Attachment 4: Lab Handout 3

A. Objectives

- Become familiar with how to finalize graphs or maps
- Understand how the ways in which you visualize data can impact its interpretation
- Continue/begin development of the EdGCM portion of your final research project

B. Background

In this lab you will learn more about map projections and best showing your results before beginning to think about your own research questions. For the your own research project, you will be asked to undertake your own research into climate change using EdGCM.

C. Manipulating Maps and Visualizations: A Guide to Making Different Maps

First open EdGCM and follow the steps from last lab to create a map. With EVA, open your map and look at the dropdown menu of options for map projects. In Panoply, look at the "Map Projections" dropdown menu that's arrayed as one of the series of tabs at the bottom of your map screen, once your visualizer has opened.

I. Map projections fall into one of four categories:
1. Azimuthal perspective;
2. Azimuthal non-perspective and related maps;
3. Cylindrical maps;
4. And, pseudocylindrical maps.

II. Each category has an advantage that might help you answer your research question.
1. Azimuthal and related projections preserve direction from a central reference point, but are progressively more distorted toward the edges.
2. Azimuthal non-perspective and related maps are for mixed uses. The Azimuthal non-perspective maps are most often used for polar or regional projections (e.g. the Lambert Azimuthal, The Aitoff and Hammer Aitoff projections display of the entire globe.
3. Cylindrical projections are most useful for looking at narrow regions centered along a given parallel (line of latitude); the poles are highly distorted and they give a disproportionate sense of importance to higher latitude features.
4. Pseudocylindrical projections are best at preserving true area, although the poles are still distorted with respect to shape. (The Robinson projection, sometimes referred to as a "compromise" projection, minimizes distortion generally within 45 degrees of the central meridian and equator, though it does not preserve equal area.)

III. So, in your map tab each one breaks down like this:
1. Azimuthal perspective = satellite, orthographic and stereographic. (The Satellite projection is a special case in which the user is also allowed to chose an altitude (in meters) and tilt angle in addition to re-centering the map on a new latitude and longitude)
2. Azimuthal non-perspective and related map projections = Azimuthal equidistant, Lambert Azimuthal, Aitoff, and Hammer Aitoff.
3. Cylindrical projections = Cylindrical, Mercator, and Miller cylindrical.
4. Pseudocylindrical projections = Goode's Homolosine, Mollweide, Robinson, and Sinusoidal.

IV. To make it simple, some of the more commonly used map projections are:

a. Equirectangular: This is a cylindrical map projection, which means it has straight meridians and parallels that intersect at right angles. Scale is true at the equator, and along any pair of parallels equidistant from the equator. While is useful for comparison of narrow regions at similar latitudes, the increasing distortion of scale toward the polar regions makes it a less-than-ideal choice for world maps.

b. Mercator: This projection is perhaps the most famous of the cylindrical map projections. It differs from other types of cylindrical projections in that it is conformal: it preserves angles, so that any two lines in the map follow the same angle as the corresponding original lines on the Earth, even though shapes become increasingly distorted toward the poles. For this reason, the Mercator projection is often used in marine navigation.
c. Mollweide: This is a pseudocylindrical map projection, which means that it has straight and parallel latitude lines and equally spaced meridians, but all but the centermost meridian are curved. This projection is often used for world maps.
iv. Orthographic: This azimuthal projection is used for perspective views of hemispheres, and so is especially useful for viewing polar regions. Area and shape are distorted, but distances along lines of latitude are true.
iv. Azimuthal Equal Area: This azimuthal projection has the distinction of being able to show areas in true proportion to the same areas on Earth. Scale decreases gradually away from the center point, while distortion increases. This projection is useful for displaying large regions, such as the Pacific Ocean, that extend equally in all directions from a center point.
v. Stereographic: Yet another azimuthal projection, this one is also useful for polar regions, and in fact is often used for navigation there. Directions are true from the center point and scale increases away from the center, and area and shapes are increasingly distorted toward the outer edge of the map.
vi. Polar: This map shows the polar regions in detail. As a result, it distorts much of the rest of the globe. However, this map may be particularly useful to our class where we might want to examine the rate ice loss in these areas.

5. Choose a map projection to see changes to **Snow and Ice Cover** that you feel is most interesting.

6. Next, manipulate the different tabs (for Panoply users) below your map or sections of commends next to your map (for EVA users) in the visualizer window that is open. Make sure you interpolate your data. For a description of what each tab does, you can refer to a detailed description in “Attachment 7: Panoply: NetCDF Visualization Software” or “Attachment 8: EVA: EdGCM Visualization Application.” Below find specific instructions for each visualizer.

For the EVA Visualizer:
a. The initial difference map created by EVA needs some adjustments so that the map can be analyzed properly. In the color bar/scale portion of the “Map Window Tool Bar,” click on the color bar menu, and select a color bar that has white in the center, such as “panoply_diff.pa1.” Next, click on the button “Center on 0.”

These two steps are very important, because the white color allows you to readily identify areas of little or no difference between the two data sets, and centering the scale assures that white does in fact represent little or no (zero) change.

b. You may wish to further adjust your difference map with respect to the endpoints and number of divisions shown the scale, to either bring out greater detail or to emphasize a range in data values. If you do, you must make sure that the endpoints of the scale remain symmetrical (e.g., -5 to +5; -12 to +12, etc.), otherwise the color bar and scale will not remain in sync. Other edits you should consider making to the difference map include changing the scale title, so that it is clear that the color bar and scale refer to an anomaly.

Once the color bar and scale for a difference map has been appropriately set, the resulting map may produce a very different impression than the initial map generated by. This part of the

process EVA may seem more art than science, but it is vital for accurate representation of the data.

For the Panoply Visualizer:

a. *The Array(s) Tab:* In the plot tab for a dataset, the first attribute that can be modified is the array of data that you wish to show. The plot toggle menu allows you to switch back and forth between a map plot and a zonal average (the average variable value across a given latitude). The interpolate checkbox to the right allows you to show the data as gridded cells or smoothly transitioning between values.

Within the Array(s) tab, you can also change the time interval of interest according to the data available in the dataset. In the example below, you can select the month of the year you want to see plotted by either typing in a month number or selecting a month from the drop-down menu. If you are plotting more than one array in a single plot (e.g., if you are differencing two datasets), the properties for the second array can be modified in the same way as for the first array. Make sure that you have the appropriate array selected in the drop-down menu of the array(s) tab before you begin changing plot properties.

b. The Scale Tab: This tab controls the way the color bar scale is displayed below the plot. You may or may not have the ability to modify some of these settings, depending upon the type of data in your dataset. The settings within the Scale tab include:

i. Units: The unit selection depends upon the units assigned to variables in the dataset. In the example below, units are given in degrees Kelvin (K).

ii. Divisions: This setting refers to the number of major segments on the map color bar scale or the major y-axis labels of a zonal average plot. There can be between two and six labeled divisions.

iii. Format: This setting refers to the display of numeric labels as real numbers in decimal form (%f), numbers in scientific notation (%E), or the option to display in either form (%G). The labels f, E and G are standard Fortran variable formats; the other choices in the drop-down menu (ranging e.g. from %.0f to %.6f) denote the number of significant digits to be displayed for a particular format. For the average user, %G is a reasonable format selection.

iv. Scaling Factor: For datasets where the range in values is quite small, a scaling factor, or exaggeration, expressed in exponential form can be useful in underscoring variability.

v. Min., Max./Fit to Data: This setting can be used to impose a scale of a certain range, for example, if a user wanted to have a scale with minima and maxima rounded to whole numbers. If the “Always Fit” checkbox is selected, however, the scale will be fitted precisely to the data, and no modification of the scale endpoints will be possible.

c. The Colors Tab: This tab is primarily for use with map plots, as it is in this tab that you can select which color bar you want to use.

i. Color bar: Thirty different color bars have been included in Panoply, and each is listed in the “Color bar” drop-down menu; you can, however, use a custom color bar if you wish. The “Flip Scale” checkbox allows you to reverse the order of colors in a color bar selected from the list. If at any point you would like to see the spectrum of colors that would be displayed for a given color bar, go into the Panoply Windows menu and select “Color bars Browser” (shown at right).

ii. Background: This setting can be used for both map plots and zonal average plots. It allows you to make the plot background either white or black.

iii. Invalids: This setting allows you to indicate areas without data in a map plot by selecting a particular color (black, dark gray, gray, light gray, or white) that will contrast appropriately with your Color bar selection.

d. The Maps Tab/Zonal Grid Tab: Whether you are working with a map plot or a zonal average plot, the fourth tab at the bottom of the plot window will display controls for modifying the gridded view of the data. Map plots have a greater number of settings that can be adjusted.

e. The Captions Tab: This tab, the same for both map plots and zonal average plots, allows you to change the name of the plot window, the plot title (which will be carried over to any exported images), and the scale caption. The scale caption by default is the long variable name plus the appropriate units. Custom title and scale captions are permitted to be quite long, but you should aim to keep them concise so as to avoid cluttering your plot.

IV. Questions

1. Which map projection best illustrates the previous two lab exercises?

Azimuthal non-perspective and related maps are for mixed uses are best suited to examining changes to snow and ice cover in the polar regions. The azimuthal and related projections help with northern latitudes.

2. Which one do you think might work best for a research question that your group will investigate?

Students can apply any of the above definitions to their own research questions and deserve full credit for ideas that make sense.

D. Developing Your Own Research Hypotheses with EdGCM

You may have noticed that there are a few other tabs to post-process and visualize using Panoply or EVA. These include the "Vertical Slices," "Zonal Averages," and "Diagnostic Tables." We will not be covering these as a group because not all research questions will require them. However, if you are interested, you might explore what they plot. For more details on each, refer to the EdGCM Manual *(*http://edgcm.columbia.edu/documentation/EdGCM_Manual_v3.2.pdf*)*. It's time. Come up with your own original research question using any of the class resources we've seen so far or that we will soon be looking at. Remember that with EdGCM you can undertake real climate science research by altering climate forcings at setup, post-processing specific year frames, and displaying more than 80 variables with a variety of different visualizations. This part of the lab will help you to begin determining what role you might use EdGCM to play in your own research.

Instructions

1. Formulate your own research question. Use the resources sheet to investigate different potential topics.

2. Next break your research down into paired hypotheses (you may wish to investigate more than one). If you are not clear on what paired hypotheses might be, please ask your instructor for help in writing them.

3. Bring your work to the instructor to make sure you're on the right track. Follow the instructions for your own research project given by your instructor.

4. As you know, the course will be devoted to you undertaking your own research into climate change. One part of this will be using at least one EdGCM scenario and control run.

5. Be sure to ask your instructor to approve your initial research question and paired hypotheses **as soon as possible.** Although you do not need to have this approved today, the sooner you know what you're working on, the better. Don't be afraid to ask for help when you need it.

Open Exploration

The remainder of the course will be devoted to you undertaking your own research into climate science. Be sure to ask your instructor to approve your initial research question and paired hypotheses and ask for help when you need it.