary conditions work compatibly with GCM runs.

Geovisualization applications with attracting features (e.g., 3D representation, animations, and interaction) will be developed for analyzing and visualizing climate data. One application will integrate existed climate data analysis software, Ferret (2010), with the common earth browser data format, KML. Another application will be a multiple Google Earths platform. By taking advantages of Google Earth and KML, the Ferret application allows users to dynamically visualize climate data in three dimensional spaces, and the platform offers one way for comparing model output data to observational data because multiple earths can be rendered and controlled asynchronously or synchronized.

Results

At this point, our results include a web-based interface for setting up and running simulations, an OpenLayers application for designing vegetation boundary conditions, and the geovisualization applications mentioned above (see Figure 1).

The interface is accessible at http://edgcm.columbia.edu/~jianzhou/web/. To lower the access threshold of setting up simulations, it allows users to import pre-setup simulations (e.g., Global warming and Doubled CO2). Users can design their own simulations by modifying the parameters for components like 'Ocean Model', or 'Greenhouse Gases Trends'. The parameters are error checked and then sent to the server for building up model simulations (run folders). The interface was implemented as a web-based version of EdGCM setup simulation interface, thus still it could be daunting for the general public because of so many entries. Further efforts are expected to build a dynamic interface according to different users' interests and expertise.

The OpenLayers application is available at http://rose.geog.mcgill.ca/~jian/veg/. Extensive cooperation between climate scientists, GIS experts, and computer scientists makes it possible to implement the integration of Geoweb (e.g., OpenLayers API and Google Chart API) and climate model input. Instead of manually type vegetation percentages for each grid cell in climate model, this application provides an intuitive and interesting interface for designing, creating, and modifying vegetation boundary. It supports visually selection and manipulation of multiple cells. Similar applications are expected to be implemented for working with other climate model inputs (e.g., topography boundary condition).
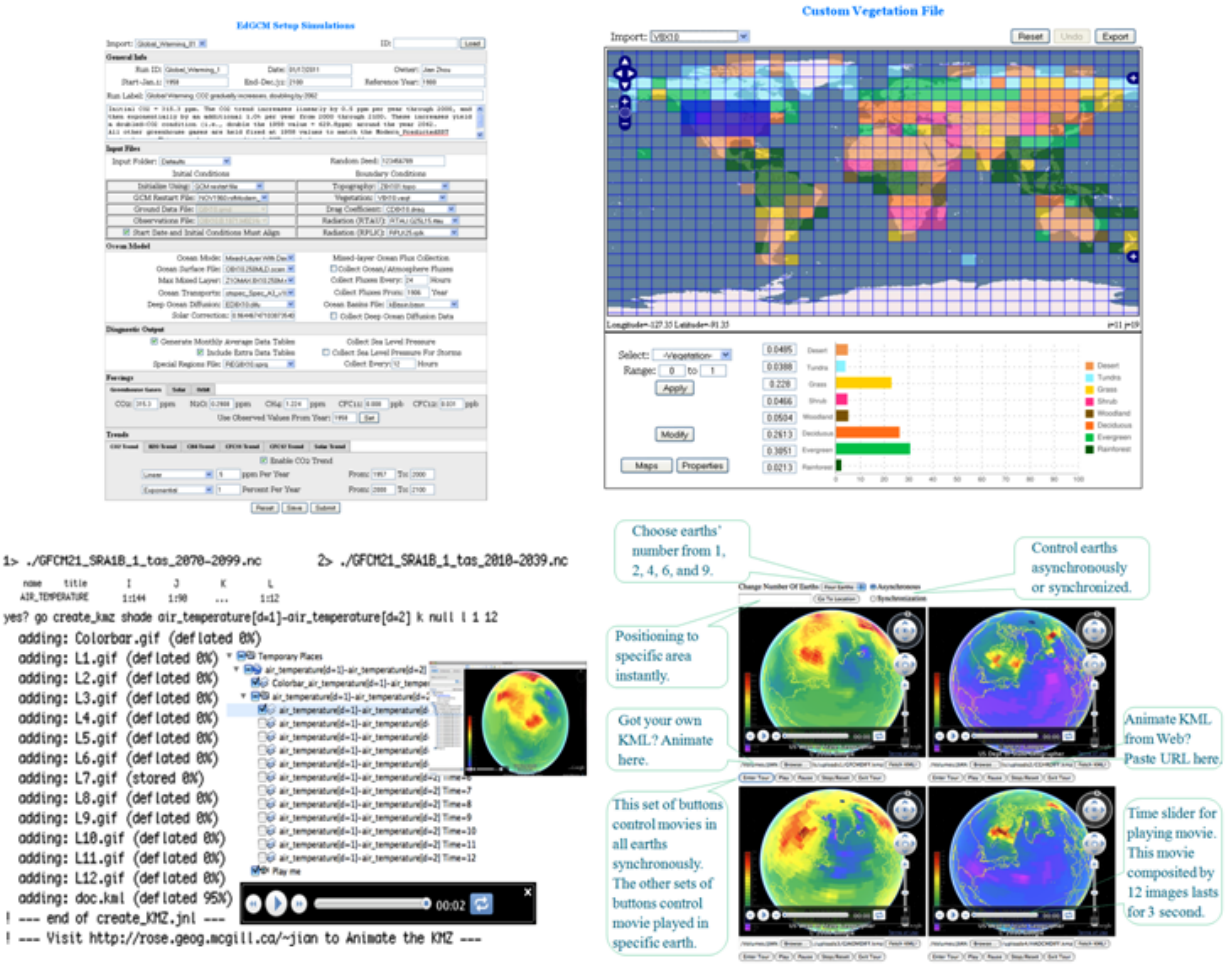
Figure 1. Collage of Geoweb applications. (clockwise from top left) Web-based interface for setup simulations; OpenLayers application for designing vegetation boundary conditions; multiple Google Earths platform for visualizing and comparing model outputs; and Ferret scripts for integrating Ferret with KML.

The Ferret scripts were implemented to integrate Ferret with KML. They contain many enhancements for climate data. Firstly, they are capable of generating multiple images along either spatial or temporal dimensions from a standard NetCDF data set at one time (executed with a single Ferret command). Secondly, the scripts support KMZ (zip KML files with supporting images) as the output format. They extend Ferret's features and have been publicized together with the newest version of Ferret V6.6.4.

The multiple Google Earths platform supports displaying of 1, 2, 4, 6, or 9 earths at one webpage according to the user's need. What is more, the multiple earths could be controlled asynchronously or synchronized. For example, if four earths are displayed with each earth fetched its own KMZ file outputted from the scripts, in the synchronized mode, the platform could show you four movies (touring) synchronously. The platform is available at http://rose.geog.mcgill.ca/~jian. One critical limitation for using the platform is that it requires Google Earth API (not available for Linux machine) installed in the client machine.

Our further work is to wrap up all the applications and to present them to EdGCM users group for feedback. Two issues have already been identified. The first was about the extensibility of our applications. The web-based interface and OpenLayers applications are designed and implemented for the same GCM (Model II from NASA/GISS) used in EdGCM. How can we extend our applications to work with other GCMs (e.g., Model E) from NASA/GISS or even GCMs developed by other institutes (e.g., Hadley Center and NCAR)? The second issue was raised from the social concern perspective. As mentioned, climate models require significant scientific knowledge to design simulations as well as to understand model outputs. Our applications enable users to design and to run simulations. However, how can they also help with understanding model outputs? Climate change deniers may also use our applications to run simulations to prove that climate change is not happening. Since all models are "wrong", those deniers (most of whom are non-expert in climate science) may not be able to understand different model simulations scientifically. This is not only a social concern for our project, but also a problem for the whole climate modeling community.

Conclusions

An initiative to use Geoweb technologies to improve the accessibility of climate models has been introduced. By attempting to bring a realistic global climate modeling experience to the public, hopefully it will promote public's interests and capability to participate in climate change communication.

Continued efforts are expected to improve our applications as well as to encourage others to develop applications to facilitate climate change communication. It will be interesting to look at how online social networks and collaborative work could promote public's awareness of climate change.

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