The Basic Guide to *Ed*GCM

www.edgcm.org

v. 2.3.4
January 4, 2005

DRAFT

The GISS GCM is under continuous development at NASA's Goddard Institute for Space Studies (http://www.giss.nasa.gov). A detailed description of GISS Model II, the GCM used by *Ed*GCM, is given in the following reference:

J. Hansen, G. Russell, D. Rind, P. Stone, A. Lacis, S. Lebedeff, R. Ruedy, and L. Travis, Efficient Three-Dimensional Global Models for Climate Studies: Models I and II, *Monthly Weather Review*, vol. 111, no. 4, April 1983.

Additional copies and/or updated versions of Panoply may be downloaded from http://www.giss.nasa.gov/tools/panoply/.

Dear soon-to-be climate modelers,

In bringing users into direct contact with complex computer models such as a Global Climate Model (GCM), *Ed*GCM exposes the model's strengths and weaknesses in a way that scientific papers and newspaper articles frequently obscure. The danger in creating a point-and-click interface for a GCM is that users might be tempted to treat the model as a black box. To the extent that they might do so, after using *Ed*GCM, we will not have achieved one of our main goals: to encourage ***more*** people to learn ***more*** about climate models. We hope that *Ed*GCM will lead greater numbers of students to pursue Earth science careers, and that the experience will allow them to participate in climate research at an earlier stage in their education.

*Ed*GCM doesn't require a sophisticated understanding of climate to use, but an understanding of the atmosphere, oceans and geology will definitely enrich the experience. We are currently working with educators to produce curricula and teaching materials that will greatly enhance *Ed*GCM's potential as a learning tool. *Ed*GCM is being pilot-tested in courses that range from 9th grade to graduate level, and it is being used for research projects at both NASA and Columbia University. If you are a teacher or researcher and would like to learn more about the *Ed*GCM Cooperative effort, please contact us!

Happy Modeling!

Mark Chandler
mchandler@edgcm.org

Contents

1.2 Some Notes Before You Begin

1.2.1 Performance: How Fast Will It Run?

The speed at which the GISS GCM runs is based primarily upon the speed of the computer's CPU. Other factors that play a role include the number of applications running at the same time, compiler optimizations, and whether or not your system is dual- or single-processor. The advent of 64-bit CPUs in machines such as the PowerMac G5 will allow the GCM to run significantly faster, since twice as many calculations are possible during one clock cycle than in the typical 32-bit systems used by most desktop computers.

The GISS GCM divides the atmosphere into a three-dimensional grid system. The version incorporated into *Ed*GCM uses an 8° X 10° latitude by longitude grid system, and has nine vertical layers in the atmosphere and two ground layers. Running the climate model entails the solving of a series of complex physics equations for every cell in the grid, and a single simulated year involves many billions of calculations. Real-world performance has always been essential for the GISS GCM for research purposes, so the model was originally coded to be highly efficient. It has been further optimized to run at acceptable speeds on desktop computers without sacrificing any accuracy, but newer desktop computers will run the model the fastest.

Over the past four years, the number of simulated years per day (syears/day) for the GCM has increased more than twenty-fold on desktop Macs. An original iMac 233MHz computer could finish a 5-year simulation in about one day, while a new PowerMac dual-G5, running at 2GHz, could complete two 120-year simulations in the same amount of time. As a general guideline, most simulations that would be of interest (either in the classroom or for research) need to run at least 10 simulated years. Simulations with altered forcings, such as increased greenhouse gases, must run using the predicted ocean option and require a minimum of 35 simulated years to reach equilibrium.

Table of simulated model years per day. The speed at which the GISS GCM runs on a desktop computer scales closely with CPU speed. However, changes to the microchip architecture and the optimizations used at the time of compiling may also have a significant impact. The 64-bit G5 processors in particular are significantly faster per CPU clock cycle than older processors. Although we do not have Windows PC benchmarks at this time, we expect PCs to scale with MHz in a fashion similar to the G4 processors.

Computer (CPU)	CPU Speed	Simulated Years / Day
iMac (G3)	233 MHz	~10
eMac (G4)	800 MHz	~35
PowerMac (dual-G4)	533 MHz	31.2
PowerMac (dual-G4)	1.42 GHz	66.1
PowerMac (dual-G5)	2.0 GHz	120-200*
Dell OptiPlex (P4)	2.8 GHz	130

*Dependant upon compiler optimizations.

Return to Contents

It is also important that you not let the computer "sleep" when the GCM is running. Sleep mode will cause the run to stop and can corrupt the files required to complete the simulation. To prevent the computer from going into sleep mode, the Energy Saver settings for your Mac (Figure 1-13) should be set to "never sleep the computer." (Setting the display to sleep is fine, and will not effect your simulations). In addition, do not check the box that allows the hard disk to sleep, as this may also damage simulation output files.

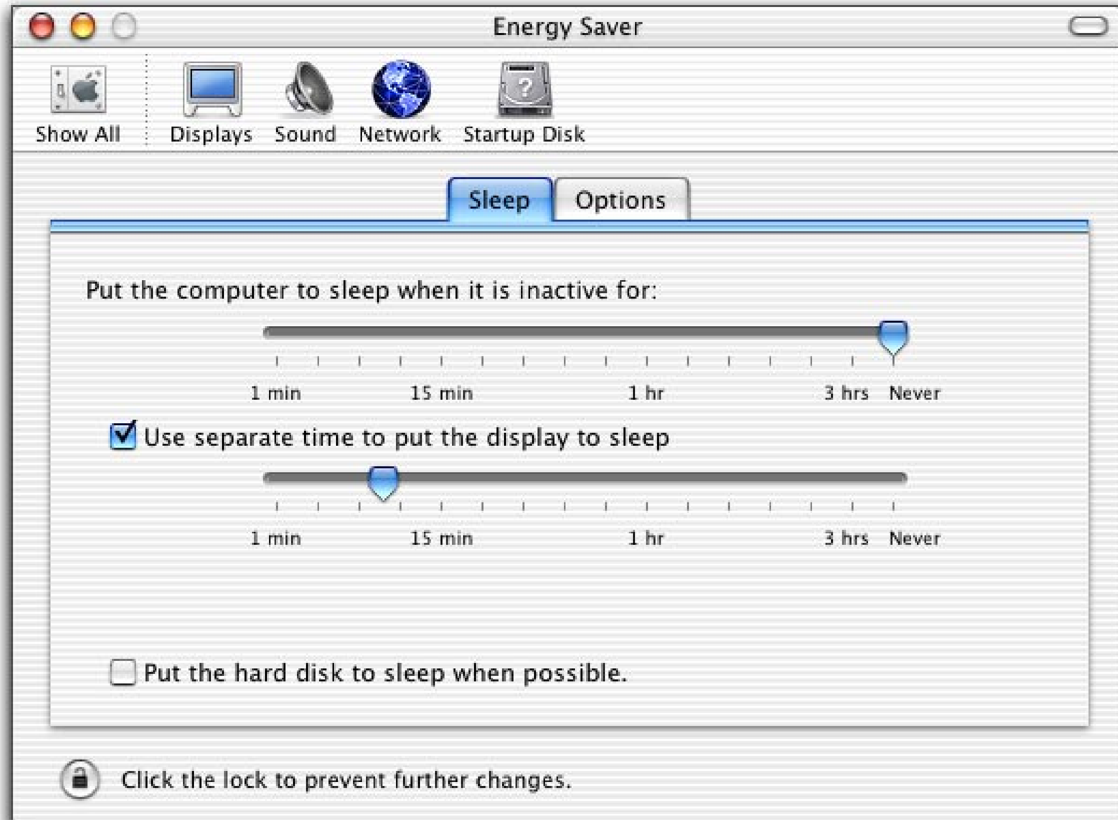


Figure 1-13. For Macs, the Energy Saver settings (within System Preferences) should be set such that the computer never sleeps.

For PCs, the appropriate power settings are set through the Control Panel (Figure 1-14). In the Control Panel, double-click on "Power Options" to bring up a dialog box to display Power Option Properties (Figure 1-15). Select the Power Schemes tab, and from the drop down menu select the "Always On"option. As with Macs, allowing the monitor to go to sleep will not affect the running of the GCM.

Figure 1-14. The Control Panel is accessed through the Start Menu.

Return to Contents

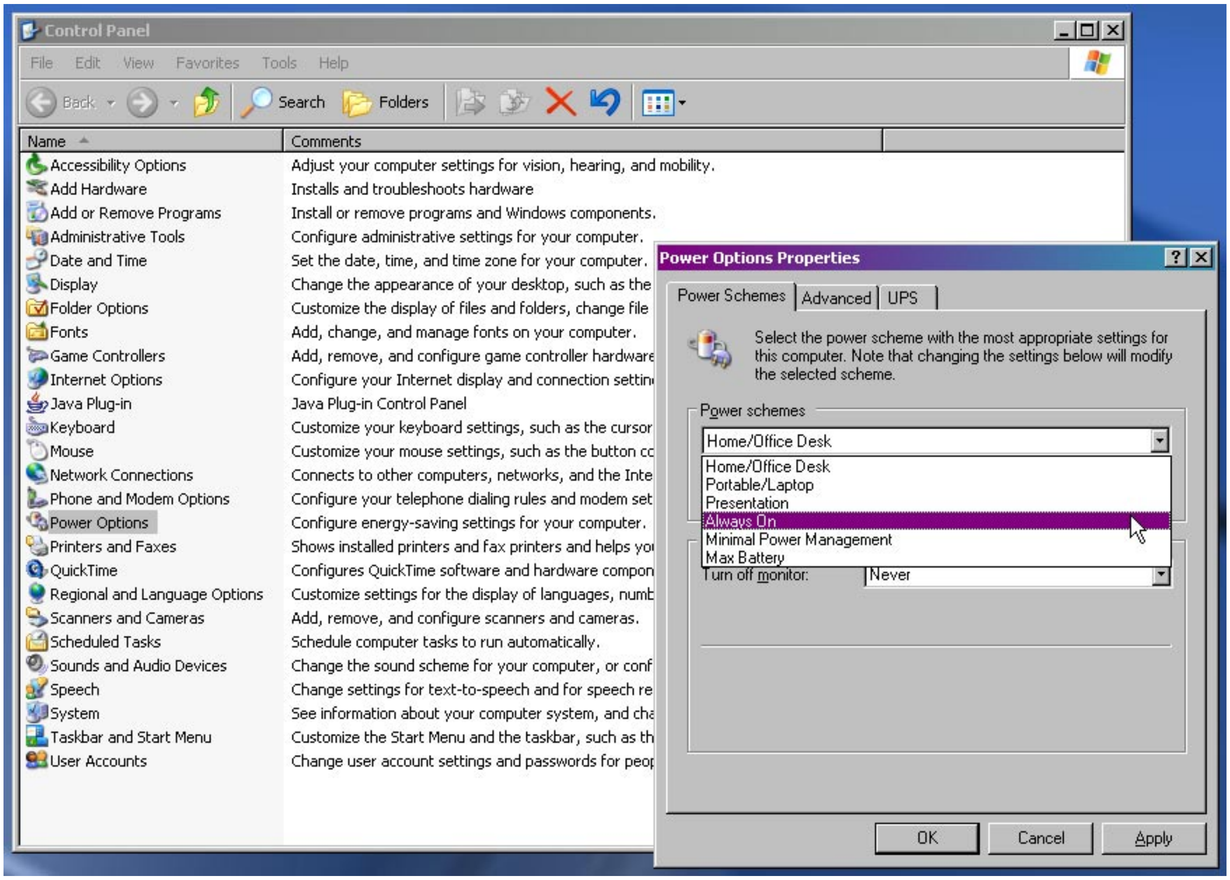


Figure 1-15. For PCs, the Power Scheme should be set to "Always On" to prevent the system from going into sleep mode while the GCM is running.

Under both Mac OS X and Windows 2000/XP you may run additional applications, such as Microsoft Word or Excel, while the GCM is running. You may even start more than one simulation at a time, although the simulations will then have to share processor time. On single-processor systems any additional applications will slow the GCM dramatically, but will not harm the simulation in any way. On dual-processor computers the impact on the speed of the run will be minimal unless you run many applications at once.

Finally, you can quit the *Ed*GCM 4D interface once a simulation is running, because the GCM runs as a separate application in the background. However, you will need to restart the *Ed*GCM 4D interface and choose a currently running simulation if you want to pause the simulation, or to analyze the output once the run has finished.

1.2.2 Hard Disk Clean Up

In addition to simulating global climate, another thing GCMs do very well is comsume huge amounts of hard disk space. Most research institutions use large arrays of disk drives to store these massive amounts of GCM output, but that is a luxury few schools will have. As a solution, *Ed*GCM contains a "smart" clean-up utility for removing files from individual run folders inside the Output folder.

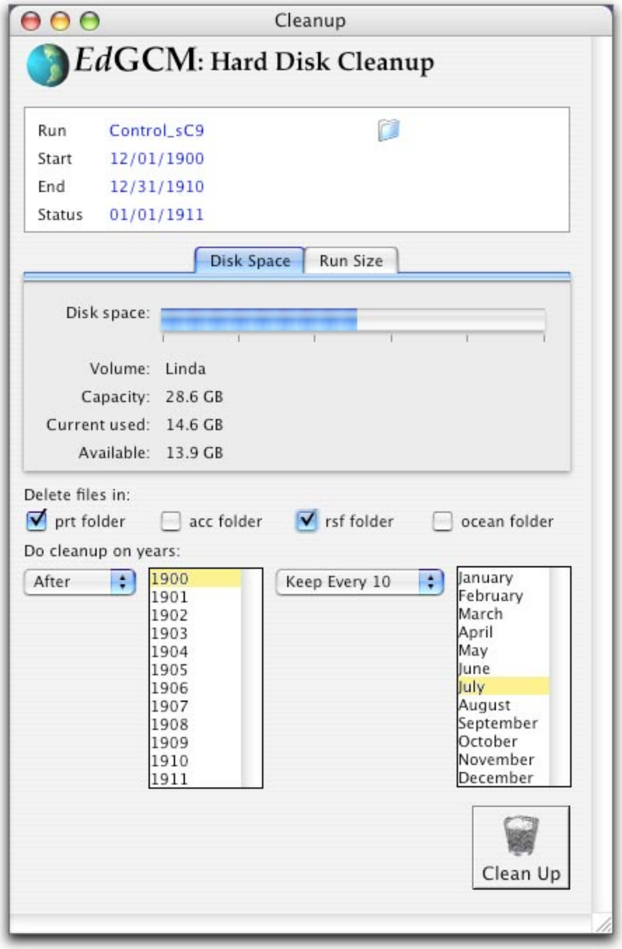


Figure 1-16. The hard disk clean-up utility menu.

Located in the File menu in *Ed*GCM, Cleanup (Figure 1-16) enables users to keep track of disk space, including the amount occupied by GCM simulation output. If storage space becomes limited, Cleanup allows users to intelligently delete files without damaging the ability to later use simulations for analysis.

In selecting files for removal, note that "rsf" and "prt" files can be safely deleted without damaging your ability to perform future analyses of simulation output. ***Warning: If you delete "acc" files, which contain the raw diagnostic output (climate variables) from the GCM, it will be impossible to analyze any output from that run.*** However, any previously processed and viewed variables from that run will not be effected and can be viewed again using the visualization utilities.

1.2.3 QuickTime Video Tutorials

Note: The QuickTime video tutorials are only available for EdGCM version 2.1. The videos for version 2.3 need to be redone owing to changes made to the interface. Please watch our web site (www.edgcm.org) for news on the availability of the new video tutorials.

As a supplement to this guide, the *Ed*GCM DVD includes a series of brief QuickTime videos that provide an overview of the interface and additional software. These are found in the Multimedia folder inside the *Ed*GCM 4D folder. Users who have not taken part in a training workshop are strongly encouraged to take a half hour to view these videos. The subjects of the videos in the Multimedia folder are best viewed in order and include:

*Ed*GCM Tutorial, all the movies in order

*Ed*GCM 00 Intro, introduction to EdGCM

*Ed*GCM 00 Intro2, overview of the windows in EdGCM

*Ed*GCM 01 Setup1, the General Info section in Setup Simulations

*Ed*GCM 01 Setup2, boundary conditions in Setup Simulations

*Ed*GCM 01 Setup3, the Forcings section and trends in Setup Simulations

*Ed*GCM 01 Setup4, how to run a simulation and the appearance of the GCM

*Ed*GCM 02 Output1, overview of the tabs in Analyze Output

*Ed*GCM 02 Output2, the Tables tab in Analyze Output and SuSpect

*Ed*GCM 02 Output3, the Sets tab in Analyze Output

*Ed*GCM 02 Output4, the Plots tab in Analyze Output and PlotShop

*Ed*GCM 02 Output5.1, the Maps tab in Analyze Output

*Ed*GCM 02 Output5.2, Panoply viewing output from Maps

*Ed*GCM 03 SimLibrary, how to search in Simulation Library

*Ed*GCM 04 eJournal1, overview of the eJournal and the Image Browser

*Ed*GCM 04 eJournal2, how to edit in the eJournal

*Ed*GCM 04 eJournal3, adding images to an eJournal

*Ed*GCM 04 eJournal4, converting an eJournal to a webpage

1.2.4 Known Software Problems and Issues

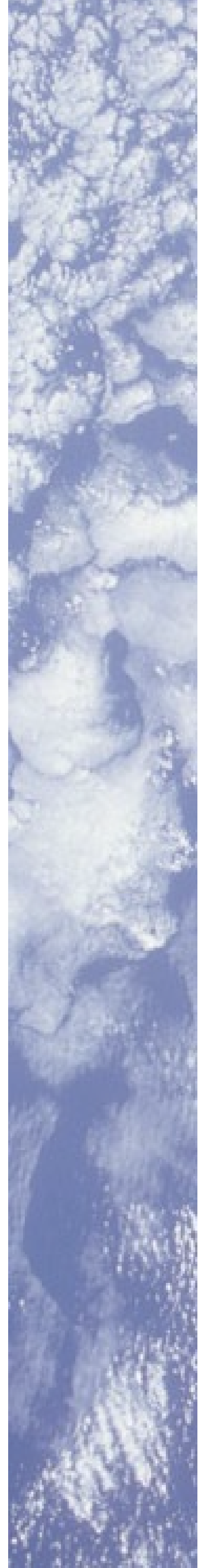
• Using the "Average" button in the Analyze Output window sometimes causes a failure (which is evidenced by a message relating to an error in program : SumandPD"). If you choose a range of years that does NOT include the first year of the simulation, you can avois this problem. We are currently working to fix this issue.

• If allowed, the GCM will run until all available disk space is used up. The performance of most hard disks drops noticeably if they are more than 90% full. In addition, Mail, Eudora, and Entourage will corrupt their mailboxes if the GCM is allowed to fill up the hard disk.

• PlotShop is development software for Macs only, and has many limitations. The serious bugs in PlotShop include: the data tab shows incorrect data values for all but the first year; opening a second file from *Ed*GCM when there is already an open PlotShop window causes a failure; files with less than 5 columns or 9 rows will not open; print and save are not enabled. If PlotShop does not fit your needs, use a program such as Excel or Kaleidagraph for line plotting. The "plot" files produced by *Ed*GCM are all stored as tab-delimited text.

• It is possible to set a mixture of boundary condition files that cause the GCM to crash. Furthermore, users cannot easily alter or create their own boundary condition files without extensive programming experience.

• Most of the GCM errors reported in the Fortran terminal windows are admittedly cryptic. However, messages such as "STOP 12" and "STOP 13" are NOT errors! These equally cryptic codes indicate that the GCM has halted normally. STOP 12 means the run has been paused or has reached the end date. STOP 13 means the run has finished.



CHAPTER 3

Using *Ed*GCM

3.1 Setting Up and Running Simulations

Traditionally, a global climate model is controlled and started (initialized) through a combination of computer programs and Unix shell scripts. *Ed*GCM removes this layer of complexity by placing all control of the climate model into a graphical user interface (GUI). The designing of experiments is handled within the “Setup Simulations” window, using an interface with well-defined fields for entering the names of input files. There are also easily manipulated “point and click” controls for choosing a variety of climate modeling options such as the length of experiment, the quantity of greenhouse gases in the atmosphere, the distribution of vegetation types, the configuration of continents, etc.

The interface is divided into several logical sections, each of which the teacher can show or hide depending upon which components of the GCM they want to be the focus of study.

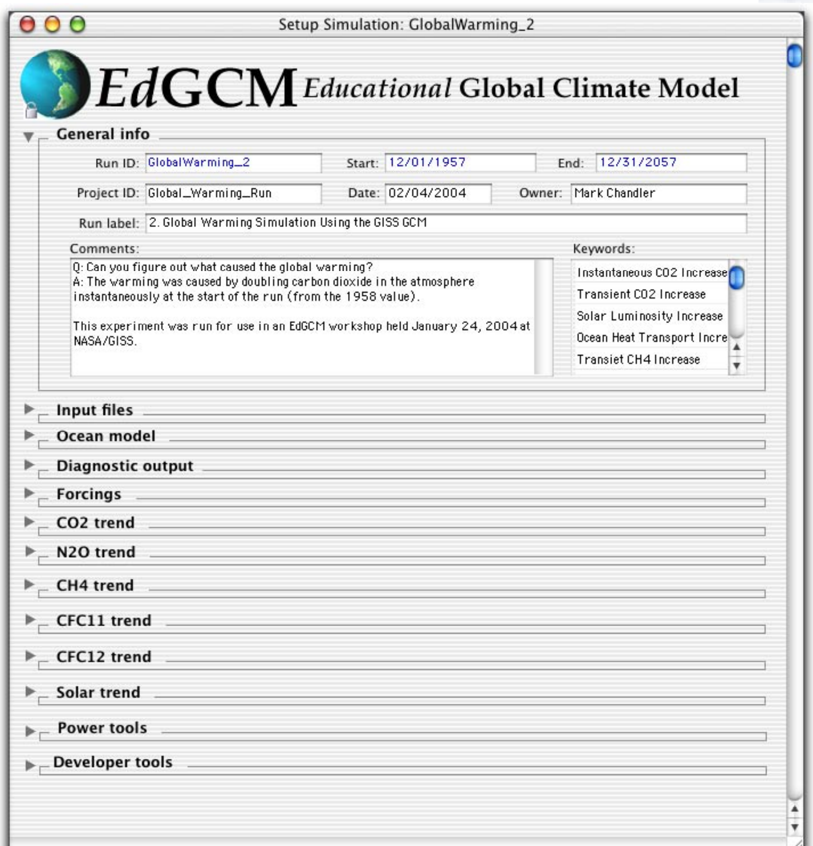


Figure 3-1. The Setup Simulations window in EdGCM is the starting point for every experiment, as the initial conditions for the experiment are set here.

Using *Ed*GCM, teachers and students can easily create experiments that simulate a wide variety of climates of the past, present and future. In this way the teacher can enhance and expand upon lessons on the fundamentals of the climate system with experiential learning, which involves students in the methodologies that scientists themselves are using to study the Earth's climate system. Teachers can simulate climates of various periods in geologic history, for example, the Cretaceous Period or the Last Glacial Maximum. They can simulate climate changes that may occur in the future, such as global warming or the effects of deforestation. And, they can simulate the impacts of modern climate events such as El Niño/La Niña cycles or volcanic eruptions. The new interface allows such detailed control over model functions that *Ed*GCM arguably has more user-definable capabilities than does the research-only version.

3.2 Analyzing Simulation Output

The most important aspect of any climate modeling project is the analysis of results once the simulations are complete. For most global climate models, preparing model output for analysis can be as involved as setting up the simulation in the first place. This preparation of model output for analysis is referred to as post-processing and it involves several steps (most of which are hidden from the user in *Ed*GCM). Variables of interest must first be extracted from the large binary files that are a GCM's raw output, next they are averaged over meaningful time periods or geographic areas. Finally, the values are scaled to standard meteorological units (e.g. degrees Celsius) and are then converted to formats that can be usefully analyzed by desktop software. Much of this work is performed by professional programmers at most modeling labs because the task can be so time consuming it eats into the time available for the analysis of results. While performing post-processing can be a limitation for many research programs, it is probably closer to an "insurmountable obstacle" for most high schools and many undergraduate institutions.

In order to tackle this problem we have automated a number of the most frequently used post-processing programs for use in *Ed*GCM and have added user-friendly interfaces to perform any steps that can't be entirely hidden. To date, we have adapted four key programs to help clear the path for analyzing model results. These include utilities that:

1. Generate summary ***tables*** of all diagnostic variables produced by the global climate model (over 400 variables!) averaged over months, seasons, and years for any portion of a simulation.

2. Create global ***maps*** of approximately 90 different climate variables that can be used to analyze geographic patterns of climate change.

3. Produce time series ***plots*** of approximately 90 climate variables that can be used to track climate changes that occur throughout the duration of a simulation.

Return to Contents

4. Produce ***vertical slices*** of approximately 100 climate variables that can be used to analyze altitudinal changes in climate parameters from pole to pole along a specified longitude.

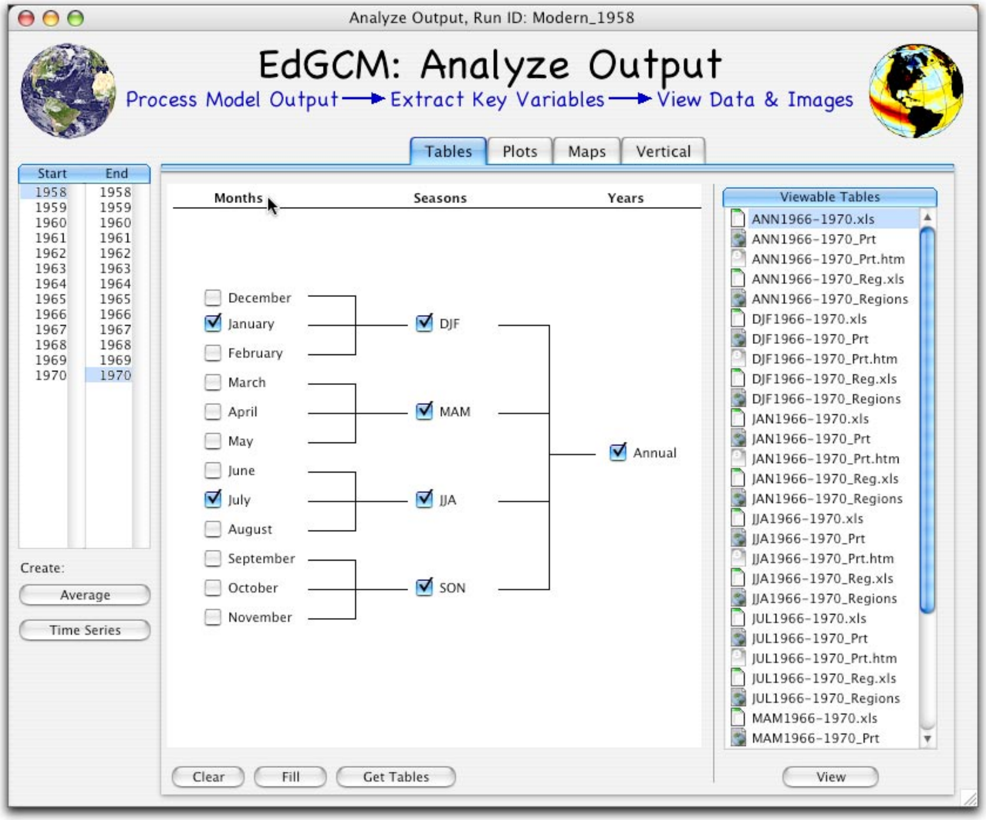


Figure 3-2. The Analyze Output window offers a number of options for processing and viewing the output of climate experiments.

3.3 Reporting Experiment Results

A unique feature of *Ed*GCM is the eJournal, which allows students to create reports that discuss the results of experiments. eJournals can incorporate both text and images and encourage students to construct "manuscripts" in a style similar to that which researchers use for publishing their findings in scientific journals or on the web.

eJournals contain up to 20 text and image sections. Sections can be added or rearranged at anytime during the creation of the report. eJournals are closely integrated with the Image Browser and with GCM simulations. Images can be cut and pasted (or use drag and drop) from the Image Browser into an eJournal report. The attached text information is transferred to the report as a figure caption, but figure captions are also editable so that students can point out specific information pertinent to their analyses. Links can also be established (linking interface not shown) between eJournal reports and individual simulations so that the database establishes a relationship between simulations and their analyses. The relational database then keeps track of occurrences when many students are analyzing and reporting on an identical experiment, or when one student analyzes and reports on many different experiments.

Return to Contents

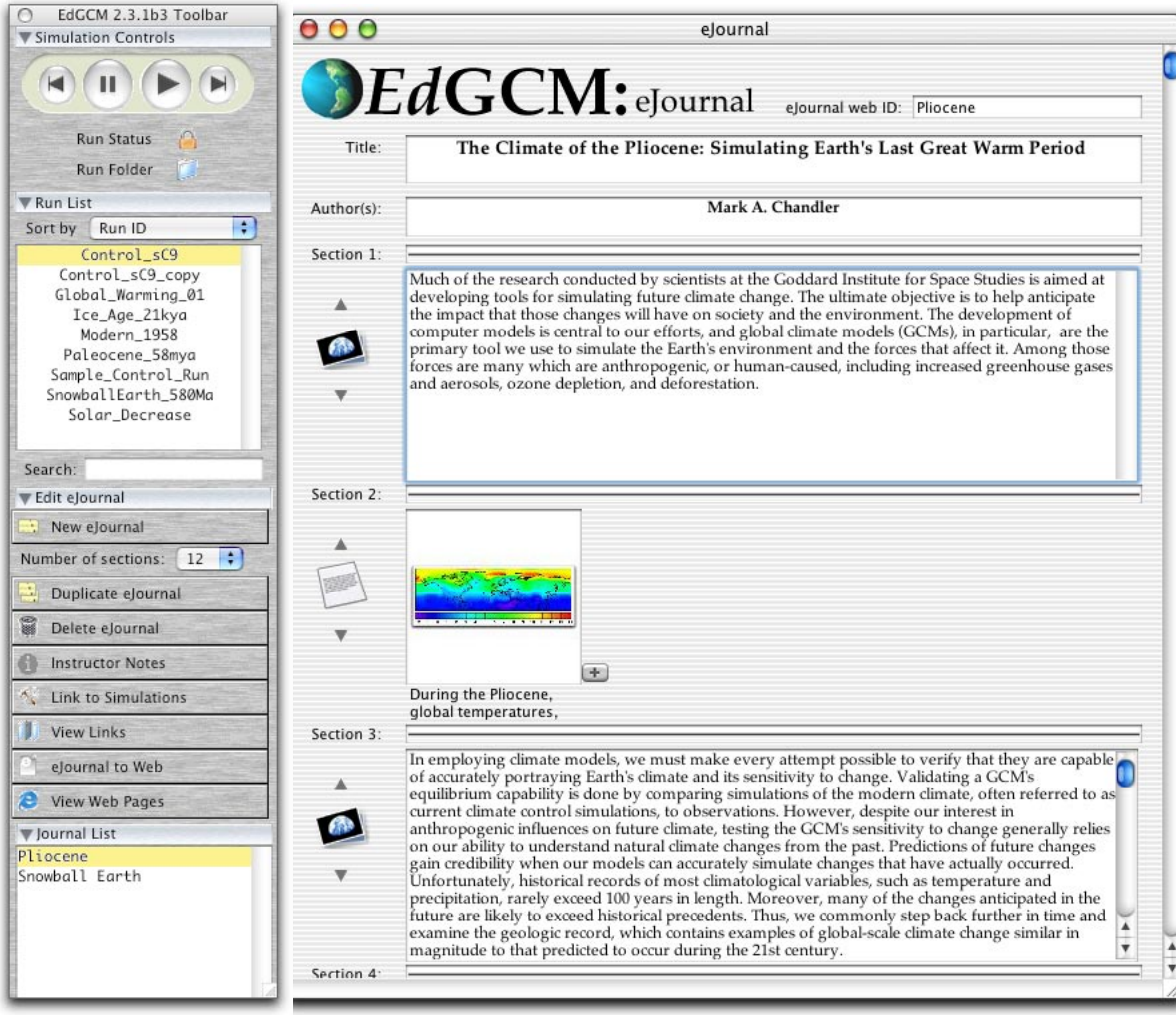


Figure 3-3. The eJournal window in EdGCM permits the user to compile a report, complete with figures, for easy publishing to an HTML-format document.

3.4 Using *Ed*GCM's Database Features

*Ed*GCM has been developed using a database as an underpinning because the volume of information produced by any global climate model can easily exceed the manageable level. The database structure removes the need for the teacher or researcher to spend time organizing large volumes of data, model output and supplementary information. The teacher is then free to spend more time planning how to better utilize the information for specific class needs. It also allows researchers and educators to focus more effort on analyzing experiments and less time on organizing them. Moreover, the database engine of *Ed*GCM makes it simple to search, sort and access information from several different classes or from an entire semester.

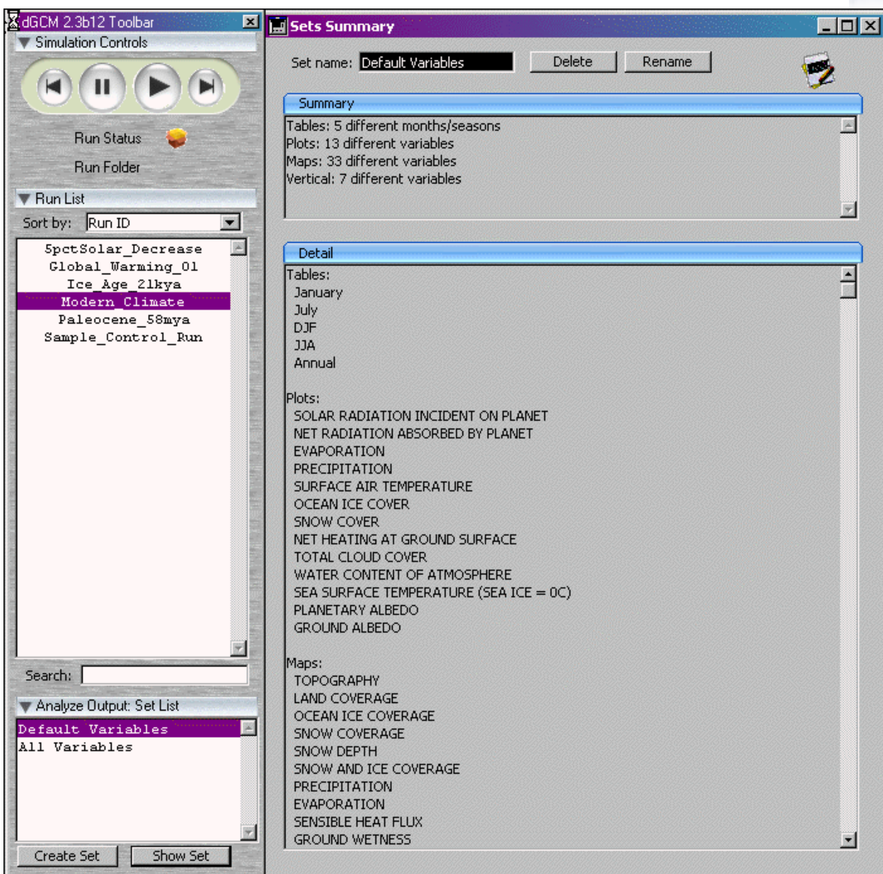
Because GCMs produce so much output - too much for almost any individual to analyze in an efficient manner - *Ed*GCM has a built-in utility that allows the teacher to specify, prior to its use, which climate variables students are allowed to access. Thus, teachers can either customize *Ed*GCM's interface to match the level of the students, or they can create project-specific ***sets*** of variables to better guide students to the key values that apply to particular lesson requirements.

Return to Contents

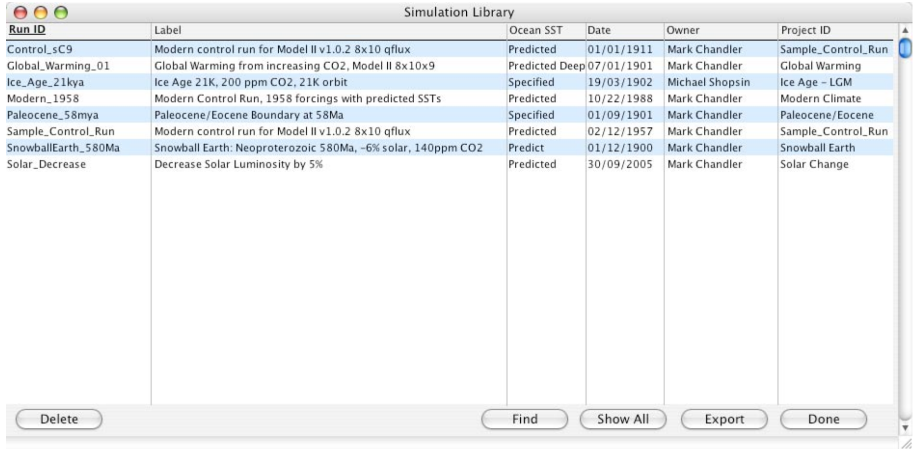
Sets of variables can be defined to reduce the numbers of variables that are visible to the students in the Analyze Output interface. Teacher-specified variable sets can be created using the list and buttons that appear at the bottom of the *Ed*GCM Toolbar whenever the Analyze Output window is open (Figure 3-4). Teachers may choose to organize sets of experiments around physical criteria (e.g., greenhouse gas experiments, hydrological variables) or around administrative criteria (e.g., course title, student working groups). Two special “Sets” of variables have been provided with *Ed*GCM: a Default Set of commonly viewed variables, and a set containing ALL available variables.

New sets are easy to create. Simply open the Analyze Output window and select all of the variables of interest. Make sure to go through each tab and either clear the variable check boxes (none selected) or select those of interest. Once you have all your variables of interest selected, click the “Create Set” button on the *Ed*GCM Toolbar. You will be asked to name your new variable set, and then a summary of the set will appear. You can print the summary by clicking on the paper and pencil icon in the upper right hand corner of the summary window. After closing the summary window you will now see your special set listed in the Sets list in the EdGCM Toolbar. Select that Set and the Analyze Output window will reveal only your variables of interest. ***(Note: The variables in your set may still be turned on and off individually. Creating a set simply makes it possible for both teacher and students to view only a subset of all model variables.)***

Figure 3-4. The Sets Summary displays the variables selected for analysis, and can be written to a file for sharing among students and other teachers.



The Simulation Library is the master list of all experiments run, and can be searched by run ID, owner, theme, or other parameter for ease of data management.



Run ID	Label	Ocean SST	Date	Owner	Project ID
Control_sC9	Modern control run for Model II v1.0.2 8x10 qflux	Predicted	01/01/1911	Mark Chandler	Sample_Control_Run
Global_Warming_01	Global Warming from increasing CO2, Model II 8x10x9	Predicted Deep	07/01/1901	Mark Chandler	Global Warming
Ice_Age_21kya	Ice Age 21K, 200 ppm CO2, 21K orbit	Specified	19/03/1902	Michael Shopsin	Ice Age - LGM
Modern_1958	Modern Control Run, 1958 forcings with predicted SSTs	Predicted	10/22/1988	Mark Chandler	Modern Climate
Paleocene_58mya	Paleocene/Eocene Boundary at 58Ma	Specified	01/09/1901	Mark Chandler	Paleocene/Eocene
Sample_Control_Run	Modern control run for Model II v1.0.2 8x10 qflux	Predicted	02/12/1957	Mark Chandler	Sample_Control_Run
SnowballEarth_580Ma	Snowball Earth: Neoproterozoic 580Ma, -6% solar, 140ppm CO2	Predict	01/12/1900	Mark Chandler	Snowball Earth
Solar_Decrease	Decrease Solar Luminosity by 5%	Predicted	30/09/2005	Mark Chandler	Solar Change

Figure 3-5. The Simulation Library is a searchable database of previously run experiments that allows users to find experiments with similar themes, as well as export experiments to exchange with other members of the EdGCM Cooperative.

Chapter 4

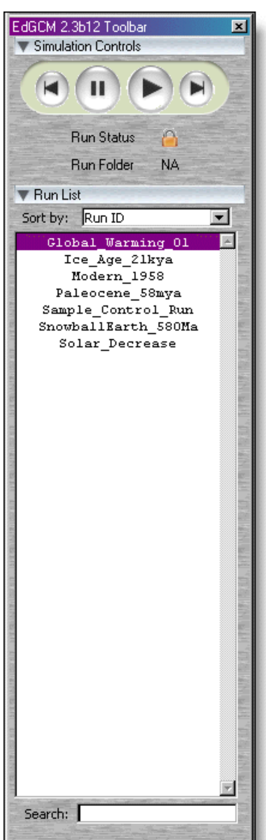
*Ed*GCM Tutorial

The purpose of the following tutorial is to familiarize you with the setup, running, and post-processing of a climate simulation. This example is one based upon one of the global warming scenarios included on your *Ed*GCM CD-ROM. Although you will see the fields and options that can be changed for customized simulations, we will mainly demonstrate the use of the pre-programmed values in the global warming scenario for this tutorial. Unless otherwise indicated, each step will be the same in both the Mac and Windows versions.

4.1 Launching *Ed*GCM and Setting Up a Simulation

1. ***Mac:*** In the *Ed*GCM 4D Database folder, double-click on the file called "EdGCM.4DB" to launch the application.

Windows: In the *Ed*GCM 4D Database folder, double-click on the file called "EdGCM Structure File" to launch the application.



The first window that will appear will be the basic *Ed*GCM Toolbar, which includes a list of simulations already available (the run list). The buttons in the Toolbar will automatically change to provide new options as various *Ed*GCM functions are selected, but the run list will always be present. The run list may also be used to search for a particular run ID, or to sort through a long list of run IDs.

Figure 4-1. The basic EdGCM Toolbar.

Return to Contents

2. In the menu at the top of the screen, click once on "Window" to display the various function windows within *Ed*GCM 4D, and select "Setup Simulations" (or press cmd + 1 for Macs, ctrl + 1 for Windows). To see the initial conditions for the Global Warming 01 scenario, make sure it is selected in the run list. Note the changes to the Toolbar relevant to the Setup Simulations window (Figure 4-2).

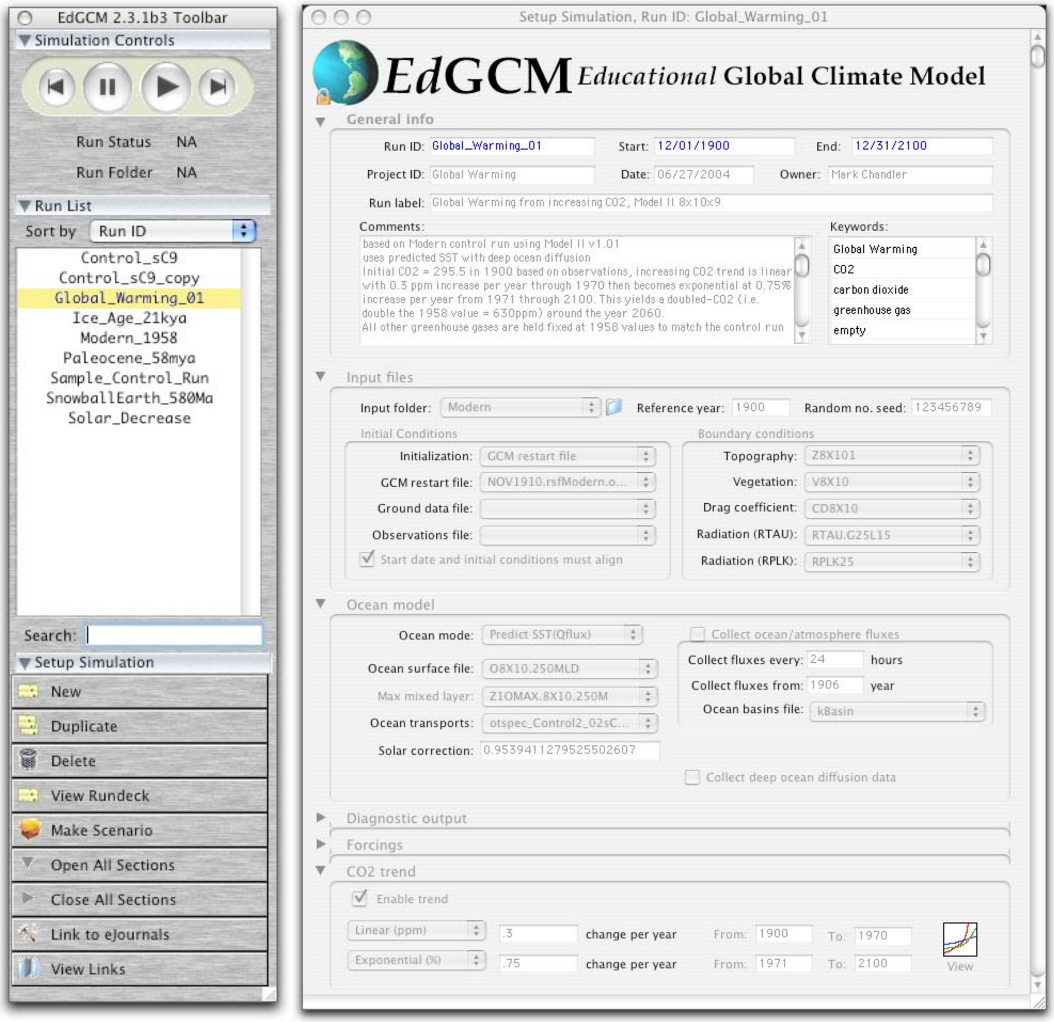


Figure 4-2. The Setup Simulations window and its associated Toolbar.

3. The comments section in the **General info** section of the Setup Simulation window provides the simulation description. This scenario was designed to induce global warming by increasing carbon dioxide in the atmosphere at the linear increasing rate of 0.3 ppm for the first 70 years of the experiment, followed by an exponential increase rate of 0.75% per year over a 130-year interval, starting with the observed value of 295.5 ppm in 1900.

4. The scenario included on the CD-ROM is locked, which means that none of the parameters can be changed (note the small lock icon next to "run status" near the top of the toolbar). In order to create a copy of this scenario that can be modified, click the Duplicate button under "Setup Simulation" in the toolbar. You have now created a copy of the simulation (Global_Warming_1_copy in the run list) that can be modified to your

Return to Contents

specifications.

If you were to continue setting up a new scenario, the remaining sections of the Setup Simulations window would be used to input your modifications. The **Input files** section sets the geographic boundary conditions (i.e., land mass distribution, topography, vegetation distribution) at the appropriate grid resolution for the model, according to the files selected. For modern control runs, future climate simulations and Pleistocene ice age experiments, the choice of files need not be modified from the default selections. Users wanting to do paleoclimate simulations must take care that all the boundary condition files here are set appropriately for the time period of interest, or else the GCM will crash.

The **Ocean model** and **Diagnostic** sections are intended for advanced users, and need not be modified for most simulations.

The **Forcings** section (Figure 4-3) allows you to set the value of solar luminosity and various greenhouse gases, the levels of which would remain uniform through the entire experiment. The values entered into this section are independent of each other and can be set to whatever values you wish. However, the GCM is not guaranteed to behave properly if the values entered are too far beyond modern values (e.g., solar luminosity set to more than 10% above or below modern; more than 10X modern carbon dioxide).

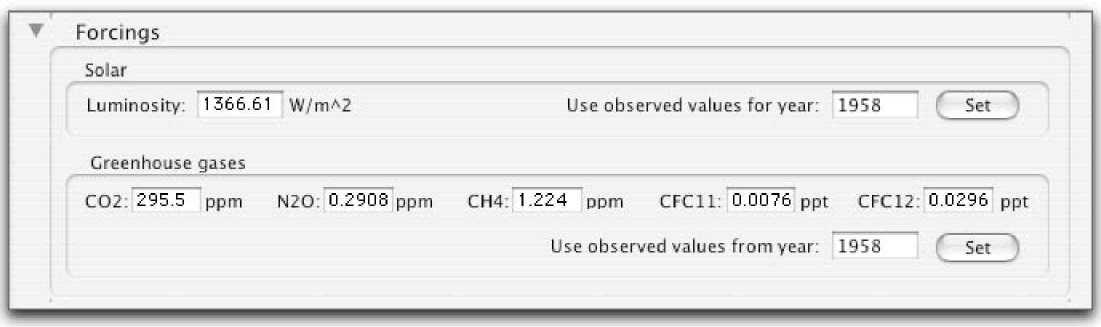


Figure 4-3. The Forcings section allows basic manipulation of the GCM boundary conditions.

More complex variations of the solar luminosity and various greenhouse gases are also possible by adjusting individual **Trends**. As previously noted, the simulation used for this tutorial sets a linear increase followed by an exponential increase per year for carbon dioxide. It is also possible to include a transient increase in carbon dioxide. Just to illustrate this option, open the CO2 Trend section of the Setup Simulation window, click once on the second drop-down menu bar and select "Step (ppm)" as the second trend (Figure 4-4). Then fill in a value of 500 for the step function for the years 1970-2010.

Return to Contents

Figure 4-4. The CO2 trend section, like the other trend sections, permits the levels of greenhouse gases to change during the course of a simulation.

To see a graphic representation of how the level of CO2 would change through time, click on the "View" icon on the right side of the CO2 Trend section to launch the PlotShop program (for Mac users) or Excel (for Windows users) and display the trends (Figure 4-5). (Note for Mac users: You can change the trend values and year ranges as often as you like prior to starting the simulation. However, if you wish to view additional trends, it is necessary to close the previously opened PlotShop window before a new trend can be displayed.)

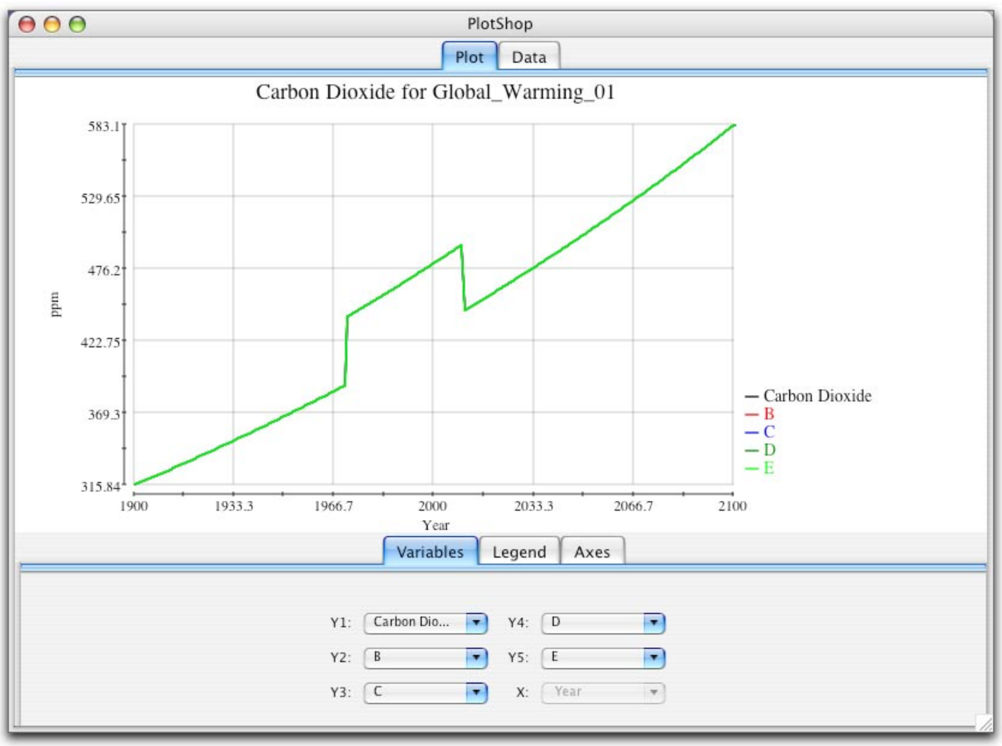


Figure 4-5. PlotShop display of changing CO2 trends as selected in Figure 4-4.

The **Power tools** and **Developer tools** sections are intended for advanced users, and should not be modified without special direction.

NOTE: For the purposes of this tutorial, we have already run the simulation and provided you with the output files. ***Do NOT begin a new simulation run, otherwise you will overwrite the tutorial's data files.***

If you are later running your own simulation, you need to take the following steps to get the experiment under way:

Return to Contents

5. With the boundary conditions now set for this simulation, press the “play” button under “Simulation Controls” at the top of the toolbar. A new window will pop up to show you the progress of the model simulation in Fortran. The model will initially run through the first hour of the simulation and then stop (Figure 4-6), to ensure that no major error have been made in the selection of boundary conditions (e.g., a Snowball Earth land mass distribution with modern vegetation).

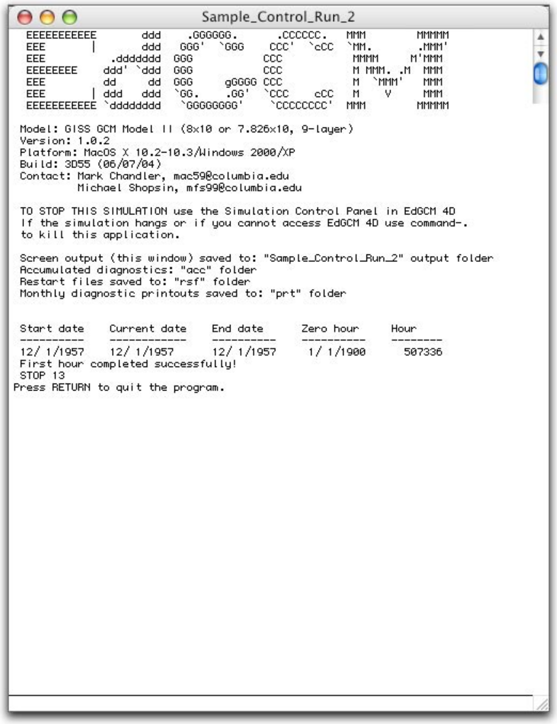


Figure 4-6. The first hour of a simulation was successfully completed.

6. At this point, the GCM must be restarted. Click on the start button at the top of the toolbar again in order to restart the simulation.

7. Another Fortran window will open, this time staying open until the simulation is complete. Since Fortran runs independently of *Ed*GCM 4D, the interface can be closed down until the run is finished and you are ready to analyze the results.

4.2 Analyzing Output

1. After the simulation has been completed, re-launch *Ed*GCM 4D. Now select “Analyze Output” (cmd + 4 for Macs, ctrl + 4 for Windows) from the menu at the top of the screen. A window titled Analyze Output will appear (Figure 4-7).

The Analyze Output window is used to process four types of data: tables, linear plots, maps, and vertical slices. Each of these data types is represented as a tab in the center of the window; clicking on the tab brings you to that given data type and the list of variables available for that type.

On the left side of the Analyze Output window, the years run for a given simulation are displayed twice so that you may select the starting and ending dates for the interval you want to analyze. On the right side, a list of data files will appear as you process the results of the simulation.

Return to Contents

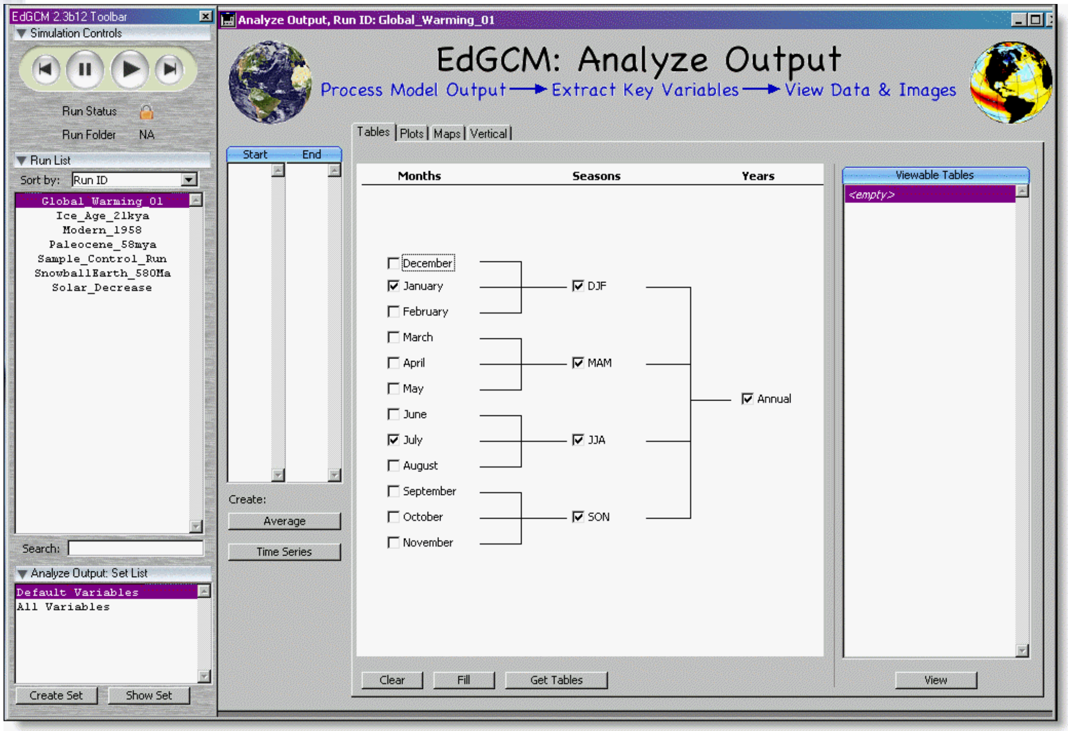


Figure 4-7. The Analyze Output window and associated toolbar.

2. To generate tables of data showing annual, seasonal or monthly averages, click on the Tables tab, and then select the first and last year of the time interval over which you would like the results averaged. (Typically the last five to ten years of the run are selected for averaging, a practice which helps reduce the amount of noise in the data.) Select the periods for which you would like to calculate averages, then click once on the "create average" button located below the start and end date lists. A Fortran window will appear briefly while the tables are being generated. Then click the "get tables" button, and a list of processed data files will appear on the right side of the window (Figure 4-8).

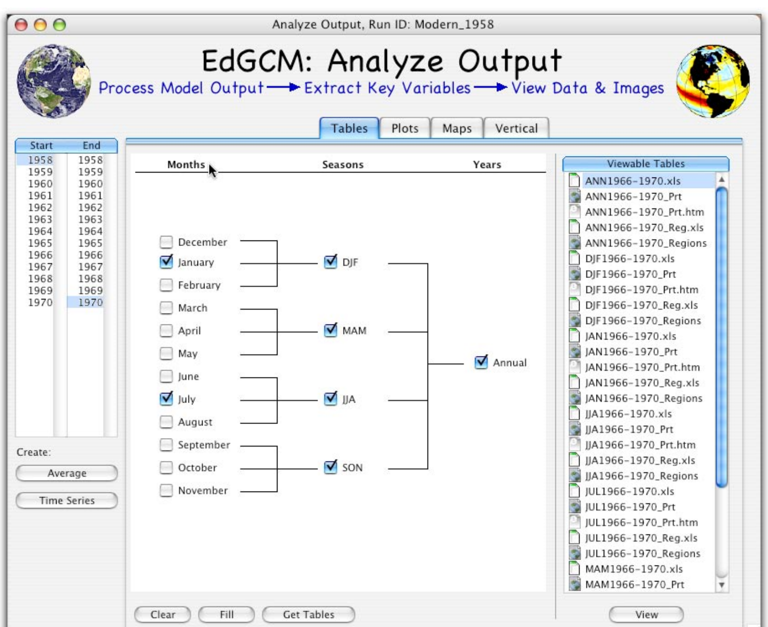
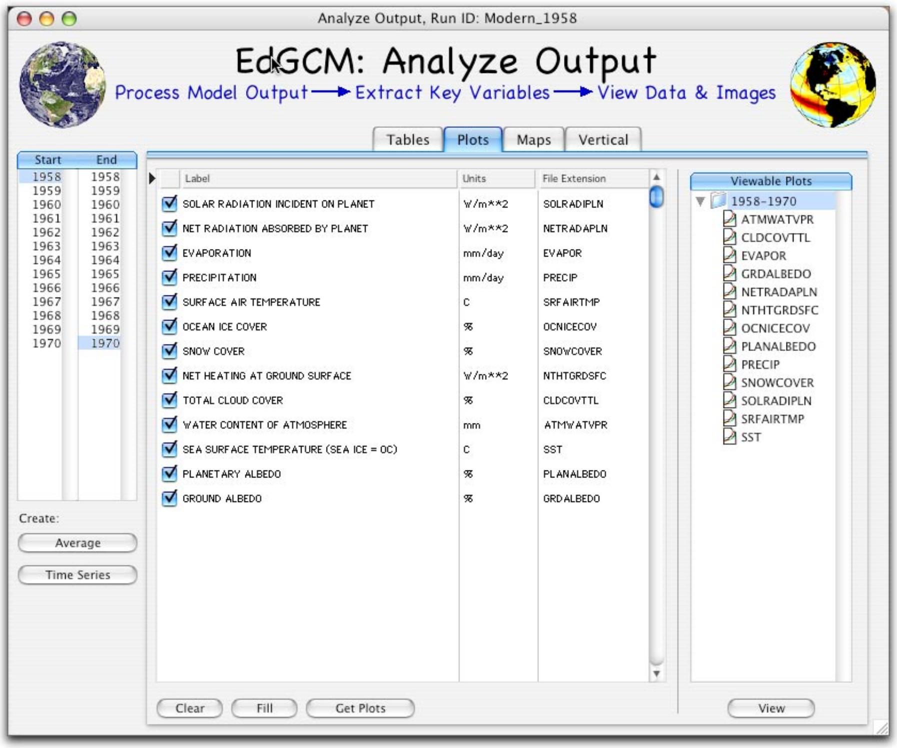


Figure 4-8. The Tables tab in the Analyze Output window, showing the list of files generated by post-processing. The icons next to the file names indicate the format of the file: Excel, HTML, and SuSpect (the latter for Macs only).

Return to Contents

3. To generate a time series that can be plotted linearly, click on the Plots tab, and then select the first and last year of the time series you want to create. Select the variables that you would like to plot, and then click once on the “create time series” button located below the start and end date lists. A Fortran window will appear briefly while the data for the plots are being generated. Then click the “get plots” button, and a list of processed data files will appear on the right side of the window (Figure 4-9).

Figure 4-9. The Plots tab in the Analyze Output window, showing the list of files generated by post-processing. The icon next to the file names is for PlotShop, but Windows users will be able to view and plot these files in Excel.



4. To generate maps displaying annual, seasonal or monthly averages, click on the Maps tab, and then select the first and last year of the time interval over which you would like the results averaged. Select the variables which you would like to map, then click once on the “create average” button located below the start and end date lists. A Fortran window will appear briefly while the data for the maps are being generated. Then click the “get maps” button, and a list of processed data files will appear on the right side of the window (Figure 4-10).

5. To generate vertical slices displaying spatial data along pole-to-pole transects, click on the Vertical tab, and then select the first and last year of the time interval over which you would like the results averaged. Select the variables which you would like to view, then click once on the “create average” button located below the start and end date lists. A Fortran window will appear briefly while the data for the vertical slices are being generated. Then click the “get vertical” button, and a list of processed data files will appear on the right side of the window (Figure 4-11).

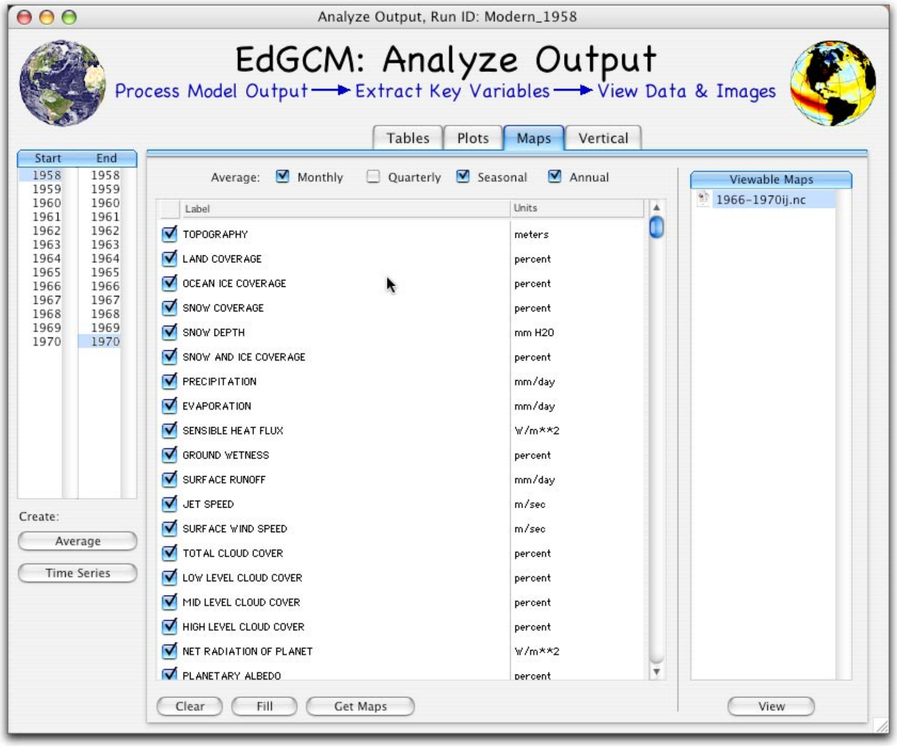


Figure 4-10. The Maps tab in the Analyze Output window, showing the list of files generated by post-processing. The icon next to the file represents the netCDF format, a popular cross-platform format for spatial data.

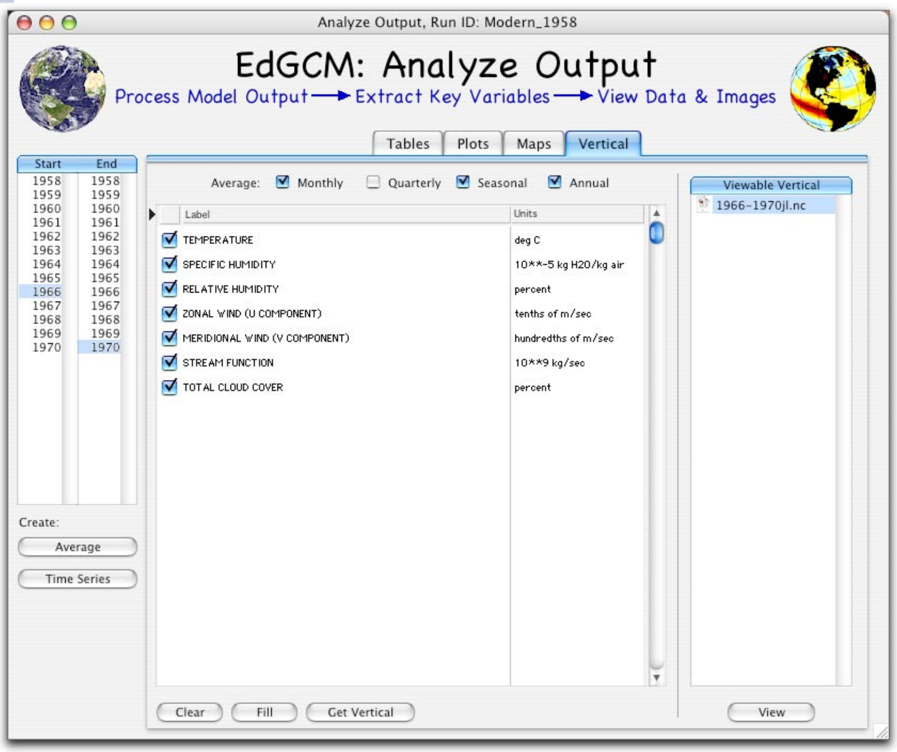


Figure 4-11. The Maps tab in the Analyze Output window, showing the list of files generated by post-processing. Vertical slice data files are also in netCDF format.

4.3 Viewing the Data

The data generated in any of the Analyze Output tabs can be viewed simply by either selecting a file name in the right column of the tab and clicking once on the "View" button at the bottom of the column, or by double-clicking on the file name. The appropriate program will then launch to display the data.

For the tables, Windows users may choose between Excel and HTML to view the data. The HTML file is perhaps easier to view, as it starts with a series of links to the tables for each variable (Figure 4-12). Mac users have the additional option of viewing their data in SuSpect (Figure 4-13), which also allows the sync'ed viewing of multiple data files simultaneously.

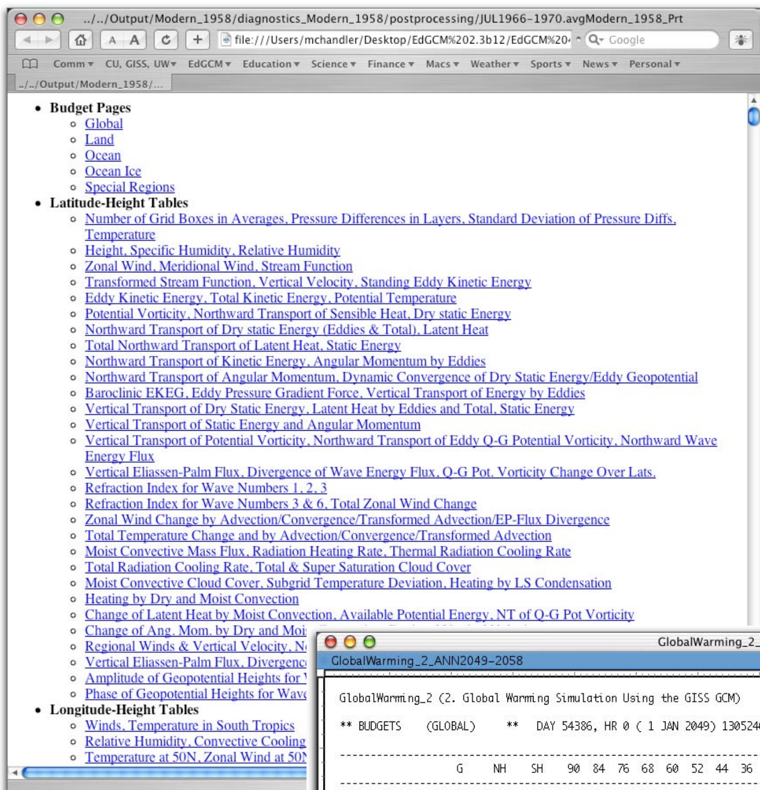


Figure 4-12. The HTML display of tables data begins with a series of links to tables for the individual variables selected for analysis.

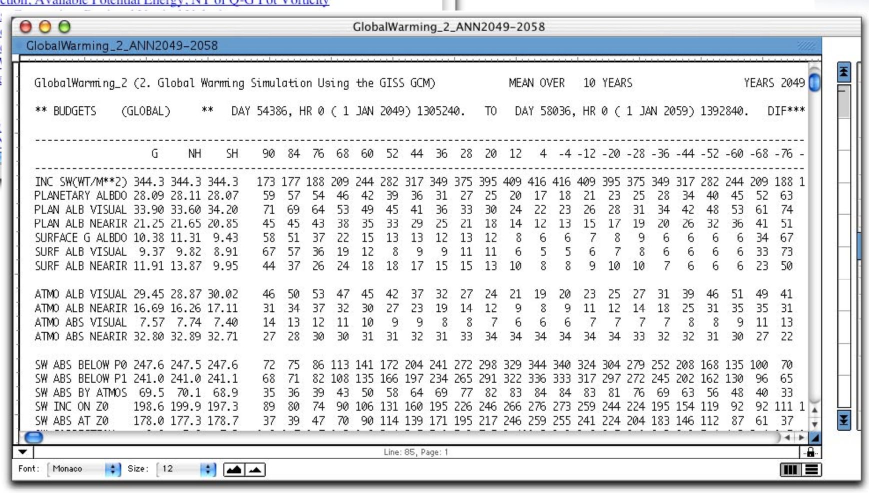


Figure 4-13. Mac users can employ SuSpect to view their data.

For the linear plots of time series data, Windows users will have an Excel file in which they can construct their own plots. Mac users may opt for Excel, or else they can view the data in PlotShop (Figure 4-14).

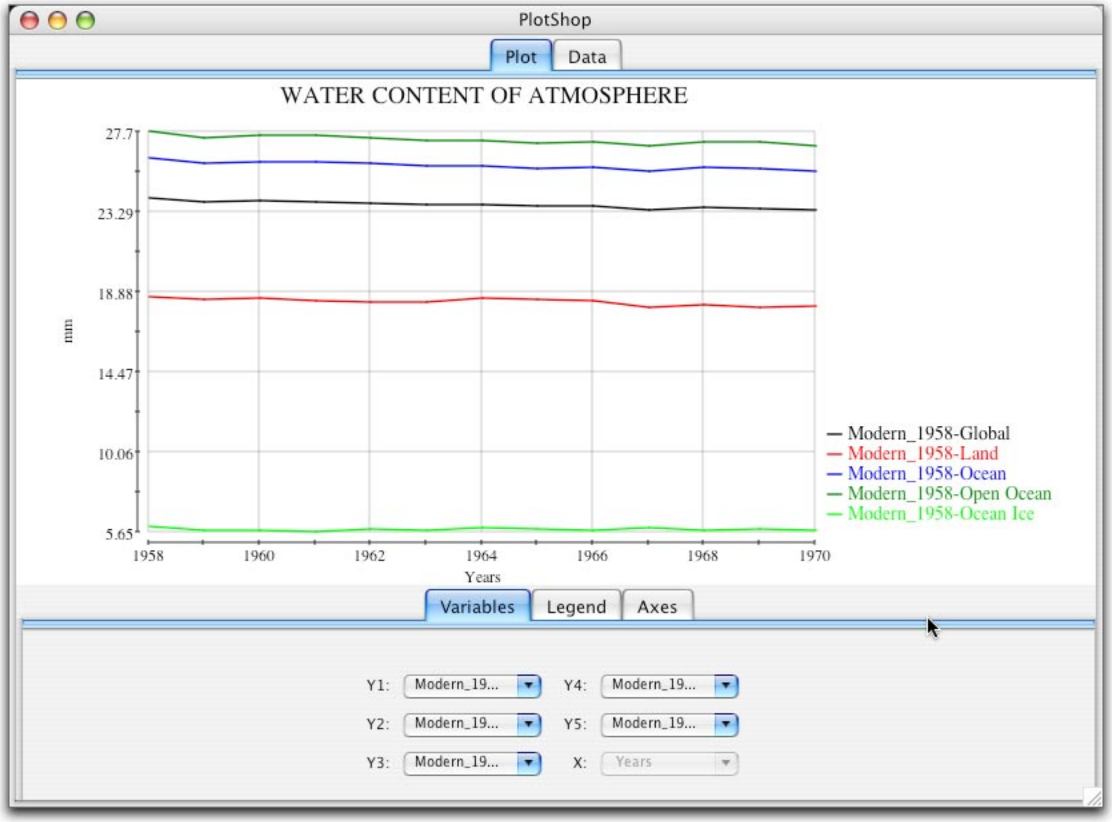
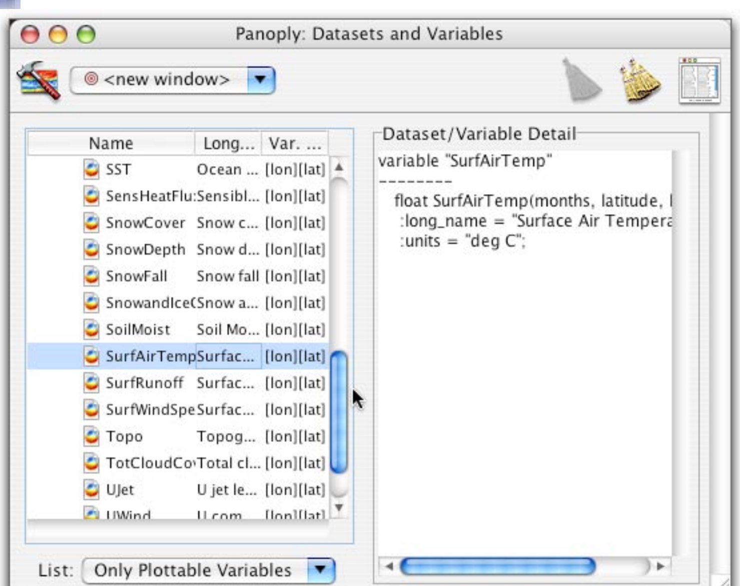


Figure 4-14. Times series plot generated by PlotShop for Mac users.

For maps and vertical slices, the netCDF files can be displayed on both Macs and Windows machines in Panoply, a cross-platform application. To launch Panoply, simply double-click on a netCDF file name listed in the Maps or Vertical tabs. Panoply will first display a list of variables that can be plotted. (Figure 4-15).



Select the variable you wish to map, then click once on the hammer icon in the upper left corner of the window. A new window with 2 tabs will open, showing both the map and a spreadsheet of the dataset being plotted.

Figure 4-15. List of plottable variables in Panoply.

Return to Contents

There are a number of options for displaying the data in map view. For this tutorial, select “ANN” from the drop-down menu in Array 1, and check the interpolate button. The result will be displayed in Mollweide projection by default (Figure 4-16).

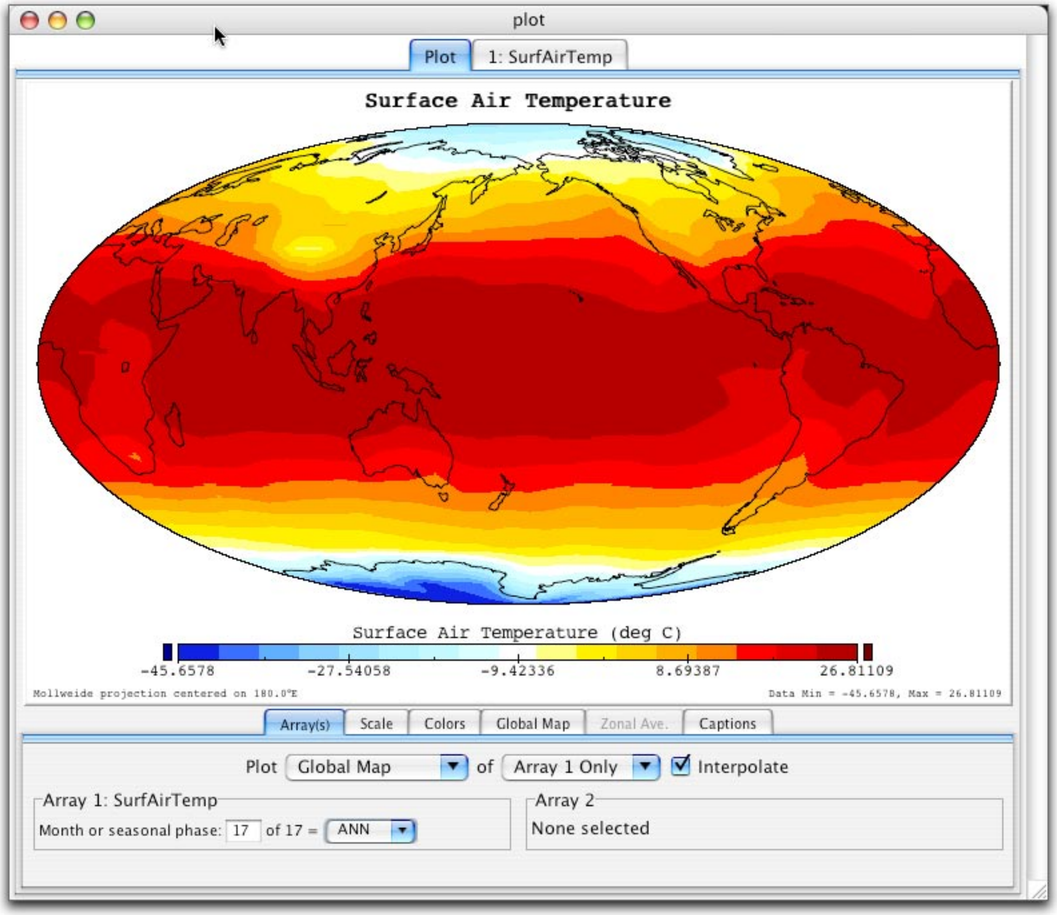


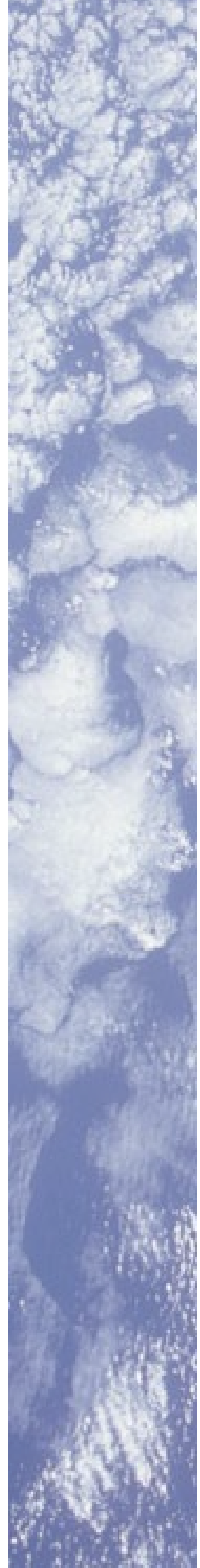
Figure 4-16. A simple map plot in Panoply.

If you wish to know the variable value at any given point on the map, holding down the option key (Mac) or alt key (Windows) and double-clicking the mouse will produce a small pop-up window noting the latitude and longitude of the point, the grid cell in which it lies, and the value for the variable.

There will often be times when it is desirable to compare two data sets, either from different simulations or from different time intervals within the same simulation. Panoply includes a function that allows you to graphically display the differences, which are commonly referred to climate anomalies.

As an example, let’s look at the surface air temperature anomaly produced by differencing two separate intervals in a global warming simulation that employs a transient change in atmospheric CO2. First, you will need to create the appropriate netCDF files.

1. Open the *Ed*GCM interface.



Return to Contents

2. Select Analyze Output from the Window menu.

3. Click on the Maps tab in the Analyze Output window.

4. Turn on the check boxes next to the variables you wish to analyze. You can check as many variables from the list as you want. We recommend limiting your choices to those variables most relevant to the analysis at hand, to reduce clutter in Panoply's datasets window later on.

5. Select the simulation you want from the run list in the toolbar at left.

6. Select a five-year period over which to average your variables.

7. Click on the Create button to generate your time-averaged data set.

8. From the list of viewable maps, select the file you just created (identifiable by its run number and the year range you selected in the filename). Once the file is selected click, on OK. Panoply will launch to display this file.

Now repeat steps 5-8, but use a different five-year interval to create the second data set.

At this point, Panoply's Datasets and Variables window should now be open with two data sets listed (Figure 4-17). Note that Datasets are shown as folders, which can be double-clicked to hide/show the variables inside. You may have to scroll down in the left hand field to see all the variables in both data sets at once.

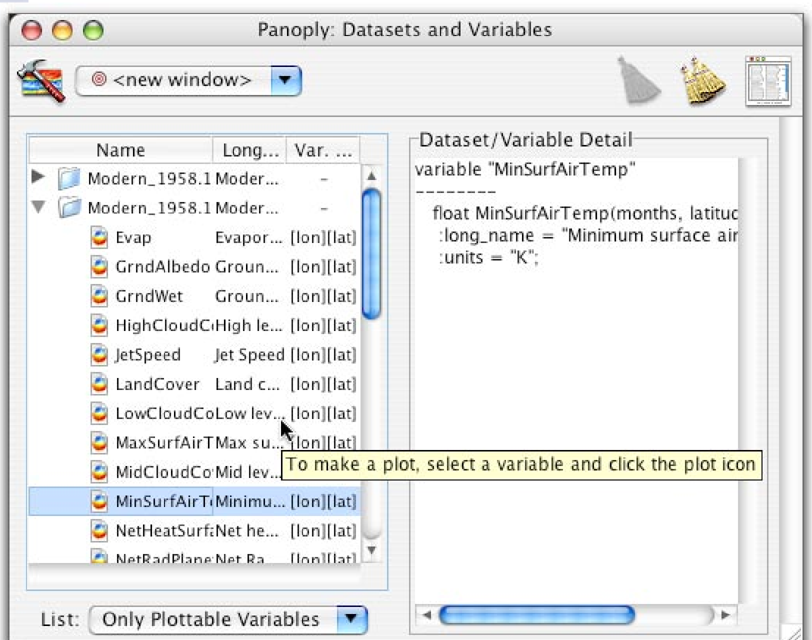


Figure 4-17. Two data sets in Panoply, available for difference plotting.

Now, to plot the differences between the data sets:

1. Select a variable from the first dataset, such as "Surface Air Temperature," and click the hammer icon in the upper left corner of the window. A new window will open, showing a map of the data in one tab and a spreadsheet of the corresponding numeric values in a second tab (as in Figure 4-16).

2. Go back to the Datasets and Variables window in Panoply and select the "Surface Air Temperature" from the other dataset.

3. In the drop menu next to the hammer icon, in the upper left corner of the window, select "plot 2" (not "<new window>"). The hammer icon will turn to a double-hammer icon. Clicking the double-hammer icon will plot the difference of the two variables in the plot window (Figure 4-18).

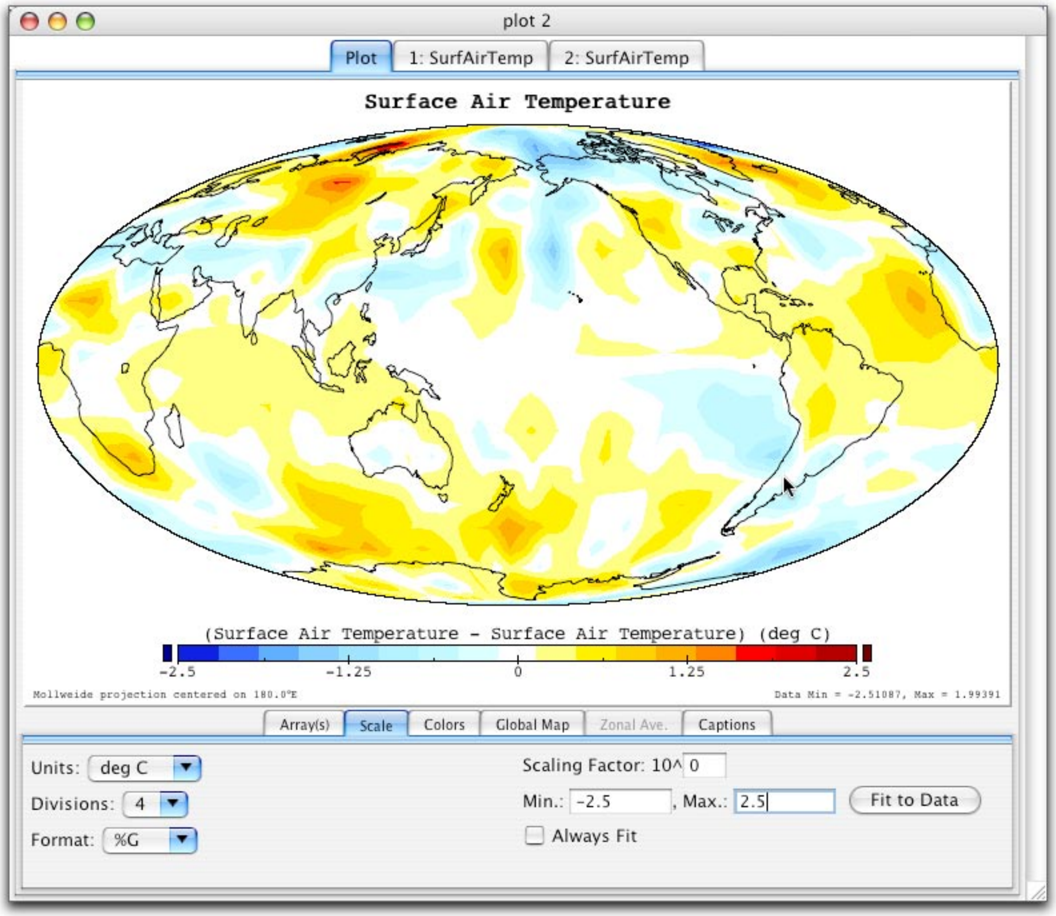


Figure 4-18. A difference map plot in Panoply.

Hint: Choosing the Right Color Bar

When plotting differences, always choose a color bar (in the Colors tab at the bottom of the Plot window) that has white in the exact center of the bar (e.g., panoply_diff PAL-1). In this way, white = no difference. Then, within the Scale tab, uncheck the "Always fit" box and set your scale so that the Max = -1 x Min (e.g., Max = 5.0 when Min = -5.0). This creates a color bar with a symmetric scale, so that it is easy to distinguish positive anomalies (e.g., colors to the right of white are regions that warmed) and negative anomalies (e.g., colors to the left of white are regions that cooled).

Return to Contents

4.4 Reporting Your Results

An important feature of *Ed*GCM is the ability to share simulation results and interpretations by publishing to a web site easily accessible to others. The entire process is greatly simplified through *Ed*GCM's eJournal function.

To report results:

1. Return to *Ed*GCM, and select "eJournal" from the menu at the top. The eJournal toolbar and setup window will appear (Figure 4-19).

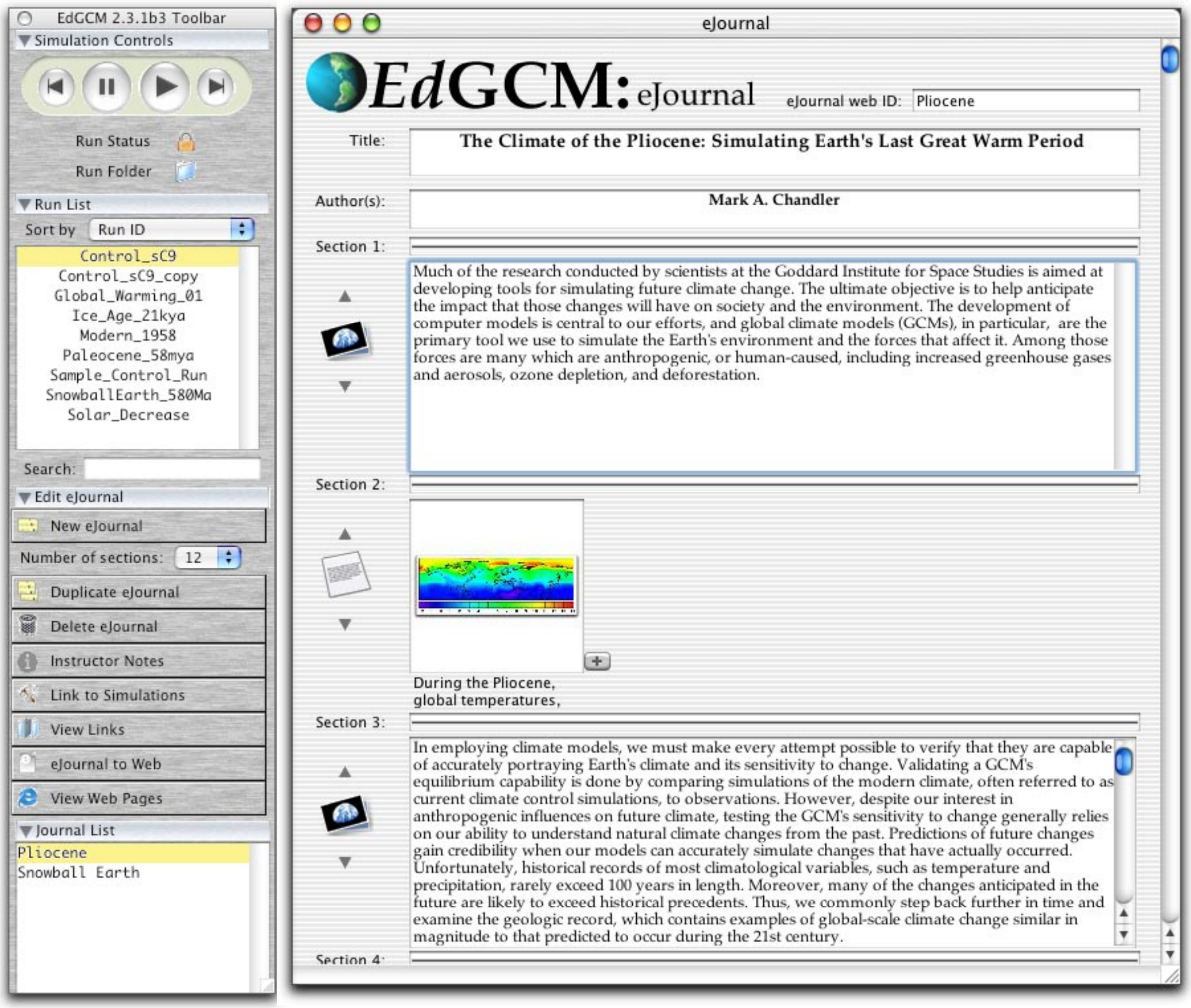


Figure 4-19. The eJournal setup window and its associated toolbar.

2. Each section of the eJournal (up to a maximum of 20 sections) can be used for either text descriptions or figures. To convert between one type of section to the other, simply click on the button to the left of the section (clicking on a photo button sets up the section for figures; clicking on a text button sets up the section for text).

3. Three additional figures may be added to a given section (for a total of four figures) by clicking the "+" button at the lower right corner of the figure window. Up to two lines of figure caption text, if available, will be visible for each figure in the eJournal setup window, although longer captions will be

Return to Contents

displayed in their entirety when the eJournal is published to HTML.

4. Images of any size or format can be imported from the Image Browser (Figure 4-20), which is accessible from the *Ed*GCM file menu. Images from the Image Browser may be inserted into an eJournal section by simply dragging and dropping the image into a figure box, such as the one seen in section 2 of the eJournal page in Figure 4-19.

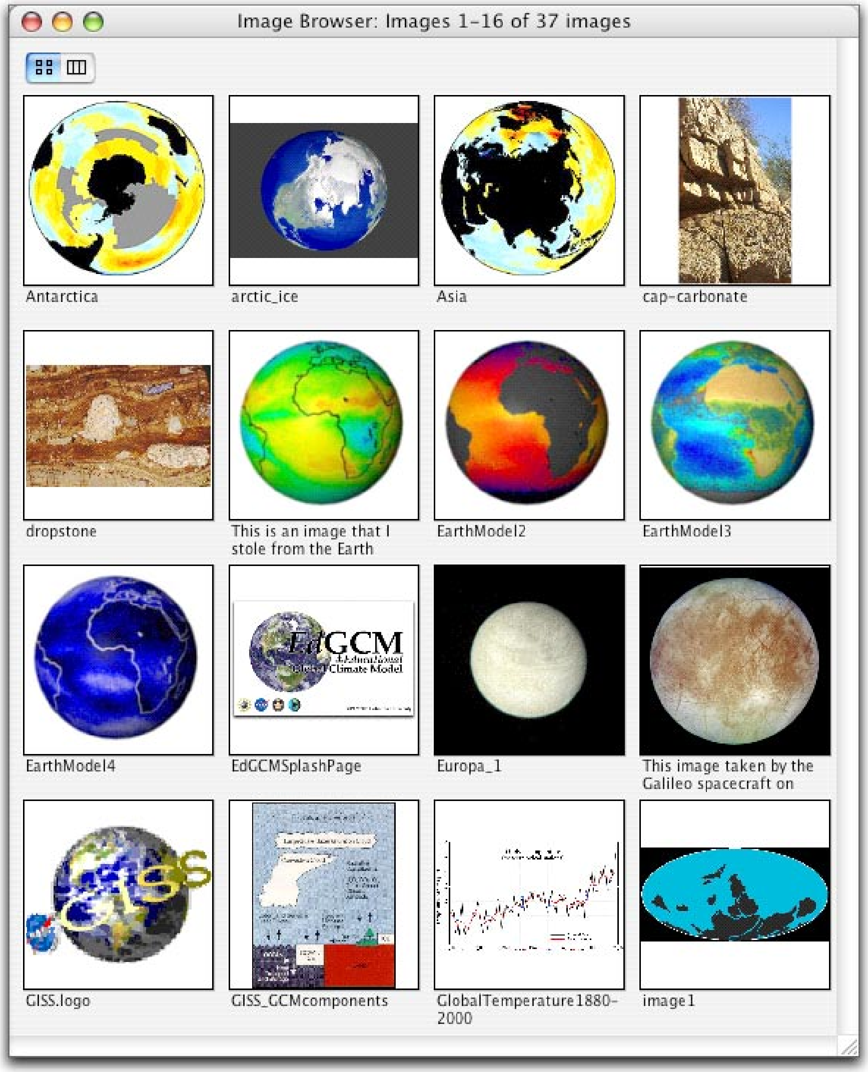
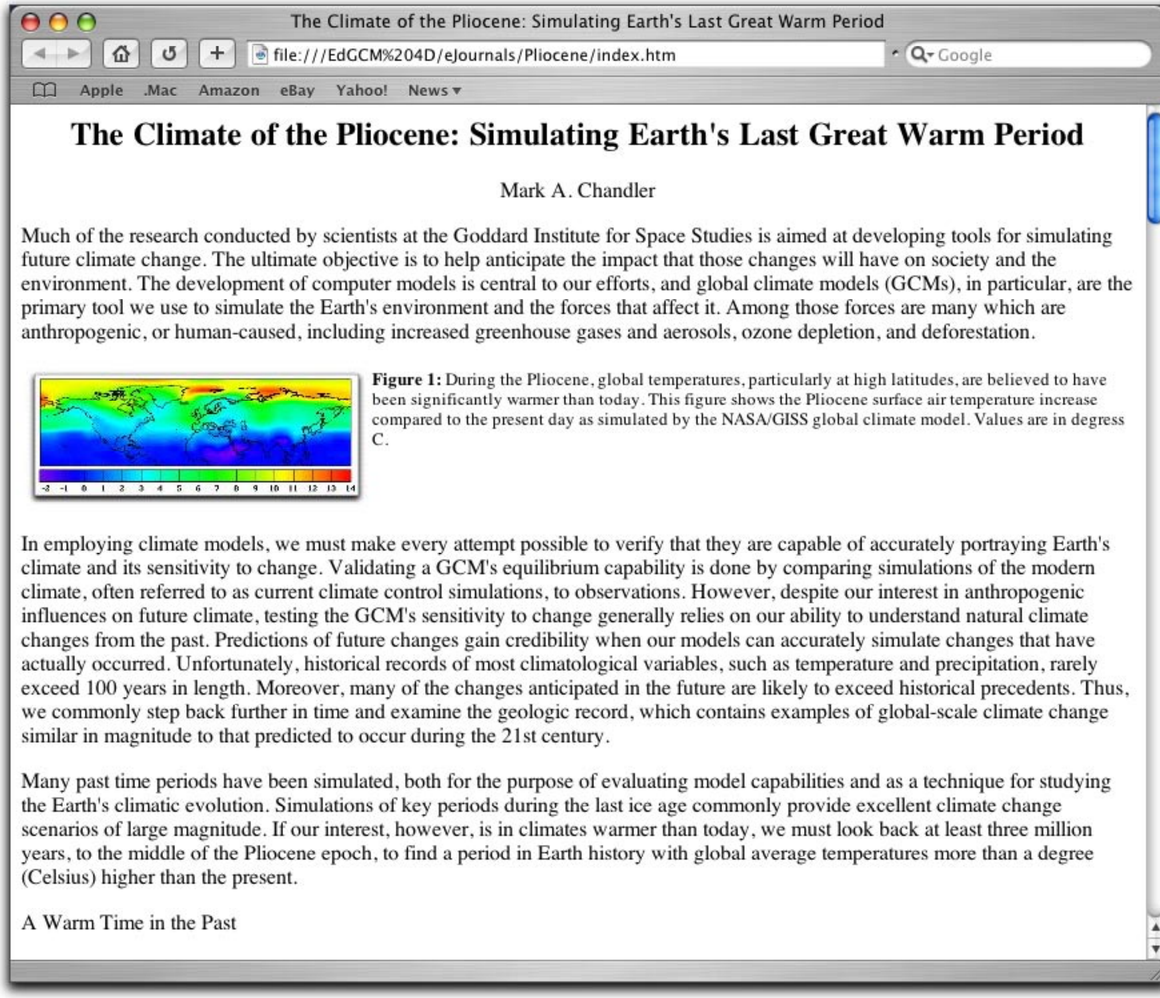


Figure 4-20. The Image Browser is a library of photos, graphs, and maps that can be used to illustrate key points for discussion in a student's eJournal report. The images can be sorted by name, date created or modified, or by theme (e.g., Pliocene images, global warming images). The Image Browser may be added to at any point by students or teachers.

5. To page through multiple pages of the Image Browser, click on the "forward" and "reverse" buttons in the Image Browser toolbar. It is also possible to search for images by name, or sort images by name, creation date, etc.

6. When an eJournal is ready for web publication, return to the filled-out eJournal page and click on the "eJournal to Web" button in the toolbar (see Figure 4-19). The eJournal page will be converted to an HTML file, which will open automatically in a new window within your default web browser (Figure 4-21).



The Climate of the Pliocene: Simulating Earth's Last Great Warm Period

Mark A. Chandler

Much of the research conducted by scientists at the Goddard Institute for Space Studies is aimed at developing tools for simulating future climate change. The ultimate objective is to help anticipate the impact that those changes will have on society and the environment. The development of computer models is central to our efforts, and global climate models (GCMs), in particular, are the primary tool we use to simulate the Earth's environment and the forces that affect it. Among those forces are many which are anthropogenic, or human-caused, including increased greenhouse gases and aerosols, ozone depletion, and deforestation.

Figure 1: During the Pliocene, global temperatures, particularly at high latitudes, are believed to have been significantly warmer than today. This figure shows the Pliocene surface air temperature increase compared to the present day as simulated by the NASA/GISS global climate model. Values are in degress C.

In employing climate models, we must make every attempt possible to verify that they are capable of accurately portraying Earth's climate and its sensitivity to change. Validating a GCM's equilibrium capability is done by comparing simulations of the modern climate, often referred to as current climate control simulations, to observations. However, despite our interest in anthropogenic influences on future climate, testing the GCM's sensitivity to change generally relies on our ability to understand natural climate changes from the past. Predictions of future changes gain credibility when our models can accurately simulate changes that have actually occurred. Unfortunately, historical records of most climatological variables, such as temperature and precipitation, rarely exceed 100 years in length. Moreover, many of the changes anticipated in the future are likely to exceed historical precedents. Thus, we commonly step back further in time and examine the geologic record, which contains examples of global-scale climate change similar in magnitude to that predicted to occur during the 21st century.

Many past time periods have been simulated, both for the purpose of evaluating model capabilities and as a technique for studying the Earth's climatic evolution. Simulations of key periods during the last ice age commonly provide excellent climate change scenarios of large magnitude. If our interest, however, is in climates warmer than today, we must look back at least three million years, to the middle of the Pliocene epoch, to find a period in Earth history with global average temperatures more than a degree (Celsius) higher than the present.

A Warm Time in the Past

Figure 4-21. A published eJournal report.

These files can then be published to a school web site or to the student's own web space for public access. A copy may also be added to the school's eJournal library, a searchable offline database for the reports (Figure 4-22).

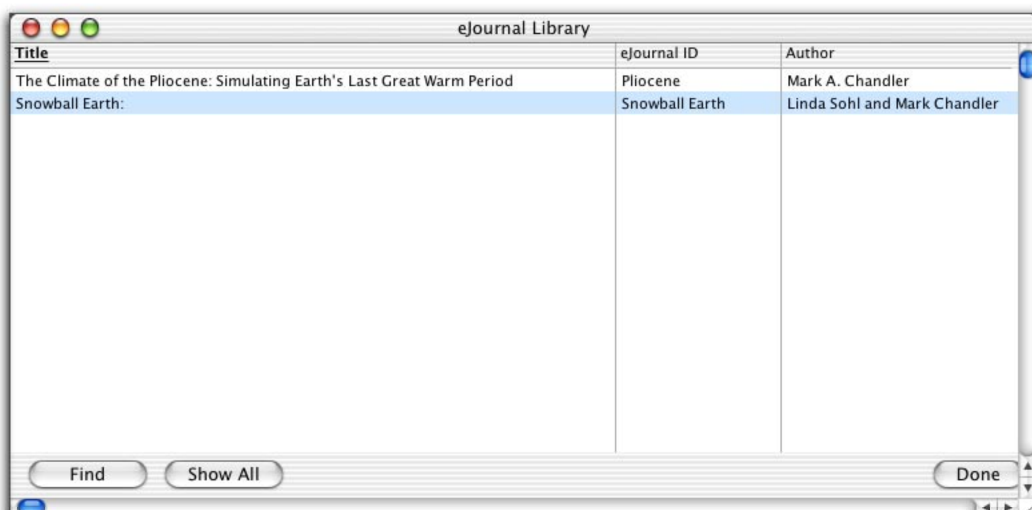


Figure 4-22. The eJournal database.