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

About the “Draft” *Ed*GCM Manual

This is the first draft of a document that will eventually become the *Ed*GCM manual. For starters, please be aware that *Ed*GCM is a suite of software containing several individual applications all working together as a cohesive unit. The *Ed*GCM applications contain hundreds of features in total, which this draft manual only begins to describe, to say nothing of the fact that all of the *Ed*GCM software controls an even more complex piece of software, the NASA/GISS Global Climate Model (GCM).

Currently the Draft *Ed*GCM Manual includes:

1) installation instructions for PCs and Macs
2) a description of the key components of *Ed*GCM and of the file system structure
3) a basic *Ed*GCM tutorial
4) correlations between *Ed*GCM activities and several national education standards and science benchmarks

Many “instructions” in this draft remain little more than outlines of features that need to be more fully described. We’re working to create regular updates to this manual about once a month, so check the downloads page on our website for updates to both the manual and the software:

www.edgcm.org/EdGCMCooperative/Downloads.php

Thanks,
Mark A. Chandler and Linda E. Sohl

About Us

The *Ed*GCM development team includes the following personnel:

Mark Chandler, Project Leader, mchandler@edgcm.org
Michael Shopsin, Lead Programmer, mshopsin@edgcm.org
Steven Richards, Education Coordinator, srichards@edgcm.org
Linda Sohl, Content Editor and Technical Writer, lsohl@edgcm.org

Contents

Acknowledgments

The *Ed*GCM Cooperative project is supported by the Earth Science programs at NASA and by the National Science Foundation, Division of Atmospheric Sciences–Paleoclimate Program. We gratefully acknowledge the help of the scientists and programmers at NASA's Goddard Institute for Space Studies in New York, who have worked for over 25 years developing Global Climate Models (GCMs), including the model at the core of *Ed*GCM. Model development at GISS is supported by NASA's Climate Program. Special thanks to Robert Schmunk, Matthew Shopsin, and David Hirschfield, who have written the visualization utilities, and to Jean Lerner, who assists in updating the GISS GCM.

GLOBAL CLIMATE MODELING

The *Ed*GCM Cooperative

RESEARCH AND EDUCATION

Overview of the *Ed*GCM Cooperative Project

Climate change will profoundly impact our planet's environment and the world's economy in the coming decades. The general public needs to have a fundamental grasp on the workings of the Earth's climate system, so that informed judgments may be shaped at all levels of society with regard to critical issues. In order to achieve this goal, teachers need to be provided with the resources that will engage students in the scientific and technological processes used by scientists to forecast climate change. In so doing, students will become knowledgeable about a topic that will surely affect their lives, and the next generation of scientists grappling with a myriad of complex climate issues will be better prepared.

Computer-driven global climate models (GCMs) are one of the primary tools used today in climate research. Unfortunately, few secondary school or undergraduate educators have access to GCMs, which have generally required supercomputing facilities and skilled programmers to operate. In addition, the lack of familiarity with climate modeling techniques often engenders public distrust of important scientific findings based on such methodology. As a result, graduate-level programs end up teaching fundamental techniques that could have been taught much sooner, and younger students miss out on excellent opportunities to participate in real-world research projects.

Our goal is to improve the quality of climate-change science teaching and learning through broader access to GCMs, and to assist teachers by providing the appropriate support, technology and materials to use these models effectively. With research-quality resources in place, linking classrooms to actual research projects becomes possible, to the benefit of both educators and scientists. In order to fulfill our goal we have created *Ed*GCM, a software suite that allows teachers and students to run a 4-D climate model on desktop computers. The GCM at the core of *Ed*GCM was developed at NASA and is currently used by researchers to study climates of the past, present and future. *Ed*GCM itself has a user-friendly interface that simplifies the management of climate simulations. Experiments are automatically archived in a searchable database, and easy-to-use utilities for mapping, plotting, and data analysis are fully integrated.

Climate change will profoundly impact our planet's environment and the world's economy in the coming decades. The general public needs to have a fundamental grasp on the workings of the Earth's climate system, so that

informed judgments may be shaped at all levels of society with regard to critical issues. In order to achieve this goal, teachers need to be provided with the resources that will engage students in the scientific and technological processes used by scientists to forecast climate change. In so doing, students will become knowledgeable about a topic that will surely affect their lives, and the next generation of scientists grappling with a myriad of complex climate issues will be better prepared.

Computer-driven global climate models (GCMs) are one of the primary tools used today in climate research. Unfortunately, few secondary school or undergraduate educators have access to GCMs, which have generally required supercomputing facilities and skilled programmers to operate. In addition, the lack of familiarity with climate modeling techniques often engenders public distrust of important scientific findings based on such methodology. As a result, graduate-level programs end up teaching fundamental techniques that could have been taught much sooner, and younger students miss out on excellent opportunities to participate in real-world research projects.

Our goal is to improve the quality of climate-change science teaching and learning through broader access to GCMs, and to assist teachers by providing the appropriate support, technology and materials to use these models effectively. With research-quality resources in place, linking classrooms to actual research projects becomes possible, to the benefit of both educators and scientists. In order to fulfill our goal we have created *Ed*GCM, a software suite that allows teachers and students to run a 4-D climate model on desktop computers. The GCM at the core of *Ed*GCM was developed at NASA and is currently used by researchers to study climates of the past, present and future. *Ed*GCM itself has a user-friendly interface that simplifies the management of climate simulations. Experiments are automatically archived in a searchable database, and easy-to-use utilities for mapping, plotting, and data analysis are fully integrated.

*Ed*GCM permits teachers and students to explore the fundamentals of climate science with unparalleled ease, utilizing tools identical to those used in major climate research programs. Many simple climate experiments are possible (e.g., how does the sun warm the planet?). However, it is also possible to conduct in-depth investigations of current, future and past climates on time frame similar to those used in ongoing climate research. *Ed*GCM comes with some pre-prepared scenarios for investigating a variety of interesting climate issues (global warming, snowball Earth), but teachers can easily construct their own scenarios to satisfy curricular requirements. The model interface can also be configured for different levels or topics to produce customized instructional materials (text, charts, images), and gives both teachers and students the ability to easily export research reports to the web. *Ed*GCM readily scales for use at grade levels from high school to graduate school, making it a unique tool for linking research to a broad spectrum of classroom settings.

Our future plans involve the creation of the *Ed*GCM Cooperative, a network of researchers and educators actively collaborating on climate research projects. We envision the Cooperative as a forum for the free and independent exchange of project ideas and data.

Return to Contents

Chapter 1

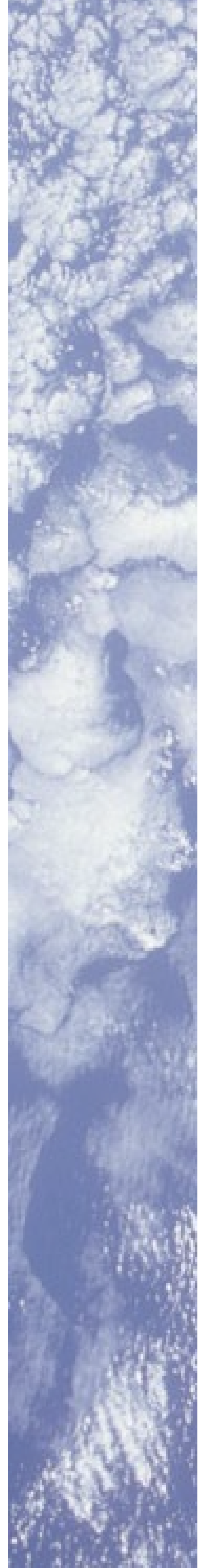
Introduction to *Ed*GCM

Welcome to *Ed*GCM, an integrated software suite designed to simplify the process of setting up, running, analyzing and reporting on global climate model simulations. The software package includes a full copy of 4th Dimension® database software (4D, Inc.) and the NASA/Goddard Institute for Space Studies' Global Climate Model II (i.e., GISS GCM II). The GISS GCM II is currently in used for climate research at NASA labs and several universities. For a complete description of the GISS GCM II see Hansen *et al.*, 1983, included inside *Ed*GCM's ***doc*** folder.

The *Ed*GCM CD-ROM includes everything your need to begin exploring climate science using a research quality computer climate model. Despite the complexity of the underlying GCM, the *Ed*GCM interface and associated utilities will allow the model to be operated and managed by teachers, students, and researchers with minimal training. Please note, however, that this is a beta version with limited documentation, so if you have not already attended one of our training workshops you may have difficulty utilizing the many functions available in this package. You are welcome to contact us for help in getting started, but we are currently only offering significant support to institutions that are collaborating with us for evaluation purposes. If you would be interested in attending a training session please DO contact us. Contact information and updated workshop schedules are available on the *Ed*GCM web site: http://www.edgcm.org.

System Requirements

- Mac OS X 10.2 (Jaguar) or better; Windows 2000/XP (Pro edition recommended)
- Any Mac with a G3, G4 or G5 processor running at 500 MHz or faster; any PC with an Intel or AMD processor running at 300 MHz or faster
- 1 GB of free disk space (for installation only; simulation results may require as much as an additional 10-15 GB)
- 128 MB of RAM, 256 MB recommended
- Internet connection is helpful but not required



1.1 Installation Guides: Macs and Windows

1.1.1 For Mac OS X

1. Insert the installation disk, or download the latest version from the *Ed*GCM web site. Double-click on the *Ed*GCM icon for the Mac installer (i.e., the icon on the left side of Figure 1-1). Please note that you must type in an administrator's password to complete the installation; if you do not have one, you will need to ask your IT administrator for assistance.

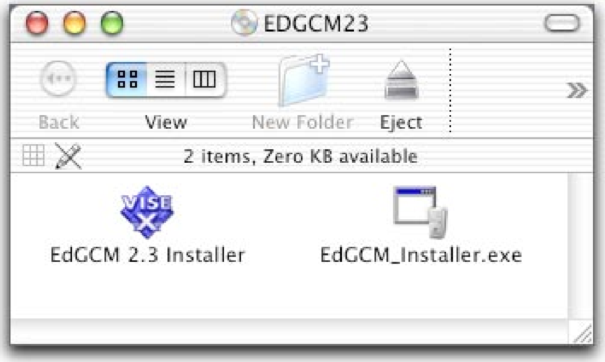


Figure 1-1. The EdGCM 2.3 installation disk includes both Mac and Windows versions of the installer. For Mac installation, click on the left icon.

2. The first screen of the installer is simply a splash page (Figure 1-2). Click on the "Continue" button to proceed with installation. The next screen will ask you to accept the terms of the licensing agreement; click on "Agree" to continue.

Figure 1-2. The EdGCM installer places all the software needed to run EdGCM on your hard drive.

Return to Contents

3. The next screen will ask you what type of installation you would like (Figure 1-3). The "Easy Install" option is recommended.

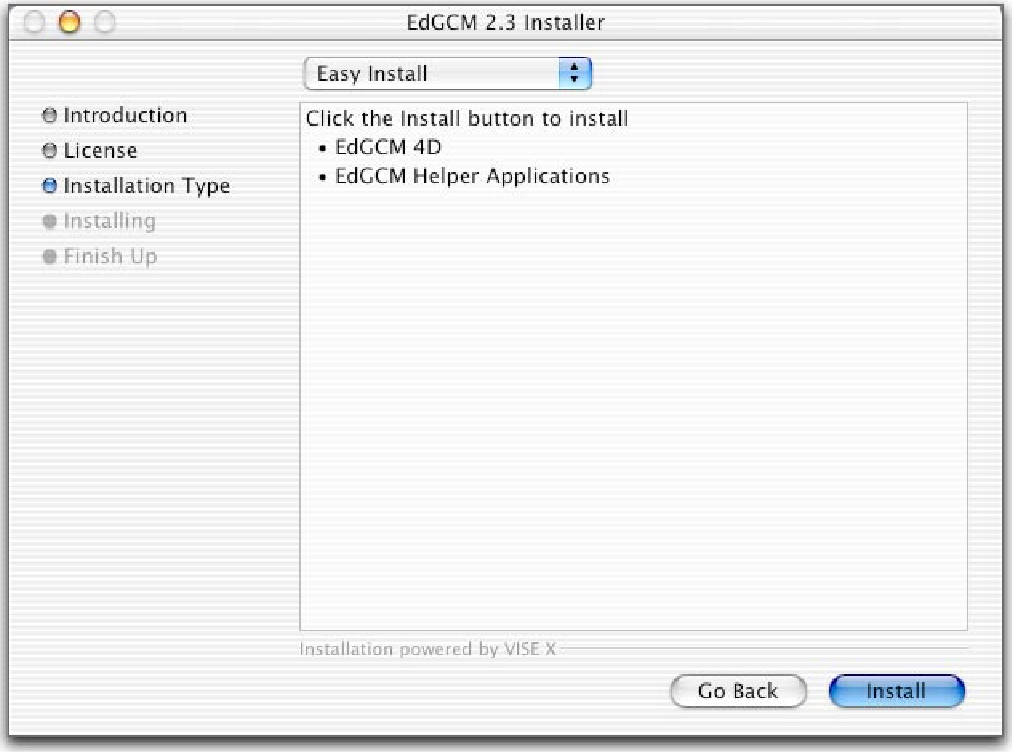


Figure 1-3. Select "Easy Install" for a stress-free installation of the full EdGCM package.

4. The installation process will proceed by automatically placing the *Ed*GCM folder on your desktop (Figure 1-4). If you want it in another location, you can drag the folder there once installation is complete. The installer will also place an icon in your Dock.

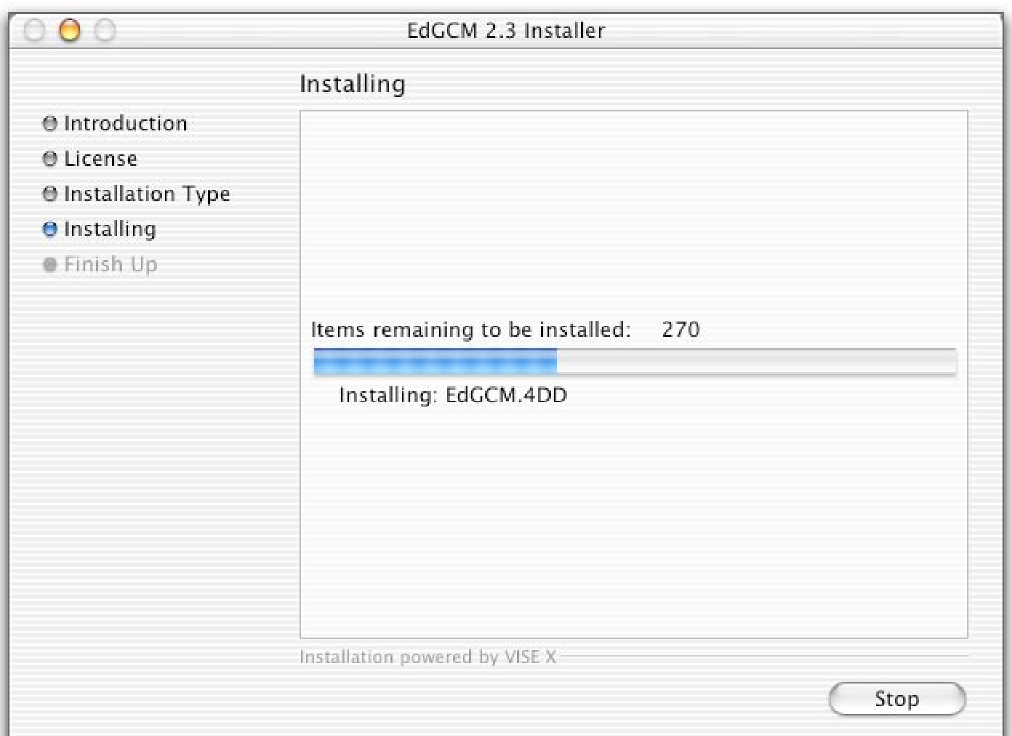


Figure 1-4. Installation of the EdGCM package may take several minutes to complete.

6.When installation is complete, you will be asked to launch *Ed*GCM for the first time. Click on "Launch" to start up *Ed*GCM 4D (Figure 1-5).

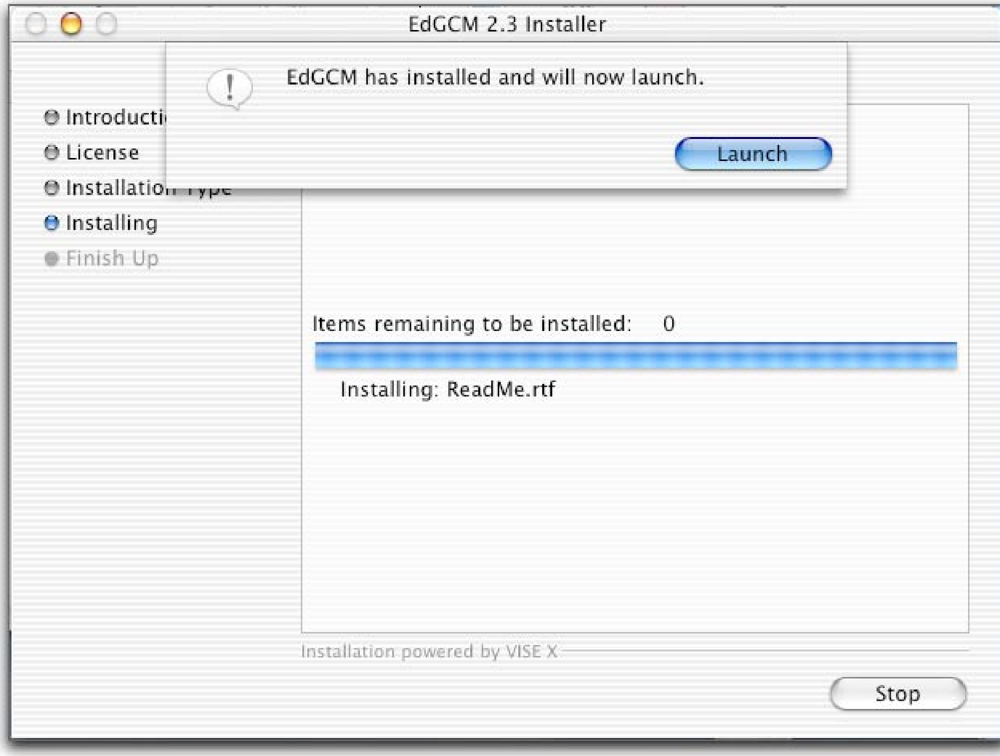


Figure 1-5. Once installed, EdGCM is ready to launch for the first time.

Note on cross-platform compatibility

All output files produced by the Mac OS X version of *Ed*GCM 2.3 are compatible for use with the Windows 2000/XP version, with the exception of files used by SuSpect and PlotShop, as these programs currently have no Windows equivalents.

1.1.2 For Windows 2000/XP

1. Insert the installation disk, or download the latest version from the *Ed*GCM web site. Double-click on the *Ed*GCM icon for the Windows installer (i.e., the icon on the right side of Figure 1-6). Please note that you may need an administrator's password to complete the installation; if you do, you will need to ask your IT administrator for assistance.

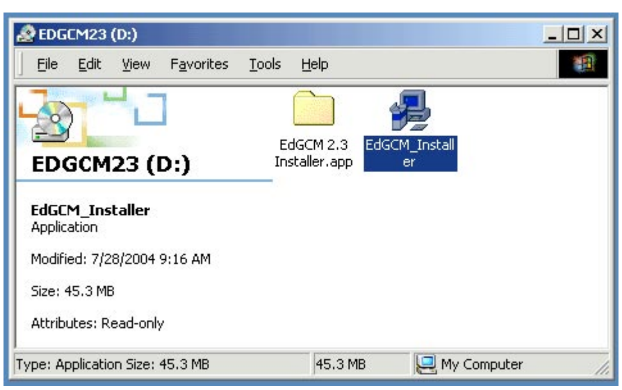


Figure 1-6. The EdGCM 2.3 installation disk includes both Mac and Windows versions of the installer. For Windows installation, click on the right icon.

2. The installer will open to display a splash screen with the *Ed*GCM logo. Click "Next" to proceed to the first installation screen (Figure 1-7).

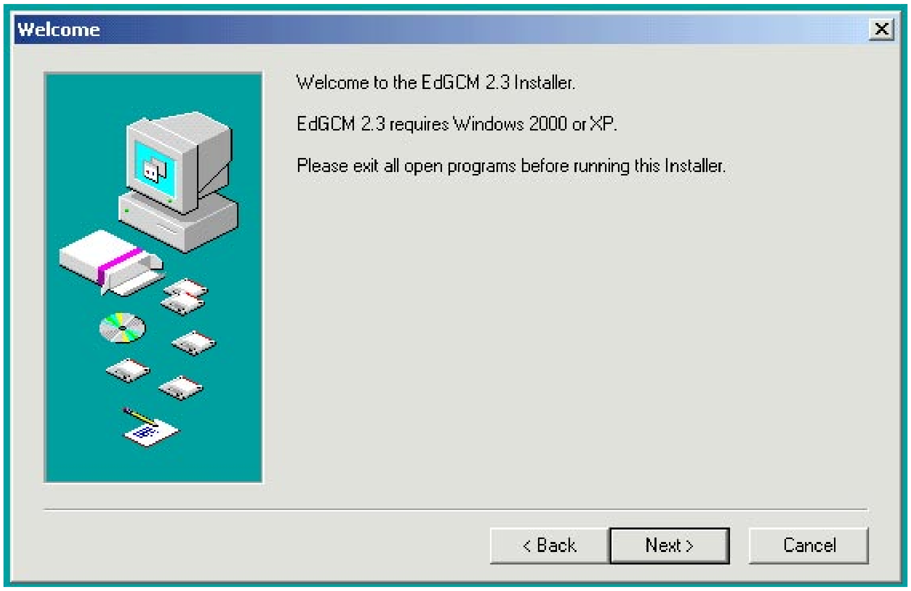


Figure 1-7. Before proceeding with the installation of EdGCM, close all other open programs.

3. You will be asked to select the type of installation you wish (Figure 1-8). We recommend that you select a Typical installation to avoid any problems.

4. The next window will allow you to select which components of the *Ed*GCM package that you wish to install (Figure 1-9). We recommend that you leave all choices checked.

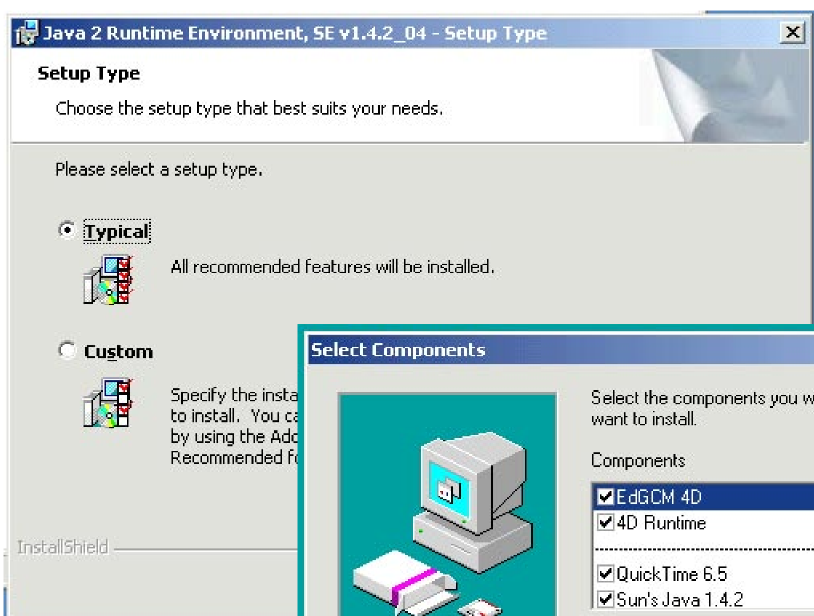


Figure 1-8. Select a Typical installation.

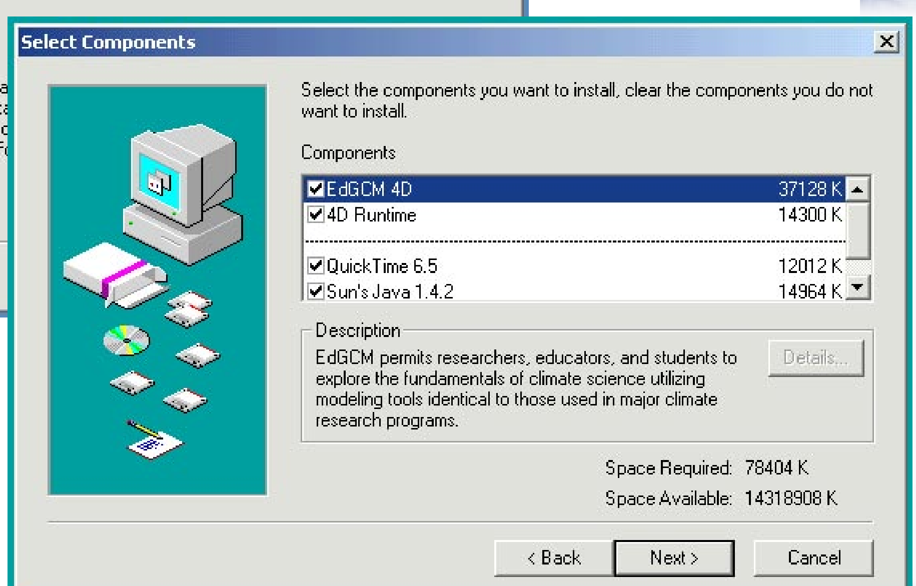


Figure 1-9. To install all parts of the EdGCM package, leave all boxes checked on this screen.

Return to Contents

5. The next screen will confirm your installation choices. Click next to begin installation (Figure 1-10). When installation is complete, a window will open displaying the icon to launch *Ed*GCM (Figure 1-11).

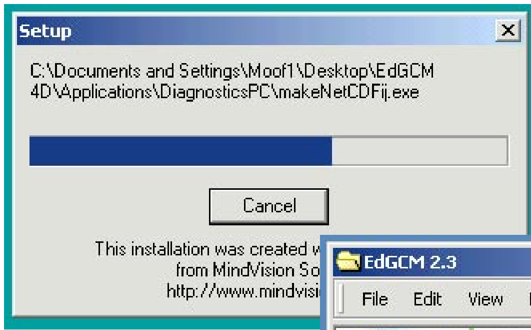


Figure 1-10. EdGCM installation in progress.

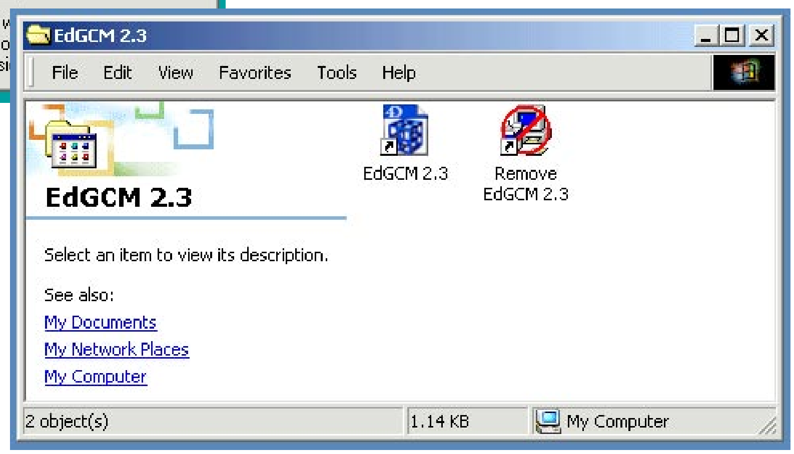


Figure 1-11. When installation is complete, the icons for launching and uninstalling EdGCM will be shown.

6. If you do not already have QuickTime and Java on your PC, installation of these components will begin now. Simply accept the license agreements and opt for a typical setup rather than a custom installation. The installation process for these programs may take several minutes each, depending upon the speed of your computer. You will be notified when installation is complete (Figure 1-12).

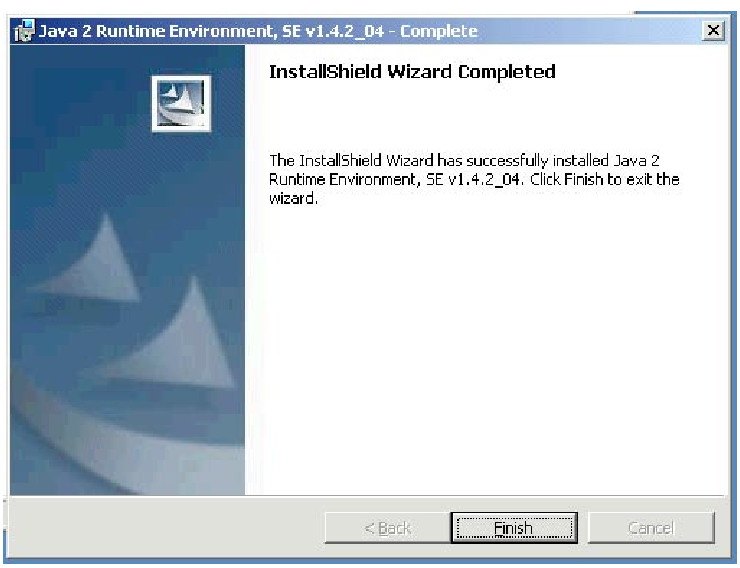


Figure 1-12. Java Runtime's installation wizard will let you know that the installation is complete.

Note on cross-platform compatibility

All output files produced by the Windows version of *Ed*GCM are compatible for use with the Mac version.

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.

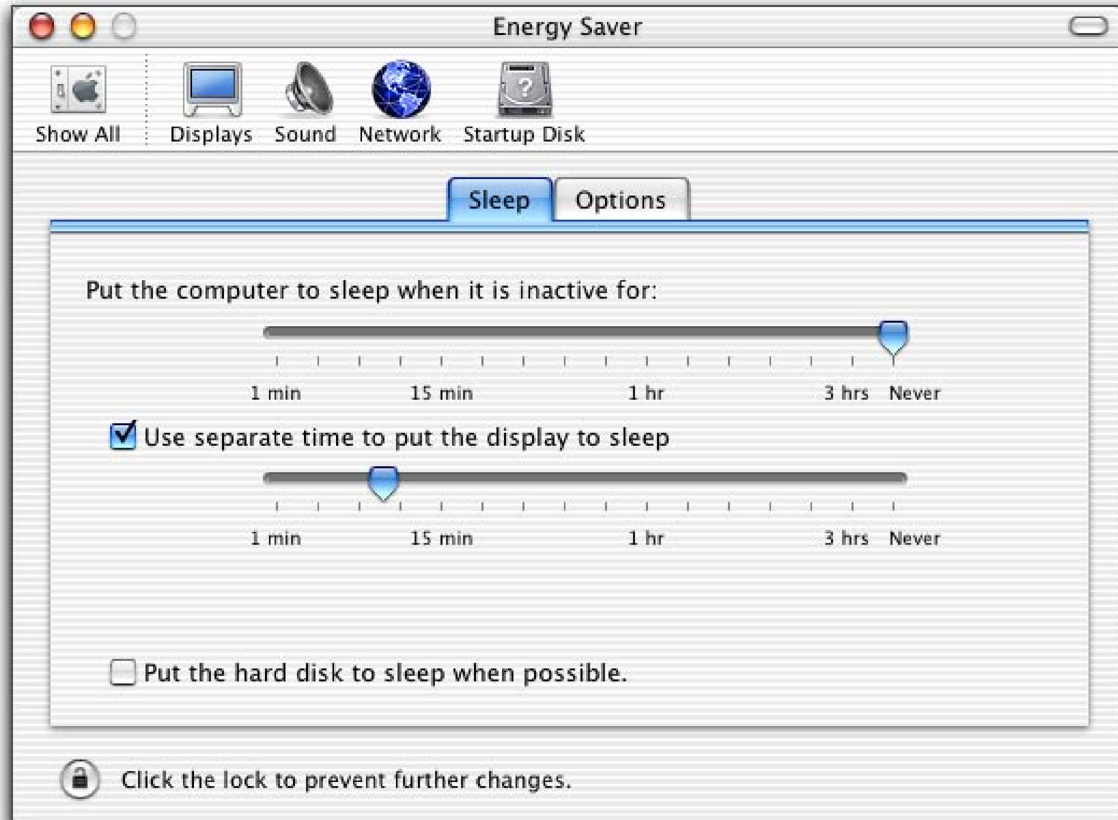


Figure 1-13. For Macs, the Energy Saver settings (within System Preferences) should be set such that the computer never sleeps.

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

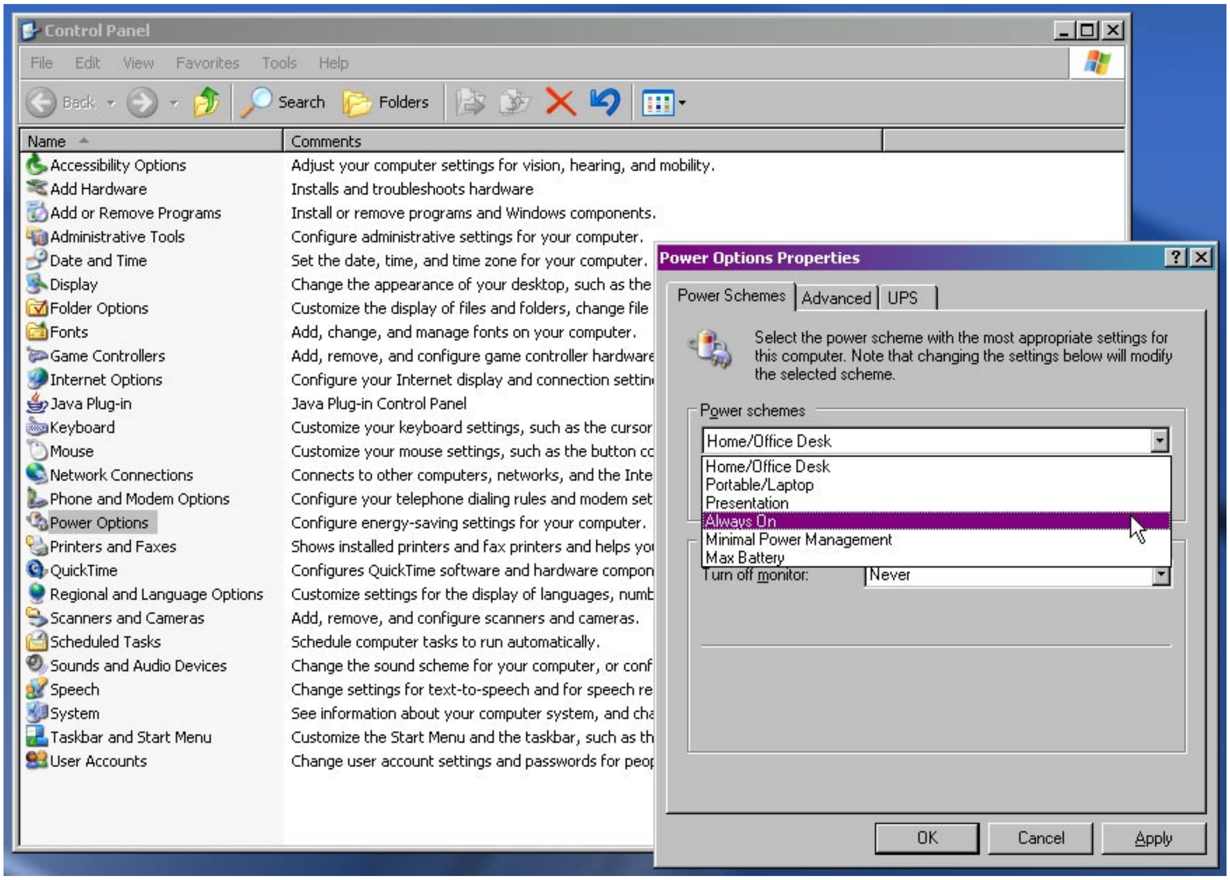


Figure 1-15. For PCs, the Power Scheme should be set to "Always On" to prevent the system from going into sleep mode while the GCM is running.

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.

Return to Contents

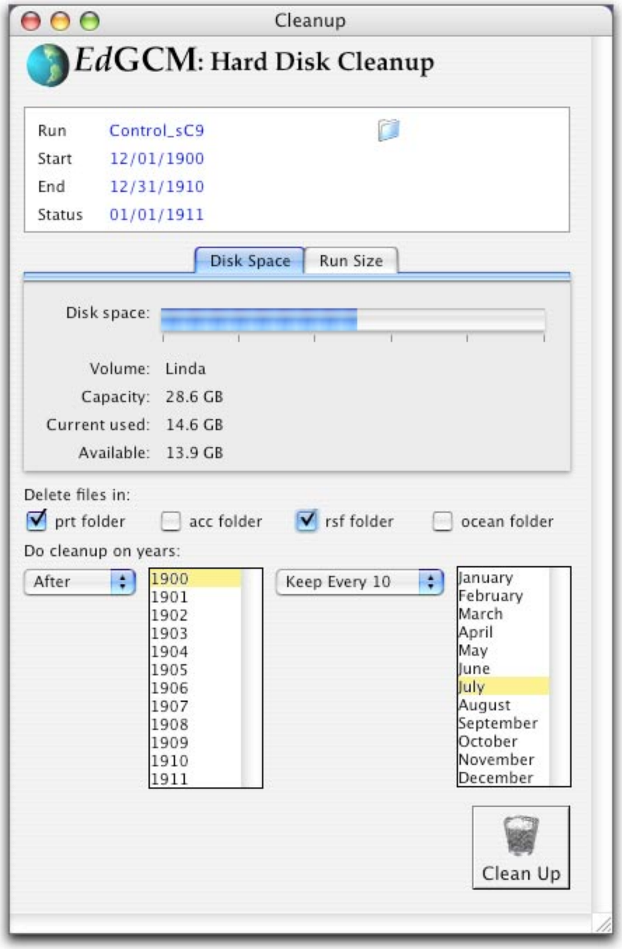


Figure 1-16. The hard disk clean-up utility menu.

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.

Return to Contents

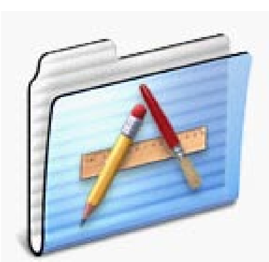
Chapter 2

*Ed*GCM on Your Hard Disk

There are four main components to the *Ed*GCM software suite: the *Ed*GCM 4D folder hierarchy, which provised the organizational framework for the suite; the 4th Dimension® database, which provides the structure for the *Ed*GCM 4D interface and database, and integrates the two; the GISS GCM Model II, the GCM at the heart of this software package; and the visualization software - Panoply, SuSpect, and Plotshop - that permit the simulation data to be displayed and more easily understood.

2.1 The *Ed*GCM 4D Folder Hierarchy

*Ed*GCM incorporates a large folder hierarchy to integrate the graphical user interface with the GCM, the database, the visualization programs, and a host of other utility programs. This hierarchical structure is absolutely necessary to the proper function of *Ed*GCM and its components, so users should not rename, delete, or move any of the folders within the *Ed*GCM 4D folder. However, the *Ed*GCM 4D folder itself can be moved as long as no programs are running and the internal organization of the folder is not altered.



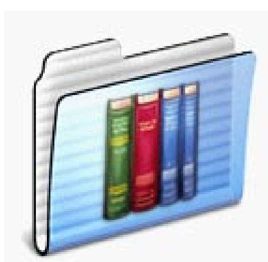
The ***Applications*** folder contains all the Fortran programs to analyze output and many other support files. It also contains copies of parts of the *Ed*GCM Suite, but may not contain the most up-to-date versions. Users should not change the contents of this folder unless specifically informed to do so by an update message.

The ***Database*** folder contains the *Ed*GCM interface and ALL of the information about the simulations. ***Never replace the contents of this folder with those from another computer since this will overwrite all of your simulations!*** Similarly, if you delete this file you will lose all information about your simulations.

The ***Docs*** folder contains several important documents, most in Adobe Acrobat format, including: 1) this installation guide; 2) the paper describing the GISS GCM Model II (Hansen *et al*., 1983 first appeared in the American Meteorological Society's *Monthly Weather Review* journal); 3) the original proposal to the National Science Foundation that funded *Ed*GCM; and 4) an *Ed*GCM presentation poster from the Geological Society of America's 2003 annual meeting in Seattle.

The ***eJournals*** folder contains any eJournals that have been exported for use on the web via the "eJournal to web" command in *Ed*GCM (see the toolbar when the eJournal window is open). The individual folders contained inside the eJournal folder can be copied to any website or e-mailed to us if you wish to have them considered for publication on the *Ed*GCM website.

The ***Images*** folder contains any images you wish to make available through *Ed*GCM's Image Browser utility. If folders containing images are removed or added to the Images folder, it is necessary to click on the "Update" button inside *Ed*GCM (see the toolbar when the Image Browser is open). The Image Browser will accept any images that are stored in a QuickTime compatible format. This does NOT, however, include images in the "gif" format.



The ***Input, Input Oceans and Input Forcings*** folders contain boundary conditions and initial condition files that are used by the GISS GCM. Since these files are necessary for initializing runs, deleting files from either of these folders is not recommended because it may destroy your ability to set up and run simulations. Adding files to these folders, while not damaging to simulations, will cause clutter in various menus within the *Ed*GCM interface. It is best to add files to these folders only when instructed to do by an update message.

The ***Multimedia*** folder contains a series of tutorial QuickTime videos about using many of *Ed*GCM's features. (Note: These videos apply to *Ed*GCM v. 2.1.3. Check www.edgcm.org for news on updated video availability.) WARNING: The first video is only a static screenshot with a voiceover welcoming you to the *Ed*GCM tutorials, so don't be alarmed that you don't see the cursor moving during the video. Subsequent videos all show the cursor performing various actions, which are described in the accompanying voiceover. While these are a very helpful way to quickly learn more about how to use the many features of *Ed*GCM, we strongly recommend that you sign up for one of our day-long training workshops, which are full of additional information about *Ed*GCM and how to utilize it.

The ***Output*** folder contains output from any simulations that have been run using *Ed*GCM. Each time a new simulation is started, a “run folder” is created inside the Output folder. Run folders are named after the “run ID” in the Setup Simulation window. Any run folder is basically a stand-alone simulation that could theoretically be moved, intact, to another computer and started. However, we recommend that you leave the run folders within the *Ed*GCM folder so that you may use

2.2 The 4th Dimension® Database

4th Dimension® is the tie that binds the *Ed*GCM 4D graphical user interface together with the databases generated by simulations. A powerful relational database that runs on both Mac and Windows platforms, 4th Dimension® organizes the huge quantity of output generated so that users can focus upon analyzing the results of their simulations rather than having to search for the information of interest.

2.3 The GISS GCM Model II

The heart of *Ed*GCM is the GISS GCM Model II (described in detail in *Hansen et al.* [1983]), a three-dimensional model which solves numerically the physical conservation equations for energy, mass, momentum and moisture, as well as the equation of state. GISS Model II has a horizontal resolution of 8° latitude by 10° longitude, nine layers in the atmosphere extending to 10mb, and two ground hydrology layers. The model accounts for both seasonal and diurnal solar cycles in its temperature calculations. Cloud particles, aerosols, and radiatively important gases (e.g., carbon dioxide, methane, nitrous oxides) are explicitly incorporated into the radiation scheme. Large-scale and convective cloud cover are predicted, and precipitation is generated whenever supersaturated conditions occur. Snow depth is based on a balance between snowfall, melting and sublimation. Sea surface temperatures (SSTs)

Return to Contents

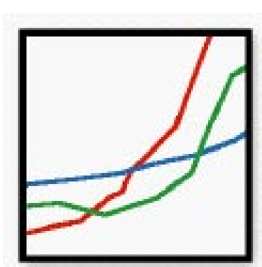
are calculated using model-derived surface energy fluxes and specified ocean heat convergences. The ocean heat convergences vary both seasonally and regionally, but are otherwise fixed. This is the primary mixed-layer ocean model developed for use with the GISS GCM (described in detail in *Russell et al.* [1985] and in appendix A of *Hansen et al.* [1988]).

Certain boundary conditions necessary for simulations (e.g., levels of various atmospheric gases, solar luminosity) can easily be adjusted for customized simulations. Other boundary conditions, generally those that are geography-dependent (e.g., alternate land mass distributions for paleoclimate simulations; topography; vegetation) are not customizable for the purposes of most *Ed*GCM users. Development of geography-dependent boundary conditions is a highly labor-intensive task, so new alternatives are not likely to be released in the short term. However, if *Ed*GCM users express a strong interest in a particular paleoclimate or future climate scenario that requires a set of alternative boundary conditions, we will make an effort to incorporate that scenario in a future release.

2.4 Visualization Programs

Panoply is a mapping tool that allows users to plot latitude-longitude gridded data contained within datasets in the popular netCDF format (generated in this case by *Ed*GCM in the course of data processing). The user may select from a large menu of global map projections and slice specific latitude-longitude arrays from larger multidimensional arrays, which might also have dimensions in altitude or time. Since Panoply is as Java application, it will run in both Mac and Windows environments.

SuSpect is a Mac-only data viewer designed for searching and exploring large text-formatted data sets. It was specifically designed for viewing the standard climate diagnostic tables generated by the GISS GCM and includes the ability to interpret IBM line printer control characters (e.g., page feeds, overstrikes, etc.). It gives the user an efficient means of comparing data tables that reside within one text file, but its real power lies in its capabilities for comparing multiple data files.



PlotShop is a Mac-only line plotting program for use in examining how variables change through time in the GISS GCM. The user can also control some aspects of the plot layout using this program. PlotShop's functionality can be reproduced using other common plotting programs such as, Microsoft Excel® or Kaleidagraph®. However, PlotShop is designed to read the specific formats generated by *Ed*GCM and can still be useful for quick viewing of results.

Return to Contents

2.5 Additional Utilities

Several additional Mac-only utilities have also been included within the *Ed*GCM suite. The function of these utilties is largely transparent to the user, although some may find the features of MapProjector and ColorBarTender useful even beyond the needs of *Ed*GCM data visualization.

MapProjector converts 2-D map images into 3-D global views. MapProjector creates three publication-quality projections: Mollweide, stereographic, and orthographic. It also supports vector overlays and high quality PostScript printing.

ColorBarTender allows the user to create and edit scientific color tables similar to those used on The Weather Channel™. ColorBarTender supports the color table formats used by many popular programs including: PAL, HDF, and AppleWorks Palette. AppleWorks®, IDL®, Transform, NOeSYS®, and Panoply have been tested with color tables created in ColorBarTender.

FileInfo changes the creator (owner) of a file, the type file, and attributes of files or folders (e.g., whether the file extension is displayed, a file or folder is locked).

Drop•HDF will covert files in the Maps folder of a simulation to HDF format instead of netCDF. This utility is not recommended for anyone other than an advanced user who has a specific need for the HDF format.

Return to Contents

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.

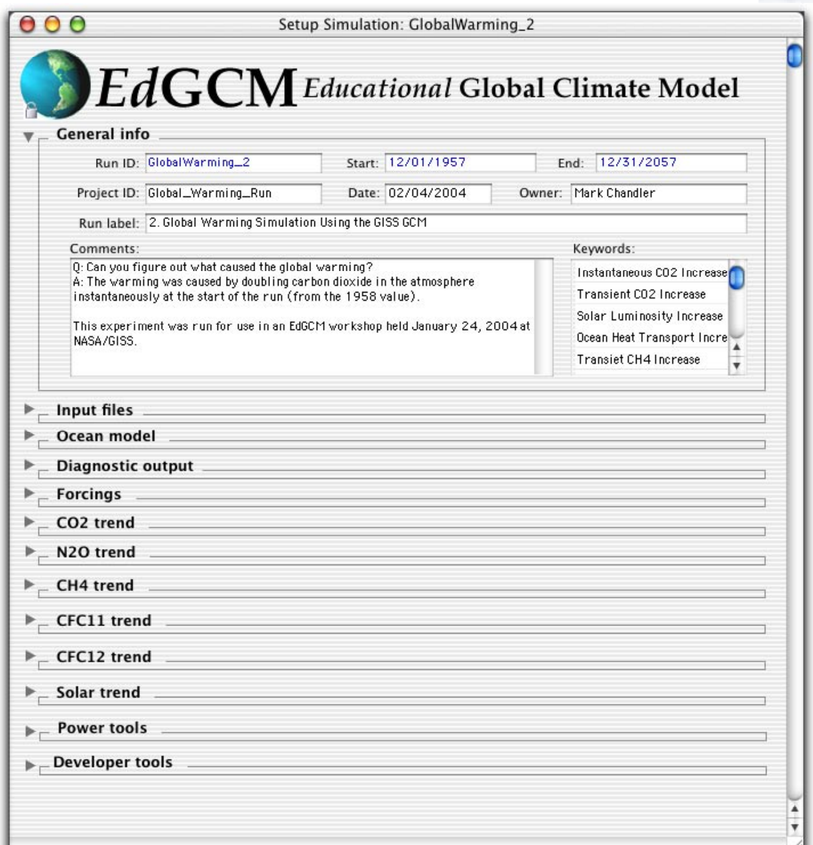


Figure 3-1. The Setup Simulations window in EdGCM is the starting point for every experiment, as the initial conditions for the experiment are set here.

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.

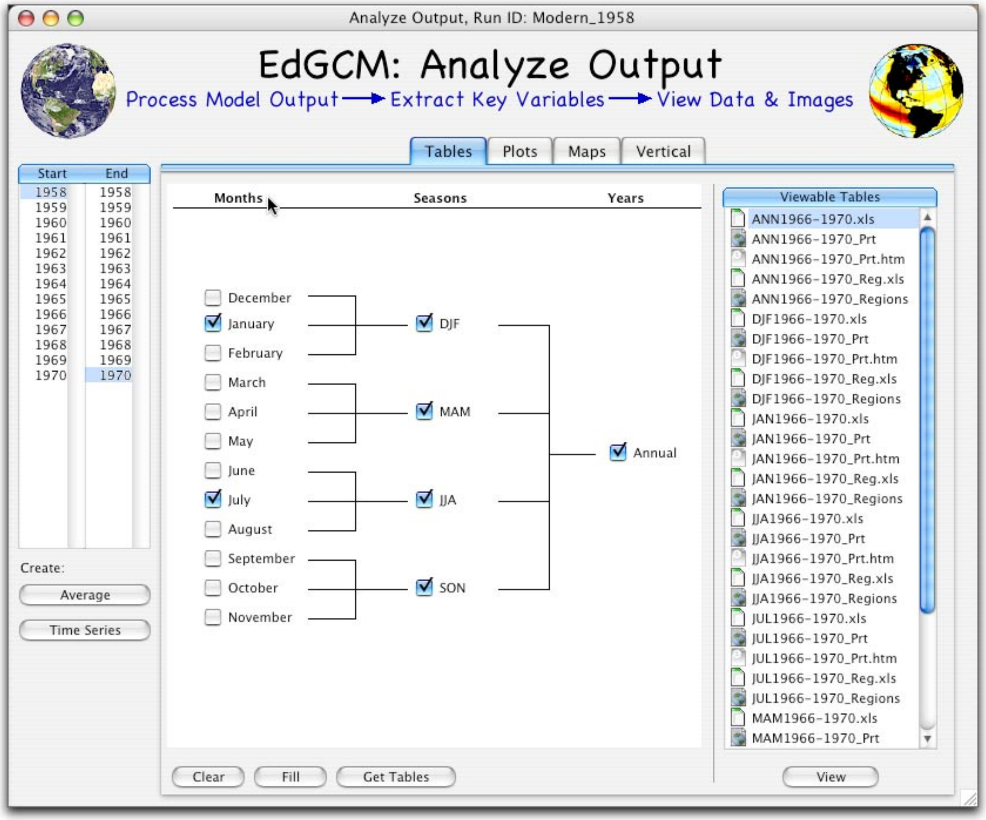


Figure 3-2. The Analyze Output window offers a number of options for processing and viewing the output of climate experiments.

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.

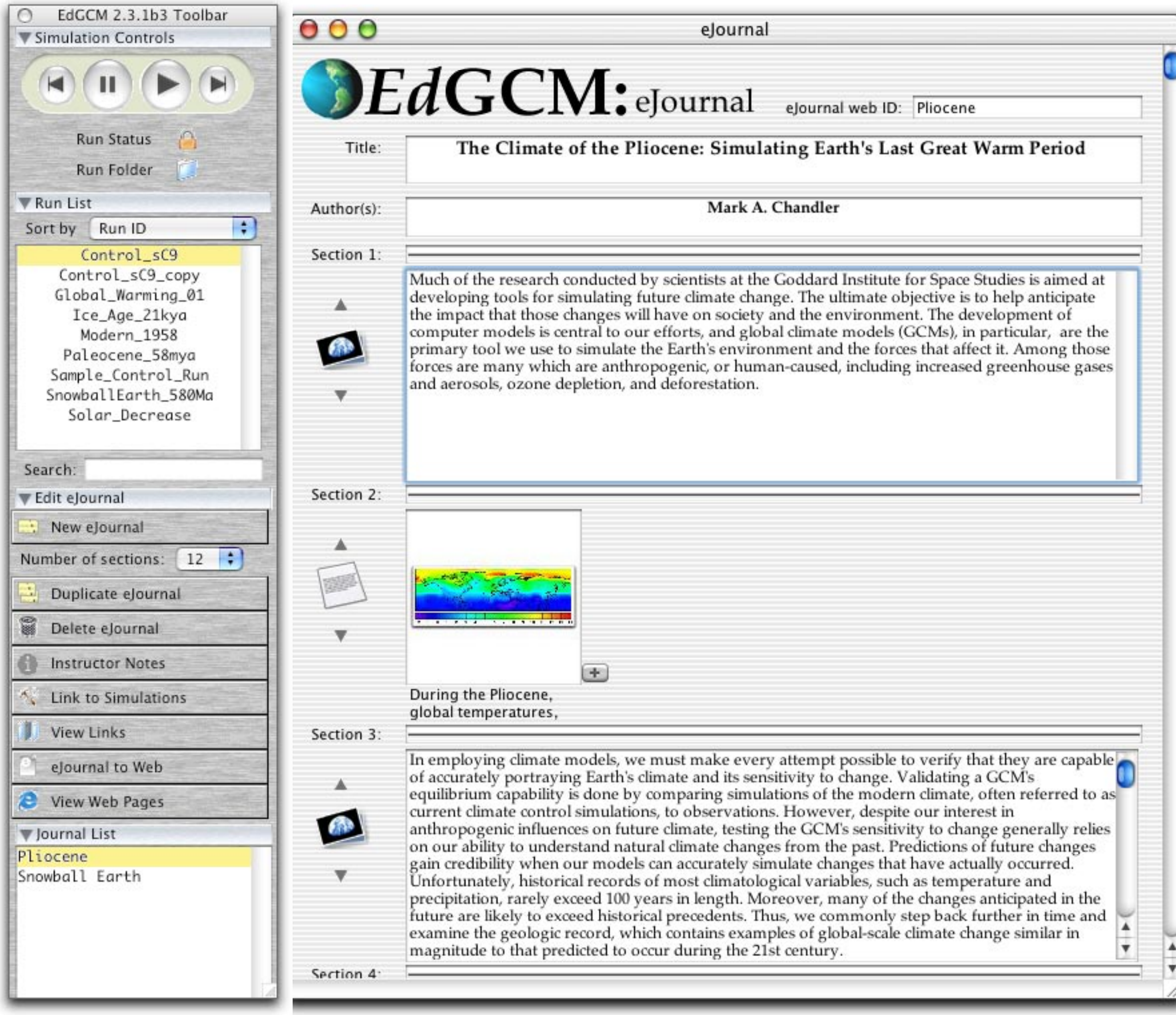


Figure 3-3. The eJournal window in EdGCM permits the user to compile a report, complete with figures, for easy publishing to an HTML-format document.

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.)***

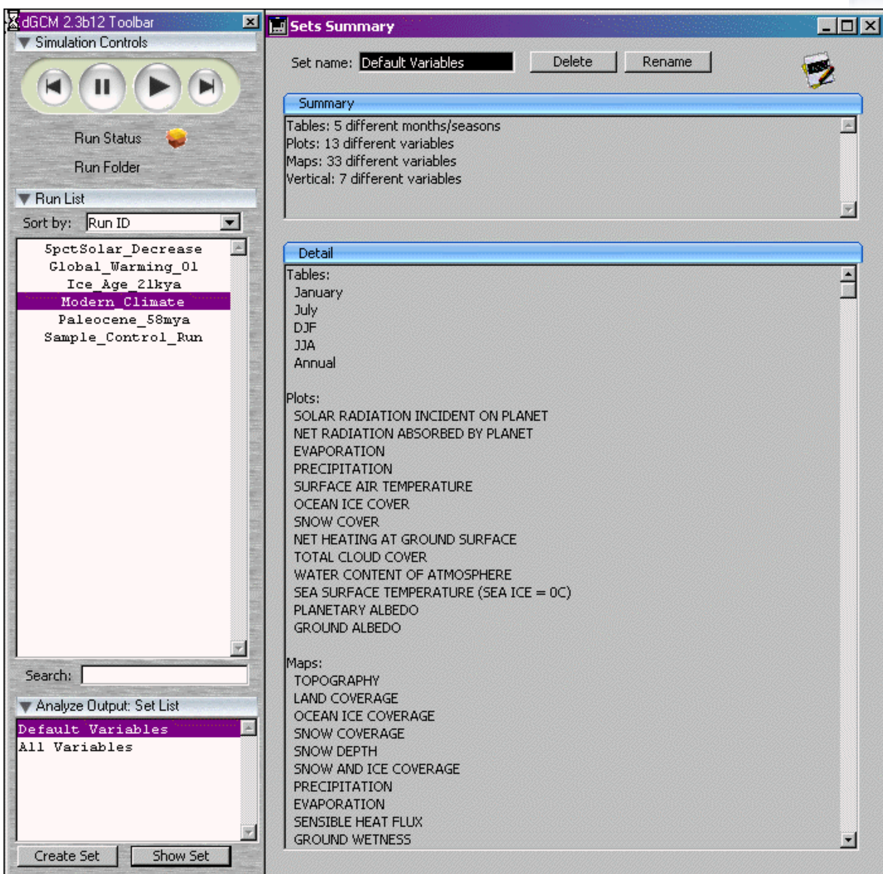


Figure 3-4. The Sets Summary displays the variables selected for analysis, and can be written to a file for sharing among students and other teachers.

Return to Contents

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.

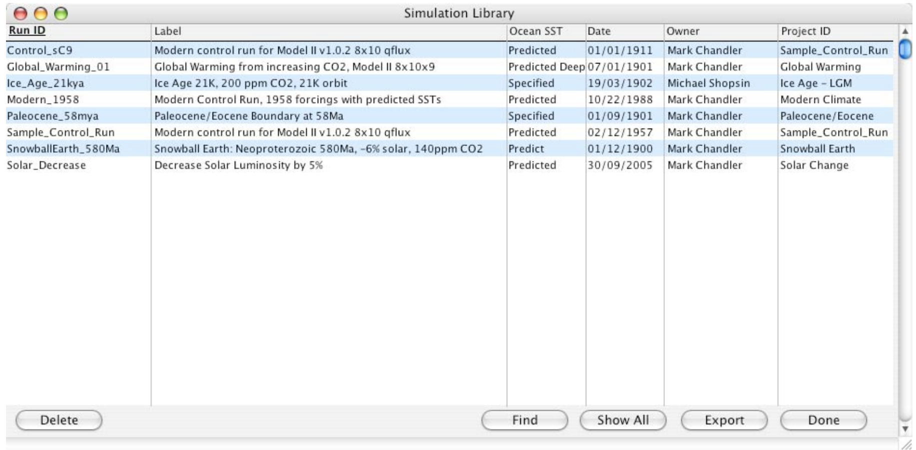


Figure 3-5. The Simulation Library is a searchable database of previously run experiments that allows users to find experiments with similar themes, as well as export experiments to exchange with other members of the EdGCM Cooperative.

CHAPTER 4

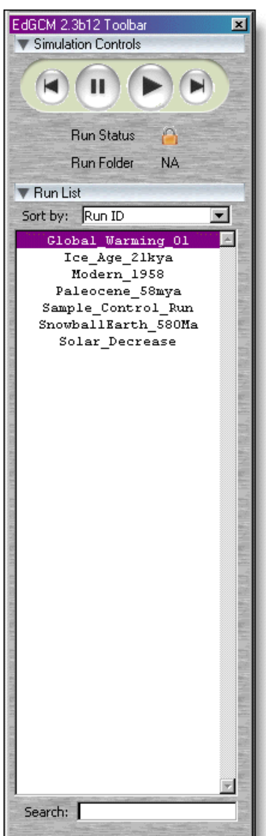
*Ed*GCM Tutorial

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).

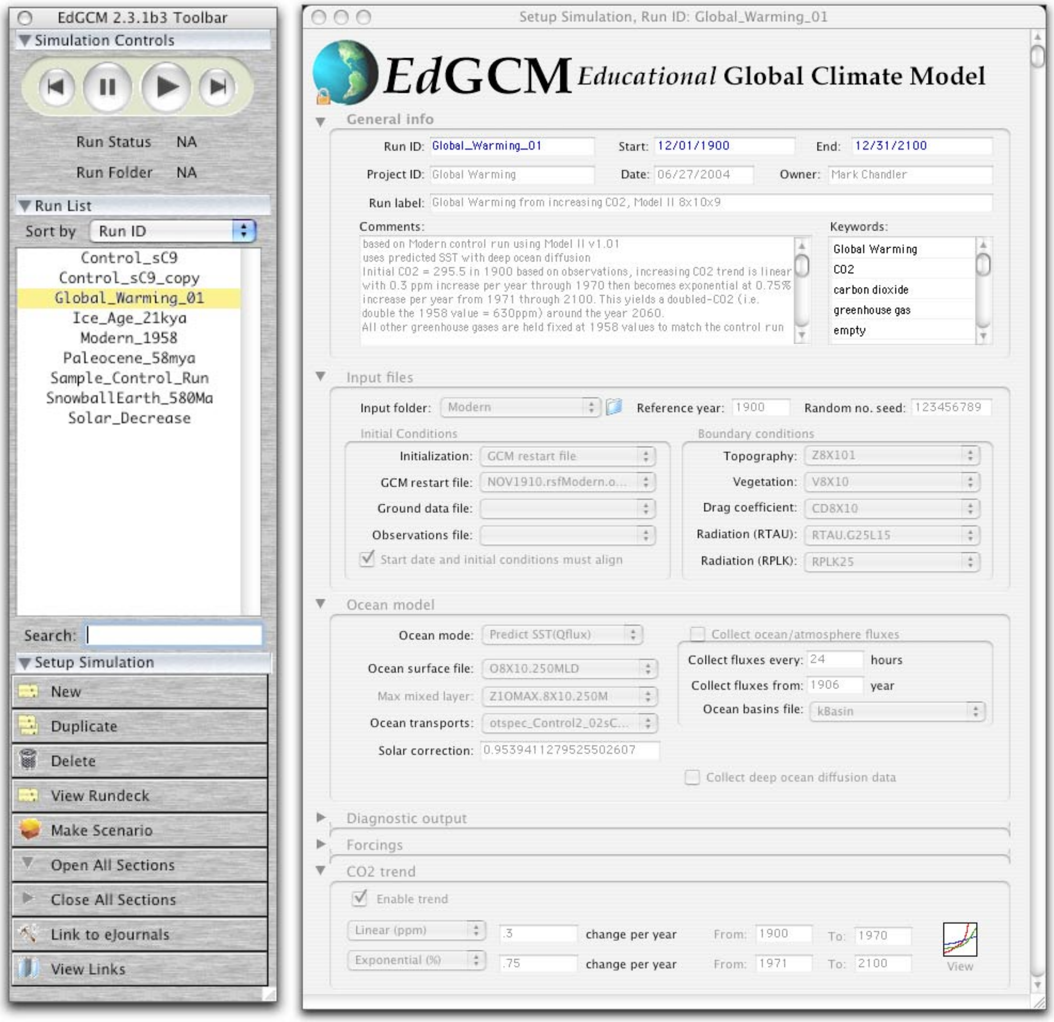


Figure 4-2. The Setup Simulations window and its associated Toolbar.

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

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).

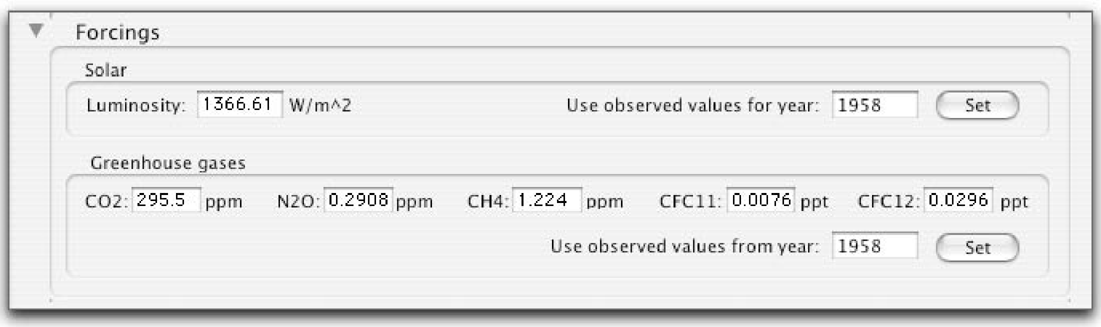


Figure 4-3. The Forcings section allows basic manipulation of the GCM boundary conditions.

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

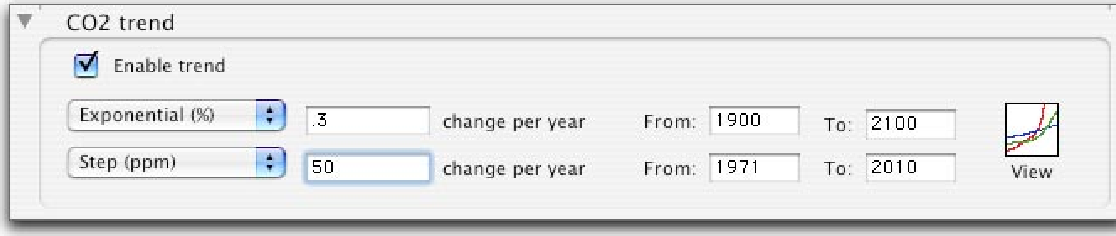


Figure 4-4. The CO2 trend section, like the other trend sections, permits the levels of greenhouse gases to change during the course of a simulation.

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.)

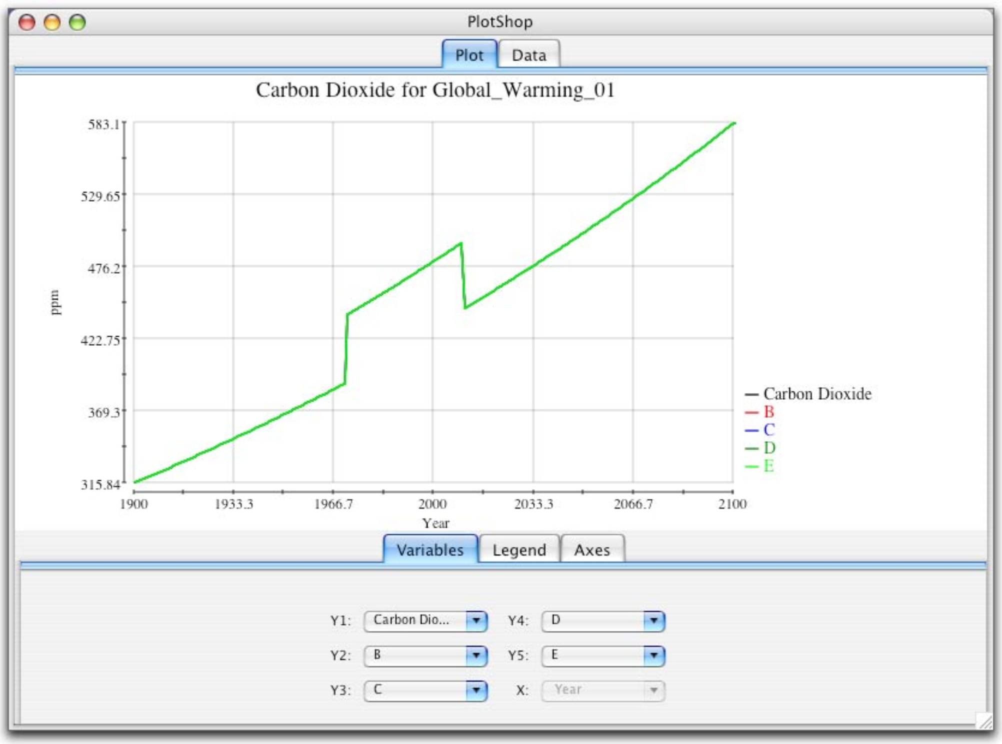


Figure 4-5. PlotShop display of changing CO2 trends as selected in Figure 4-4.

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:

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).

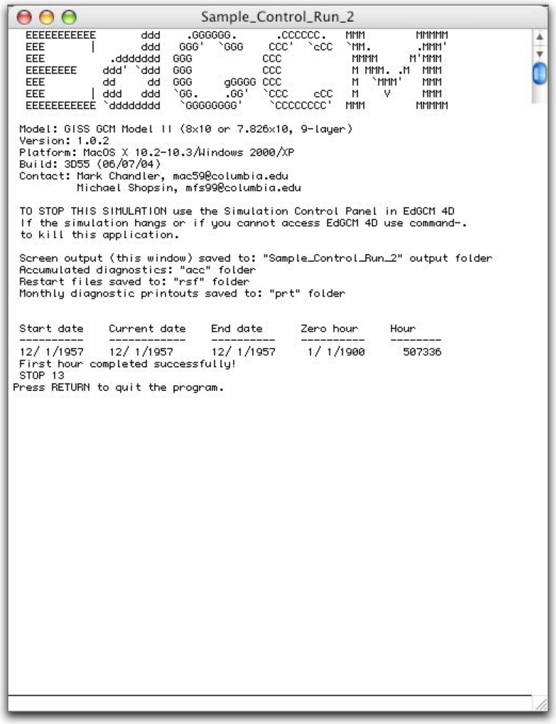


Figure 4-6. The first hour of a simulation was successfully completed.

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.

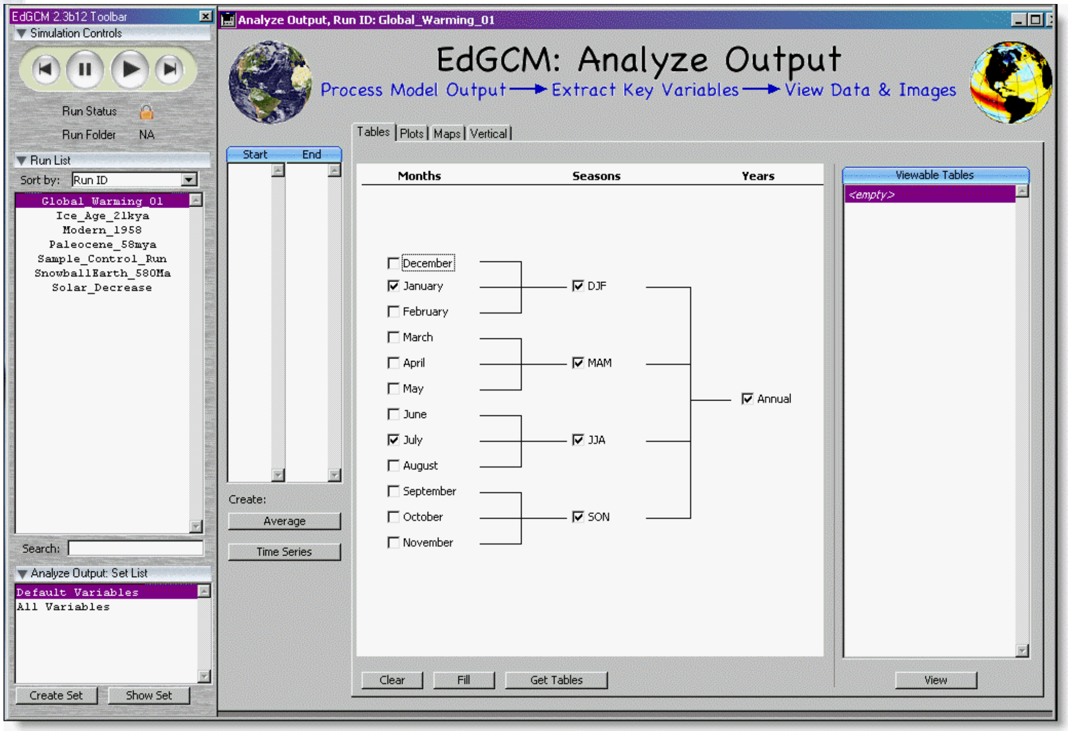


Figure 4-7. The Analyze Output window and associated toolbar.

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).

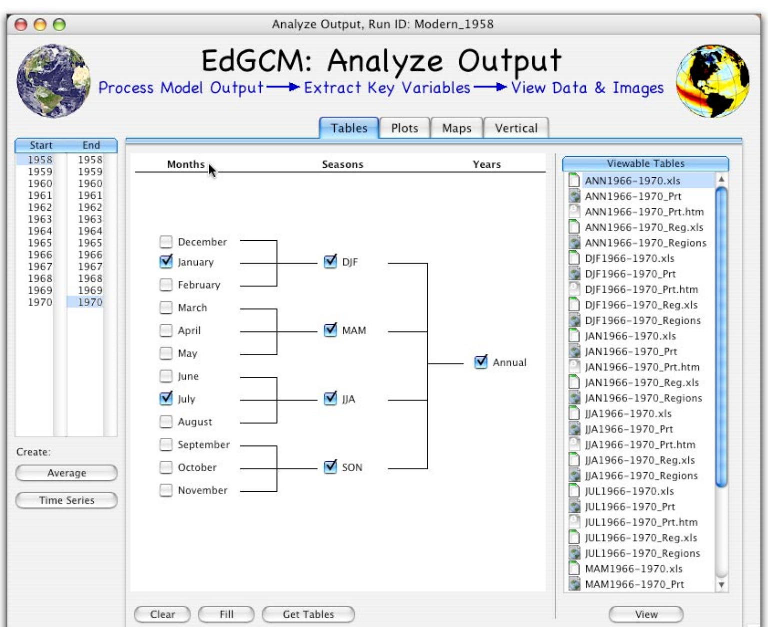


Figure 4-8. The Tables tab in the Analyze Output window, showing the list of files generated by post-processing. The icons next to the file names indicate the format of the file: Excel, HTML, and SuSpect (the latter for Macs only).

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).

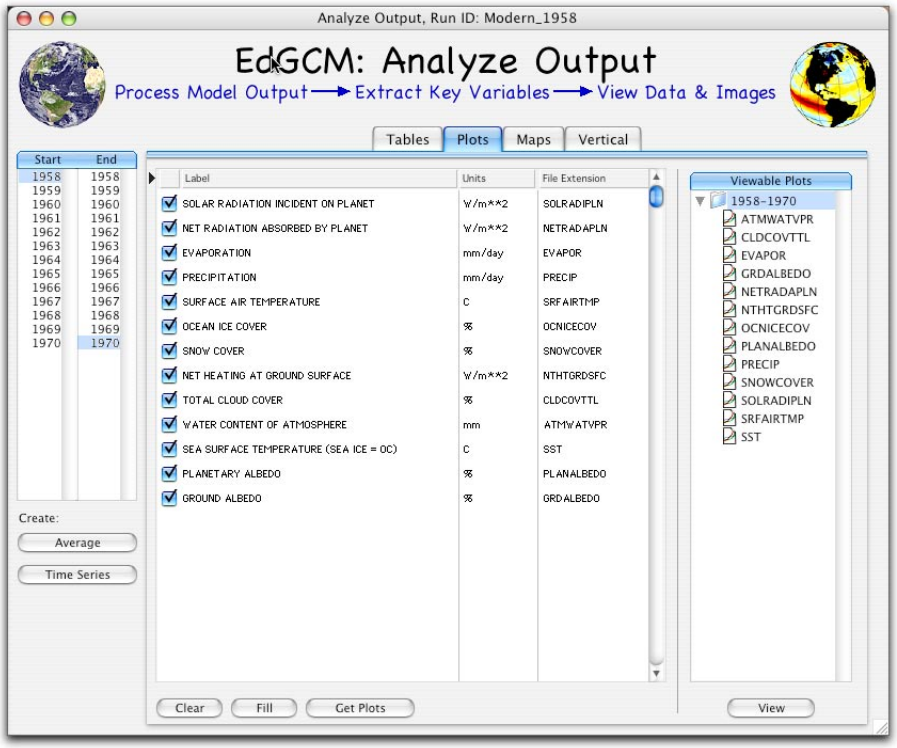


Figure 4-9. The Plots tab in the Analyze Output window, showing the list of files generated by post-processing. The icon next to the file names is for PlotShop, but Windows users will be able to view and plot these files in Excel.

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).

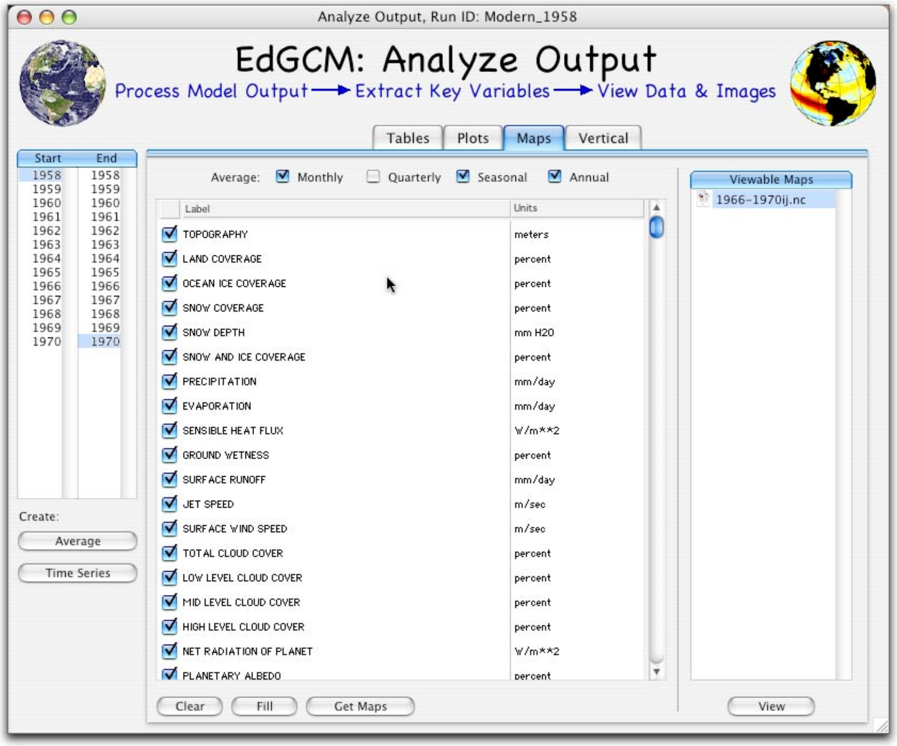


Figure 4-10. The Maps tab in the Analyze Output window, showing the list of files generated by post-processing. The icon next to the file represents the netCDF format, a popular cross-platform format for spatial data.

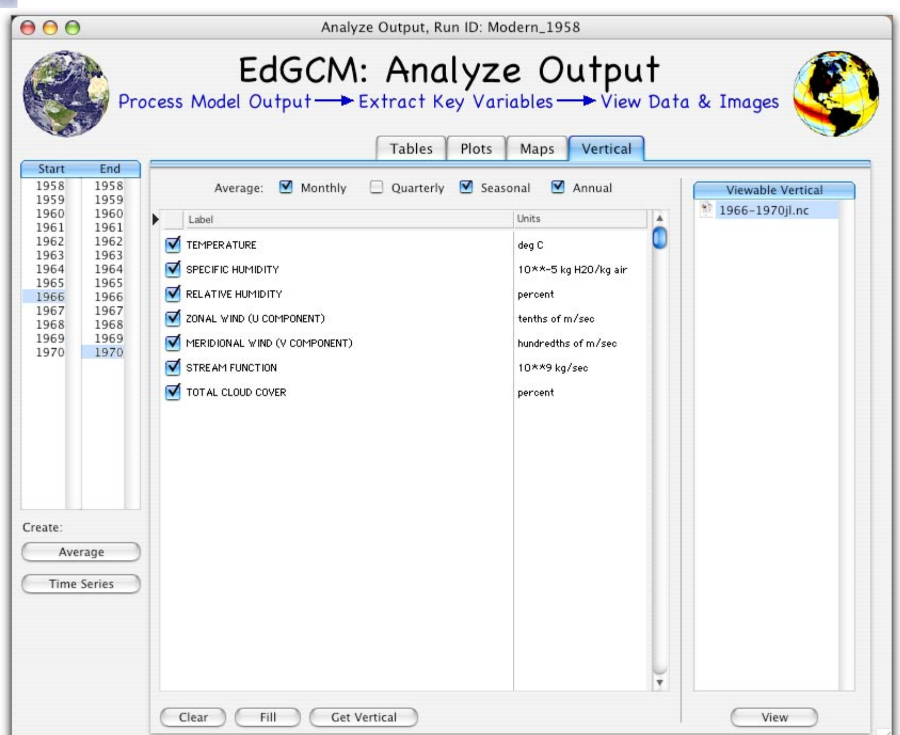


Figure 4-11. The Maps tab in the Analyze Output window, showing the list of files generated by post-processing. Vertical slice data files are also in netCDF format.

Return to Contents

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.

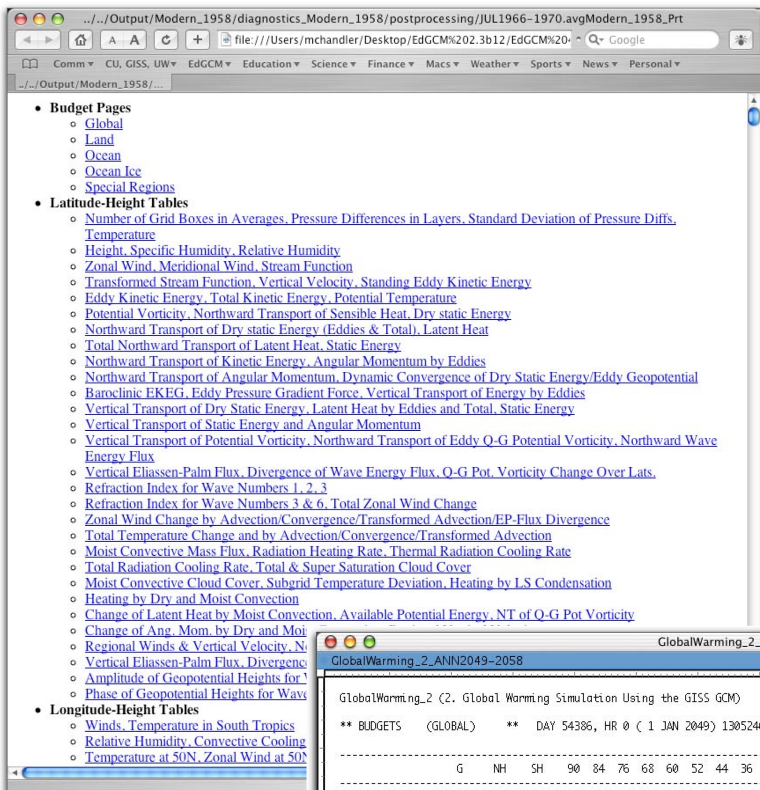


Figure 4-12. The HTML display of tables data begins with a series of links to tables for the individual variables selected for analysis.

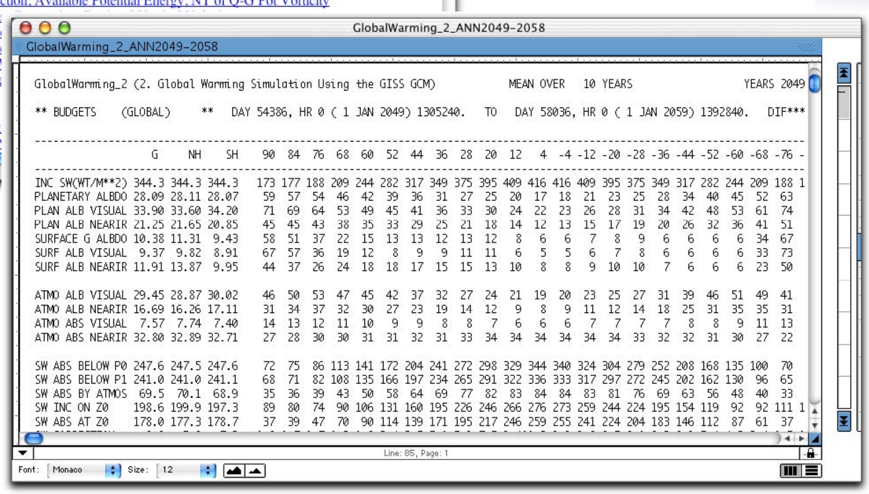


Figure 4-13. Mac users can employ SuSpect to view their data.

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).

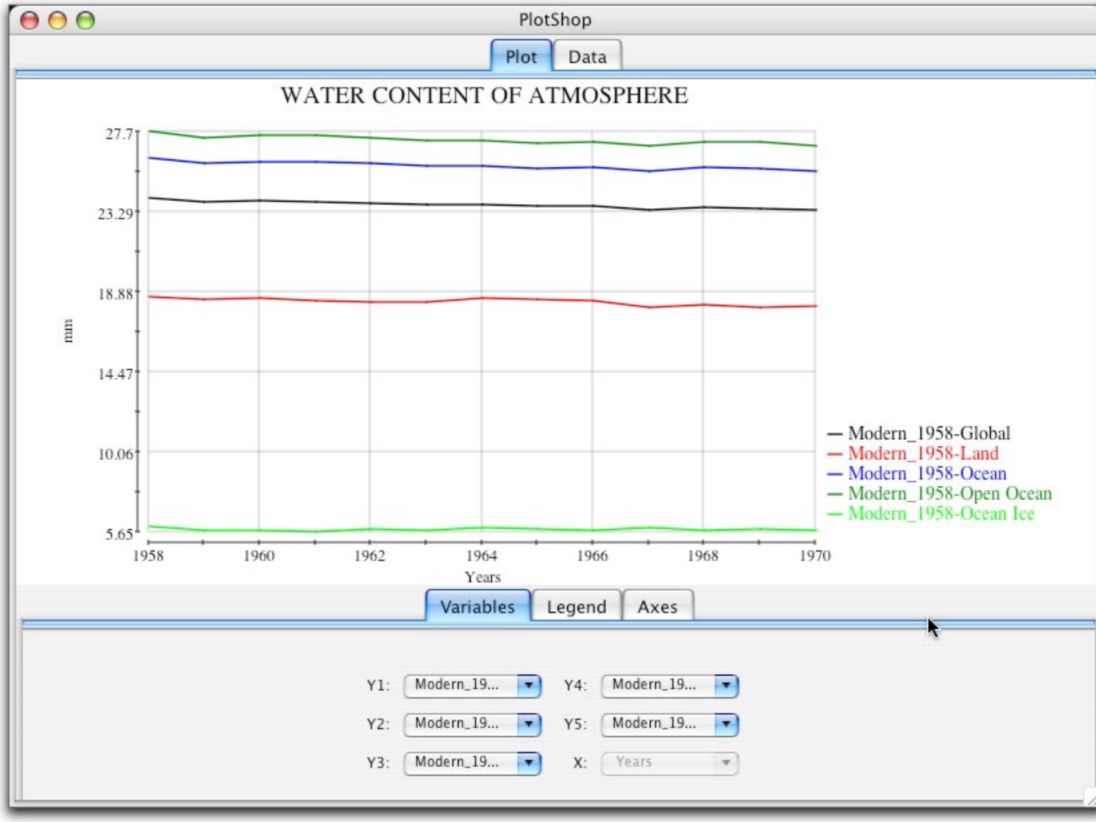
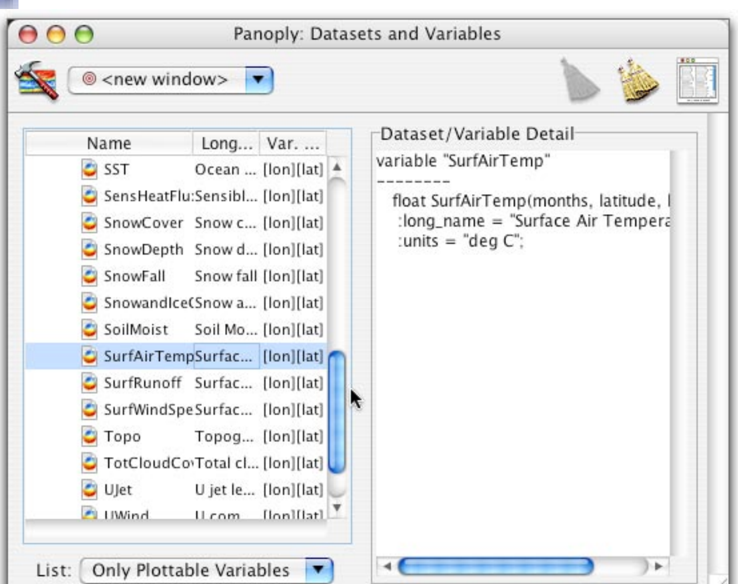


Figure 4-14. Times series plot generated by PlotShop for Mac users.

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.

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).

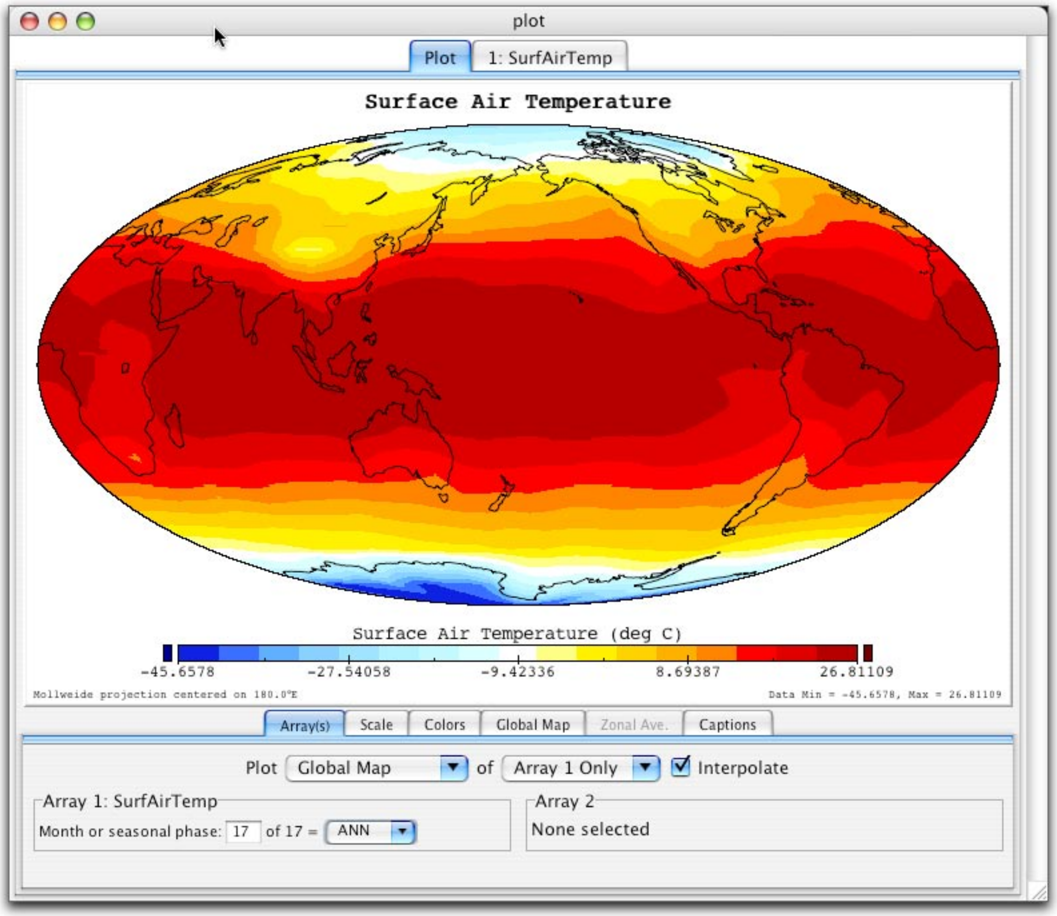


Figure 4-16. A simple map plot in Panoply.

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 CO_2. First, you will need to create the appropriate netCDF files.

1. Open the *Ed*GCM interface.

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.

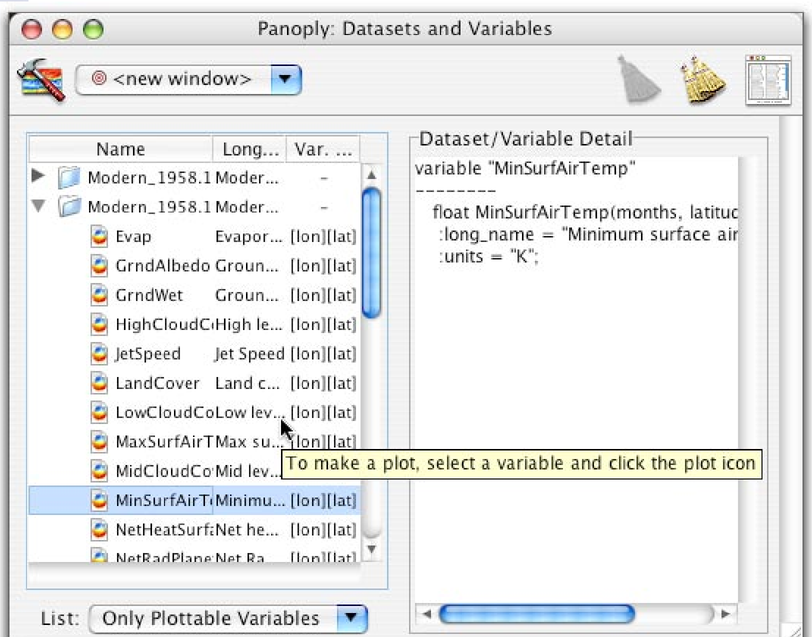


Figure 4-17. Two data sets in Panoply, available for difference plotting.

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).

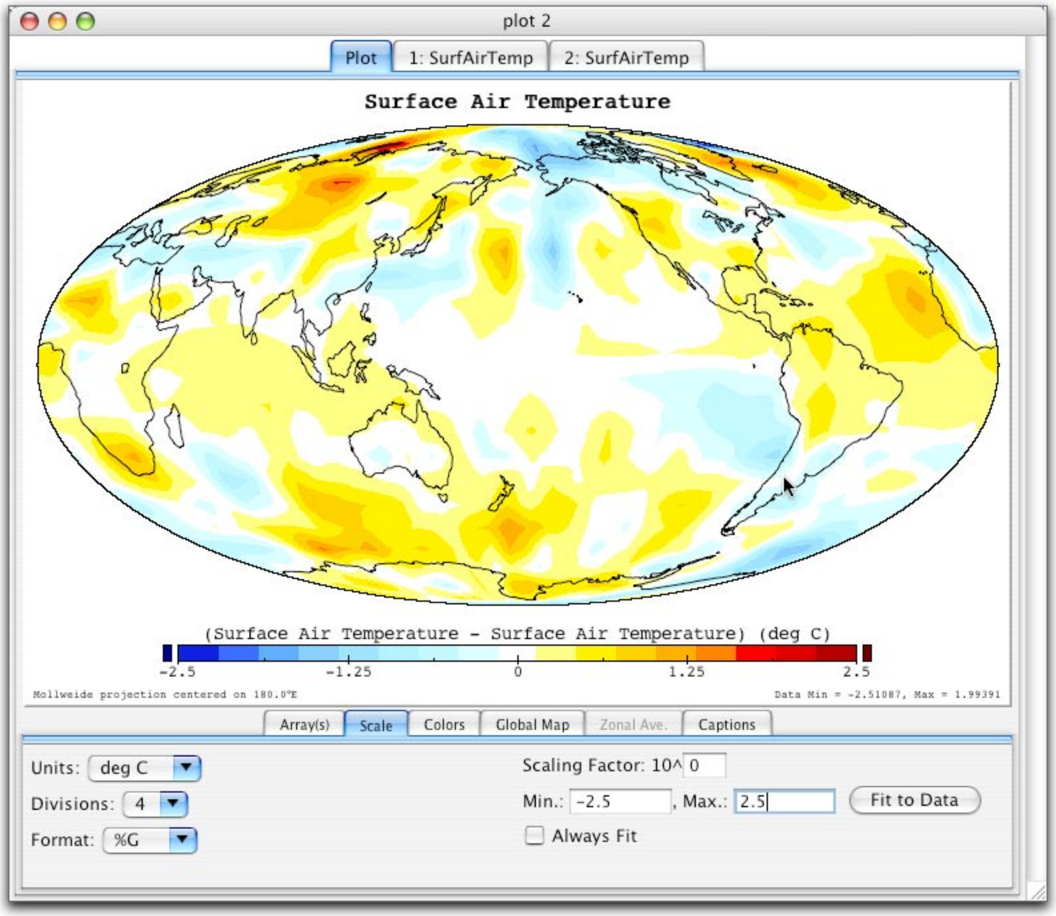


Figure 4-18. A difference map plot in Panoply.

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).

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).

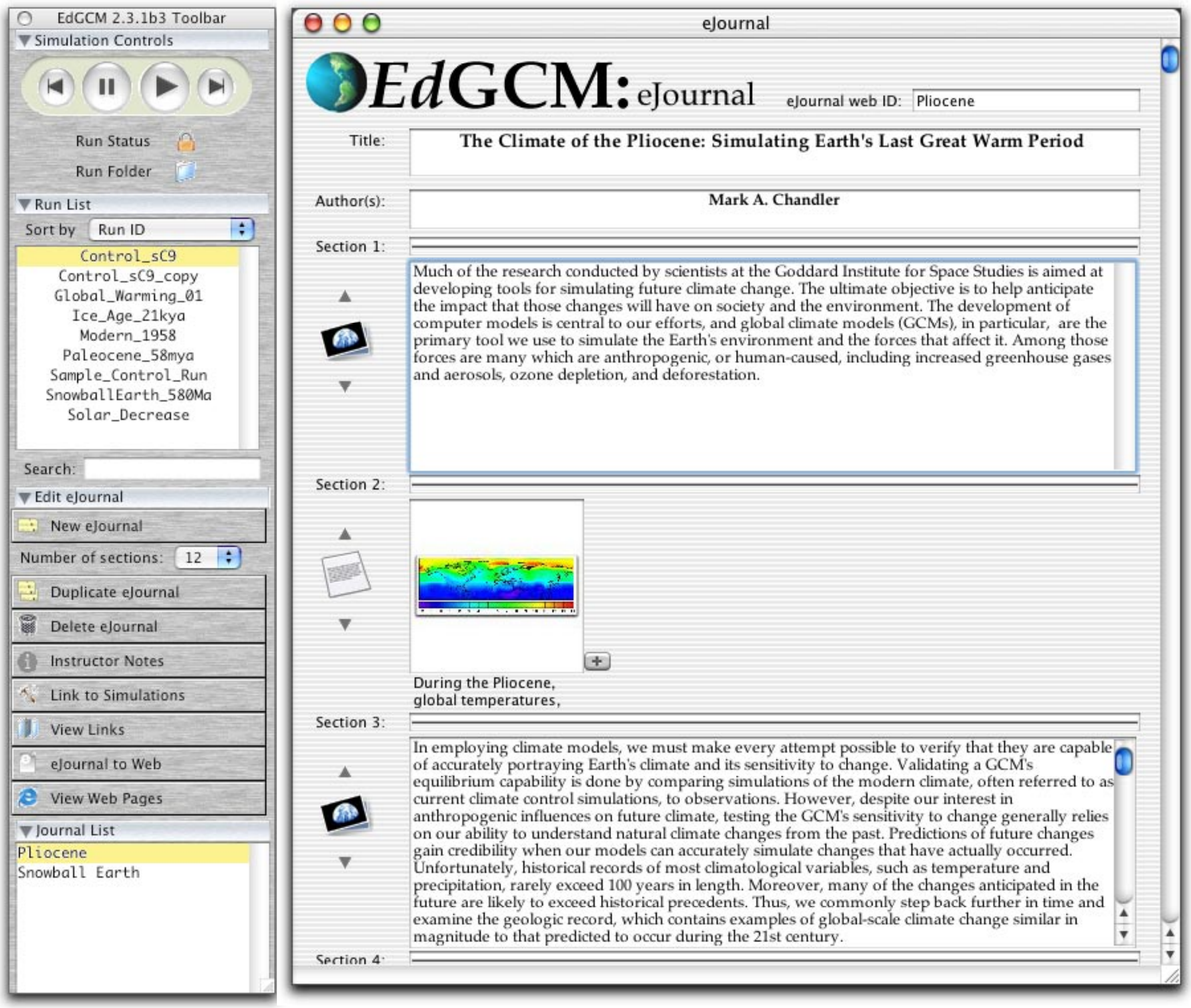


Figure 4-19. The eJournal setup window and its associated toolbar.

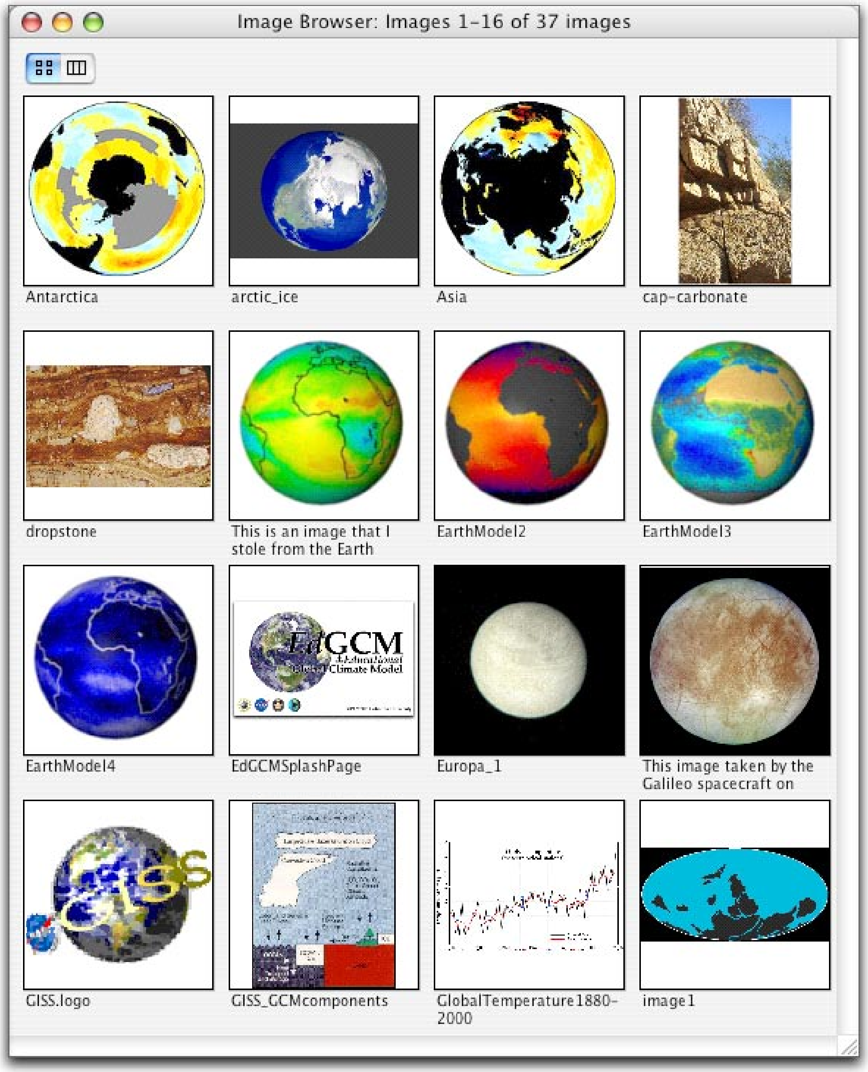
2. Each section of the eJournal (up to a maximum of 20 sections) can be used for either text descriptions or figures. To convert between one type of section to the other, simply click on the button to the left of the section (clicking on a photo button sets up the section for figures; clicking on a text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

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).

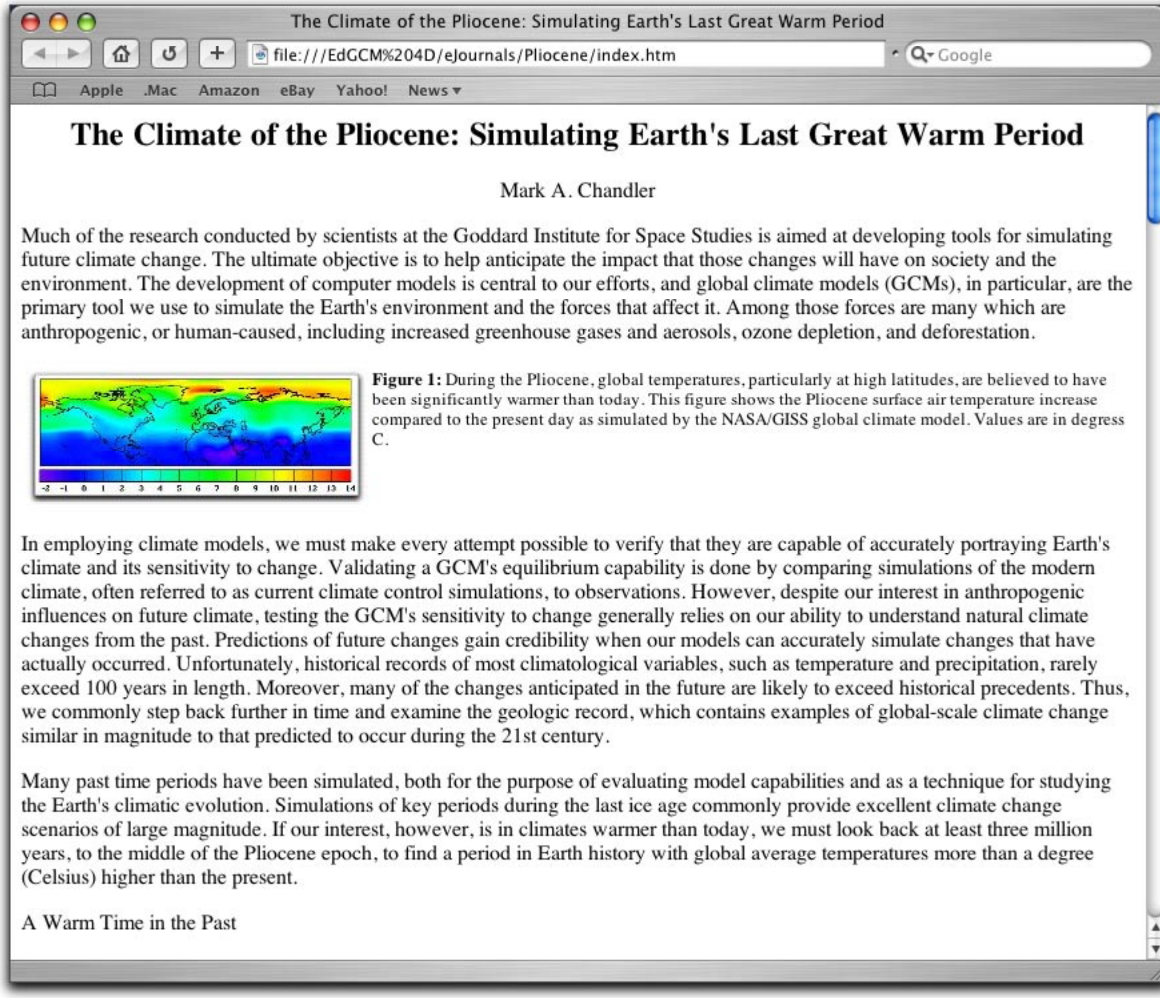


Figure 4-21. A published eJournal report.

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).

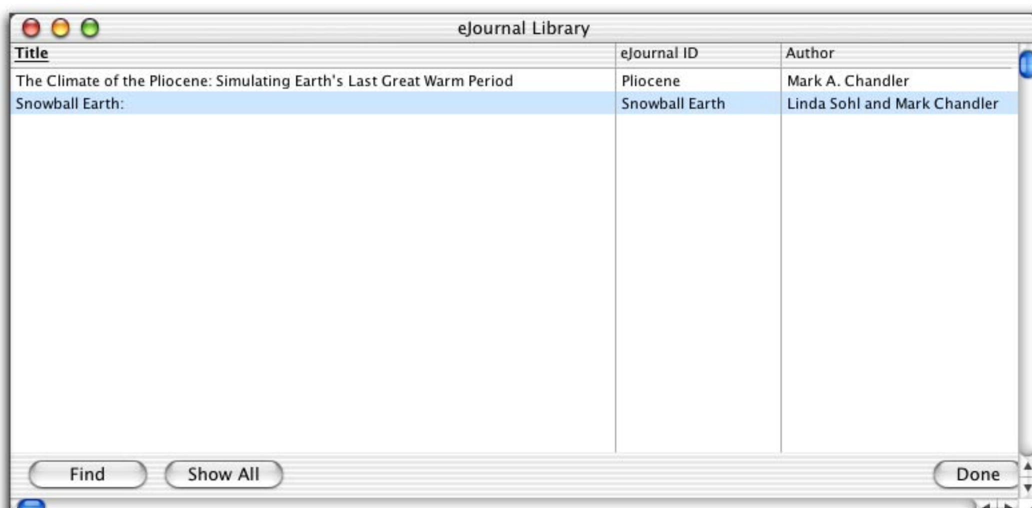
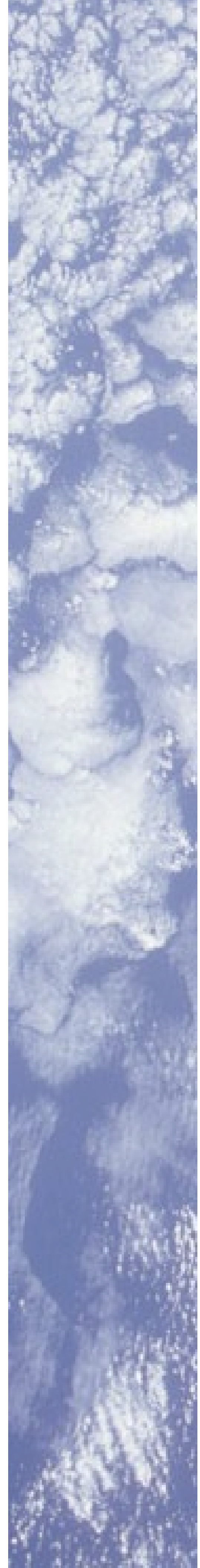


Figure 4-22. The eJournal database.



Appendix A

*Ed*GCM: In Step With National Education Standards

From its inception, the *Ed*GCM project has been proactive in ensuring that its educational goals, objectives and science-research activities are in concert with a large number of national educational standards that have been developed by organizations such as the National Research Council (National Science Education Standards); the American Association for the Advancement of Science (AAAS Project 2061 Benchmarks); the International Society for Technology in Education (National Educational Technology Standards for Students); and the National Council for Geographic Education (National Geography Standards for Students).

A series of correlations of national standards to *Ed*GCM research activities, which follows, illustrates the wide-ranging congruity of the *Ed*GCM program to these standards.

Return to Contents

A.1 *Ed*GCM Correlations to National Science Education Standards – Science Content Standards (High School)

CONTENT STANDARD A:

As a result of activities in grades 9-12, all students should develop understanding of

• Abilities necessary to do scientific inquiry

• Understandings about scientific inquiry

EdGCM ACTIVITIES IN SUPPORT OF CONTENT STANDARD A:

• Students actively participate in scientific investigations, and use the cognitive and manipulative skills associated with the formulation of scientific explanations.

• EdGCM investigations are meaningful to students. They are derived from current questions and issues that impact the lives of all people around the globe.

• Students use computers for the analysis and display of data in a variety of formats.

• Students formulate and revise scientific explanations and models using logic and evidence

CONTENT STANDARD B:

As a result of their activities in grades 9-12, all students should develop understanding of

• Structure and properties of matter

• Motions and forces

• Chemical reactions

• Conservation of energy and increase in disorder

• Interactions of energy and matter

AS A RESULT OF EdGCM ACTIVITIES STUDENTS SHOULD DEVELOP THESE UNDERSTANDINGS OUTLINED IN CONTENT STANDARD B:

• Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

• In some chemical reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

Return to Contents

CONTENT STANDARD C:

As a result of their activities in grades 9-12, all students should develop understanding characteristics of

• The cell

• Matter, energy, and organization in living systems

• Behavior of organisms

AS A RESULT OF EdGCM ACTIVITIES STUDENTS SHOULD DEVELOP THESE UNDERSTANDINGS OUTLINED IN CONTENT STANDARD C:

• Plant cells contain chloroplasts, the site of photo-synthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

• As matter and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.

• Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

Return to Contents

CONTENT STANDARD D:

As a result of their activities in grades 9-12, all students should develop understanding of

- Energy in the earth system

- Geochemical cycles

- Origin and evolution of the earth system

In conducting climate research, students develop a deeper understanding of the evidence of earth's past and unravel the interconnected story of earth's fluctuating climate. The students' studies develop the concept of the earth system existing in a state of dynamic equilibrium. They discover that while certain properties of the earth system may vary on short or long time scales, the earth system will generally stay within a certain narrow range for millions of years. This long-term stability can be understood through the working of planetary geochemical cycles and the feedback processes that help to maintain or modify those cycles.

As an example of this long-term stability, students find that the geologic record suggests that the global temperature has fluctuated within a relatively narrow range, one that has been narrow enough to enable life to survive and evolve for over three billion years. They come to understand that some of the small temperature fluctuations have produced what we perceive as dramatic effects in the earth system, such as the ice ages and the extinction of entire species. They explore the regulation of earth's global temperature by the water and carbon cycles. Using this background, students can examine environmental changes occurring today and make predictions about future temperature fluctuations in the earth system.

AS A RESULT OF EdGCM ACTIVITIES STUDENTS SHOULD DEVELOP THESE UNDERSTANDINGS OUTLINED IN CONTENT STANDARD D:

Energy in the earth system

- Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.
- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

- Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.

Geochemical cycles

- The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.

- Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.

The origin and evolution of the earth system

- Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Current methods include using the known decay rates.

Return to Contents

CONTENT STANDARD G:

As a result of activities in grades 9-12 , all students should develop understanding of

• Science as a human endeavor

• Nature of scientific knowledge

• Historical perspectives

AS A RESULT OF EdGCM ACTIVITIES STUDENTS SHOULD DEVELOP THESE UNDERSTANDINGS OUTLINED IN CONTENT STANDARD G:

• Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

• Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirma-tions and are therefore unlikely to change in the areas in which they have been tested. In areas where data or under-standing are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incom-plete, but this is also where the opportunity for making advances may be greatest.

• The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

Return to Contents

A.2 *Ed*GCM Correlations to National Science Education Standards – Science Teaching Standards (High School)

TEACHING STANDARD B:

• Teachers of science guide and facilitate learning. In doing this, teachers

• Focus and support inquiries while interacting with students.

• Orchestrate discourse among students about scientific ideas.

• Challenge students to accept and share responsibility for their own learning.

• Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

EdGCM ACTIVITIES IN SUPPORT OF STANDARD B:

• *Ed*GCM research activities are inquiry-based. Students are encouraged to interact and exchange ideas with each other, their teacher, and with research scientists during the course of their investigations.

• Teachers introduce the functions of the *Ed*GCM application; explain the use of climate models in climate research; and describe the process by which scientists evaluate their conclusions and submit their research to peer review.

TEACHING STANDARD D:

• Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

• Structure the time available so that students are able to engage in extended investigations.

• Make the available science tools, materials, media, and technological resources accessible to students.

• Identify and use resources outside the school.

EdGCM ACTIVITIES IN SUPPORT OF STANDARD D:

• *Ed*GCM activities can be conducted for various periods of time, including extended research.

• The *Ed*GCM software application, a fully operational desktop version of a global climate model, is a unique resource that enables students to conduct genuine research activities in collaboration with research scientists and educators in colleges and universities.

Return to Contents

TEACHING STANDARD E:

• Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

• In doing this, teachers and their colleagues

• Nurture collaboration among students.

• Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.

• Model and emphasize the skills, attitudes, and values of scientific inquiry.

EdGCM ACTIVITIES IN SUPPORT OF STANDARD E:

• The research activities of EdGCM may be carried out by groups of students in a collaborative effort, with each pupil assigned specific tasks within the research framework.

• Research tasks assigned to groups of students require that a continuing exchange of ideas and results be communicated in a scientifically appropriate manner.

• In order to ensure that EdGCM student research is properly planned and conducted, teachers stress the skills, attitudes and values of scientific inquiry.

LESS EMPHASIS ON

Treating all students alike and responding to the group as a whole.

Rigidly following curriculum

Focusing on student acquisition of information

Presenting scientific knowledge through lecture, text, and demonstration

Asking for recitation of acquired knowledge

Testing students for factual information at the
end of the unit or chapter

Maintaining responsibility and authority

Supporting competition

Working alone

MORE EMPHASIS ON

Understanding and responding to individual student's interests, strengths, experiences, and needs

Selecting and adapting curriculum

Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes

Guiding students in active and extended scientific inquiry

Providing opportunities for scientific discussion and debate among students

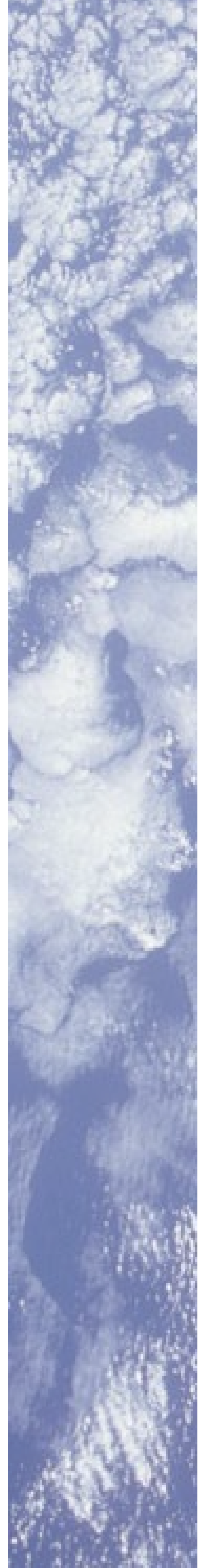
Continuously assessing student understanding

Sharing responsibility for learning with students

Supporting a classroom community with cooperation, shared responsibility, and respect

Working with other teachers to enhance the science program

Return to Contents



A.3 *Ed*GCM Correlations to AAAS Project 2061 Benchmarks – Science Content Standards (High School)

1. THE NATURE OF SCIENCE A. The Scientific World View

Aspects of the scientific world view can be illustrated in the upper grades both by the study of historical episodes in science and by reflecting on developments in current science. Case studies provide opportunities to examine such matters as the theoretical and practical limitations of science, the differences in the character of the knowledge the different sciences generate, and the tension between the certainty of accepted science and the breakthroughs that upset this certainty.

• From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science.

• No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better under-standing of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK A:

• Students actively participate in scientific inquiry, and use the cognitive and manipulative skills associated with the formulation of scientific explanations.

• *Ed*GCM research investigations are meaningful to students. They are derived from current questions and issues that impact the lives of all people around the globe.

• Students formulate and revise scientific explanations and models using logic and evidence derived from *Ed*GCM climate model data and analysis.

1. THE NATURE OF SCIENCE B. Scientific Inquiry

Students' ability to deal with abstractions and hypothetical cases improves in high school. Now the unfinished and tentative nature of science may make some sense to them. Students should not be allowed to conclude, however, that the mutability of

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK B:

The *Ed*GCM research experience involves students in the following science inquiry activities:

• Formulating a hypothesis

• Selecting variables to be tested

Return to Contents

science permits any belief about the world to be considered as good as any other belief. Theories compete for acceptance, but the only serious competitors are those theories that are backed by valid evidence and logical arguments.

The nature and importance of prediction in science can also be taken up at this level. Coverage of this topic should emphasize the use of statistics, probability, and modeling in making scientific predictions about complex phenomena often found in biological, meteorological, and social systems. Care also should be taken to dissociate the study of scientific prediction from the general public's notions about astrology and guessing the outcomes of sports events.

By the end of the 12th grade, students should know that:

• Investigations are conducted for different reasons, including exploring new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.

• Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

• Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.

• There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments.

• And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance.

• Running authentic climate simulations

• Revising and reformulating a hypothesis

• Running a revised climate simulation, when required

• Analyzing climate simulation data

• Drawing conclusions from these data

• Developing explanations for past climates

• Predicting future climate trends

• Collaborating with classmates, students from other schools and universities, and research scientists

• Publishing and sharing the results of research via the Internet

Return to Contents

• Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.

• In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.

• New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.

1. THE NATURE OF SCIENCE
C. The Scientific Enterprise

No matter how the curriculum is organized, it should provide students with opportunities to become aware of the great range of scientific disciplines that exist. There is no sense, however, in having students memorize definitions of anthropology, astrophysics, biochemistry, paleobacteriology, and the rest of the family. Individual students or small groups of students can study different disciplines in some detail—most scientific societies are happy to help out—and then share their findings with one another. The focus of such studies should be substantive (what are typical studies like in the discipline) and sociological (how is the field organized and who is in it), and they should probably involve, over an extended time, interviews, field trips, readings, data analysis, and, if possible, the conduct of small-scale experiments or field studies. Such activities will contribute to science literacy goals, and they should also help

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK C:

• The *Ed*GCM research experience may often involve students in projects that could require appropriate simultaneous studies within the Earth System, biological, environmental, and chemical sciences in collaboration with groups of students in other schools, university faculty, and research scientists.

• As a result of their experiences, students will become knowledgeable about the inter-disciplinary nature of climate research.

Return to Contents

students realize how many different career possibilities exist in science.

• Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some subdisciplines spin off to become new disciplines in their own right.

4. THE PHYSICAL SETTING
B. The Earth

By the end of the 12th grade, students should know that

• Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor.

• Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere.

• The action of gravitational force on regions of different densities causes them to rise or fall—and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK B:

*Ed*GCM research activities enable students to acquire a thorough knowledge of:

• the hydrologic cycle

• the transfer of solar radiation at and near the earth's surface

• the influence of dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans on the transfer of solar energy

• the heating of earth's surface and atmosphere by the sun in driving convection within the atmosphere and oceans, producing winds and ocean currents

• the interactions among the solid earth, the oceans, the atmosphere, and organisms that have resulted in the ongoing evolution of the earth system

Return to Contents

E. Energy Transformations

Two major ideas merit introduction during these years, but without resort to mathematics. One of these is that the total amount of energy available for useful transformation is almost always decreasing; the other is that energy changes on the atomic scale occur only in discrete jumps. The first of those is not too difficult or implausible for students because they can experience in many ways a wide variety of actions that give off heat. The emphasis should probably be on the practical consequences of the loss of useful energy through heat dissipation.

By the end of the 12th grade, students should know that

• Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount.

• Heat energy in a material consists of the disordered motions of its atoms or molecules. In any inter-actions of atoms or molecules, the statistical odds are that they will end up with less order than they began—that is, with the heat energy spread out more evenly. With huge numbers of atoms and molecules, the greater disorder is almost certain.

• Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it.

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK E:

• Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New tech-nologies often extend the current levels of scientific understanding and introduce new areas of research.

• Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.

• Many scientific investigations require the contributions of individuals from different disciplines, including engineering.

• New disciplines of science, such as geophysics and biochemistry often emerge at the interface of two older disciplines

12. HABITS OF MIND
B. Computation and Estimation

Where do calculators and computers come into the picture? The answer is, nearly everywhere. And computers, with their easy-to-use spreadsheet, graphing, and database capabili-ties, have become tools that everyone can use, at home and at work, to carry out extensive quantitative tasks.

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK B:

*Ed*GCM research activities enable students to:

• create computer spreadsheets, graphs, and tables to assist in quantitative data analysis

• graphically compare data and analyses

Return to Contents

By the end of the 12th grade, students should be able to

• Use computer spreadsheet, graphing, and database programs to assist in quantitative analysis.

• Compare data for two groups by representing their averages and spreads graphically.

D. Communication Skills

Good communication is a two-way street. It is as important to receive information as to disseminate it, to understand other's ideas as to have one's own understood. In the scientific professions, tradition places a high priority on accurate communication, and there are mechanisms, such as refereed journals and scientific meetings, to facilitate the sharing of new information and ideas within various disciplines and subdisciplines. Science-literate adults share this respect for clear, accurate communication, and they possess many of the communication skills characteristic of the scientific enterprise.

By the end of the 12th grade, students should be able to

• Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure.

• Choose appropriate summary statistics to describe group differences, always indicating the spread of the data as well as the data's central tendencies.

• Use and correctly interpret relational terms such as if . . . then . . . , and, or, sufficient, necessary, some, every, not, correlates with, and causes.

• Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

• Use tables, charts, and graphs in making arguments and claims in oral and written presentations

of data

EdGCM ACTIVITIES IN SUPPORT OF BENCHMARK D:

*Ed*GCM encourages students to:

• join in on-line group discussions about their research activities with other students, undergraduate faculty/students, and research scientists

• create and publish Internet-based research papers and reports either independently or in collaboration with students in other schools, undergraduate faculty/students and/or research scientists

*Ed*GCM activities require that students:

• Use tables, charts, and/or graphs in making arguments and claims in oral and written presentations regarding their research findings

Return to Contents

A.4 *Ed*GCM Correlations to International Society for Technology in Education (ISTE) National Educational Technology Standards for Students (High School)

ISTE Standards for High School Students

Routinely and efficiently use online information resources to meet needs for collaboration, research, publications, communications, and productivity. (4, 5, 6)

Select and apply technology tools for research, information analysis, problem solving, and decision-making in content learning. (4, 5)

Investigate and apply expert systems, intelligent agents, and simulations in real-world situations. (3, 5, 6)

Collaborate with peers, experts, and others to contribute to a content-related knowledge base by using technology to compile, synthesize, produce, and disseminate information, models, and other creative works. (4, 5, 6)

EdGCM Activities in Support of ISTE Standards:

Students routinely use the on-line Forum, eJournal, SimExchange (simulation exchange) and web publishing components for communi-cations, collaborative research, and publishing of results.

The *Ed*GCM global climate model (GCM) provides students with an opportunity to be engaged in genuine scientific research that requires hypothesis development, experiment design, running simulations, visualization, analysis and interpretation of data, and reporting results. These processes assist students in solving real scientific problems.

*Ed*GCM allows students to simulate past, present, and future climates using an actual NASA/GISS GCM.

*Ed*GCM fosters collaborations between precollege educators, students, university faculty, and the research community. These partnerships are accomplished through the ongoing utilization of the on-line components cited above.

Numbers in parentheses following each performance indicator refer to the standards category to which the performance is linked. The categories are:

3. Technology productivity tools
4. Technology communications tools
5. Technology research tools
6. Technology problem-solving and decision-making tools

Return to Contents

A.5 *Ed*GCM Correlations to the National Council for Geographic Education (NCGE) – National Geography Standards for Students (Grades 9 - 12)

NCGE Standards for Students Grades 9-12

STANDARD 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.

STANDARD 4: The physical and human characteristics of places.

STANDARD 5: That people create regions to interpret Earth's complexity.

STANDARD 7: The physical processes that shape the patterns of Earth's surface.

STANDARD 8: The characteristics and spatial distribution of ecosystems on Earth's surface.

STANDARD 9: The characteristics, distribution, and migration of human populations on Earth's surface.

STANDARD 12: The process, patterns, and functions of human settlement.

STANDARD 14: How human actions modify the physical environment.

STANDARD 16: The changes that occur in the meaning, use, distribution, and importance of resources.

STANDARD 17: How to apply geography to interpret the past.

STANDARD 18: To apply geography to interpret the present and plan for the future.

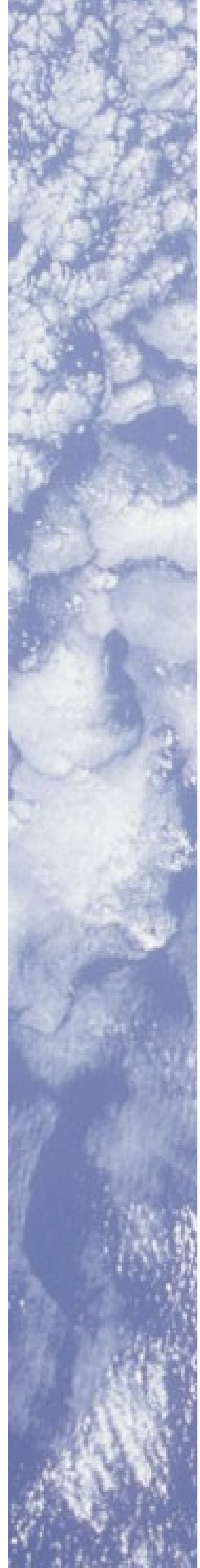
EdGCM Activities in Support of NCGE Standards:

• *Ed*GCM provides students with the tools to create computer-generated maps of atmospheric and oceanic variables, plotted in a variety of projections and regions, which they analyze and interpret in order to draw conclusions regarding their research studies.

• During the course of their research, *Ed*GCM student-participants are often required to compare and contrast numerous characteristics of the Earth's surface and its environment.

• Student research can also be required to draw conclusions regarding human actions, processes, population characteristics, patterns, and migrations as they relate to specific investigation topics and results.

• During the course of numerous climate research studies, students will define the interactions between climate, continental distribution, and topography in the past and present.



Return to Contents

*Ed*GCM Software License for Educational and Research Use

("Licensee"), and Columbia University in the City of New York ("Columbia"), regarding current and future versions of software produced by the *Ed*GCM Cooperative. License includes all programs, code, examples, manuals and other documentation included in the release (collectively, "the Software").

1. Licensee agrees that the Software and the Derivatives will be used solely for non-commercial research or educational purposes. Licensee is not permitted to sell, lease, distribute, transfer, sublicense, or otherwise dispose of the Software and the Derivatives, in whole or in part, for any form of actual or potential commercial gain or consideration;

2. Copyright of the Software is and will remain with The Trustees of Columbia University in the City of New York and/or its employees, consultants and students, and shall at no point transfer to Licensee. Any copyright notices on the Software shall be included on all copies of the Derivatives, or any parts or portions thereof, in any form, manner or substance, which are produced by the Licensee including but not limited to incorporation of the Software into any other program, technical data, documentation, firmware, or other information of the like kind, type or quality;

3. Any externally disseminated publications such as, but not limited to, manuals, technical reports, articles in journals, papers in conference or workshop proceedings, and marketing brochures or advertisements for sale or distribution of products, written in whole or in part by Licensee personnel, including but not limited to employees, consultants or students of Licensee, that are based in any part on the ideas of the Programming Systems Lab or the Software shall acknowledge Mark Chandler and the *Ed*GCM Cooperative at Columbia University, with citations to their published literature when appropriate;

4. Licensee acknowledges that the Software is being supplied in an "as is" condition without any support services or future updates or releases. Columbia may or may not make future updates and releases available to Licensee under this same or another licensing agreement, but Columbia is in no way obligated to do so. If Licensee discovers any defects or limitations in the Software,

5. Columbia makes no guarantees, warranties or representations of any kind, either express or implied. Furthermore, Columbia disclaims and Licensee waives and excludes any and all warranties of merchantability and any and all warranties of fitness for any particular purpose. Licensee agrees that neither Columbia nor its future, current or former personnel, including but not limited to employees, consultants and students, shall be held to any liability with respect to any claim by Licensee or a third party arising from or on account of the use of the Software or the Derivatives, regardless of the form of action; whether in contract or tort, including negligence. In no event will Columbia be liable for consequential or incidental damages of any nature whatsoever;

6. Licensee will guarantee that all actual or potential users of the Software, and all actual or potential producers of the Derivatives, within Licensee organization, or in organizations who have obtained or may obtain the Software or the Derivatives from Licensee, are aware of this agreement and of the terms for using the Software and producing Derivatives.

Return to Contents